Evaluation of *Primary Investigations*

A research report

prepared for the

Australian Academy of Science

and the

Commonwealth Department of Education, Science and Training

by

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Peter Aubusson

Executive summary

Background

This evaluation was commissioned by the Commonwealth Department of Education, Science and Training and the Australian Academy of Science, in response to a recommendation made by Goodrum, Hackling and Rennie in their report, *The status and quality of teaching and learning of science in Australian schools* (2001).

Primary Investigations (PI) was developed by the Australian Academy of Science in answer to a growing need for a hands-on, investigation-based sequence of activities for primary school science. It endeavoured to provide a whole school, step-by-step guide to the teaching of primary science, using a constructivist theoretical framework. The program was extensively trialled before its launch in 1995 and initial indications were that PI was very successful in helping reluctant primary school teachers begin to teach science (Featherstone, 1995; Goodrum, 1996). However, a recent national study of science teaching in schools (Goodrum, Hackling and Rennie, 2001) showed that many primary schools are still not teaching science, and that more needs to be done to improve the quality of primary science. As PI has now been available for seven years, it is timely to evaluate its performance.

Objectives of the evaluation

1. Assess and provide advice on the quality, efficiency and effectiveness of PI in meeting its stated goals, namely, to obtain:
   - 1.1 a significant uptake by schools
   - 1.2 an increase in teacher confidence
   - 1.3 an improvement in students’ attitudes to science
   - 1.4 an increase in student achievement
2. Assess and provide advice on:
   - 2.1 the factors that facilitated the meeting of the stated goals
   - 2.2 the barriers that inhibited the meeting of the stated goals
   - 2.3 PI’s future development and direction

3. Make recommendations concerning options or approaches to enhance or extend the project.

Method

Data sources

The method used in this evaluation of PI involved both quantitative and qualitative techniques of data collection, as follows:

- analysis of secondary sources;
- 22 face-to-face interviews, 1 electronic interview by email and 13 phone interviews with key stakeholders (including academics, members of education departments, teachers, members of science teachers associations, PI trainers, and others with expert knowledge of PI);
- focus group discussions with 19 teachers (8 from Western Australia, 4 from New South Wales and 7 from the Australian Capital Territory);
- a survey of 52 teachers (40 users of PI and 12 non-users);
- a survey of 220 upper primary school students.

Data analysis

Secondary sources reporting on PI were reviewed. Interpretive procedures were used to analyse qualitative data. Descriptive statistical techniques were applied to quantitative data.

Research questions

This evaluation set out to answer the following research questions:

1. Has there been a significant uptake of PI by schools?
2. Has PI improved teacher confidence?
3. Has PI improved students' attitudes to science?
4. Has PI improved student achievement in science?
5. What factors have helped PI to meet its goals?
6. What factors have inhibited PI from meeting its goals?

7. What should be PI's future development and direction?

Answering the research questions

Has there been a significant uptake of PI by schools?

There has been a significant uptake of PI by schools in Western Australia, Queensland, the Australian Capital Territory, parts of New South Wales, and perhaps Tasmania.

Has PI improved teacher confidence?

Teachers who have used PI are more confident about teaching science and are less reluctant to teach it.

Has PI improved students' attitudes to science?

Because PI has enabled more teachers to teach interesting and engaging science, it has resulted in more students having positive attitudes to science.

Has PI improved student achievement in science?

While there has been no large-scale State or national study to assess the impact of PI on student achievement in science, the evidence from this evaluation suggests that it has had a positive impact.

What factors have helped PI to meet its goals?

A variety of factors interacted to help PI meet its goals. The major influences were the quality of the program; the support of education systems and other key groups; the degree of match with the State or Territory syllabus; and the presence of committed local advocates.

What factors have inhibited PI from meeting its goals?

While a range of factors helped PI to meet its goals, one factor alone seems to have been sufficient to sink it: the lack of support of the State or Territory education system and science teachers association in raising awareness about PI and encouraging professional development.

What should be PI's future development and direction?

PI should be retained and revised. Suggested features that should be incorporated into a revised version have been identified (see

Appendix 5). The process of revision should include the cooperation of stakeholders to develop, trial, promote and support a revised PI.

Conclusion

PI has made a significant positive contribution to primary science education in Australia. With modification and support it is likely to build on this foundation to further promote productive teaching and learning of science in many primary schools.

Recommendations

1. Revise *Primary Investigations*

1.1 It is recommended that PI be revised. It should retain many of the good features of the original program but be flexible and adapted to different State requirements and the needs of different teachers. Suggested attributes of a revised PI are in Appendix 5.

2. Hold a cooperative forum to develop guidelines for the revision of *Primary Investigations*

2.1 It is recommended that a forum be convened by the Australian Academy of Science. This forum should include primary teachers from State science teachers associations, representatives of State and Territory departments of education, the Australian Academy of Science, the Australian Science Teachers Association, the Commonwealth Department of Education, Science and Training, and science education researchers. It would also be beneficial to include less confident teachers of primary science.

2.2 The forum should use the results of this evaluation to develop guidelines for the revision of PI.

2.3 The forum should establish a working party to take on the task of revising PI. The revision should be overseen by a steering committee comprising representatives of State and Territory departments of education, the Australian Academy of Science, the Australian Science Teachers Association, the Commonwealth Department of Education, Science and Training, and science education researchers.

2.4 If possible, revision should include extensive trials in all States and Territories, in cooperation with State and Territory education systems.

2.5 The steering committee should promote mechanisms within each State and Territory to ensure effective trialling, implementation and ongoing support for the revised PI. These support mechanisms should involve, among others, the State science teachers associations and State and Territory departments of education.

3. Establish a mechanism to regularly survey primary schools about students' science experiences.

3.1 A variety of strategies and programs have recently been employed to improve primary science in Australia. Now is an ideal time for the Commonwealth Department of Education, Science and Training to begin to regularly survey primary schools about students' primary science experiences.

3.2 The student questionnaire used in this study (Appendix 1) may be an inexpensive and effective way to achieve this. Mapping primary school students' experiences over time would identify schools where change for the better had occurred. Case studies of selected schools in each State would allow the factors that led to this change to be identified. This would allow primary science programs to be better designed and targeted and would yield information that could be applied to other strategies and programs aimed at improving the educational experiences of students in Australian schools.

Evaluation of *Primary Investigations*

Background

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Method

The method used in this evaluation of PI involved both quantitative and qualitative techniques of data collection, as follows:

- analysis of secondary sources;
- 22 face-to-face interviews, 1 electronic interview by email and 13 phone interviews with key stakeholders (including academics, members of education departments, teachers, members of science teachers associations, PI trainers, and others with expert knowledge of PI);
- focus group discussions with 19 teachers (8 from Western Australia, 4 from New South Wales and 7 from the Australian Capital Territory);
- a survey of 52 teachers (40 users of PI and 12 non-users);
- a survey of 220 upper primary school students.

Analysis of secondary sources

Secondary sources included published and unpublished reports. Several documents were generated as departmental reports (eg, Deshon, 1998), and some as preliminary research conducted by several key stakeholders who were interviewed during this study (eg, Kroll, 1997).

Interviews and focus groups

Semi-structured interviews were carried out with key stakeholders in the Australian Capital Territory, New South Wales, South Australia, Queensland, Victoria and Western Australia. These included science education academics (New South Wales, Queensland, Victoria, Western Australia), members of education departments (New South Wales, Queensland, Victoria, Western Australia, South Australia), teachers (New South Wales, Queensland, Victoria, Western Australia, Australian Capital Territory), members of science teachers associations (New South Wales, Australian Capital Territory, Queensland, national), personnel of the Australian Academy of Science, and others with expert knowledge of PI (Queensland, Australian Capital Territory, national). Only one stakeholder in South Australia was interviewed. Two others were contacted and briefly commented on PI but indicated that they had little information to offer. Some contacts in South Australia may be followed up in the near future. All other listed States and Territories were well-represented in the sample.

The following questions formed the framework for these interviews:

- What is your experience with PI?
- What do you consider to be the strengths and weaknesses of PI?
- What factors facilitate or inhibit the uptake/success of PI?
- What is the effect of PI on teacher confidence, students' attitudes and student achievement?
- What are your recommendations for any future development of PI?

These questions were provided to interviewees before they were interviewed. Most interviews ranged in length from 45 to 90 minutes. The shortest interview was 15 minutes and the longest was 2 hours. In order to keep the flow of the discussion, and to allow the conversation to develop along lines that were appropriate to the interviewee, not every question was asked in each interview. For example, in some instances the interviewee would include the strengths of PI in a discussion of factors that facilitated uptake, at which point the question on the strengths of PI was considered to be unnecessary.

Although all interviews covered the same information, the format varied according to circumstances. Most academics, members of education departments, personnel of the Australian Academy of Science and officials of science teachers associations were interviewed face to face, with the exception of one who was overseas at the time and replied to our questions in an extended email.

Three teacher focus groups were used, in Western Australia, New South Wales and the Australian Capital Territory. The use of focus groups saved time in arranging separate meetings with busy teachers, and incorporated another dimension to the interview. In these discussions a group of teachers (some of whom were also consultants on primary science) were able to respond to each other's ideas and comments as they arose. This allowed the interview to proceed along lines directed by the teachers and facilitated the spontaneous generation of new ideas.

A further subset of interviews was conducted by phone. This group included members of the Australian Academy of Science's list of PI trainers, and teachers who had shown particular interest in the teaching of primary science and represented primary science interests in a State science teachers association executive.

Face to face interviews, focus group discussions and one phone interview were recorded on audiotape. The content of the discussion was summarised and the summary sent to each participant for checking and correction. A few responded with additional views, usually in an email or at the end of the checked interview summary. Where this data has been used, it is attributed to the interviewee as if it were part of the original interview. Only minor corrections were made by interviewees to the summaries provided.

With one exception, phone interviews were not audiotaped. Notes made at the time of the discussion were sent to interviewees for perusal. Where changes and corrections were made these were incorporated into the final summary of the interview that was then used in the writing of this report.

Survey of teachers

Themes identified in the first 18 interviews with key stakeholders and the first focus group discussion were used as the basis for the survey questions. Statements summarising the views of these interviewees were listed on the questionnaire (Appendix 1) and teachers were asked to rate whether they strongly disagreed, disagreed, were neutral, agreed or strongly agreed with these statements, using the five-point Likert scale. Some background information about the sample was also collected, including the years of experience with PI, types of professional development undertaken and an assessment of their level of confidence in teaching science.

Two open-ended questions were also included. Those teachers who had never used PI were asked to give a reason for not using PI, and teachers who had stopped using PI were asked why they had made this decision.

Two teachers and an academic, all familiar with PI, were sent a draft version of the questionnaire to complete, in order to check for errors and ambiguities. They suggested no changes. The questionnaire was also checked by the Australian Academy of Science's Reference Committee which was established to oversee this research.

The questionnaire was sent to schools in New South Wales, Western Australia, Victoria and Queensland. Because of the different nature of the syllabus in New South Wales a slightly modified version of the questionnaire was used, in which 'science' was replaced by 'science and technology'.

Target sample

Clearance to send the surveys to primary schools was obtained from State education departments in New South Wales, Western Australia, Victoria and Queensland, provided that the permission of the principal was first obtained. For consistency, all school principals were contacted before surveys were sent to teachers in their schools. A roughly equal mix of teachers who did and did not use PI was the targeted population, and principals were asked to give the survey to one teacher in their school who used PI and one who didn't. These phone conversations with the principals elicited incidental information about whether schools were using PI or not.

The schools that were approached in each State were selected from the Australian Academy of Science's list of purchasers of PI, and included those schools from Western Australia, Queensland and New South Wales that had spent more than $1000 on PI, and schools from Victoria that had spent more than $500 on PI. An initial attempt to locate schools where only some teachers used PI, by generating a random list of schools that had spent more than $150 on PI, failed. Too many schools were found not to be using PI at all, and the time-consuming nature of this method of locating appropriate teachers meant that a more effective method had to be found. By calling schools that had spent larger amounts of money on PI, we reasoned that we were more likely to find teachers that had used or were using PI.

Permission was obtained from 62 schools (including Catholic, State and independent) and two surveys were faxed to each school, along with copies of permission letters from State education departments and the University of Western Sydney's Ethics Committee, and an information statement. Teachers were asked to complete the questionnaire and fax it back.

Characteristics of the teacher sample

A total of 52 surveys was returned, a return rate of 42 per cent. The number of surveys returned from teachers who had never used PI was especially low, only 12 of the 52 teachers (23 per cent) being in this group. The return rate was disappointing given the time needed to contact each school and locate those that had used PI. One problem with the fax-out and fax-back approach may be the time needed for secretaries and principals to distribute the questionnaires to the appropriate people. It was clear from phone conversations that many principals were uncertain about the resources used for teaching science in their schools.

There were also some problems with fax machines not working, and we were not sure that all surveys had reached their destinations.

Most teachers in the sample were experienced teachers (mean 19.1 years teaching, SD 8.9) and their self-rating of confidence in science teaching was very high (mean 3.88, SD 0.65). The 12 teachers who had never used PI rated themselves as neutral or confident.

Nearly half of the sample (48.6 per cent) reported that their whole school used PI. This was a much higher proportion than would be expected from the feedback from the target sample, as only in Western Australia did most schools say they were using PI across the school. The figures can't be explained by a high return rate from Western Australia, as only four surveys were returned out of 52. Explanations as to why the sample consisted mainly of PI users are not available to us at this stage.

The mean years of use with PI was 3.7, implying that these teachers were very experienced with the program. Teachers who had used PI in each of the seven years of primary school were also represented.

From these figures it can be seen that the sample is very well able to comment on the strengths and weaknesses of PI and to make recommendations founded on experience. However, no reliable figures have been obtained from this sample as to why PI is not used in many schools.

Analysis of survey data

The data was analysed using the statistical analysis software package, SPSS. Responses to questions using the Likert scale are presented as mean scores, where the mean represents the extent of agreement with a particular statement. A higher mean indicates greater agreement.

A formal test for reliability has not been done at this time, however there is consistent agreement on like questions, such as 'PI should be matched to my syllabus' compared with 'Does not meet the requirements of the syllabus'. Comments added to question 50, on reasons why teachers chose to stop using PI, support other findings from the survey. There is also a high degree of consistency between the survey data and findings from later interviews. This triangulation of the data leads us to believe that the survey was a reliable and valid measure of teachers' views on PI.

Survey of students

The questionnaire used to determine students' attitudes to their PI science classes was the same questionnaire used by Goodrum, Hackling and Rennie (2001) in their national survey on primary science. The reliability and validity of this instrument has already been established. The same conditions for administration of the survey were used in this study.

Characteristics of the student sample

The list of schools that had spent large amounts on PI was used as a starting point. Schools were phoned in order to identify those where PI was used as the main resource in an upper primary school class. The permission of the principal was then sought, and consenting principals were sent a package containing questionnaires, parent permission notes, information statements, a letter to participating teachers and instructions for administering the survey. Schools in New South Wales were sent a covering letter explaining that references to 'science lessons' in the survey should be taken as meaning 'science and technology lessons'.

Of 15 sets of student surveys sent out, 12 schools (80 per cent) returned completed forms, resulting in a sample of 220 students. This return rate was high, probably because principals had only agreed to do surveys in circumstances where the staff had already expressed their willingness to comply with our request. The sample consists of a slightly higher proportion of boys (61.3 per cent), most students are in year 5 (59.9 per cent) or year 6 (22.5 per cent), and schools from both the State and private sector are represented.

Analysis of survey data

The data was analysed using SPSS and is presented in full as frequency of responses to individual questions in Appendix 2.

Ethical considerations

Names of schools and students were not appended to the survey. All surveys were accompanied by requests for parental permission and all permission notes were accompanied by a letter informing the parents of the nature of the research. Teachers were asked to remind students that they did not need to fill out the questionnaire, even if their parents had given permission, and a sentence to this effect was included on the front page of the survey.

The research was approved by the University of Western Sydney's Ethics Committee and by the departments of education in each State. A condition of this approval was that all participants in the research remain anonymous in reports. The initials used to identify participants in this report are pseudonyms. The gender of participants, as reported by pronouns, also may not accurately be that of the actual participant. Focus groups are identified by State or Territory.

Some of the interview extracts in this report have been slightly edited for clarity.

Analysis of secondary sources

PI – development and trialling

PI is a program for primary science that promotes hands-on, investigation-based science learning. The program draws on the work of the Biological Sciences Curriculum Study and is underpinned by a constructivist approach to science teaching. The complete program is organised into seven books, each of which is focused around a major concept:

Book 1 Awareness and observation

Book 2 Order and organisation

Book 3 Change and measurement

Book 4 Patterns and prediction

Book 5 Systems and analysis

Book 6 Energy and investigation

Book 7 Balance and decisions.

Each book explains the teaching strategies recommended for all of the units, namely the constructivist model of the 5Es (Engage, Explore, Explain, Elaborate and Evaluate) developed by Trowbridge and Bybee (1990), and cooperative group learning.

The intention of the Australian Academy of Science was to introduce a ‘well-structured and well-taught science and technology program into primary schools across Australia’ (Australian Academy of Science, 1996). Teachers were consulted at each stage of the development process and extensive trialling took place across 41 schools. The materials were rewritten in response to feedback from the trials (Australian Academy of Science, 1996). One such trial has been reported in depth by one school science coordinator (Pearson, 1995), who observed that teachers in her school were ‘genuinely impressed with the material and how user friendly it has proved to be'. Ebbers (1997) also reported that enthusiasm was high at the conclusion of the trialling period.

PI – implementation

PI was released at the start of the 1995 school year. By March 1996, according to the Australian Academy of Science's report (1996), at least 800 schools had purchased the program on a whole-school basis and teachers in more than half of these schools had attended sessions given by qualified trainers. The uptake of PI was particularly high in Western Australia, where over 50 per cent of schools had adopted the program by 1995 (Goodrum, 1996). In 1999 the Academy reported that 37 per cent of schools across Australia had purchased at least one PI book, including 86.8 per cent of schools in Western Australia, 67.3 per cent in the Australian Capital Territory and 51.5 per cent in Queensland.

The release of PI was associated with a coordinated professional development program. A team of presenters was trained by the project director, Dr Denis Goodrum, and these trainers then conducted inservice workshops in schools (Deshon, 1998). Whole-school professional development was considered to be an essential component of successful PI implementation. This extensive training program was funded by a number of organisations, including the Australian Academy of Science, government departments and private industry (Australian Academy of Science 1996; 1999). By 1999 there were about 300 qualified trainers across Australia (Australian Academy of Science, 1999). A 'Do-it-yourself' inservice video was also made available.

In 1995 a trial television broadcast to 33 schools attempted to promote teacher knowledge and awareness of PI. Watters and Ginns (1996) observed the outcomes of one of these satellite learning experiences and recorded that the television broadcasts were of limited use as a way of 'realistically achieving any conceptual development' (p. 64). However, the accompanying trial of PI material was successful in helping the teacher gain confidence in science teaching, improve her content knowledge and implement cooperative group learning.

The launch of PI coincided with a focus on science in primary education in Western Australia. Western Australia's Department of Education initiated the primary science teacher-leader project in 1995-96, and at the same time the Science Teachers Association of Western Australia endorsed PI (Deshon, 1998). A study of the success of the teacher-leader project showed that these two events were then effectively linked, many of the newly trained science coordinators citing the implementation of PI as the main achievement in leadership for 1995-96 (Venville, Wallace and Louden, 1998). Also as part of the State-wide emphasis on science, funding was allocated for professional development and school resources, allowing teachers to attend PI workshops conducted by Denis Goodrum and his team (Deshon, 1998). This combination of initiatives probably accounted for the fact that by 1996, 67 per cent of primary schools in Western Australia had elected to implement PI across the whole school.

Despite the enthusiastic uptake of PI by Western Australia, the Australian Capital Territory and Queensland in the first three years of its inception, there is evidence that the amount of time spent on teaching primary science is still inadequate. In a national study Goodrum, Hackling and Rennie (2001) found that the average amount of time spent teaching science in primary school was 59 minutes a week, although this varied widely between individual schools. These authors have called for more resources to be allocated to enable the time spent on science to be increased.

PI in schools – teachers' experiences

Featherstone's (1995) evaluation of PI surveyed 100 teachers who had used PI during 1995-96. He found that 'teachers agreed that in general PI had:

- raised the status of science
- resulted in a whole school approach
- increased student interest in science
- resulted in reluctant teachers teaching science.' (p.55)

The participants in this study generally agreed with the stated aims of the program, however they did not agree that PI gave them the opportunity to respond to individual needs. Teachers in Featherstone's study also thought that the program was of most benefit in conducting student investigations and less useful for planning, reporting and evaluating. The majority of respondents neither agreed nor disagreed that equipment was easy to obtain or adapt, but most (70 per cent) agreed that organising equipment was very time-consuming. Most of the teachers surveyed understood the meaning of the stages of the 5Es, but many (61 per cent) were using more than just the strategies offered in the program.

A study by Ebbers (1997) focused on three schools in Western Australia that had implemented PI to varying degrees. One school had been part of the trial and then maintained PI at all levels, another had decided to use only those parts of the program that blended with the teaching themes they had chosen, and the third had elected to try PI in only one class. From her case studies of these three schools, Ebbers found the benefits of PI to be that it:

- provides a good model for starting teachers
- provides organisational structure for science lessons
- helps teachers to learn science
- increases continuity across grades
- increases student motivation
- supplies are easy to obtain.

The concerns raised by teachers in Ebbers' study centred on the prescriptive nature of PI. Ebbers found that those teachers who rated themselves as reluctant teachers of science were happy with PI, but confident teachers of science often thought they could do better. Many of the confident teachers were using aspects of PI in their teaching.

Overall, Ebbers was favourably impressed by the program, stating that 'within less than five years it has provided teachers with a well structured science program that takes the concerns of reluctant teachers to heart' (Ebbers, 1997, p.32).

The successful implementation of a whole-school program based on PI was reported by Deshon (1996). A study at Kalamunda Primary School found that whole-school professional development and a commitment by the school to provide adequate resources had led to an increase in teacher confidence and student achievement. The teachers at Kalamunda were concerned that PI did not allow the students to plan their own investigations, so they responded by developing a set of investigable questions, based on the strategies offered in the program. Deshon reports that the teachers' commitment to new ideas played a large part in the success of this implementation.

Mulholland and Wallace (2000) followed 'Katie' through teachers' college and her first year of teaching and observed her first attempts to teach science. PI was adopted by the school where Katie commenced her employment. Katie was committed to hands-on activities for her class, but the reality was that she often felt obliged to sacrifice these activities in order to maintain classroom control. The lack of simple facilities such as a sink or a free bench were also significant problems in managing successful lessons. At the end of her first year she decided that teaching science was not as rewarding as she had hoped it would be, although the children had definitely enjoyed the experiences she had struggled to provide.

The difficulty with obtaining and managing some of the equipment for PI was also noted by Pearson (2001) in her case study of two experienced teachers who were implementing the program. For example, one teacher used magnets that she found around the school and the outcome of the tests for magnetic properties was influenced by the fact that many of these magnets were old and weak. This created a situation that made explanation very difficult. Not only that, the teacher had had to spend a lot of time 'scrounging' these inadequate scientific resources. As reported by the teachers in Featherstone's (1995) evaluation, Pearson observed that the time spent organising resources for science teaching in the primary school was an impediment to the implementation of PI.

Kroll (1995) interviewed 12 primary teachers from Queensland about PI and reported that the program gave those with little science background the confidence to conduct science lessons on a regular basis, and that students and teachers showed improved 'attitude, interest, enthusiasm and motivation for science' (p.16). A later study of five classrooms in the Brisbane diocese (Kroll, 1997) confirmed these positive aspects of PI implementation. This study also measured the degree to which a constructivist environment was achieved in the classroom. Kroll found that success in implementing PI's constructivist teaching strategies depended on the personal epistemologies of the teachers. One teacher, who held a very traditional view of science as a body of content knowledge, was able to teach an activity from PI in a very teacher-led way that was not consistent with the aims of the program.

Other studies have indicated that although PI provides teachers with a framework that allows them to teach more science than previously, in some instances this science is not being taught in the way the curriculum intended. Ebbers (1997) observed that teachers misinterpreted the 5Es model of instruction and reverted to a more teacher-directed style. She speculated that this might have been partly due to failure to attend all of the professional development workshops. The case study of 'Katie' (Mulholland and Wallace, 2000) identified that she was often encouraged by her more experienced colleagues to drop those aspects of PI that could result in a loss of classroom order, particularly the cooperative group work and hands-on investigations.

Similarly, a case study of two teachers over a full year (Pearson, 2001) found that when they were implementing PI they were often tempted to return to a teacher-directed style of lesson. Although experienced in teaching, both teachers lacked a deep understanding of science content. This lack of confidence resulted in the teachers being reluctant to allow the students to ask their own questions and to freely explore a phenomenon. The teachers felt that when they didn't know all the answers to questions about content it introduced uncertainty into the lesson, disrupting the 'seamless' flow. Both teachers continued to control the children's experiences so that they would reach the 'right' answer or acquire the greatest amount of scientific knowledge. This control of questioning also allowed them to maintain discipline and to keep the children focused on a task.

The teachers in Pearson's (2001) study were constrained by their own epistemology of science. Like the traditionalist teachers observed by Kroll, they 'are faced with the dilemma of acknowledging the need to provide interactive experiences to develop children's understanding of science concepts, with their certainty that science is a set of "truths" that have to be learned' (p. 209). They are not able to come to terms with the concept of allowing children to construct their own theories. Such resistance to the implementation of constructivist programs, and to curriculum change in general, has been observed elsewhere (Wallace and Louden, 1992; Duffee and Aikenhead, 1992; Cuban, 1990).

In summary, the literature indicates that there are three main reasons why teachers fail to adopt a constructivist strategy when teaching PI. These are:

- their conviction that 'free' investigation is a threat to classroom order
- their belief that science is a body of knowledge that must be learnt
- their lack of confidence in their own content knowledge.

PI in schools – student outcomes

There is some evidence that the emphasis on primary science in Western Australia has resulted in improved student learning. Figures from State-wide testing in 1997 showed that science performance by primary students improved in all areas tested in year 7 (Deshon, 1998, p.6). The study by Featherstone (1995) reported that 70 per cent of teachers felt that PI-based lessons allowed students to develop a good understanding of concepts. In two Western Australian schools, where science testing has been consistently carried out since the implementation of PI, the results have been positive. Students were achieving results slightly above the State-wide averages (Pearson, 1995; Butcher, 1999). Due to the multi-pronged nature of the Western Australian science initiative, it is not possible to say that these results were due to PI alone, but it seems likely that it was an integral factor in the achievement.

Summary of findings from secondary sources

The review of secondary sources suggests that PI:

- improves teacher confidence
- improves student motivation
- promotes increased student achievement, when used in conjunction with other initiatives
- raises the profile of science in the primary school.

The principal weaknesses indicated are that:

- it can be used in such a way that teachers feel confident that they are teaching science, even though they are not teaching it in the constructivist way that the curriculum or PI may have endorsed or intended
- it is too rigid in structure and does not allow the teacher to tailor the program to their students
- the time needed to plan lessons and organise equipment is excessive.

An analysis of the implementation of PI in Western Australia suggests that the achievement of its stated goals was facilitated by the concurrent State-wide initiative in primary science, involving cooperation among many stakeholders.

Results and inferences

Research question 1: Has there been a significant uptake of PI by schools?

In 1999 the Australian Academy of Science reported that 37 per cent of schools across Australia had purchased at least one PI book. The inference is that the use of PI in schools might be expected to mirror this figure. However, data from the present study, discussed in detail below, indicates that purchase figures may not be an accurate measure of PI uptake in schools.

At the outset of this study the intention was to approach schools which had been randomly selected from the Australian Academy of Science's list of purchasers of PI and ask them for help in completing a survey of teachers' experiences with PI and students' attitudes to science as a result of study with PI. In order to conduct the student survey it was necessary to locate classes of students that had used PI as their principal resource for at least one term. This task proved to be more difficult than expected.

A list of purchasers of PI, accurate to mid-2001, was obtained. A summary of purchases to that date is shown in Table 1. However, a deeper analysis of this list showed that many schools had spent very low amounts, almost certainly less than would equip a school to fully implement PI. In New South Wales, for example, the total number of schools that had purchased PI was 512, and 101 of these had spent $150 or less, some as little as $49. Schools that had spent $150 or less were unlikely to be consistent users of PI and were subsequently excluded from the random list of schools to be approached in this research. A substantial number of PI purchasers remained, for example 411 in New South Wales and 316 in Victoria.

Table 1 Patterns of purchase and use of PI

State	Total purchasers	Purchase greater than $150	Major purchasers sampled	Always use PI	Partial use of PI	Never use PI
New South Wales	512	411	23	13	5	5
Victoria	404	316	16	4	3	9
Western Australia	463	296	16	9	1	6
Queensland	825	730	22	7	4	11
Australian Capital Territory	60	54	none			
Nationwide	2204	1753	77	33	13	31

When schools on the list generated for New South Wales were contacted for their permission to conduct research, in a pilot sample of 14 schools only three were using PI as the principal resource in at least one class. To reduce the time spent in approaching schools that were not able to help with surveys, a more restricted list consisting of schools that had spent the largest amounts on PI was generated. It was reasoned that these schools would be most likely to be using PI widely in their classrooms.

Of the major users who replied when contacted, 43 per cent (n=77) said that they used PI as a principal resource. Another 40 per cent either said that they were using PI as one of a number of resources, or that only a few teachers were using PI. The remaining 17 per cent did not use PI at all. The figures varied across the States, with Queensland, the biggest purchaser of PI in dollar terms, having the lowest proportion of major purchasers that always used PI (32 per cent). Western Australia showed a higher proportion (56 per cent) of major purchasers that were using PI as a principal resource.

The indication from the figures obtained in this study is that fewer than expected schools are using PI, and even fewer use PI across the whole school. Although this sample is relatively small, there are strong indications than in all States except Western Australia and the Australian Capital Territory the use of PI is not widespread.

Previous figures released by the Australian Academy of Science (1999) showed that 51.5 per cent of Queensland schools had purchased at least one PI book. Of the schools that had spent more than $1000 on the texts, less than half are using PI across the school. It is reasonable to assume that an even smaller percentage of the remaining purchasers are using PI as a whole-school program. Overall, there may well be less than 20 per cent of Queensland schools that use PI in a systematic fashion. Conversations with teachers suggest that the use of PI may have been greater in the recent past.

In Victoria the initial purchase figures were low, and the usage was estimated to be even lower. It is probable that very few schools in Victoria use PI as a principal resource. In New South Wales the dollar amount of PI purchased was less than half that of Queensland, and a similar proportion of major purchasers (44 per cent) do not use PI across the school. From these figures it would seem likely that substantially less than 20 per cent of New South Wales schools use PI as a school-wide program.

One consequence of this pattern of uptake of PI in New South Wales, Queensland and Victoria is that State-wide measures of student achievement in science are unlikely to reflect any influence. Another consequence is that gains to teacher confidence or student attitudes reported by the sample used in this study must be viewed as occurring only within schools where PI has been used.

Reasons given as to why schools had purchased PI and then ceased, or failed, to implement it, were varied and will be discussed elsewhere in this report.

Finding

There has been a significant uptake of PI by schools but the uptake across Australia has been uneven.

Research question 2: Has PI improved teacher confidence?

Thirty-four interviewees and focus group teachers perceived that PI had improved teacher confidence to teach primary science. The remainder of those interviewed were unwilling to comment on its impact on teacher confidence as they had no evidence to inform their view.

Those who claimed that PI had improved teacher confidence often cited evidence for this. Some cited feedback from teachers, derived from their experience as consultants or trainers, with many teachers claiming, for example, that PI had *helped them [teachers] incredibly* to *teach science* (DB). NI explained, *Based on my experience with teachers...PI has increased teacher confidence...[It provided a] simple scaffold that allowed teachers to start to teach science in a way that moved them towards becoming a confident teacher...I can't think of another resource that has done this.* In particular, some explained, PI provided support and built confidence among inexperienced teachers and those who lacked confidence to teach science. It offered *teachers who didn't know what they were doing – who were new out of college, or who had never taught science (and research shows this was a fairly high proportion), or who felt out of touch – an achievable way to go about doing science* (CL).

Teachers often described what had happened when PI had been used in their schools. HK explained that since the introduction of PI in his school, *there are no reluctant teachers of science in my school. A teacher who takes time to look at PI comes away saying, 'that is my science for the whole year'*. Many observed that *teachers are now teaching science where they weren't before* (DD). The situation described by DD seems not atypical. All teachers at her school were reluctant science teachers, DD included. *Until PI they were doing chalk and talk lessons they found boring. None were confident of their science knowledge but PI has improved teacher confidence.* DD claimed that *she had had similar feedback from other teachers who had done the [PI] in-service training. That is, that PI encourages reluctant teachers of science*.

Some teachers who identified themselves as reluctant teachers of science described the impact PI had had on them*, with me it has [made me more confident]. Science has never been my forte. Once, I always used to avoid it like the plague...PI is so easy to follow and so clearly put together...Science had always been a lot of fiddling about before* (Australian Capital Territory).

Some teachers, already confident about teaching science before using PI, indicated that PI had had no effect on their levels of confidence, often commenting that they were *already confident* (Australian Capital Territory). Others said that it had improved their confidence further, for example, *Confident science teachers became more confident and they were using it in a more confident way. If you were confident it just helped and improved your confidence even further. It did for me. There were new ideas and different ways of doing things. That has to help in growing confidence* (New South Wales).

Throughout the interviews many provided anecdotes about teachers whom they knew or about whom they had had reports. Often these anecdotes detailed the positive impact PI had had on the teacher. Sometimes these were brief. *Teacher said she hadn't taught science for 20 years – and it gave her the confidence to teach science* (Western Australia). Others elaborated in rich detail, for example:

A 60-year-old teacher was teaching at a very good school in Perth. She had never taught primary science. The school took on the program and the whole school did the professional development. She was concerned about teaching her year 3 or 4 class science. The day came and she taught her first science class. After the class the kids were so excited by what they had done – her reaction was, 'that's probably the best lesson I have taught in 10 years'. That gave her confidence that she could teach science and she moved on to teach using PI well. I've heard that same story repeated over and over again by many teachers.

Building confidence as a transition to better science teaching

Many regarded PI as an initial program of transition, where teachers might begin to teach primary science using PI. Then they could move to more sophisticated teaching, where they would adapt and develop PI to make it more interactive and responsive to students' particular views, needs and interests. EH, for example, commented that PI is the 'Holden' of constructivist science programs and that having driven the Holden they might move on to the Ferrari of genuine interactive science teaching/learning. Teachers in the Western Australian focus group claimed that teachers' experience with PI *gave confidence to many to allow them to plan their own science programs [and] made some ready for the new curriculum frameworks...because of PI many can cope with new requirements*. However, we have no evidence that there is a widespread pattern of PI giving teachers the confidence to move on to more sophisticated science teaching.

Question 50 of the teacher survey asked teachers to comment on why they had stopped using PI. Of the eight teachers who replied, only one cited moving on to a new approach as a reason for abandoning PI, saying they *substitute more interesting topics but retain strategy*. When schools were phoned for permission to carry out the teacher surveys, seven schools said that they had used PI in the past but had discontinued its use. The reasons given were not related to the teachers having moved beyond the scope of PI.

Notwithstanding this lack of supporting evidence from other States, it remains possible that a move toward a more flexible teaching program is beginning among some teachers in Western Australia, where the uptake of PI was greatest. What is clear is that those in the Western Australian focus group, most of whom had extensive experience with PI, indicated that they and some of their teaching colleagues were keen to move beyond the present PI to a revised program (outlined later in this report).

In the survey, most teachers agreed with the statement that PI 'increased my confidence to teach science' (mean 3.9, SD 0.80). Most also agreed that PI had helped them to learn science (mean 3.5, SD 1.1), although the larger standard deviation indicates a wider spread of views on this. The view that PI increases teacher confidence is more widely held among primary teachers who have used PI.

False confidence

Many of those interviewed commented that PI was so easy to use that science could be taught with little thought. This is discussed further below, but this perceived lack of thought in using PI was identified as a problem by four of those interviewed. They were concerned that PI might create a false or misplaced confidence among teachers. MG and KT were primarily concerned that teachers might feel confident that they would be meeting the requirements of the syllabus by using PI, when in their view they would not.

KT explained, *The research shows that teachers who use PI become more confident, but are they really getting the correct [syllabus] outcomes?* MG agreed, saying that it is *no use making teachers confident if they are not teaching what the syllabus wants to achieve*.

They also argued that teacher confidence generated through PI was associated with the expectation that a great deal of learning could be achieved through reliance on a text. Both expressed their concern that this confidence in the capacity of a text to deliver learning was misplaced.

Even if the student worked through PI [books] from beginning to end would they really understand more?...fundamental understandings come from a teacher using examples from the student's life and experience, from teaching to the circumstances prevailing in that school at that time. A book cannot replace fundamental learning experiences (MG).

KR and SU also argued that the confidence generated among teachers by PI may be a false confidence. The ease with which the PI books can be implemented, and the simple presentation of ideas in some workshops, may prevent teachers thinking deeply about their teaching of science and thereby poorly equip them to work with students' ideas, in contexts relevant to students. In short, PI may make teachers feel confident that they are teaching science well when they may not be. SU explained,

I went to some workshops run by PI trainers. Basically, they presented a set of activities that were good fun but they did not pick up on underlying concepts or the teaching approaches like the 5Es, constructivist approaches or cooperative learning...This may have just been a function of the two facilitators...the problem is it tends to lock the teacher into sets of behaviours...It's written to be teacher proof and I object to that. I heard it sold as 'anyone can follow the process'...It's as if any bunny can pick it up and use it...this denies teacher professionalism...The art of teaching involves responding to individuals and what individuals say. A resource can't do that. [It promotes] a false confidence to teach science...Some of the discussions would be very difficult to run well without expertise in science – so it's a false confidence.

> Finding
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> The overwhelming evidence from secondary sources, interviews and surveys is that PI has increased primary school teachers' confidence to teach science. However, some have raised concerns that this confidence may be misplaced.

Research question 3: Has PI improved students' attitudes to science?

Almost all interviewees and focus group teachers indicated that they had some evidence that students liked PI. Many simply stated, *They [students] love it*. A few reported briefly that they had heard from teachers that students liked it but most seemed in no doubt that students using PI responded positively to their school science. Some had anecdotal evidence and associated the positive attitudes promoted by PI with the teaching of science, or specific aspects of the PI program such as collaborative group work and the hands-on activities. *Kids love to do science. PI helps teachers to teach science and anecdotal comments indicate that students enjoy PI.*

PI did improve student attitudes as students enjoy being involved in hands-on activities and they enjoyed the collaborative work too.

Others recounted experiences in their own classes in detail, and three of the teachers interviewed reported that surveys they had conducted in their schools indicated students had developed very positive attitudes towards PI, or science when using PI.

Students in my school, they loved it. I'd do a survey each year to see how staff felt about the program, including how students felt. With a staff of almost forty they [teachers] were all very positive about PI and one teacher said her class cheered whenever she told them that they were doing science that day. Kids were particularly positive about it. It was a really positive science experience for them.

I'd support that very much [Interjection]. It really brought science alive in my school (New South Wales).

Two teachers in Western Australia whose schools were using PI as their science program also reported results from surveys of students. One had surveyed 470 students in her school, seeking their views on all the key learning areas. She reported that science was *liked best* of all the key learning areas. KR reported a survey of 500 students in her school. She concluded that the students had *very positive attitudes to science* and commented that there was *huge enthusiasm from kids where PI is used...Kids were talking science and could tell you about the science they did a year ago*.

This positive influence of PI was also reported about students visiting the CSIRO Science Education Centre in Canberra. *What struck me in response to this question [about student attitudes] was a comment from Graham Smith, who was then at the CSIRO Science Education Centre in Canberra. He said that when primary schools came in to use the centre, he could tell just from the way students went about their work whether they had been using PI or not. Those that used PI knew immediately, without being told, how to organise themselves into teams and immediately get to work* (OM).

In the teacher survey used in this evaluation of PI, teachers were asked the extent to which they agree or disagree with the statement that PI 'improves student attitudes to science'. The mean score was 4 (SD 0.81).

This indicates strong agreement among teachers that PI improves students' attitudes towards science. Teachers were similarly asked to respond to the statement 'Kids love it'. The high mean of 3.9 (SD 0.92) shows a strong agreement among the teachers surveyed that students like PI. These scores on both items indicate that, according to teachers, PI has been a positive experience for primary students and has enhanced students' attitudes towards science.

As with the attempt to evaluate the improvement in student achievement in science, there is no baseline data with which to compare the attitudes to science of students using PI. Nevertheless, most of those interviewed were unequivocal in claiming that PI had improved students' attitudes or that students liked PI. Furthermore, the survey data in three schools confirms this positive attitude of students towards their science when using PI. Finally, the teachers also strongly agreed that PI had improved students' attitudes to science. Any of these data sources viewed alone would leave doubt about the impact of PI on students' attitudes but the consistency of all sources leads to the confident conclusion that PI has improved students' attitudes towards science.

The question then arises, was the positive attitude promoted by PI peculiar to the PI program or was it simply a function of science being taught in schools where previously it had largely been ignored. Some of those interviewed addressed this issue and most thought that the positive attitudes to science were a result of interesting hands-on activities and cooperative group work, as outlined above. EH took this further, suggesting that the positive attitudes were not just a function of the hands-on activities but were associated with an intellectual engagement with ideas.

PI teachers have told us that students respond positively to PI. They enjoy doing hands-on. They'd enjoy doing any hands-on in any science program but some programs provide hands-on activities but lack the rigour of intellectual engagement. By contrast, PI provides a basis for intellectual study of science but the teacher is still critical...PI doesn't do it by itself. That's why the professional development is so important.

Whether other programs that might have features such as hands-on activities, cooperative learning and intellectual engagement would have had a similar impact on students' attitudes is not at issue here. What is significant in this study is that all the data indicates that PI has had a positive impact on students' attitudes towards school science.

Finding

PI has improved students' attitudes to science.

Research question 4: Has PI improved student achievement in science?

Many of the interviewees and almost all of the teachers in the focus groups indicated that they thought PI had probably improved student learning of primary science. Often this claim that PI had improved student achievement was based on a simple logic, that any science had to be better than none. As outlined by the New South Wales focus group: *PI had resulted in science being taught; taught more or taught better by most teachers. If it's taught, then students will learn more than if it's not taught.*

A member of the New South Wales focus group explained further. *It raised the amount of science and technology, especially science, taught in the school and got some, not all, teaching – trying science and technology...In my school it was the only way people would get any achievement in science and technology lessons. Without PI there just weren't lessons in science. So if we didn't use it they didn't do science.* Furthermore, those interviewed often pointed out that as PI was a good program, if it was used then student achievement would improve. *My own view is that most teachers are doing science now when before PI many were not. And they are using a well designed, carefully constructed program – children should be achieving more* (GE). Others argued that it was difficult to show an improvement in student achievement but other indicators implied that an improvement in student achievement was likely. *I don't think I could give you hard evidence...but it has increased teacher confidence and where teacher confidence goes up so does student achievement...student achievement is linked to inspiring passionate delivery* (NI).

Many of the teachers we spoke to talked about student learning in particular units. They expressed the view that their students had learnt science when using PI. HD, for example, claimed that *students achieve the outcomes set at the beginning of the unit, for example in the space/earth one they understood rotation and axis, what caused the seasons and night and day*. Teachers, consultants and trainers also reported that observations and reports from teachers indicated that teachers were happy that students were learning science when using PI. ND summed this up, saying, *It's had an impact on learning in the* *primary classroom...Teachers identified that there was little learning in science. The learnings from students and teachers have been wonderful (based on observations and reports from teachers), they see what science is about...there's no need to be in a lab. It's something relevant to them that can explain everyday science without too much complexity in a form that's understandable for students*.

Quantitative data that provided evidence of the effect of PI on student achievement was rare, and we found none outside Western Australia. Within Western Australia, some data collected on a few schools provides some evidence about the impact of PI on student achievement. KR had researched the impact of PI in her school, a disadvantaged school drawing on a population of low socio-economic status. In this school, students' scores in State-wide science tests had improved with the introduction of PI and she noted that *teachers [in this school] put this down to PI*. The teachers also observed that *the students could talk about science they'd done 12 months ago, sensibly, using correct science terms*. This seemed indicative to them of improved student learning in science. Two teachers in the Western Australia focus group had also monitored achievement by students in their school on State-wide tests. Both said that, in comparison to previous cohorts, the data indicated that achievement by years 3 and 7 students on these tests had shown an improvement and this had coincided with the use of PI in the schools. One of these teachers noted that while knowledge of concepts had improved, there was no evidence of any improvement in investigating skills as assessed by these tests. While the teachers reported this data, they did not claim that the data showed that PI had improved achievement in science. Rather, their view that PI had improved student achievement in science was attributed to their many informal conversations with teachers, when many teachers had conveyed the view that primary students who were using PI were learning more science than they had in the past. Only one teacher in the focus group had any reservations about whether PI had improved student achievement in science. GE described an analysis of scores achieved by all students in Western Australia which compared scores attained in the 1993 tests, before the introduction of PI, with scores attained in 1997. While students' average scores improved on all dimensions in year 7, the scores on the various dimensions for year 3 were *up and down with only improvements in two areas and a decrease in others. Although PI had been widely adopted in Western Australia I think it tenuous to link this all to PI. It had only been implemented for one or at most two years*.

While a majority of teachers were willing to comment on student achievement, many of the others interviewed considered there was insufficient evidence to comment with any certainty. They pointed out that the data was often ambiguous and that the introduction of PI was often associated with other initiatives within States and schools. This makes it difficult to confirm a link between PI and any perceived improvement in science achievement. In addition, it is difficult to measure directly and with confidence an improvement in science achievement in the absence of baseline data. This view is perhaps best summarised by KB. *I'm very nervous about anyone drawing conclusions about student achievement as this was not researched before PI was implemented – so this would be a long bow to draw valid student achievement claims*. Of the interviewed researchers who had studied PI only one (EH) was willing to assert that PI had improved student achievement. This assertion was based on his own studies of PI as well as various published and unpublished research. He concluded, *It's pretty clear that [in Western Australia] it has improved student understanding and achievement. But a lot of performance data cannot be convincingly linked to PI*.

In summary, there is a perception among the majority of those interviewed that PI has improved student achievement but there is insufficient evidence to support a direct link between the use of PI and measured increases in student performance in State-wide science tests.

The teachers surveyed shed little further light on this. When asked the extent of their agreement with the view that PI 'improves student achievement', a majority agreed and none disagreed (mean 3.7, SD .64, range 3-5) but many were 'neutral' on this item. Thus, the survey data is consistent with that from interviews. That is, a majority believe that PI has improved student achievement, none thinks it has decreased student achievement, but many are unsure. Thus the survey data adds weight to the general perception that PI has improved student achievement, but further research is required to obtain quantitative data to support this conclusion.

The case for PI improving student achievement in science is stronger in Western Australia than in other States. It is notoriously difficult to determine convincingly whether any intervention in science education (or education generally) improves learning. However, our analysis of the fragmented data pertinent to this issue suggests that it is likely that PI has improved student achievement. The teaching community holds the perception that it has. Certainly, it is more likely that PI has had a positive impact on student achievement in science than that PI has had no effect or a negative effect on student achievement.

> Finding
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> The evidence suggests that PI has had a positive impact on student achievement in primary science. There has been no large-scale State or national study to assess this impact.

Research question 5: What factors have helped PI to meet its goals?

Strong advocates

Essential to the successful uptake of PI was the promotion of the program by key players, particularly within the main education systems. Notably, in Western Australia the program was promoted in the government and Catholic systems, by the Science Teachers Association and by an influential and well-regarded university academic (Denis Goodrum). In Queensland, PI was promoted throughout the Catholic diocese of Brisbane by Barbara Kroll and then Shelley Peers, as well as by the Science Teachers Association through Paul Parkinson. In the Catholic system, the uptake of PI was greater than 50 per cent in parts of Brisbane (RR, CL). By contrast there was no strong advocate in the State education system in Brisbane and PI was taken up to a lesser degree. In Victoria and New South Wales (with the possible exception of north-eastern New South Wales) there appears to have been no current, strong advocate for PI, which may partly account for its lower uptake in these States. Alternatively, the low uptake may lead to trainers having a very small role to play and hence a low profile.

There were five main types of advocates for PI:

- enthusiastic trainers who promoted PI, provided inservice and ongoing support to teachers;
- influential teachers within particular schools that promoted and supported the use of PI;
- officials of government or Catholic education systems (some of whom were also trained in PI), who supported PI and promoted the professional development for PI and the use of the program;
- university academics who used PI with pre-service teachers, provided PI professional development, and researched PI;

- Australian Academy of Science personnel.

Enthusiastic trainers

One of the factors that may have influenced the impact of these trainers was local credibility. One factor promoting PI was key people promoting it in various States. Part of this promotion involved the train-the-trainers model. *This provided a local touch...a passionate and enthusiastic advocate, with real experience in the program. This was a big factor in the take-up in some States* (NI). The success of this train-the-trainer model as a way of spreading the word about PI in Western Australia has been well-documented by Venville et al. (1998). In Queensland, people like Barbara Kroll and Shelly Peers saw the benefits of PI and were advocates for it. They ran workshops in the Catholic systems and teachers responded (RR). Similarly, Sister Majella in Tasmania was very enthusiastic and she promoted it among Catholic schools where it was and is widely used in Tasmania and some trainers were also very effective, for example in parts of north-eastern New South Wales (EH). OM also noted the role of trainers in promoting PI. *Good trainers, who championed the program [promoted the use of PI]. There are networks of PI users wherever a trainer was enthusiastic, even in States [such as Victoria] that were not supportive.* Thus, a key feature of effective trainers was not just that the 'good trainers' offered training but that they were genuine advocates who championed the program by singing its praises.

Influential teachers

Having key people in schools...people who promoted PI and encouraged the school to take it up (NI) promoted the use of PI. *Schools where it really took off were ones where there was a coordinator who did all the hard work* (CL, TR). *One of the key roles of the school leader, often the science coordinator or chair of the school science committee, was the organisation of resources. In the years I've taught science and PI...and spoken with teachers at other schools...the difference between good practices and learning [and poor] was organised resources. And PI helps you have it all there. Those schools that have well-organised resources have a good PI program* (YK). The Australian Capital Territory focus group also endorsed this view and claimed that if YK hadn't established and maintained the resources for PI in their school, PI would probably not have been adopted and flourished.

OM also noted that the *support of the principal was often important to the uptake of PI. Support by the principal or a respected teacher within a school. Schools that had a champion within the school seemed to do* *better in organising equipment, finding time for professional development, getting external sponsorship or support.* An example of this was HK who commented that he had *turned them on to PI* at his present school.

In one school contacted about student surveys, the principal commented that she thought the previous principal had used PI as she had been a ‘sciency’ person, but the school had ceased to use PI. Another said that the previous principal had bought PI for a previous RFF (release from face-to-face) teacher and *now they are both gone PI is not used any more.* This indicates that an in-school advocate for PI may have been needed not only to set up PI but also to maintain interest in its use. Members of the New South Wales focus group commented that *it was really good at the beginning but after the person who ran it left it fizzled out. So it can be quite personal.* (Yeah, agreed two others).

But at my school, I set up PI and I set it up so that it could continue after I left.

Word of mouth between enthusiastic users was commonly cited as an important means by which the use of PI spread. *There was a keen committed group of primary people saying, ‘we love PI science’. There were advocates who recognised PI and felt part of it. They were involved in PI early...got the vision and convincingly told other teachers about it* (RR). Some considered this one of the most effective ways in which teachers were convinced that PI was worth trying, as teachers place credence in the views of other teachers about resources they have used. *Word of mouth among teachers was the most effective form of promotion*. And, *In the early days there were a lot of people promoting PI. Some people were from AAS – whether this worked or not I’m not sure. Teachers are suspicious of paid zealots. Word of mouth is much more effective than paid zealots* (KB).

Officials of education systems

The critical role of support by officials in education authorities in promoting PI was mentioned by many, including OM who explained that [It] *was successfully introduced into State schools in Western Australia and Catholic schools in Tasmania through the backing of Fred Deshon and Sister Majella respectively* (OM). Barbara Kroll, Shelley Peers and Sister Majella were consultants in the Catholic education system. In Western Australia, officials in both the Catholic and government system supported PI. Fred Deshon was particularly influential in promoting PI in Western Australia, partly because his support encouraged the perception that the Western Australian Department of Education officially supported PI (Western Australia, OM) and also because he was an enthusiastic supporter of PI in his own right (OM, EH, Western Australia).

Only in Western Australia were there people who occupied an official general role in the Department of Education and at the same time strongly supported PI. *We had very good people involved in implementing it* [in Western Australia]. *Helen De Pilato was very enthusiastic and provided excellent high quality professional development. She was a centrally based support person for primary science. Also district-based support officers provided excellent support. The primary teachers and trainers involved had great credibility with primary teachers* (GE).

University academics/researchers

Denis Goodrum (Edith Cowan University) was identified as an effective advocate for PI by people interviewed in every State, but his influence appears to have been greatest in his home state of Western Australia. *Denis was well-respected by primary science teachers and we can't underestimate the influence he had on primary science people in Western Australia. Denis had street credibility* (GE). Denis Goodrum also provided train-the-trainer programs throughout Australia, which were highly regarded. In Queensland, Jim Watters was influential, as he instigated using PI as part of the primary pre-service teacher education at the Queensland University of Technology. Such activities may give the impression of academic approval and also make the program more widely known. However, while in Western Australia Denis was a major factor influencing the uptake of PI, in Queensland the consultants and trainers seem to have been more influential.

Australian Academy of Science personnel

People at the Australian Academy of Science were also influential in promoting PI, particularly during its early days. A key feature of this promotion seemed to be the use of other organisations such as the Australian Science Teachers Association and its branches, and the CSIRO, to promote PI. *Nancy Lane was a zealot. She worked the networks very well. She had good contacts in ASTA and other organisations and in the early days there was a lot of correspondence. But gradually this [correspondence and articles] changed. Perhaps it just got tired as a resource.*

Official endorsement and support

In conjunction with the promotion of PI by a strong advocate, was the actual or perceived endorsement by a major school system (eg, Catholic education system in Queensland and Department of Education in Western Australia) and the local science teachers association. Endorsement by the Australian Academy of Science and lobbying by Sir Gus Nossal was also regarded as advantageous, especially where it led to promotion by other entities (science teachers associations and departments of education).

NT noted that the support of departments of education in a relevant State or the Catholic education system...*made a huge difference in Western Australia and Queensland*. However, official endorsement of PI, where education systems officially promoted it, seems to have been rare. In the Goulburn diocese, according to KY, there are...*Catholic ed documents endorsing PI [in Australian Capital Territory] as an appropriate resource for teaching primary science in the diocese*. In Western Australia 'the Education Department of Western Australia committed itself before a senate select committee to seek to have *Primary Investigations* into 75 per cent of government schools by the year 2000' (Thiele and Morecombe, 1996, p.24). Other State education departments did not take an active role in promoting PI. In Victoria, the active endorsement of other resources for science teaching by the State Department of Education may have worked against the acceptance of PI.

The actual or perceived endorsement of PI by education systems appears to have been important to teachers, giving them the sense that, if they used PI, they would be doing a 'right thing' in primary science (see above section on strong advocates).

The endorsement of the Australian Academy of Science was also identified by many as being important to teachers and others involved in science education, as it lent credibility to PI (KY). *The Australian Academy of Science's rubber stamp carried a lot of weight for science teachers and has some influence on primary school teachers...People in STAV recognised the Australian Academy of Science as a good pedigree...There was a letter to principals signed by Gus Nossal. That adds weight* (NS). Yet, it also adds pressure, which, according to NS and SU, may be resented. Note that none of those interviewed indicated that they resented this 'pressure' but rather that others may have.

Many noted that the support of the State science teachers associations was also considered a factor in promoting PI. Some also indicated that the perceived approval by the national science teachers association

(ASTA) also had a positive impact. Where this was most effective was where the PI training was provided through, or in cooperation with, State science teachers associations.

Support of departments of education is a big help – also ASTA. If they say this is good and approve it then people are going to start using it. OG further commented that *there was some variation in this support across States and where PI was supported by departments of education it was more successful. It is good to have ASTA and State science teachers associations on side, but they have more influence in high schools.*

In two States, Western Australia and Queensland, PI was considered a worthwhile way to promote primary science, just at the time that the State science teachers associations of both States wanted to make a greater contribution to primary science and also promote their associations more vigorously to primary teachers.

STAQ wanted to focus on the primary teacher and teaching science at the time. We asked, 'how can we support primary teachers?' Here was PI. A great resource...STAQ conducted workshops using PI to support teaching of primary science. It was a tool to improve primary science (RR).

Although there is little evidence of any direct endorsement for PI in curriculum support documents, the activities of various official entities in using PI as a vehicle for inservice, and the role of some system officials in promoting PI, seems to have led to an important and strong perception that PI had official systemic endorsement (in Western Australia and Queensland) and hence was a suitable program for the teaching of primary science.

Teacher networks

Teachers in local trial schools were also influential in promoting the uptake of PI, in that positive 'word of mouth' support from local teachers was influential in encouraging other teachers to try PI. These informal networks were complemented by more formal exchanges of information among teachers. Some of those who had trialled PI presented at conferences and formed focus groups to talk about PI and primary science, particularly in Western Australia, Victoria and Queensland. Others wrote short reports on PI in national or local science teacher association journals. *A lot of articles were written* [eg, in Investigating] *and conference presentations given in the early days about PI and these promoted it* (KB). This combination of formal and informal communication about PI appears to have raised its profile and use among the primary teaching community, within each State and across States.

This promotion through formal teacher networks and conferences was strongest in Western Australia and Queensland, but it was also a factor in the Australian Capital Territory, Victoria and Tasmania. *STAWA is robust in Western Australia and PRISM is strong. Every year 50 plus primary science teachers get together. So, there was a body of keen science teachers already there who heard about PI and liked and promoted it* (KR). This view was supported by all of those interviewed in Western Australia. It is further supported by the experience of this research. In Western Australia, a focus group of interested primary teachers could very quickly be identified and organised to meet as a focus group. By contrast, in other States such focus groups were very difficult to organise, suitable teachers proving difficult to identify, contact and meet.

In Victoria, *teachers using PI formed groups and talked about PI to other teachers...Teachers put out the good word on it [PI]...There were people going to conferences. Teachers presented at STAVCON...sharing samples of kids work and [saying] how well it works in their classes...They put out the good word on it...Teachers developed units around PI and said, 'This is what we did'. They talked about kids' intellectual understanding and said, 'This is progress'. Well, that influences teachers* (NS).

In many Catholic dioceses, the systems run network meetings for teachers *and PI is often on the agenda* (ND). Similar comments were made by CL, TR and KY. At these meetings teachers set the agenda and bring ideas that they want to share. Often they shared their experiences with PI. Indeed, within the Catholic system in Goulburn and Brisbane, the push to have PI as part of schools' professional development programs did not initially come from directors in Catholic education or consultants, but arose from requests from schools either for inservice in science or inservice in PI as part of their regular professional development days (according to CL, TR and ND). Thus PI was promoted both through a 'bottom up' request for assistance, supported by 'top down' PI professional development, and regularly invigorated through teacher network meetings where teachers themselves set the agenda.

Ongoing support by local trainers

A feature identified as promoting the continued use of PI was *the support provided within the State, trainers within the State. Someone they could call with time to help* (NI). However, most interviewees who commented on this support noted that it has gradually waned and lamented the loss of trainers over time and the resulting reduction in assistance available in recent years, *when PI first started there were people to provide it* (Western Australia). Often these comments were prefaced by statements such as *in the early days* (KB), and a few were critical of the Australian Academy of Science for not maintaining this support and replacing trainers who moved on. Indeed, in this research, we found that although we targeted some trainers to be interviewed, many who had previously been PI trainers no longer played an active role in promoting PI, because of their new position (principal, government school consultant or curriculum officer etc.).

Trial schools

Because PI had proved successful in trial schools and was liked by teachers, these teachers often recommended PI to teachers in other schools. KY noted this effect in north Brisbane where teachers involved in trials of PI *responded positively to PI and said so* (KY). OG commented on a similar pattern of influence by many trial schools. *When the Academy asked schools to try PI for one year we were nearly overwhelmed by the response...In the trials a community spirit started in the schools. This had a positive influence towards PI on the trial schools and other schools.*

Timing and coincidence

The timing of the release of PI was an important factor in its uptake. In Western Australia, for example, PI became available just as the Department of Education was attempting to improve primary science. According to GE and teachers in the Western Australia focus group, the department was pushing primary science. This support included funding for professional development in primary science. Teachers were looking for resources to help them teach primary science, often for the first time. Thus, in Western Australia, PI fell on fertile ground that was well tilled by key players such as Denis Goodrum and Fred Deshon. Similarly, in Queensland, PI was available and being promoted when teachers and science consultants were looking for something new to replace their ageing primary science syllabus and the resources that supported it. But in other States the timing was not ideal (as discussed below under research question 6).

Science seen as a priority at the time PI was introduced (Western Australia). *PI coincided with a system-wide initiative and desire to improve primary science. The system was ready to pick up on primary* *science. Data indicated that it was not going well. So the time was ripe. The [PI] program seemed good and was there to be used and we were able to train people up...It was not top down. Teachers or schools chose it. Individual teachers supported it* (GE). *People here were hungry for something. After 20 years of 'I do science' they wanted something new* (KR). *The time was ripe in Western Australia for primary science development. There was coincidence with other initiatives of the Department of Education and the National Professional Development Project, which used PI as its main vehicle in Western Australia* (EH). Thus, in Western Australia, PI was available when both teachers and the Department of Education wanted a 'good' program to support primary science.

In Queensland, *Teachers were anxious about a new syllabus that was to come and the old syllabus was known to be on the way out. PI filled a void between the old and the new* (KY). ND, CL and TR all described a similar situation in Queensland in the mid 1990s when PI was launched. Notes from an interview with RR outline their views:

PI came out at a time when Education Queensland was floundering and couldn't make up its mind about [science] curriculum and what to do about the national statement and profiles...there was a big build-up and hype but nothing happened...so schools grabbed it [PI]...People knew that the curriculum was aged and due to be replaced. The only other program that was being used a lot was the source books and these had been around a long time...PI was seen as a 'good resource' and 'modern replacement' for the old syllabus and the source books...Coincidence with an absence of anything really good being available with Queensland and it being associated with the national profiles which, at the time, people knew they were going to have to deal with.

In short, at the time PI was launched there was a perceived void in the primary science curriculum in Western Australia and Queensland, which PI could readily fill.

Lack of competition

In Queensland and Western Australia there was *no other concentrated effort for professional development in science* (KY). PI came at a time when primary science was a priority and there was just nothing else around. The existing syllabus resources dated back to 1981 (CL, TR). In the Australian Capital Territory, other professional development programs were available and mainly provided by the University of Canberra. However, according to KC, *There was less involvement of non-government schools in PECSTEP [Primary and Early Childhood*

Science and Technology Education Project]. Perhaps those not involved in other science professional development programs were more inclined to take on PI. Those involved in PECSTEP were encouraged to use an interactive approach that was more open-ended and not very compatible with the lock step [perceived] PI program. A similar view was also put forward by YK.

Professional development

The initial PI professional development program was highly regarded as being skilfully delivered and well-linked to the teacher and student books. It encouraged teachers to begin to use PI. However, in some States (eg, New South Wales, South Australia, Victoria), the professional development was not supported by school systems or schools and hence not well enough funded for teachers to participate during school time. By contrast, in Western Australia and to a lesser extent Queensland the professional development was more strongly supported and funded by schools and some school systems. In those States where professional development was funded, PI was more successful in meeting its goals.

Teachers who completed the survey were asked about the number of hours of professional development they had undertaken and the type of professional development they had done. Of the teachers who had used PI, 30 per cent (12) had undertaken no professional development. The average time spent on professional development by the remainder was between 2 and 3 hours. It should be noted that our sample consists predominantly of teachers from States other than Western Australia. Table 2 shows the distribution of these hours among the different types of professional development offered.

Table 2 Distribution of professional development hours

Type of professional development	Number of teachers (n=38)*	% of teachers
Train-the-trainer	1	2.6
Face-to-face workshop (whole school)	16	42.1
‘Do-it-yourself’ video	7	18.4
Workshop in school with trainer	5	13.2
Satellite	1	2.6
Other	2	5.3
None	12	31.6

* There were two invalid responses to questionnaire items asking about professional development and some teachers participated in more than one type of PD.

The majority of respondents who had undertaken professional development had participated in whole school workshops (42 per cent).

Some (18 per cent) had used the 'Do-it-yourself' video and a few (13 per cent) had been instructed individually by a trainer. It would be fair to say that only a very small proportion of this sample had completed the amount of professional development envisaged as optimal by the developers of PI. The amount of professional development undertaken by the surveyed teachers was less than that undertaken by the interviewed teachers and focus group teachers. This may be a function of the sampling. For example, fewer teachers responded to the survey in Western Australia than in other States but one of the focus groups consisted of Western Australian teachers. We suspect that the data in Table 2 represents the lower end of teacher participation in PI professional development, but further research would be required to test this suggestion.

Teachers were also asked to respond to the statement 'the professional development was inadequate', and the mean for this response was 3.3 (range 2-5, SD 1.0). This figure implies than most teachers agree that the professional development was inadequate, although this does not appear to have been a strongly held conviction. Given the proportion of the sample that had undertaken no professional development, this lack of concern about professional development is surprising.

Many of the teachers and academics interviewed regard the PI professional development program as essential to the successful use of PI. Indeed, we note that in commenting on PI, many of those interviewed prefaced their statements about the success of PI with comments such as, *Where the whole school did the professional development...*

The following comments are typical:

PI was very successful especially where the whole school did the professional development, and when the teachers chose to do the professional development. Less successful when only a couple of teachers did it. [It was] less effective where the principal imposed PI.

The professional development was excellent and so is the resource but without the professional development it probably would not be used. It would just be languishing on shelves.

A lot of teachers are very anxious about teaching science so combining the professional development with the books helps them overcome this.

One of the most telling comments on the importance of the professional development has been quoted above but it bears repeating here.

PI provides a basis for the intellectual study of science but the teacher is still critical...PI doesn't do it by itself. That's why the professional development is so important (EH).

One of the best features of the professional development that many commented on was the peer teaching. *One of the best things, that really got us going, was when we all had to take a [PI] lesson and prepare it with your own class. I wasn't so sure about this at first but I had this one on magnets...and it went so well and we all told each other what we had done. When you see it working for everyone else and it works for you too. Well!*

Another characteristic of the professional development that many commented on positively was the way in which it was closely linked to a resource. This made it possible for teachers to put into action at least some of what they had learnt during the professional development sessions and to continue with PI in the long term. The model of teacher change is 'attractive'. *It's all well and good to do professional development on teaching and learning but it's not successful if it isn't supported by resources. The strength of PI is that it provides resources to support good 'practice'* (SU).

The professional development for PI was managed differently in different school systems and it varied within and between States. ND, CL and TR explained the different ways in which professional development was provided in the government and Catholic sectors in Brisbane, and suggested that as a consequence PI was adopted by a greater proportion of Catholic schools than government schools.

In the Catholic system, from 1995 to 1997 about one-third of teachers in Brisbane diocese were given one and a half days of professional development followed by evenings in their own time. The one and a half days were pupil-free days that schools could direct as they chose (from guidelines offered that included science education). Because science was a priority at the time, many chose to do PI. Since 1997 no new professional development has been offered but about 60 per cent of schools in the diocese use PI (which suggests that about half of these did not do much professional development). In the State system the content of pupil-free days was not directed by the teacher or school. Schools had to use the time for other discussions, therefore professional development on PI had to be done in other time. Professional development was not carried out as systematically and PI was not as widely taken up in State schools (TR and CL).

According to those interviewed, the professional development was successful in promoting PI. However, there is some evidence that the professional development promoted the sets of activities in PI without dealing in depth with theoretical underpinnings or the instructional model (the 5Es). One of the trainers interviewed stated flatly that he did not emphasise the 5Es. SU, who attended a training program in Victoria, outlined his perception as follows:

I went to some workshops run by PI trainers. Basically, they presented a set of activities that were good fun but they did not pick up on underlying concepts or the teaching approaches like the 5Es, constructivist approaches or cooperative learning...This may have just been a function of the two facilitators.

It seems likely that some trainers were better than others. On the basis of the data obtained in this evaluation it is clear that the training programs provided by Denis Goodrum were highly regarded.

According to reports in interviews, teachers seem to have valued the PI professional development and it seems to have allowed teachers to use the activities in PI. However, it is not clear how effectively the professional development promoted an understanding of fundamental underpinnings of the program, such as the 5Es. What is clear is that most of the teachers we spoke to, other than those in Western Australia, made no comment on the 5Es as a feature of the program until asked directly about it, and all but one did not consider it an important feature of their teaching when using PI. One reason for this may have been the short time spent in inservice workshops by teachers outside Western Australia (a sample strongly represented in the teacher survey). If teachers spent only 3 hours in training, it is likely that they had time to complete sample activities but not to consider in depth the theoretical concepts that underpin PI. It is also possible that those teachers who did not do any professional development (30 per cent of our sample) were more focused on PI as a source of activities than as a constructivist teaching strategy.

Consistency with syllabus

A good match between PI and the syllabus was another factor in the establishment of PI in a particular State. There was some disagreement among those interviewed as to whether PI was and is consistent with syllabus requirements in each State. This is discussed further below. However, a perception that PI matched the syllabus meant that PI was more likely to be used. When asked to rank the importance of a good match between PI and the syllabus in order for them to use it, most teachers agreed that such a match was important (mean 3.7, SD 1.01, range 1-5). Key stakeholders (eg, EH, GE, CL and TR) agreed that the match was strong in Western Australia and the Australian Capital Territory, and in Queensland prior to the introduction of the current syllabus. In these States the syllabus facilitated the uptake of PI.

Although a good match with the syllabus is very desirable to teachers, survey data is ambiguous on the matter of whether an individual State syllabus matches PI. Outside Western Australia and the Australian Capital Territory only one of the ‘key players’ interviewed claimed that PI was a good match with the current State syllabus. Teachers using PI were asked the extent to which they agreed with the statement that PI ‘does not meet syllabus requirements’. The results (mean 2.8, SD 1.14, range 1-5) indicate that views varied widely among teachers, with some agreeing strongly and others disagreeing strongly. This is not surprising as the survey combined data from several State systems and the range of match to the various syllabuses could be expected to be wide. However, even within States there was considerable disagreement about how well PI matched the syllabus. In New South Wales, in the opinion of some, the technology aspects of the syllabus were covered, *It’s covering what the syllabus wants us to cover* (DD, echoed by HD, BG and NE); or not covered, in the opinion of others, *Weak on the technology side* (HK, KT and MG). In Queensland, Barbara Kroll and Shelley Peers had produced a guide to help teachers match their new syllabus to PI. These key players (along with ND) felt that PI covered the essential concepts. However, many Queensland teachers did not agree, and comments as to why they had stopped using PI were often of the type given by one principal, *Teachers [in my school] now use PI as one of the resources. Used to use it more but now they are moving to the new outcomes-based curriculum it no longer meets their requirements.*

What is clear from the interviews is some teachers consider that PI matches the syllabus well if the concepts and ideas covered are similar to those of the syllabus (eg, RR, KY and FH). More consider it important that these concepts and ideas are covered in the right years or stages and in the ‘right’ depth (eg, NS, CL, TR and SU). Given that information in PI’s student books is designed for use within classes at specific year levels, the placement of content at levels and years inconsistent with the syllabus could be considered a major disincentive to the use of PI. Thus, when most teachers agree that a match with the syllabus is important we take this to mean not just similar coverage of content, skills, process and teaching/learning approach, but also the organisation of these at year levels consistent with the syllabus.

The number of contradictory statements suggests that teachers have very different interpretations of either their syllabus requirements or the learning outcomes of PI. Perhaps the most telling comment on this issue was *for 80 per cent, the reluctant ones, it's close enough to the new frameworks* (KR). It seems that the degree of match between the syllabus and PI is, like beauty, in the eye of the beholder.

Past practices

Where PI was in some ways similar to resources previously used to support primary science, it seemed to be easier for teachers to take it on. In Western Australia, for example, teachers were accustomed to the use of student and teacher books in primary science. Many teachers in Queensland commented on the way in which PI was better than the source books teachers had previously used to plan their primary science teaching. *They had had source books and teachers were accustomed to them but they were seen as being a bit tired...It had reached a stage where the whole philosophy was no longer being followed and here was a new resource [PI] that was seen as better* (RR). KY explained further, *It provides a resource that is better than the dated source books which came out in about 1983. [These had] no pedagogical structure*. Similarly ND commented, *Teachers wanted more than just a recipe of activities as in the source books. PI had much more than a set of activity recipes. Teachers liked it. It gives them something to hang their activities on. It gives them a meaning and purpose but in the past they just would do an activity from the source book, almost at random, now with PI it's organised into a sensible sequence.*

Thus, in Queensland, teachers were accustomed to using source books of activities. For many, PI was viewed as a replacement for this dated resource.

The quality of the program

A major factor contributing to the use of PI is the perceived quality of the program itself. Teachers were surveyed on their views of selected strengths. Some of these perceived strengths are considered in detail below.

Many primary school teachers find it difficult and challenging to teach primary science. Many of those interviewed elaborated on this. GE, for example, explained:

It tries to get teachers confident – it does that. The structured program simplifies science teaching and provides a sequence to follow. It serves its purpose [of assisting the reluctant science teacher]. It selectively and *carefully puts together science skills, processes and knowledge in a way that cuts across traditional science discipline barriers to integrate ideas. If teachers are going to pick up and teach primary science then they need a scaffold to get them started. Once they start, teachers recognise that their students enjoy science, enjoy their science teaching; and that they can teach science.*

Interviewees typically considered PI a good starting point for teachers who lack the confidence and experience to teach primary science. Teachers often commented that PI had helped them or their colleagues to begin to teach science. Some claimed that without PI they would never have started to teach science. In the survey, most teachers strongly agreed that PI was a good starting point for the teaching of primary science (mean 4.5, SD 0.60).

PI makes it easier for them to teach science. Specifically, PI provides a whole-school program that outlines the teaching of science throughout the primary years. Teachers appreciated being able to share a common language to discuss their science teaching. New teachers, and teachers beginning a new year, knew where the students were placed in their science learning. Surveyed teachers agreed that PI organises time well for the teaching of science (mean 3.8, SD 0.65) and that it provides a program that systematically promotes skill and concept development (mean 4.0, SD 0.87). The student and teacher books provide a sequence that even reluctant teachers of science can employ. *My principal said to me, 'What teachers need is a folder with everything there, step by step'. It's simple. All you needed was the box of books and resources. Even if you were really pressed for time you could still teach your science lesson* (New South Wales).

PI has an extensive repertoire of activities. *There are so many fantastic experiments and activities in it.* The activities work and are usually easy to do with primary classes, according to interviewees. The hands-on activities are particularly valued. Asked the extent of their agreement with the statement PI 'is a good source of activities' most teachers strongly agreed (mean 4.2, SD 0.67).

Almost all of those interviewed commented that the simple equipment and materials required made it relatively easy to use PI. Most teachers agreed with this view (mean 3.9, SD 0.70).

Nevertheless, as described above, time had to be invested to obtain and maintain these resources, otherwise PI was inclined to falter. PI kits are available, but were considered to be too expensive by some. Others claimed the kits were essential to the continued use of PI in their schools.

As simple as the resources were it still – someone has to get it all and set it up. That takes time. We used the commercial company in Western Australia. If not for them providing the resource kits, we probably wouldn't do it (New South Wales). Such difficulties with maintaining resources, and the time-consuming nature of gathering the equipment for PI activities, have been reported in the literature (Pearson, 2001; Mulholland and Wallace, 2000). Those schools that had overcome this problem often had a parent or teacher who undertook to maintain the resources for the entire school.

Cooperative learning

The feature most often identified by interviewees as a strength of the PI program was cooperative learning. All argued that PI had allowed teachers to use cooperative learning in their teaching of science. Many claimed that PI even promoted its use across other key learning areas. The roles students learnt to play were particularly valued, though a few suggested that the repetition of 'training' in cooperative learning in the first unit of each book was excessive and boring for students who had completed PI in previous years. Teachers strongly agreed that cooperative learning was a useful feature of PI (mean 4.4, SD 0.58).

The teaching approach

The constructivist approach to teaching and learning, which strongly influences PI, was universally regarded as a good approach for the teaching of primary science. The 5Es approach, which has a constructivist theoretical base, was recognised as a way to easily operationalise a constructivist approach. Some spoke favorably about the 5Es, a few (eg, SU) have reservations about it and whether it is the best way to put into practice a constructivist approach. However, what is clear from interviews with non-teachers is that PI was considered to be a comprehensive, well-balanced program; one that provided a theoretically based, well-trialled, whole-school program with easy to use and follow activities. This content was organised through a teaching-learning framework, the 5Es, that was relatively easy for teachers to understand and helped them to implement cooperative learning in science, which they considered desirable. For example:

The 5Es constructivist model provides a good learning teaching approach. *Interpreting constructivism in the classroom is complicated and teachers see it as complex. The 5Es is a simple way of operationalising constructivism. Follow the stages and you have a fair* *chance of getting effective learning...But the professional development is critical to doing it effectively* (GE).

With pre-service teachers, we have presented 'Bybee's 5Es' as a simple starting point. It illustrates the idea of learning cycles and students find this very appealing. Having PI as part of the [pre-service] preparation of teachers has helped them to develop a theoretical framework for teaching science. The Australian Catholic University also uses PI...It's provided a model that helps them understand constructivist teaching and learning in science (KY).

The significance of the 5Es teaching approach in influencing teachers to use PI may be less than its significance to other stakeholders. In Western Australia, teachers seem to be aware of the 5Es and their significance in PI. However, teachers interviewed outside of Western Australia rarely mentioned the 5Es when asked open-ended questions about the strengths of PI. Although teachers were usually aware that the 5Es teaching approach was a feature of PI, they dismissed it quickly even when asked directly about it, often preferring to talk again about cooperative learning. In the survey, teachers mainly agreed that the 5Es model was a good approach to teaching science (mean 3.7, SD 0.96). It is difficult to interpret this data. We suspect that the 5Es model is a feature of PI which, for many teachers, lies in the background and may have little influence, of itself, on how they teach primary science. Teachers may like to know it is there but may pay little attention to it. Even in Brisbane where teachers know of and discuss PI, it takes a long time before the teachers understand constructivism.

One of the strengths of PI was said to be the constructivist model, but Shelley questioned whether a constructivist learning environment was really being achieved. Her feeling was that the teacher could follow the directions and teach with the 5Es without creating a constructivist environment. This happened because the teacher did not understand the fundamental strategy, possibly because they had learned science in a different way, and therefore did not know how to make the links that were so important to teaching the unit as a whole. The teachers tended to take out activities and use them without keeping the sequence and then the links between content areas were lost (TR).

CL thought that the teachers doing the professional development in the Catholic system that had been offered in the last two years were just beginning to get that idea of sequencing. *Teachers are now planning using the 5Es but it has taken that long. We are getting back the language, for example, one teacher said, 'No, we can't do that yet, we* *haven't got them to engage and explore'. It's been a slog but I do think we are starting to get there.*

Similar observations have been reported in the literature. Pearson (2001) found the teachers in her case study did not always maintain a constructivist environment in the classroom, possibly due to their lack of science knowledge. Kroll (1997) also noted that a teacher could take activities from PI but continue to teach in quite a teacher-directed style.

Combined with professional development, the 5Es may help to render constructivism more understandable for some teachers and help them to put it into practice. This notion is attractive to many key players in science education. However, the 5Es instructional model and constructivist ideas may prove to be attractive notions but illusive in practice. The 5Es model is a fundamental feature of PI but may not be crucial to many teachers use of PI.

The kids love it

The perception held by teachers that PI improves students' attitudes to science, has been discussed elsewhere. The success of PI lessons in enthusing their students was an important motivating force in convincing many teachers to continue with PI and with science.

Background information

The background science information provided in the PI teacher books was regarded as a valuable feature by most. A few of those interviewed claimed that this information combined with PI had helped teachers to learn science (ND, KY). When surveyed, teachers were asked the extent to which they agreed with the statement, PI 'helped me to learn science'. The range of views expressed was wide (mean 3.5, SD 1.05, range 1-5). It is clear that many teachers consider that their knowledge of science has improved as a result of PI. Some, however, did not claim to have improved their knowledge of science as a result of using PI.

Findings

- Enthusiastic and able advocates, typically PI trainers, were essential to the success of PI. Only in Queensland and Western Australia, where the uptake was much higher than in other States, did all of these advocates maintain a sustained presence.
- The support of regional or State education systems is crucial to the success of PI.

- Teacher networks promoted PI and provided mutual ongoing support among PI users as teachers shared ideas and enthusiasm with colleagues.
- Ongoing local support by trainers assisted the continued use of PI.
- The trial of PI not only serves to test, refine and develop the program but also promotes PI to the wider primary teaching community.
- In some States, the timing of the launch of PI was beneficial.
- A lack of competition from other resources may have made the use of PI more likely.
- Where professional development was well-resourced and well-regarded it promoted the uptake of PI and facilitated good teaching with PI. In some States other than Western Australia and Queensland the professional development was either not available to teachers or was inadequate to deal with the theoretical principles and approaches in the PI program.
- PI is more likely to be used where it closely aligns with the State syllabus. Although there is disagreement on the extent of this match, in some States (eg, New South Wales, Queensland and Victoria) there is a strong perception that PI does not match the current syllabus.
- PI was more likely to be used where teachers were accustomed to using one main text-based resource.
- PI made the teaching of science easy by
    - providing a systematic whole-school program;
    - allocating time effectively to the teaching of science;
    - providing a step-by-step program that teachers could readily follow;
    - providing a good source of science activities;
    - using simple equipment (which was easy to obtain and maintain if someone in the school was committed to doing so).
- The cooperative learning model employed by PI is very attractive to teachers and PI has powerfully influenced many teachers to use it.
- Primary students like PI.
- The background science information in PI assists teachers to learn some of the science that they teach.

- The teachers' knowledge and use of the 5Es varied and may have been dependent on their professional development experience. The teaching of many of those using PI is probably not guided by the 5Es, other than in so far as the resources are organised according to this model.

Research question 6: What factors have inhibited PI from meeting its goals?

Mismatch with the syllabus

The overwhelming factor preventing PI from achieving its goals is its limited uptake in some States. The main factor preventing its uptake, identified by almost all of those interviewed, is the perception that it does not match the requirements of a particular State syllabus or some emphasis for primary education within the State, such as integration of science with other learning areas. Often the main problem was that the subject matter in PI was not consistent with the content of the current syllabus. This was identified as a problem in Western Australia, New South Wales, Victoria and Queensland. In South Australia and the Australian Capital Territory the syllabuses are more open and permit large variations in the content of science covered in each school. Thus, any perceived mismatch between PI and syllabuses in the Australian Capital Territory and South Australia does not seem to relate to the content per se.

The main problems identified by people in all States and Territories are PI's lack of integration of science with other learning areas; its lack of open-ended investigations; and the way it doesn't encourage teachers to develop learning experiences directly in response to ideas and views held by students in a particular class. These are typically not a requirement of the syllabuses in each State but are expectations or emphases that have come to the fore in primary education. Comments such as the following were typical, even in States where a mismatch between the syllabus and PI was not considered a major impediment to its use:

What we've been pushing here [in South Australia] is an interdisciplinary science which goes across all other areas of learning. PI doesn't help to do that. Teachers don't have time to offer science one hour every week. Teachers who do science well here do a lot of their literacy through their science (RS).

Now there is perceived to be a tension between PI and frameworks [in Western Australia]. Some claim PI doesn't match frameworks...PI has been mapped against frameworks. The organisation is not the same but the content overlap is quite good. Teachers are being told that they should build their teaching and program from the frameworks and integrate learning areas. This does not work well with PI...The main problem is that PI needs to be more open-ended if it is to address requirements of frameworks (GE).

In New South Wales, the mismatch between the syllabus and PI content appears to be large. The syllabus is 'Science and Technology' and many of those interviewed claimed that the treatment of technology in PI was not adequate. There were two main criticisms. The first and most common was that there is simply not enough technology in PI and the second was that the technology in PI misrepresents technology. *PI sees technology as a tool, which is appropriate for science education but not adequate for technology education* (MG). In New South Wales they did not want some aspects of the syllabus (eg, technology) to be dominated by others (eg, science).

In Victoria, as in New South Wales, departmental officials were concerned that the promotion of PI by them might result in mixed messages when combined with relatively new primary syllabuses. *The resource itself was fine but it conflicted with CSF, giving mixed messages about where things [ideas, content concepts] are [situated in CSF]* (NS).

Departmental officials and at least some influential Victorian academics wanted teachers to concentrate on the syllabus rather than a resource, such as PI, that may conflict with the structure and information in the syllabus.

Gus Nossal lobbied Victoria to have it take up PI as its 'reference' for primary science. At the time, CSF had begun and PI had to match the CSF. We didn't want to back a resource that might mislead teachers and PI did not match CSF well (ID).

This problem of a mismatch between PI and syllabuses was most strongly identified for science in Victoria, where everyone interviewed commented on the difficulty. This view was beautifully understated by DB: *The subject matter is a little wanting for the Victorian curriculum*. Most comments were more strident and included criticism of the organisation of PI and the development of its concepts.

PI is structured differently from CSF and sometimes the ideas that are grouped in a unit don't provide sound conceptual development of ideas.

For example, change as an idea is fine but the conceptual links within it were inappropriate, change in ecosystems and change in materials – conceptually they just don't logically work well together, as the principles of change in ecosystems are very different from those underpinning change in materials...Conceptually this organisation of ideas is antagonistic to the Victorian CSF, national statement and profiles and students developing deep understanding (SU).

Concerns existed that PI had concepts and content organised at inappropriate levels for the then new curriculum. These problems could not be repaired with a simple 'cut and paste' of parts of PI units so that they might be delivered to year groups identified by the CSF.

It would have undermined the program here [in Victoria] to push PI. Gus Nossal spoke to a lot of people to get Victoria to consider using PI. People argued that you could rejig PI to match the CSF. But outcomes in year 6 were linked to lower primary materials in PI, so the depth was never going to be right. It would have required far more sweeping change, for it to address the CSF (SU).

Relationship to State CSF curriculum and assessment was not a good fit...The Australian Academy of Science wanted PI used in Victoria and had CSF mapped against PI. The results showed a lot of CSF would be covered but PI was covering topics in different years, from different starting points, and organised under different main topics. So, the classroom teacher found it difficult to pick it up and run with it – especially as teachers had to report against CSF...The mapping helped but didn't solve the problem (DB).

Despite these concerns, we found no evidence that the use of PI by teachers was ever actively discouraged by any departmental officials. As SU explained, *No one ever discouraged the uptake of PI but it was not given imprimatur by the government* (SU).

In Queensland, PI may have either fitted comfortably with the old syllabus or filled the void, becoming a de facto syllabus for some teachers when they knew the old syllabus was about to be replaced and no replacement was readily available (see above). With the recent arrival of the new syllabus in Queensland a mismatch between the syllabus and PI has become apparent. The problem is similar to that in Victoria. The main difference seems to be that in Queensland many have used PI, would like to use PI and would like to see the problem resolved. Thus, while in Victoria this problem is viewed as a problem for PI and its developers, in Queensland it is also viewed as a problem for teachers and those wanting to promote primary science in Queensland. The problem was outlined in depth by ND who argues that the organisation of concepts in PI does not match the syllabus:

The science content [of PI] is much the same [as the new syllabus] but the organisation is not. Science 1-10 has content organised in disciplines, chemistry, biology, physics, geology. That is very different from PI. So the learning framework is very different...PI's structure is processes organised by year level and across disciplines. Teachers can relate to this and it makes sense to them to do change and dip into physics and chemistry...By contrast, the syllabus is organised by discipline and conceptual development. [People have] tried hard to show how PI fits in with the current syllabus but it just doesn't fit nicely. PI is losing its place as a whole-school program and becoming a resource that sits in the library and is dipped into occasionally (ND).

Mapping concepts in PI against those of the syllabus is problematic because they cannot be easily lifted from one year level and dropped piecemeal into another.

I can't see how the present PI could be adapted to the new outcomes. Concepts in Book 1 need to be in years 3 and 4. You just can't pull it out of its developmental sequence as a one off. You lose all the continuity and development of ideas (ND).

As a consequence, the use of PI has diminished and is likely to diminish further.

Mapping PI against the Queensland syllabus is OK but all it does is break PI up into chunks...The learning gets very haphazard and it's difficult to convincingly see where PI and the syllabus overlap...this has stifled the uptake of PI since 1999...Until that stage [the new syllabus] it was a good thing (ND).

Some of those interviewed have suggested that a good mapping of PI against the syllabus in each State could overcome perceptions that PI does not address syllabus requirements. For example, *PI doesn't match exactly with a number of State curriculums. Sometimes it's just a matter of having things in the wrong year level. So, teachers have to modify PI to make it match. That's not very difficult. The whole school could sit down and do it but, especially in Victoria, it's not seen as easy to do. They are not willing to reorder the sequence of PI and pick bits from different books* (IU). Nevertheless, all but one of those interviewed who have close affiliations with a particular State do not regard this as a solution to the problem. It is neither practical, as the sequences of PI activities are situated in year level books, nor appropriate, as content is dealt with at levels in PI that are very different from the levels at which the content is treated in the syllabus.

Teachers in the survey who were using PI were asked the extent to which they agree with the statement that PI 'does not meet syllabus requirements'. In this sample, the mean is close to the mid point of the scale and there is a large standard deviation (mean 2.8, SD 1.14, range 1-5). Among these teachers there are wide-ranging views and there is no clear consensus on whether PI does or does not match their syllabus. Nevertheless, teachers sampled in the survey were more likely to consider that PI matched the syllabus than the key players interviewed. However, this may be a function of the sample since those responding to this item on the survey are in schools that had elected to use PI.

Trying to meet syllabus requirements is like trying to hit a moving target. The syllabuses change. In Queensland, the new syllabus has made PI less attractive to schools than did the old syllabus. By contrast, in New South Wales the syllabus has recently been 'clarified'. This has resulted in a reduction in the outcomes and the outcomes are less specific. Although, arguably not a good match, PI is probably more consistent with the 'clarified' syllabus than its predecessor. In Western Australia, new interpretations of the syllabus have led to a growing perception that PI may not match the syllabus as well as was once thought. In Victoria, PI has never matched the syllabus well and the uptake of PI has been very poor. In the Australian Capital Territory and South Australia, the syllabuses are very open. We have less data on factors influencing the use of PI in the Australian Capital Territory and South Australia but none of it suggests that the syllabuses, per se, inhibit the use of PI.

Waning support and promotion

Many of the key players indicated that support provided for PI seems to have gradually waned. This view needs to be considered in conjunction with 'Ongoing support by local trainers', under research question 5, above. In particular, a need was identified for further promotion of PI and new professional development for teachers beginning with PI and also for those who were experienced with PI.

Initially there was a lot of support and promotion from the Australian Academy of Science but this gradually seemed to drop off (KB).

Professional development deteriorated. Eventually there was a shift towards the Do-it-yourself video. That was not effective (DB).

There was a flurry of activity for 2-3 years but it needs to be sustained and continued. It was an exciting time with science having a high profile, *photos of Ministers in PI schools in the paper etc. The Academy of Science has not followed through to continue to support and keep the program going at its very high level. They need to keep in touch with the facilitators better* (YK).

Competition

PI was not the only game in town! The late 1980s and 1990s saw many attempts to improve primary science education. Thus the national PI program was in competition with other programs for resources and attention.

Different things are happening in different States. Some systems, government and non-government, took it up and were positive. Others were not [note not negative but not positive]. Some were promoting other science resources that the State had been involved in and were rolling out. PI could have been seen as a competitor (NI).

Primary teachers in the Australian Capital Territory have been encouraged to use an interactive resource where students become self-directed with guidance from teachers. Students identify, clarify and investigate their own questions. There was a big push from Fleer and Hardy at the University of Canberra and courses were supported by the Department of Education and many teachers (about 60 courses were delivered) became involved (KC).

At the time, the Victorian Department of Education was putting money into STEPS [Science Teacher Education Program in Primary Schools]. Although it was in its infancy we wanted it to progress (NS).

In addition to competition with other science programs there is competition with programs that have other curriculum emphases. Many cited the emphasis on literacy and numeracy as an obstacle to gaining attention and resources for science. *[When] there is an emphasis on literacy and numeracy. Science loses out* (NS). A similar view was held by teachers. *The amount of time. In the primary school system there are constant interruptions and the amount of other work you have to do. If you're short of time what goes out? Not numeracy and literacy* (New South Wales). In South Australia, the promotion of PI may have been inhibited by *a shift in emphasis from science to literacy and maths...Some schools have too many pressures on them and simply cannot take on anything else – such as science and PI* (EH).

In Victoria, New South Wales and Queensland, when PI was initially launched, State government support had either been directed away from science education towards other curriculum priorities (eg, numeracy and literacy) or towards other programs to support primary science. Where State initiatives focus on programs other than science or PI, PI is less likely to be widely adopted. This is particularly noteworthy in Queensland. The State system identified and supported its own initiatives on school development days, and did not include science (ND, CL, TR). By contrast, the Catholic system allowed schools to select their own priority areas for funded professional development and many selected science. PI was typically the chosen program of professional development in science.

In some States, Victoria, New South Wales and South Australia, other programs were being developed or had recently been promoted to support primary science. Most key players, other than those in Queensland, with affiliations to particular States indicated that competition between State-based initiatives and the national PI program was not an issue. Those with a national involvement in PI, and key players in Queensland, considered that competition with State initiatives seemed to inhibit the adoption and promotion of PI, both by State departments of education and science teacher associations.

Timing

It seems that the emphasis on the development and promotion of different learning areas waxes and wanes according to a different cycle in each State. Just as ‘good timing’ probably promoted the use of PI (see above) so too ‘poor timing’ may virtually sink it. In some States the release of PI was poorly timed. Its launch came soon after the State government had recently placed an emphasis on other programs to support primary science, as was the case in New South Wales and South Australia, or it coincided with seemingly incompatible syllabus developments and their promotion (as has been discussed above). In South Australia the *Sci-tech* program had provided extensive professional development in the late 1980s and early 1990s, and in New South Wales PRIMSTEP [Primary Science and Technology Education Program], with its trainers throughout the State, was just coming to an end. In both these States, having just had the opportunity for extended professional development, schools were probably unlikely to suddenly launch into a new and unrelated program. In Victoria, PI’s launch coincided with a period when primary science was being emphasised but its uptake was reduced because of the perception that it would inhibit the State-based initiative.

It was a timing thing in Victoria. If it had come earlier it could have been OK. Even now it might be OK as teachers are more experienced in *using and interpreting new resources. But at the start of the CSF, it was not aligned with the CSF. Teachers were working with new directions...we didn't want conflicting advice and confusion [from PI]* (ID).

It's a textbook

Some people are opposed to a textbook in any form. This is not a problem peculiar to PI but such a view inhibits its adoption. Although typically recognised as being much more than a textbook, PI does have, as core features, student and teacher books.

In New South Wales and Victoria in particular, some considered the use of book-based materials outmoded or too limiting. For example:

In Victoria, the Department is promoting multimedia, online and CD-based resources. All teachers now have laptops...The notion of a textbook is out of date (ID).

There is a limitation in being book-based, it is very linear, go from end to end...doesn't allow enough flexibility (KT).

Lack of official endorsement

In State schools in New South Wales, Victoria, South Australia and Queensland, PI was not promoted and endorsed by the systems and struggled to gain recognition and wide acceptance in these schools. In particular, there was a lack of financial support for PI in some States and Territories (eg, South Australia (KB)).

This issue has been discussed in detail above and is therefore treated only briefly here. PI was not denigrated but it was not promoted. The following comment seems typical of many States: *In South Australia...there wasn't any push from the systems' level* (RS).

A number of key players referred to advice sought from local experts, consultants or academics in New South Wales (KT), South Australia (KB and RS) and Victoria (SU) about PI. Their views seem to have influenced the extent of support for PI in these States. We have attempted to present these views throughout this report.

In New South Wales, Victoria, and Queensland, departmental officials expressed the view that, while a program such as PI might receive support such as funding for professional development and be promoted, a commercial program in primary science was unlikely to be officially endorsed as if it were an approved curriculum. For example:

Some Catholic regional offices really embraced it but the State system will not endorse a commercial product. The policy is to provide a syllabus and some teaching approaches and pedagogy, not a commercial package of any type. We can mention resources and PI is mentioned among others...Yet when I visited 30 schools, every school would ask about PI. It's so well known (ND).

Just as various departments of education were pursuing other, perhaps competing, initiatives, so too the Australian Science Teachers Association may have been less supportive than some had hoped. *PI would have been more successful if marketed through science teacher associations, as was the case in Western Australia. For some reason it was never well supported by the [ASTA] hierarchy or [some] State science teacher associations* (EH). *In Queensland the Science Teachers Association supported PI and STAQ representatives provided PI professional development programs* (RR). We had difficulty in obtaining views representative of the science teacher associations in States other than Queensland, Western Australia and New South Wales. We have little data about the extent of support for PI from the Australian Science Teachers Association or other State science teachers associations.

Lack of involvement in trialling

State education departments often were not involved in the trial of PI. The lack of involvement in trials of PI may influence the adoption of PI (EH). The apparent success of PI trials may have been less influential on State department of education decisions about PI than the views of State-based experts in science education.

Furthermore, PI was *not trialled in the Australian Capital Territory and some people were keen to be involved. I suspect that not involving them at the trial stage made them look less favourably on PI* (KC).

Lack of science being taught

Many schools teach relatively little science. If you don't teach science you don't need a resource to teach it. *Teachers don't have confidence to teach primary science and don't do a lot of it* (NS).

The home-grown factor

In some States, resources perceived to have been developed in other States are deemed to lack value. In short, they are suspicious of supporting resources that are not *home grown* (RR), and *interstate jealousy* (DB) prevents acceptance of resources perceived to be developed in other States. PI may suffer from a perception that it is a Western Australia initiative.

Furthermore, people were not sure that *the Australianness of it is strong enough* as it is a US adaptation. In South Australia some people said *PI, that's the American program isn't it?* That was perceived as very negative.

The nature of the program

A major factor inhibiting the use of PI is the perceived limitations of the program itself. Teachers were surveyed on their views of selected weaknesses. Some of these perceived weaknesses are considered in detail below.

The prescriptive nature of PI

PI is highly structured and often perceived to be inflexible. While these characteristics are regarded by some as strengths of the program (see above) others consider that they may inhibit good teaching of primary science. The highly structured, sequential, step-by-step program is unattractive to some teachers.

Teachers had a lack of confidence in the recipe type model...It tends to be a recipe program, questions, activities, resources. If you follow the steps right through you get a particular activity done. That particular approach doesn't work with teachers in South Australia...But it does work with teachers [in South Australia], as a starting point, who are unsure what to do. The books are more suited to that group (RS).

The whole-school nature of the program resulted in some teachers having to sacrifice teaching science in their preferred style. Some were willing to make this sacrifice to promote science in their school.

It can be a bit restrictive. I think maybe I'd prefer to do something else sometimes but if I don't do PI then it makes it difficult for others (Confident teacher of science, Australian Capital Territory).

PI is a whole-school program where everyone knows what has been done and what will be done. That's useful but sometimes it would be good to do something completely different...Just follow on with what the kids are interested in and take it much further (Australian Capital Territory).

The structure of PI has enabled many teachers to begin to teach science but it may not have encouraged further teacher development.

[PI is] too closed. It needs a more open-ended activity and approach. PI helped many teachers become confident but many teachers have

stagnated and not moved on. Teachers need support to move on, to continually improve their science teaching, assisting students to develop their own investigative processes (GE).

PI makes it too easy to teach science, and teachers teach science without thinking deeply about the teaching and learning in primary science, and it prevents teachers interacting with students' views and responding to 'teachable moments'.

One problem is that the books become the curriculum...Demands on time, pressures and classroom realities mean teachers fall back on the books and the structure (KT).

...the problem is it tends to lock the teacher in to sets of behaviours...It's written to be teacher-proof and I object to that. I heard it sold as 'anyone can follow the process'. It's as if any bunny can pick it up and use it...this denies teacher professionalism. I don't feel comfortable with that...I would never favour that sort of rigidity in the curriculum...It's very American and they seem to love that sort of stuff...The art of teaching involves responding to individuals and what individuals say. A resource can't do that...Having a rigid structure does not sit well with our desire to have flexibility to local conditions. PI doesn't encourage this (SU).

PI is not student-centred. It's teacher-directed [with] little student control over learning. This makes it centred on the resource, not students and opportunities for learning as they arise...It doesn't address the teaching outcomes well when used as is. When the PI activities are used as a basis for extending to open investigations, probing questions are used to seek out children's conceptual understandings and activities are selected that go to greater depth of concepts. How can you get kids to think creatively and innovatively? This is what a 'new PI' would have to do (GE).

Although designed as a programmed sequence of activities, some teachers varied the sequence and type of activities. Some experienced science teachers were willing and able to do this.

What I found I was doing was using the particular activity in PI but not following it exactly. Take the device testing the speed of wind, I used the same equipment but I put it out as an open-ended experiment with a design brief, but not following the set procedure [in PI]. That worked really well...I started to think outside the square (New South Wales).

Most teachers argued that, although possible, it was difficult to use selected parts of PI to develop their own programs, even for experienced teachers.

Aspects of PI could be useful...Good teachers should be able to dip in and out. There are some nice activities, for example on the built environment. However, the teacher must have good background knowledge in order to select the appropriate activities. For non-science people this is very difficult to do, given the way PI is structured (MG).

The all or nothing approach. Primary teachers who are not strong in science cannot navigate PI in such a way that they can select parts of the books that are relevant to the content area that they want to cover. So if the teacher was doing a theme on mini-beasts they would have to look at all the PI books in order to find activities relevant to that theme and that would be too difficult. PI is not set out in a way that would allow teachers without a strong science background to access parts relevant to the topic they are doing (BG).

The collective view of many of those who were critical of the prescriptive nature of PI was best summarised by KY:

Teachers tended to wander around and there was no intervention. It suited some teachers to let PI do the teaching. It's easy to set up and run and once it's working it tends to work by itself...Teachers need to get in there and challenge students to explain their theories...This needs to be part of the professional development framework...teachers need to follow up [in activities] to look at students' ideas and encourage scientific reasoning...

It takes the planning management and preparation out of the teachers' hands. This is good because it gets teachers teaching science but it can also be very superficial...real learning occurs when kids go beyond – when they think deeply about...but teachers lack confidence in their own knowledge.

Here, KY identifies the shortcomings of PI identified by others, but he also notes that the 'good teaching' described is difficult for those teachers lacking the confidence and knowledge to teach science. Thus he argues that professional development with a modified PI might address this problem.

Many of those interviewed asserted that experienced and able teachers of primary science did not like PI. While we did find some members of this group who do not like PI, we also found others who do.

Enthusiasts perceived that PI would inhibit them. And without professional development it probably would – they thought that they would be limited in what they taught, when what content was taught and so on. PI was a whole-school plan. Some were threatened by this as they saw it as a whole-school thing that they must follow. These enthusiasts were often very influential in the profession, and departments of education (EH).

I've heard that some teachers experienced in science teaching found PI too prescriptive...I had the opposite experience...in two of the schools where I provided PI professional development, there were two very competent and experienced and inspiring teachers of primary science but they encouraged others to use it and used it...They thought it was great (NI).

There seems to be at least two very different reactions from competent and confident science teachers. There are those who like it and use it to help others teach science and there are those who find it limits their teaching and may discourage its use actively or passively. We are not sure which is in the majority.

Teachers surveyed were asked the extent to which they agreed with the statement that PI 'is too prescriptive' (mean 2.6, SD 0.94). The average view suggests a tendency in the sample to disagree with the suggestion that PI is too prescriptive but the mean is close to neutral. Some think PI is too prescriptive. More think that it is not too prescriptive but there is no strong trend. The sample consists of a group who rated themselves as confident teachers of science, and these results are consistent with interview findings that confident teachers are divided about the benefits of the prescriptive nature of PI.

Cost

Primary schools had limited funds to support primary science education and the cost of PI, according to some, makes it unattractive. The initial policies restricting sales of PI to the meeting of a range of conditions also inhibited the purchase of materials. A few key players in each State suggested that it was difficult for schools to fund a PI program. Outside Western Australia and Queensland this view was common.

Concerns were raised about the capacity of primary schools to meet the costs of books, professional development and equipment. Some schools seemed unable to afford the time for PI professional development

The program was introduced as being important that it be a whole-school program...for a sense of continuity across year levels. So, in *terms of the budget for science in primary schools in South Australia, that cost is quite big. And the cost of the equipment is quite large* (RS).

The package required the professional development and some schools thought they couldn't afford the time. Some schools were unwilling to commit all staff. Thus the professional development that was essential was also a restriction (EH).

Cost is a major factor in preventing schools [in New South Wales] using PI. Also the requirement to make a school-wide policy decision (KT).

Typical primary schools [in Victoria] cannot afford a text per student (DB).

Primary schools don't spend money on science books. They just don't have the money to spend. It's a big outlay [for PI] (IU).

The nature of the professional development made it expensive for teachers and schools to take it on where departments of education didn't [financially] support it...PI could sometimes be funded in one year [about $3500 estimated for an average school] but the ongoing costs of purchases were significant. So, in some schools, just the cost made it likely to falter and fall over (KB).

While the cost was considered prohibitive for some schools, no one suggested that the PI program was overpriced.

Boredom

Some teachers who have been using PI for a long period become bored with it. Similarly, students who have used PI over a number of years may become bored with activities that may be too simple. This may be a function of PI's highly structured and inflexible sequence of units when implemented as a whole-school program. Some experienced PI users, many in the Western Australia focus group, consider PI to be dated and in need of revision:

After using the books for so long I am a little bored...Some activities have become too simple for the children now that they are experienced with using PI. If the activity goes on too long the kids get bored (DD).

The excitement that was first there with PI isn't there now (ND).

Teachers like things they find interesting, too. Teaching PI over many years can make them bored with science teaching. Odd that this isn't an issue with maths...Now teachers are looking for the next thing...Teachers think that the first unit each year has too little content with its emphasis on preparing cooperative learning roles at the start (KR).

The teachers surveyed were asked the extent to which they agreed or disagreed with the statement that PI 'gets boring after a few years' (mean 2.7, SD 0.92). The mean view of this sample of PI users is close to neutral. However, as indicated by the standard deviation, there was a tendency for teachers to agree or disagree with the view that PI becomes boring rather than 'neither agree nor disagree'. The views on this issue are diverse but though more are of the view that PI does not become boring, many PI users find that PI does become boring after a few years. This problem appears to be cause for concern.

Weak activities and units

In interviews, many talked briefly about weaknesses in particular activities and units. Often these views were offered by people who thought PI a good program and promoted its use. They wanted to see these 'weak spots' fixed. Listing all of these weak activities or units is beyond the scope of this study. However we note that some sections of PI need revision.

PI role overstated

PI was originally developed because many primary teachers were reluctant to teach science (EH). A few of the key players interviewed mentioned that the role of PI in improving primary science became overstated. KB argued this view most forcefully:

[PI was] marketed as a way to fix up ailing science education but didn't celebrate the good that was there. This could easily put people offside...The marketing suggested that it would suit everyone but it can't be all things for all people. It was built for reluctant science teachers and sold as this but those teachers able and confident to teach science were often the ones most influential in making decisions about science teaching in their schools...experienced able teachers [in South Australia] of science decided they didn't need it – it wasn't designed for them.

Other criticisms

Other criticisms were made of PI. These included:

- that its reading demands may be too high for some students with poor literacy
- that it does not adequately deal with relevant cultural matters, specifically Aboriginal culture

- that it does not provide adequate guidance and strategies for assessment.

People did not assert that these weaknesses inhibited the widespread uptake of PI. They considered them matters that should be addressed in any revision of PI.

Findings

- There is a mismatch between PI and the syllabus in some States and this is a major obstacle to the use of PI. People disagree on the extent of the mismatch.
- Syllabuses have changed since PI was developed and some are due for review (eg, New South Wales). The problem of a mismatch between the developing syllabuses and a stagnant PI is likely to get worse.
- The high levels of promotion and professional development available as part of PI during its early years have waned.
- In general, where limited resources are available for professional development, competition for these resources exists among programs. However there is some dispute as to whether any competition exists with PI and if it does exist it is not clear whether, of itself, it has inhibited the uptake of PI.
- The timing of the launch of PI inhibited its uptake in some States. It is unlikely that any one time will be the right time to launch a program such as PI in all States.
- Textbook-based primary science is unattractive to some influential key players in primary science.
- The lack of departmental endorsement inhibits the adoption of PI. Most large departments of education seem unlikely to officially endorse PI as an approved curriculum. However, they may promote PI as a program to enhance primary science in their States.
- Support of State and national science teachers associations may have been mixed but we have little data on this. Support of the associations is desirable in promoting PI.
- Not involving some States or Territories in trials may have led to localised resentment of PI.
- PI may have been viewed and described as a Western Australian or US program. This may inhibit its use by some.

- Some schools may teach so little science that they have no perceived need for a program such as PI.
- While some experienced teachers adapt and modify PI, the program is not well suited for this.
- The prescriptive nature of PI, combined with the mechanistic implementation of activities without employing a genuine 5Es or constructivist approach, sometimes results in teaching science without working with, and developing, students' concepts and ideas.
- In its present form, PI makes teaching science so easy that some teachers may teach science 'without thinking'. Without effective professional development, PI may not encourage them to think deeply about teaching and learning in primary science, to interact with students' views or to respond to 'teachable moments'.
- Some schools may not be able to afford the initial PI program and the ongoing outlay for books.
- Some experienced PI users are starting to find it boring and are looking for something new.
- Some activities and units are considered weaker than others. However, it is not evident that these small weaknesses inhibit the use of the program as a whole.
- The role of PI in primary science may have been exaggerated during its promotion. Some may have resented this.

Research question 7: What should be PI's future development and direction?

There was universal agreement among interviewees that PI needs to be revised. Some commented that this 'promised' revision is overdue.

In the teacher survey, most agreed that they 'would like to see PI revamped' (mean 4.1, SD 0.75).

When asked about their suggestions for a revised PI, the interviewees often produced lists of changes. Some identified minute changes to particular activities, some outlined broad principles for teacher change, while others suggested broad sweeping changes to the very nature of PI. In this section of the report we present suggestions for a revised PI. Some of the suggested changes could be included in a revision of the existing PI, while others would change its very nature.

PI is now being asked to do more than it was originally designed to do. It once may have just been expected to get teachers teaching some interesting and engaging science in primary schools. A revamped PI, it seems, must cater to the needs of all teachers, provide a range of teaching approaches and meet the needs of all State syllabuses, among other things. A significant challenge for any program!

GE outlined the key problems facing PI (or any program aiming to improve primary science). The extracts from GE's interview, and his revisions, summarise his view of the way in which PI might develop.

PI has provided a great base, now it's time to move on to investigative inquiry, teacher development of concepts, technology learning...The problem is that many teachers are still not confident. I guess a range of strategies and approaches are needed to cater for all teachers and all students...professional development needs to engage teachers as we would have teachers engage their students. Activities need to challenge teachers' conceptual ideas, model the approach, the good practices, and at the same time improve teachers' conceptual understanding in science.

[What is needed is] a central structured program for the reluctant teacher to just teach science (easy to use with simple equipment, easy to follow instructions etc.).

Then build the following around this core:

- *Questions for teachers to ask students that stimulate inquiry/curiosity, with many examples of open-ended activities that students can investigate. This can give control of learning to the student.*
- *Alternative sequences of activities that probe students' conceptual understandings (eg, of sound) and fit these into the structural core at appropriate places.*
- *Provide alternative strategies for activities that teachers could use for their students. This would get away from the 'one size fits all' approach of PI.*
- *The alternative strategies would help students improve their science as well as their literacy (including opportunities for Aboriginal students with low literacy levels in science).*

The concepts being developed in a unit need to be clear – a bigger picture is needed – rather than outcomes (really objectives) for each lesson. Learning outcomes need to be identified for a unit/year and the activities need to be linked to these. This is recognising that learning, real learning, takes place over time, not in a lesson. Need more than just *the 'patterns', 'balance', but concepts of understanding materials, energy, and so on.*

The suggested changes for a revised PI are outlined below. The first four, Match to syllabus, Other media, Professional development and Open-ended investigations, were recurring themes in both the survey of teachers and the interviews and should be given priority in a revised PI.

Match to syllabus

Eighteen interviewees and focus group teachers felt that PI needs to match syllabus outcomes. The teachers surveyed also agreed that PI needed to match their syllabus (mean 3.9, SD 0.89). In New South Wales the lack of technology in PI means that it is out of step with the State K-6 syllabus. Teachers in Queensland are waiting to see whether PI matches the new syllabus before committing themselves to the expense and time involved in taking it on. The Catholic school system's science coordinators in that State had felt the need to produce a document spelling out the links between PI and the new syllabus. Even in Western Australia, where PI is established, there is concern about how PI will match their new Frameworks. Only in the Australian Capital Territory and South Australia was this not clearly a strong recommendation.

If it's to be a national project, it needs learning sequences and activities to be incorporated into each State's framework and give examples of this...

Resources must now be linked to State frameworks – and use local people to do it! (NS).

Needs to align with Queensland requirements. Just lifting parts of it devalues PI, the 5Es are lost and sequential development goes out the window. It needs to be pulled apart and put back together in a way that suits our own syllabus (ND).

Other media

In the survey, teachers were asked two questions about the use of CD-ROMs and other media. Specifically they were asked the extent to which they agreed with the statement that 'other media should be used as well as the books' (mean 3.9, SD 0.95) and 'other media should be used instead of the books' (mean 2.7, SD 1.3). On average, these teachers would like to see other media as a supplement to PI but would not like to see other media replace the books. Most teachers interviewed wanted to retain the books. Teachers surveyed generally agreed that the 'student books should be retained' (mean 3.7, SD 0.89).

Sixteen interviewees considered that PI should be offered on CD-ROM or online, in a format that would allow for more flexibility in its use, wider access and greater quality of presentation. A flexible unit structure with possible, alternative pathways mapped out might allow the links to the syllabus to be more easily identified.

Many suggested supplementing a new edition of PI with web-based resources or CD-ROM, or substituting an online resource or CD-ROM for the books.

Some argued for this, claiming it would make the use of PI more flexible and online resources could be regularly updated to keep pace with innovations and teacher needs. Some saw the advantage of multimedia in capturing student interest and providing learning opportunities. *Use the CD-ROM medium to make material more visually exciting, interesting, adaptable and interactive* (EH). Others argued against this, saying that they would prefer a book. The following comments demonstrate the breadth of views:

To make it more useful, PI could be placed on CD or online, with a suggested learning sequence but with autonomy for the teachers to develop their own sequence by selecting parts from PI to build into their framework. That type of access to the resource would be useful. At the present stage, it's not useful to Victorian teachers.

The development of teachers' understanding of science could be extended by putting more background information online (eg, through Nova: Science in the News*). There is background information in the books but if teachers lack the knowledge needed to teach an area, a paragraph in the book won't fix it* (KB).

Put it on CD, include engaging animations and interactivity, use an online support network to boost professional development, have a help-line online to assist teachers – but teachers may not be taking up online programs in Victoria with much enthusiasm (DB).

In general, teachers are telling us don't put it all online. They want a book that they can hold, take with them and refer to. They want hard copy. Note the ASTA-Biotechnology Australia experience, they built a web site but ended up having to print it off and provide hard copy to teachers to get them to use it (KB).

Some saw a CD-ROM as being of more use as a resource for students rather than teachers:

Primary teachers make regular use of computers with classes – could include some CD-based resources for classes. Primary teachers say they love being able to send small groups off to use a CD (IU).

Use of DVD or CD are options. These could include some hard-to-do experiments and provide links to the real world (eg, if...investigating paper helicopters there could be a short film on real helicopters) (OG).

Some wanted PI to be made more flexible by making it easy for teachers to use a bank of activities to select and sequence activities. Often this was associated with suggestions that it be placed on a CD or online. Some suggested that PI be provided as small unit-size booklets, rather than a large year-long book.

Make it more flexible. Kids learn in different ways and the teacher needs to respond to students. PI is too prescriptive. Provide a lesson sequence but make it easier for teachers to organise things into their own sequence (NS).

The materials themselves, some of them are really good, no question. It would be a pity if they were to die. So, if it could be repackaged it would be good but the notion of a course is contrary to my understanding of what change really involves...Need to provide a more flexible package (eg, the best of PI) and provide a good interpretation of how it fits in with each State (SU).

My solution would be to make it loose-leaf or tiny booklets and let them just grab the bit they want. Organise it by topics (IU).

While some recommended substituting a CD-ROM and online resources for PI books, many wanted the books retained.

Not wise to substitute books with a CD or web resource – it would end up being printed sometime anyway. Teachers may want PI to include new media but this needs to be clarified. Personally I'd rather a book. It's just more convenient (OG).

There is no need for a student book. The cost is prohibitive. It's not my philosophy to have kids working step by step through a book, but the teacher's book is good (NS).

Provide additional professional development

Most teachers surveyed tended to agree that 'more professional development was needed' in PI (mean 3.8, SD 0.83). Two kinds of professional development were suggested. One was to renew professional development support for PI and provide support for existing PI users. The other was to work with teachers to develop a range of teaching strategies which may have been less explicit in the original PI. Helping teachers to develop the capacity to explore and work from students' ideas was chief among these.

Four interviewees had conducted research or made observations that showed that many teachers were not teaching PI in the way that was intended. Teachers were still using a teacher-directed approach and failing to incorporate the 5Es into their lessons. A similar conclusion can be drawn from the analysis of secondary sources. In this, PI is typical of most attempted innovations. It was suggested that more professional development be carried out to alleviate this problem. Teachers also need to be given further help in understanding how to create a constructivist environment. It is further suggested that those teachers who have become bored with PI should be encouraged to attend workshops designed to extend their knowledge and reawaken their interest in PI.

Another professional development program is needed – something like 'PI revisited' (YK).

Teachers don't have the content knowledge so they can't recognise students' alternative frameworks...need to design the right experience to match with students' conceptions...teachers don't have the capacity to capitalise on teachable moments...PI deprives them of that opportunity because it is lock-step...Perhaps PI needs to be supplemented with a suite of activities and professional development to elaborate on these. PI could identify [for teachers] misconceptions kids might have and suggest ways to challenge these (KY).

Strategies also need to be put in place to maintain ongoing, long-term professional development for PI. For example:

We've learnt that printing up books will not change teaching. PI came with professional development but it can't be one off. It's got to be ongoing with the program for the long term. Over quite a long time frame. In cycles and over...12 months – if affordable (RS).

Open-ended investigations

A suggestion made by a number of key stakeholders (7) is that PI should contain more open-ended tasks, particularly for students in upper primary. Some felt that PI should incorporate a trend from guided to open investigations as the students progressed through the series of tasks or units. The lack of open-ended structure is a principal reason why PI did not match the New South Wales curriculum (KT) and does not match other recent State syllabuses.

In order to keep pace with current trends in science education, PI needs to incorporate a more open-ended approach to science teaching and learning.

On average the teachers surveyed also agreed that PI tasks ‘should be more open-ended’ (mean 3.9, SD 1.0), but there was a range of views on this prospect. They also agreed that PI should ‘trend towards open-ended investigations’ (mean 3.8, SD 0.92).

Plan so that the materials move from guided inquiry to open-ended inquiry. Assist teachers to see how they can adapt closed tasks to make them open (EH).

Higher-order scientific reasoning

Most teachers surveyed either strongly agreed or agreed (mean 4.2, SD 0.68) that PI should include student activities and assist teachers to promote more ‘higher-order reasoning’.

It needs to promote scientific reasoning, debate and discussion of ideas...strategies need to be included that go for high-level discussion with higher-order reasoning (SU).

Background information

Provide more background information on science content. It was often suggested that this could be done online.

Needs to deal with developing teachers’ understanding of the science. Provide background material on the concepts. Primary teachers often don’t know the science they are to teach. Many are at stage 3 themselves but teaching students for stage 4 outcomes (GE).

Extensions

Provide extension activities and strategies, particularly for students and teachers who have been using PI over a number of years.

Extensions should start with what students want to know about...[PI] may need more extension activities, supplementary sections for teachers and students, new ways of carrying out primary science in extension materials for teachers (activities, teaching practices, strategies, background information).

Integrate PI with other learning areas

PI tends to stand alone, separate from other learning areas. There is a drive for integration of science with other learning areas and PI needs to make it easier for teachers to achieve this. One area identified as well suited to this integration was literacy. One teacher noted that literacy testing in his State often included reading of ‘science’ items.

...we could look at how to strongly integrate science with other areas. Perhaps an issues-based approach may work but primary science teachers probably lack the threshold knowledge to deal with this approach.

Develop the technology strand in PI
Many commented on the need for a larger technology component in PI (and not only those in New South Wales, where the syllabus includes technology). There was also some agreement among teachers that PI needed 'more technology' (mean 3.7, SD 0.93).

Make PI books more attractive
The most common suggestion was to include full colour in future productions, but some just wanted an update to make PI look new. More extensive changes to the fonts and amount of text were also suggested.

Books are still attractive but they may need a facelift just because they have been around for a while now (NI).

Make it more attractive with more colour, especially the books for younger children.

Use bigger print; put less information in books for lower levels; less reliance on written text for lower levels (IU).

Include assessment ideas and guidelines
Many interviewees, particularly teachers, commented on the need for suggested assessment tasks and strategies in PI. Most teachers agreed or strongly agreed that a 'range of assessment ideas should be included' in PI (mean 4.1, SD 0.59).

Make relevance of science more explicit
Teachers in the Western Australian focus group suggested that the relevance of the science in PI to the children's daily life should be made more explicit. Data from teachers surveyed showed no clear trend on this suggestion (mean 3.4, SD 0.85).

More material
Many simply said that they wanted more material in PI because their students wanted to learn more than was offered in PI. One teacher preferred an interactive approach and considered herself already confident in teaching science. She sometimes found PI frustrating. *It doesn't go far enough...When I did magnets, they were really keen and interested and wanted to know more. I had to go and get lots of other resources because there wasn't enough in PI [to satisfy their*

curiosity]…I guess PI has materials there but I want more and maybe if I didn't have PI maybe I'd have to get everything myself and maybe I might not have gotten that far or not done that in the first place. It's just a bit frustrating to just do so much and no more.

Findings

- PI should be retained and revised. Suggested features of a new version, outlined in Appendix 5, include:
  - retaining good features of PI
  - new editions of books
  - making PI books more attractive
  - supplementing or replacing PI books with CD-ROM and online resources
  - extension activities
  - open-ended investigations
  - support for students investigating their own questions and problems
  - more science background information
  - making PI more flexible
  - extending the range of teaching strategies, including strategies to explore and work with students' views
  - providing additional professional development (including professional development to assist teachers with metacognitive and interactive pedagogy)
  - ongoing and long-term professional development
  - suggestions to assist with the integration of PI with other learning areas (eg, literacy)
  - ensuring a match between PI and State syllabuses (this may require different adaptations of PI)
  - developing the technology strand in PI
  - assessment ideas and guidelines
  - making the relevance of science more explicit
  - units organised around concept development.
- A process for revamping PI was proposed. Features of this process include:
  - a forum to review this evaluation report and to clarify the role and directions of a revised PI, as part of a strategy to enhance primary science
  - developing, trialling, promoting and supporting a revised PI

- listening to teachers
- reviewing alternative resources for new ideas.

What students who use PI think of their science experiences

A survey was used to explore students' views of their primary science experiences. The questionnaire used was identical to that used in a recent national study (Goodrum, Hackling and Rennie, 2001). This allows comparisons between the PI students' views of their primary science experience with the views held by students throughout Australia. A table showing a comparison of all items in the questionnaire is in Appendix 3. Some items pertinent to comments made about PI or indicative of the quality of primary science education, are reported here.

On many items indicative of good science education, the PI student sample scored better than the national sample while on other items there was little difference. Only on one item did PI students score more poorly by a similar margin. Here, only items where the difference was at least 9 per cent are reported.

Talking and thinking

On a variety of items related to thinking and talking about science, PI students scored better than those in the national sample. Students in the PI sample reported that they 'needed to be able to think or ask questions' more often than those in the national sample (82 per cent vs 73 per cent, often or nearly always). The PI students also indicted that they more frequently 'explained things to each other' (76 per cent vs 61 per cent, often or nearly always). The data also shows that they were more likely to 'talk to others about my ideas' (73 per cent vs 56 per cent, in most or every science lesson) and more likely to 'have class discussions' (82 per cent vs 71 per cent, in most or every science lesson).

Working in groups

On the item 'in my science lessons we do our work in groups', 84 per cent of PI students said that they often or nearly always worked in groups. By contrast, 61 per cent of those in the national sample indicated that they often or nearly always worked in groups.

Practical work: teacher-directed and students' own investigations

One of the criticisms raised about PI was that students doing PI were likely to follow teacher-directed activities and not do their own investigations. In response to the item, 'In my science classes we do experiments the way the teacher tells us to', 86 per cent of the PI sample responded often or almost always. By contrast, 75 per cent of the national sample responded in this way. However, in PI classes students responded that they more often 'do our own experiments' (36 per cent vs 26 per cent, often or almost always) and were more often asked by their teachers to investigate (65 per cent vs 52 per cent, often or almost always). This data suggests that when doing primary science, students do more teacher-directed experiments than investigations of their own. However, this survey suggests that PI students probably do more of their own investigations than the national average.

Enjoyment and interest

On items related to their interests and enjoyment of science, PI students also scored better than the national sample. They indicated that their 'teacher makes science lessons fun' often or almost always (83 per cent vs 63 per cent for the national sample). Asked if they were bored during science 82 per cent of the PI sample responded 'never or in some science lessons'. By contrast, in the national sample 70 per cent responded 'never or in some science lessons'. On the item, 'During science lessons I am excited', twice as many students in the PI sample responded 'often or nearly always' (52 per cent vs 26 per cent). Students using PI seem to indicate that they more often enjoy and are interested in their science than those in the national sample.

> Finding
>
> The science experiences of PI students are likely to be more often characterised by features associated with good science teaching than is normal for students in primary science.

Reflection

I have listened to and often participated in discussions about the best kind of professional development for teachers. Prior to doing this research, I tended towards a philosophical opposition to my perception of the 'PI approach', which I considered so prescriptive that I thought it was unlikely to result in teachers engaging deeply in important ideas about teaching and learning primary science.

I retain philosophical and theoretical reservations about PI but, pragmatically, there are many primary teachers who now teach science in a way that students tell us is interesting and engaging, because of PI. When supported, PI has demonstrated that it can get many teachers to regularly teach a significant amount of primary science. Furthermore, students seem to enjoy science when using PI.

In this evaluation, I was sometimes told by key players that PI was not being used or supported because teachers prefer an interactive approach or another advanced approach. I don't doubt that some do and that there are many good things happening in primary science education in parts of Australia. We should recognise and celebrate these. However, it is unlikely that PI has not taken off because there are thousands of primary teachers teaching science brilliantly, using an interactive approach. Such a view is inconsistent with the evidence.

This then begs the question, could it have been done better and are there better ways to improve primary science. I'd like to think so. I'd like to think that we can learn from PI and other attempts to improve primary science in the last 10 years. However, we should not ignore the evidence that where PI was supported it seems to have worked.

An analogical interpretation of PI

When PI was developed, there were pockets and networks of good primary science but overall it was in ill health. PI was part of the solution to this problem. To extend the analogy of ill health, PI could be viewed as a long-term symptomatic treatment. In some places this treatment was used and it improved the health of primary science, but it had some side effects that were considered undesirable (eg, some teachers used the program without promoting deep thinking about science). In some places, people sought second opinions and rejected the PI treatment either because they thought there were better treatments; had just tried a treatment (that may or may not have worked) and were not willing to try another resource-draining treatment; or because they were not willing to risk the side effects. Those who tried the treatment generally found it helped, but it was not the complete remedy. PI is not a cure. Where it has been tried we have learnt a lot about how to develop this treatment and use it better. It some places the treatment was applied better than in others. For some the treatment made them feel better but they grew tired of the treatment and withdrew from the program. If the PI treatment had been taken by others would it have helped? I think it probably would have, but we will never know. Certainly, some experts claim that the PI treatment would have been incompatible with other treatments being tried at the time, and it may have been. Other treatments have been developed and tried since PI, with some success. We should also learn from these to improve PI – without destroying the features that have contributed to PI's successes. PI is one treatment that leaders in primary science education recommended and it worked for many teachers. It was not the right treatment for all teachers. It was not and is not a cure for all the ills of primary science. It should not be expected to do or have done more than is reasonable.

In so far as primary science education can be viewed as a problem, PI is not the solution. It is part of a solution.

PI should be retained, informed by this research and other recent developments in primary science, and revamped.

Recommendations

1. Revise *Primary Investigations*

1.1 It is recommended that PI be revised. It should retain many of the good features of the original program but be flexible and adapted to different State requirements and the needs of different teachers. Suggested attributes of a revised PI are in Appendix 5.

2. Hold a cooperative forum to develop guidelines for the revision of *Primary Investigations*

2.1 It is recommended that a forum be convened by the Australian Academy of Science. This forum should include primary teachers from State science teachers associations, representatives of State and Territory departments of education, the Australian Academy of Science, the Australian Science Teachers Association, the Commonwealth Department of Education, Science and Training, and science education researchers. It would also be beneficial to include less confident teachers of primary science.

2.2 The forum should use the results of this evaluation to develop guidelines for the revision of PI.

2.3 The forum should establish a working party to take on the task of revising PI. The revision should be overseen by a steering committee comprising representatives of State and Territory departments of education, the Australian Academy of Science, the Australian Science Teachers Association, the Commonwealth Department of Education, Science and Training, and science education researchers.

2.4 If possible, revision should include extensive trials in all States and Territories, in cooperation with State and Territory education systems.

2.5 The steering committee should promote mechanisms within each State and Territory to ensure effective trialling, implementation and ongoing support for the revised PI. These support mechanisms should involve, among others, the State science teachers associations and State and Territory departments of education.

3. Establish a mechanism to regularly survey primary schools about students' science experiences.

3.1 A variety of strategies and programs have recently been employed to improve primary science in Australia. Now is an ideal time for the Commonwealth Department of Education, Science and Training to begin to regularly survey primary schools about students' primary science experiences.

3.2 The student questionnaire used in this study (Appendix 1) may be an inexpensive and effective way to achieve this. Mapping primary school students' experiences over time would identify schools where change for the better had occurred. Case studies of selected schools in each State would allow the factors that led to this change to be identified. This would allow primary science programs to be better designed and targeted and would yield information that could be applied to other strategies and programs aimed at improving the educational experiences of students in Australian schools.

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Appendices

Appendix 1
Questionnaire for teachers

Evaluation of Primary Investigations

This questionnaire is designed to collect your ideas and experiences with the program for primary science *Primary Investigations*. Most of the questions list statements made by teachers in discussions about *Primary Investigations* and ask you to indicate whether you agree or agree with those statements.

A sample of this type of question would be:

Please circle the number that best sums up your response to the following statements,

	strongly disagree	disagree	neutral	agree	strongly agree
1. *Primary Investigations* was simple to use	1	2	3	4	5

If you agree with this statement you would circle the number 4.

There are also some questions about your teaching background and two questions about your experiences with *Primary Investigations* that ask for a short written response.

Your participation in this survey is voluntary and you may withdraw at any time. All results will be confidential and you do not need to put your name on the questionnaire.

Thank you for taking the time to complete this document.

Some background information about you.1

What is your gender? *Please circle* Male Female

How long have you been teaching? Years ______________

On a scale of 1-5 rate your confidence in teaching science (*please circle*).	very low				very high
	1	2	3	4	5

If you have **never used** *Primary Investigations* please answer questions 1 to 3.
If you **have used or are using** *Primary Investigations* please answer questions 4 to 50.

Reasons for NOT using *Primary Investigations*

1. Please rate the extent to which you agree or disagree with the following reasons for not using PI.

	Strongly disagree				Strongly agree
• I have never heard of it	1	2	3	4	5
• It is too expensive	1	2	3	4	5
• My school elected not to use it	1	2	3	4	5
• I prefer to use other resources	1	2	3	4	5
• It does not meet the requirements of the syllabus	1	2	3	4	5

2. Other reasons for not using *Primary Investigations (Please list below)*

____

____

3. Rate the degree to which *Primary Investigations* needs to match your syllabus in order for you to use it.	Very low				very high
	1	2	3	4	5

The remaining questions are for those teachers with **experience in the use of *Primary Investigations (PI)***

4. How many years have you used PI? ________
5. What grades/years have you used PI with? ________
6. Does your whole school use PI? Yes No
7. When using PI, do you follow most of the lessons in sequence? Yes No
8. Are you using PI this year? Yes No
9. Estimate of the number of hours of professional development you have undertaken for PI ________
10. What form of professional development have you undertaken for PI (please tick).
    a. None ________
    b. Train-the-trainer program ________
    c. Whole school face-to-face workshop ________
    d. Workshops with trainer (not whole school) ________
    e. 'Do-it-yourself' video ________
    f. Satellite program ________
    g. Other ________

Teachers have made the following statements about PI. Please indicate whether you agree or disagree with these statements by circling the number that best represents your opinion.

***Primary Investigations*:**

	Strongly disagree				Strongly agree
11. Is a good source of activities	1	2	3	4	5
12. Gets boring after a few years	1	2	3	4	5
13. Increased my confidence to teach science	1	2	3	4	5
14. Is not as attractive as modern books	1	2	3	4	5
15. Promotes skill and concept development across the whole school	1	2	3	4	5

16. Helped me to learn science	1	2	3	4	5
17. Uses equipment that is simple and easy to get	1	2	3	4	5
18. Kids love it	1	2	3	4	5
19. It is too prescriptive	1	2	3	4	5
20. Its 5Es model is a good teaching/learning approach	1	2	3	4	5
21. Requires a lot of time for collecting and maintaining the resources	1	2	3	4	5
22. Does not meet the requirements of the syllabus	1	2	3	4	5
23. Has too much reading for poor readers	1	2	3	4	5
24. Provides a common language for communication about science	1	2	3	4	5
25. Is a good starting point for the teacher who lacks experience in science	1	2	3	4	5
26. Contains insufficient assessment strategies	1	2	3	4	5
27. Improves students' attitudes to science	1	2	3	4	5
28. Improves student achievement in science	1	2	3	4	5
29. Organises science teaching time well	1	2	3	4	5
30. Professional development was inadequate	1	2	3	4	5
31. Cooperative group work is a useful teaching strategy	1	2	3	4	5
32. Doesn't include enough technology activities	1	2	3	4	5

The following suggestions about future developments of PI have been made. Please indicate whether you agree or disagree with these statements.

33. I would like to see PI revamped and updated	1	2	3	4	5
34. The student book should be retained	1	2	3	4	5
35. Other media, eg, CD-ROM, internet should be used *as well as* the books	1	2	3	4	5
36. Tasks should be more open-ended	1	2	3	4	5
37. PI should be matched to my syllabus	1	2	3	4	5
38. Selected topics should be developed in more depth	1	2	3	4	5
39. A range of assessment ideas should be included	1	2	3	4	5
40. Teaching strategies (eg, the 5Es) should be removed from books	1	2	3	4	5
41. More professional development should be available	1	2	3	4	5
42. Include ways to help struggling students	1	2	3	4	5
43. Key concepts should be broken down and more clearly illustrated	1	2	3	4	5
44. Other media should be used *instead of* books, eg, CD-ROM, internet	1	2	3	4	5
45. Make it more relevant to the child's life	1	2	3	4	5
46. Incorporate a trend from guided investigation to open investigation.	1	2	3	4	5
47. Develop strategies to promote higher order reasoning	1	2	3	4	5
48. More technology tasks should be included	1	2	3	4	5

	Very low				very high
49. Rate the degree to which PI needs to match your syllabus in order for you to continue using it or start to use it again	1	2	3	4	5

50. If you have used PI in the past but are not using it now please explain why you ceased using the program.

Thank you for your help in completing our questionnaire

Attached page

The researchers would like to investigate some of these questions in more depth. If you would be willing to participate in an interview or focus group to discuss some of these concerns in more detail, please fax us a name and phone number **separately from the survey** and we will contact you.

Please fax to (02) 9514 5410

Name ____

Contact details

Fax ____

Phone ____

Email ____

Appendix 2
Responses to rating scale items on the primary science questionnaire

The responses of students in the national study by Goodrum, Hackling and Rennie (2001) are shown together with responses from our survey of students who use PI beside them in brackets. The same groupings as in the national report are used. Responses about computer use, excursions and teacher behaviour are not included here as they are outside the scope of the present inquiry.

Table: Learning activities

	% response National survey (PI survey)			
Item	**never**	**some**	**most**	**every**
In my science lessons:				
Q1. I copy notes from the teacher	11 (26)	47 (35)	29 (28)	13 (10)
Q2. I make up my own notes	22 (17)	56 (45)	17 (29)	5 (8)
Q3. I can talk about my ideas to others	7 (3)	37 (23)	36 (36)	20 (37)
Q4. I read a science book	40 (7)	39 (25)	10 (21)	11 (46)
Q7. We have class discussions	3 (3)	26 (15)	35 (39)	36 (42)
Q9. We do our work in groups	3 (0)	36 (16)	31 (27)	30 (57)
My science teacher:				
Q18. Asks us to investigate and find out things	7 (4)	41 (31)	31 (36)	21 (29)

Table: Practical work

	% response National survey (PI survey)			
Item	**never**	**some**	**most**	**every**
In my science lessons:				
Q5. I watch the teacher do an experiment	16 (23)	46 (38)	24 (19)	14 (19)
Q6. We do experiments the way the teacher tells us	5 (3)	20 (11)	31 (25)	44 (61)
My science teacher:				
Q17. Lets us do our own experiments	33 (32)	41 (32)	16 (17)	10 (19)

Table: Thinking about science

Item	% response National survey (PI survey)			
	never	some	most	every
In science we need to be able to:				
Q27. Think and ask questions	3 (1)	24 (17)	43 (41)	30 (40)
Q28. Remember lots of facts	6 (7)	30 (26)	34 (39)	30 (28)
Q29. Understand science ideas	3 (3)	25 (19)	42 (41)	24 (37)
Q30. Explain things to each other	7 (2)	32 (22)	37 (35)	24 (41)
Q31. Recognise science in the world around us	13 (14)	34 (28)	32 (29)	21 (28)
Q21. Science makes me think	6 (4)	29 (23)	39(36)	26(37)

Table: Enjoyment

Item	% response National survey (PI survey)			
	never	some	most	every
My science teacher:				
Q26. Makes science lessons fun	11 (3)	27 (14)	25 (52)	37 (52)
During science lessons:				
Q32. I am excited	26 (11)	45 (35)	17 (25)	12 (28)
Q33. I am curious	17 (15)	40 (33)	28 (34)	12 (17)
Q34. I am bored	35 (54)	35 (29)	14 (9.6)	16 (8)

Appendix 3
Primary school science questionnaire

We are interested in what you think about your science lessons at school.

On the following pages are some questions. We would like you to circle the answer that is right for you.

Please note that even though your parents have given their permission for you to fill in this questionnaire, you have the right to choose not to be involved. You may choose to stop at any time.

Background information

(a)	I am in year		circle which year
			5
			6
			7
(b)	I am a		circle one number
		boy	1
		girl	2

On the next page are some questions about your science lessons. There are no right or wrong answers. Please read each question carefully then say what you think by putting a circle around the number that is right for you.

Here is an example.

	Never	**Some science lessons**	**Most science lessons**	**Every science lesson**
In my science lessons we do experiments	1	2	3	4

If you do experiments sometimes, but not in most lessons, you would circle number 2.

How often do these things *happen* in your science lessons?

In my science lessons	Never	Some science lessons	Most science lessons	Every science lesson
1. I copy notes from the teacher	1	2	3	4
2. I make up my own science notes with friends or by myself	1	2	3	4
3. I can talk to others about my ideas	1	2	3	4
4. I read a science book	1	2	3	4
5. I watch the teacher do an experiment	1	2	3	4

In my science lessons

6. we do experiments the way the teacher tells us	1	2	3	4
7. we have class discussions	1	2	3	4
8. we learn about scientists and what they do	1	2	3	4
9. we do our work in groups	1	2	3	4

For science	Never	Some science lessons	Most science lessons	Every science lesson
10. we do activities outside in the playground, the beach or in the bush	1	2	3	4
11. we have excursions to the zoo, museum, science centre, or places like that	1	2	3	4
12. we have visiting speakers who talk to us about science	1	2	3	4
13. we use computers to do our science work	1	2	3	4
14. we use the internet at school	1	2	3	4

My science teacher

15. gives us tests that we mark ourselves	1	2	3	4
16. talks to me about my work in science	1	2	3	4
17. lets us do our own experiments	1	2	3	4
18. asks us to investigate and find out things	1	2	3	4

How often are these things *true* for your science lessons?

The science we learn at school	Almost never	Sometimes	Often	Nearly always
19. is easy	1	2	3	4
20. is too hard	1	2	3	4
21. makes me think	1	2	3	4

My science teacher				
22. marks our work and gives it back quickly	1	2	3	4
23. makes it clear what we have to do to get good marks	1	2	3	4
24. uses words that are easy to understand	1	2	3	4
25. listens to my ideas	1	2	3	4
26. makes science lessons fun	1	2	3	4

In science we need to be able to	Almost never	Sometimes	Often	Nearly always
27. think and ask questions	1	2	3	4
28. remember lots of facts	1	2	3	4
29. understand science ideas	1	2	3	4
30. explain things to each other	1	2	3	4
31. recognise the science in the world around us	1	2	3	4

During science lessons				
32. I am excited	1	2	3	4
33. I am curious	1	2	3	4
34. I am bored	1	2	3	4
35. I am confused	1	2	3	4

Please write answers to these questions in the spaces provided.

What do you like about science lessons?

What don’t you like about science lessons?

I think we do science at school because...

THANK YOU FOR YOUR HELP

Appendix 4
Consolidated findings to research questions

1. **Has there been a significant uptake of PI by schools?**

   There has been a significant uptake of PI by schools but the uptake across Australia has been uneven.

2. **Has PI improved teacher confidence?**

   The overwhelming evidence from secondary sources, interviews and surveys is that PI has increased primary school teachers' confidence to teach science. However, some have raised concerns that this confidence may be misplaced.

3. **Has PI improved students' attitudes to science?**

   PI has improved students' attitudes to science.

4. **Has PI improved student achievement in science?**

   The evidence suggests that PI has had a positive impact on student achievement in primary science. There has been no large-scale State or national study to assess this impact.

5. **What factors have helped PI to meet its goals?**

   - Enthusiastic and able advocates, typically PI trainers, were essential to the success of PI. Only in Queensland and Western Australia, where the uptake was much higher than in other States, did all of these advocates maintain a sustained presence.
   - The support of regional or State education systems is crucial to the success of PI.
   - Teacher networks promoted PI and provided mutual ongoing support among PI users as teachers shared ideas and enthusiasm with colleagues.

- Ongoing local support by trainers assisted the continued use of PI.
- The trial of PI not only serves to test, refine and develop the program but also promotes PI to the wider primary teaching community.
- In some States, the timing of the launch of PI was beneficial.
- A lack of competition from other resources may have made the use of PI more likely.
- Where professional development was well-resourced and well-regarded it promoted the uptake of PI and facilitated good teaching with PI. In some States other than Western Australia and Queensland the professional development was either not available to teachers or was inadequate to deal with the theoretical principles and approaches in the PI program.
- PI is more likely to be used where it closely aligns with the State syllabus. Although there is disagreement on the extent of this match, in some States (eg, New South Wales, Queensland and Victoria) there is a strong perception that PI does not match the current syllabus.
- PI was more likely to be used where teachers were accustomed to using one main text-based resource.
- PI made the teaching of science easy by
    - providing a systematic whole-school program;
    - allocating time effectively to the teaching of science;
    - providing a step-by-step program that teachers could readily follow;
    - providing a good source of science activities;
    - using simple equipment (which was easy to obtain and maintain if someone in the school was committed to doing so).
- The cooperative learning model employed by PI is very attractive to teachers and PI has powerfully influenced many teachers to use it.
- The teachers’ knowledge and use of the 5Es varied and may have been dependent on their professional development experience. The teaching of many of those using PI is probably not guided by the 5Es, other than in so far as the resources are organised according to this model.
- Primary students like PI.
- The background science information in PI assists teachers to learn some of the science that they teach.

6. What factors have inhibited PI from meeting its goals?

- There is a mismatch between PI and the syllabus in some States and this is a major obstacle to the use of PI. People disagree on the extent of the mismatch.
- Syllabuses have changed since PI was developed and some are due for review (eg, New South Wales). The problem of a mismatch between the developing syllabuses and a stagnant PI is likely to get worse.
- The high levels of promotion and professional development available as part of PI during its early years have waned.
- In general, where limited resources are available for professional development, competition for these resources exists among programs. However there is some dispute as to whether any competition exists with PI and if it does exist it is not clear whether, of itself, it has inhibited the uptake of PI.
- The timing of the launch of PI inhibited its uptake in some States. It is unlikely that any one time will be the right time to launch a program such as PI in all States.
- Textbook-based primary science is unattractive to some influential key players in primary science.
- The lack of departmental endorsement inhibits the adoption of PI. Most large departments of education seem unlikely to officially endorse PI as an approved curriculum. However, they may promote PI as a program to enhance primary science in their States.
- Support of State and national science teachers associations may have been mixed but we have little data on this. Support of the associations is desirable in promoting PI.
- Not involving some States or Territories in trials may have led to localised resentment of PI.
- Some schools may teach so little science that they have no perceived need for a program such as PI.
- PI may have been viewed and described as a Western Australian or US program. This may inhibit its use by some.
- A major factor inhibiting the use of PI by some teachers is the perception that it is too prescriptive.
- While some experienced teachers adapt and modify PI, the program is not well suited for this.
- The prescriptive nature of PI, combined with the mechanistic implementation of activities without employing a genuine 5Es or constructivist approach,

sometimes results in teaching science without working with, and developing, students' concepts and ideas.

- In its present form, PI makes teaching science so easy that some teachers may teach science 'without thinking'. PI may not be encouraging them to think deeply about teaching and learning in primary science, or to interact with students' views or responding to 'teachable moments'. This may be related to the quantity and quality of PI professional development experienced by teachers.
- Some schools may not be able to afford the initial PI program and the ongoing outlay for books.
- Some experienced PI users are starting to find it boring and are looking for something new.
- Some activities and units are considered weaker than others. However, it is not evident that these small weaknesses inhibit the use of the program as a whole.
- The role of PI in primary science may have been exaggerated during its promotion. Some may have resented this.

7. What should be PI's future development and direction?

- PI should be retained and revised. Suggested features of a new version, outlined in Appendix 5, include:
  - retaining good features of PI
  - new editions of books
  - making PI books more attractive
  - supplementing or replacing PI books with CD-ROM and online resources
  - extension activities
  - open-ended investigations
  - support for students investigating their own questions and problems
  - more science background information
  - making PI more flexible
  - extending the range of teaching strategies, including strategies to explore and work with students' views
  - providing additional professional development (including professional development to assist teachers with metacognitive and interactive pedagogy)
  - ongoing and long-term professional development

  - o suggestions to assist with the integration of PI with other learning areas (eg, literacy)
  - o ensuring a match between PI and State syllabuses (this may require different adaptations of PI)
  - o developing the technology strand in PI
  - o assessment ideas and guidelines
  - o making the relevance of science more explicit
  - o units organised around concept development.
- A process for revamping PI was proposed. Features of this process include:
  - o a forum to review this evaluation report and to clarify the role and directions of a revised PI, as part of a strategy to enhance primary science
  - o developing, trialling, promoting and supporting a revised PI
  - o listening to teachers
  - o reviewing alternative resources for new ideas.

8. What students who use PI think of their science experiences

The science experiences of PI students are likely to be more often characterised by features associated with good science teaching than is normal for students in primary science.

Appendix 5
Suggested attributes of a revised *Primary Investigations*

The following suggestions should not be considered as a prescription or recommendations for a revised PI but regarded as suggestions for consideration in its development. They are outlined here to stimulate further discussion.

A revised PI should be as accessible to reluctant primary science teachers as the original version, but it should also be challenging and engaging for experienced science teachers.

It should be flexible and adapted to different State and Territory requirements and the needs of different teachers.

To achieve this, PI could be made available in three forms:

- New editions of attractive books or unit-sized booklets with supplementary materials on CD-ROM and online resources, that can be regularly updated
- A CD-ROM version of PI with all PI activities, ideas, background information on the CD, including both the contents of the books as well as extensions, alternative activities and teaching strategies and ideas to be used by teachers to build their own program
- A version of PI, adapted from the various PI resources above, tailored for each state and territory supporting PI. This would be available on CD-ROM and internet.

Features of the new PI program should include:

- Cooperative learning.
- 5Es to be used as an organiser of sets of activities, sequences and suggested teacher interventions.
- Extension activities.
- Extensive development of a technology strand in PI.
- Open-ended investigations.
- Support for students investigating their own questions and problems.

- Background information.
- Assessment ideas and guidelines.
- Making the relevance of science more explicit.
- Units to be organised for sequential knowledge and science process development, organised around overlapping concepts and processes as identified in State and Territory syllabuses rather than in national profile statements.
- Best features to be identified from other national or international resources.
- Professional development, including:
    - extending the range of teaching strategies, including strategies to explore and work with students' views;
    - providing additional professional development (including professional development to assist teachers with interactive pedagogy);
    - ongoing and long-term professional development;
    - suggestions assisting integration of PI with other learning areas (eg, literacy);
    - development of local advocates to promote PI;
    - whole school participation;
    - a focus on good features of teaching and learning exemplified in PI;
    - formal and informal dissemination of ideas among novice and advanced teachers of primary science, about teaching and learning in primary science and PI in particular. This could include funding to seed the formation of or extension of existing networks; presentations on primary science and PI at conferences; promoting these conferences and network meetings to primary school teachers; and funding teachers to participate.