

**Science and Mathematics Education Centre**

**The Effect of the Kids' Science State Professional Development  
Program on the Promotion of Scientific Literacy**

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**This thesis is presented for the Degree of  
Doctor of Philosophy  
of  
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## DECLARATION

To the best of my knowledge and belief this thesis contains no materials previously published by any other person except where due acknowledgement has been made. This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

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## **ABSTRACT**

This thesis reports a longitudinal study of the impact of the Kids' Science State professional development program in primary schools to address the issues involved in promoting and sustaining a scientifically literate society. The Kids' Science State initiative in Western Australia is a partnership between Scitech Discovery Centre in Perth and Rio Tinto through the Rio Tinto Western Australia Future Fund. The Kids' Science State initiative is based on the premise that scientific literacy is essential to the economic sustainability of Western Australia, with science education the medium for economic development. One of the services that the Kids' Science State offers is a professional development program in science.

The research reported in this thesis investigated the contribution of the Kids' Science State professional development program to improving primary school teachers' confidence, pedagogical skills and knowledge, allowing them to plan and deliver effective science programs that enabled the development of the skills of scientific literacy in primary school students.

A mixed-method approach was used in this research. Firstly, Personal Meaning Mapping (an interview-based technique) was employed to investigate the understanding of the term "scientific literacy" among primary school teachers, high school teachers and the general public. This section of the research provided a framework about people's perceptions of scientific literacy with which to compare the views of a smaller sample of primary school teachers in three case study schools that were the main focus of the research.

Secondly, research in the three case study schools, Fenchurch, Winchester and Knightsbridge Primary Schools, provided information about the longer-term impact of the professional development workshops on teachers. Data were collected by observation of the professional development workshops, interviews with Principals and teachers in the case study schools, surveys of teachers, and intensive observation of the classes of a total of five teachers, with a focus on their understanding of scientific literacy, pedagogical skills, knowledge and confidence in teaching science. Additional information from surveys and interviews with the students in the case study classes were also used to inform the research.

Personal Meaning Mapping interviews were used in this research to explore people's understanding of scientific literacy and to compare these understanding to the definition of scientific literacy used in the study. This research found that only certain aspects of scientific literacy were understood and that the concept of scientific literacy must be clearly understood by teachers for it to be successfully incorporated into a working curriculum. Professional development programs need to assist teachers to incorporate scientific literacy into their regular teaching program by providing opportunities to practice all aspects of scientific literacy. Further, professional development programs should endeavour to increase teachers' confidence and expose teachers to science content knowledge, especially as it pertains to the local curriculum structure, by providing activities that increase teachers' pedagogical skills in science.

Professional development presenters must work with individual schools to gain an understanding of the long term aspirations of the school staff to assist them to continue their professional learning. This should be done prior to the professional development program to ensure the suitability of the program for the participants and time for reflection. Finally, the findings indicate that time must be dedicated to teacher collaboration if professional development programs are to be effectively and efficiently sustained at the school level. In this context, it is clear that science education must be accorded sufficient importance by the relevant educational policy makers to ensure that science is actually taught in primary schools, and that quality professional development can be accessed frequently by primary teachers.

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# **CHAPTER 1**

## **INTRODUCTION AND OVERVIEW**

### **Introduction**

The Kids' Science State (KSS) initiative in Western Australia is a partnership between Scitech Discovery Centre in Perth and Rio Tinto through the Rio Tinto Western Australia Future Fund, with some in-kind support from the State Government and other education institutions. The KSS initiative is based on the premise that "science literacy is essential to the economic sustainability of Western Australia, with science education the catalyst for economic development" (Kids' Science State, 2002, p. 3). The KSS initiative is a 5-year project aiming to "raise the profile of science and technology, increase student participation, enhance the skills and conceptual understanding of teachers, develop teacher confidence, provide educational resources, and encourage informed debate" (Kids' Science State, 2002, p. 4).

The KSS program had four key result areas for the public:

1. To increase confidence through building conceptual understanding and skills in science.
2. To increase available resources by providing science educational materials, expertise, equipment and training.
3. To increase access for those challenged geographically and/or financially.
4. To increase the relevance of science by linking science to careers and everyday life.

The KSS plan was grounded in the findings of *The Status and Quality of Teaching and Learning Science in Australian Schools* (Goodrum, Hackling, & Rennie, 2001), a report prepared for the Australian Government's Department of Education, Training and Youth Affairs. The outcomes of this report recognised the need for a higher level of scientific awareness in the community and that teachers are the key to change in school science education. Consequently, the KSS identified three stakeholder groups, namely teachers, children and parents, and community. Parallel outcomes were formulated for each of the stakeholder groups in each of the four key result areas.

The KSS initiative included several activities and services in order to develop its five key result areas; Professional development for teachers, an expanded Science Roadshow program that toured the State, the KSS Do-It-Yourself Science Kits, new exhibits addressing Mathematics and Astronomy, and an Innovation and Careers arena (Kids' Science State, 2002, p. 3). The KSS had potential to make a significant contribution to science teaching and learning and therefore it was important that it be evaluated. An Australian Research Council (ARC) funded project between Scitech, Curtin University of Technology and the Rio Tinto Western Australian Future Fund was established to carry out a range of research activities related to the KSS initiative and its outcomes.

The research reported in this thesis was part of the ARC project. It focussed particularly on the professional development program for teachers at the primary school level. Specifically, the study aimed to determine the characteristics of professional development that are most effective in assisting primary teachers' confidence, skills and willingness to teach science. Additionally, this study examined primary teachers' understanding of the concept of scientific literacy in order to identify professional development strategies that may assist in promoting scientific literacy.

### **Background and Rationale of the Study**

The significance of this research is premised on the understanding that a scientifically literate society is imperative for Australia's future. People in our society should have an understanding of decisions they make when they are at the doctor, voting, making purchases, listening to the news and reading information. For a scientifically literate society to develop there needs to be a greater understanding of what it means to be scientifically literate, and how scientific literacy can be promoted.

Three significant aims of the KSS initiative relating to the professional development program are to enhance the skills and understanding of teachers, to develop teacher confidence, and to promote scientific literacy. The KSS professional development sessions are usually offered to teachers at their school or at Scitech, based on a fee-for-service principle. Teachers can choose from a dozen workshops covering three main areas: planning and teaching technologies for science, working



scientifically, and developing conceptual understandings in science. The KSS's four outcomes for teacher are to increase the

1. confidence of teachers of science by improving their skills and conceptual understandings of science in the context of the Curriculum Framework<sup>1</sup>.
2. quantity and quality of science education materials, equipment and training available for teachers of science.
3. access to science education materials, equipment and training by teachers disadvantaged financially and/or geographically.
4. relevance of science and technology to careers and everyday life.

Teacher professional development is pivotal to the aims of the KSS program as “teachers are the key to change” (Kids' Science State, 2002, p. 4) and “it is through this means that genuine educational input will permeate the classroom” (Kids' Science State, 2002, p. 6). To gain a perspective of why the KSS professional development was necessary an examination of the trends in the Western Australian Science curriculum since the advent of the Curriculum Framework is pertinent.

### **Background to the Science Curriculum and Scientific Literacy**

In many countries, including Australia, changes to senior high school science curricula in the 1960s and 1970s resulted in a concept-driven science curriculum that was suitable for about 20% of students in schools; those students who were most likely to pursue a career in science (Fensham, 1992). For the majority of students this meant a science curriculum that was irrelevant and detached from their understanding of the science they would encounter throughout their lives (Fensham, 1997; Goodrum, Hackling, & Rennie, 2001).

The effects of this science curriculum were not particular to the final years of schooling. The focus on a final external examination that enabled entry to tertiary studies increased the emphasis on content. This filtered down through the school system resulting in a science curriculum that catered for only a small percentage of the school population while disenchanting the majority of students (Fensham, 1997). Furthermore, the de-emphasis of the personal and social aspects of science in favour of the process and content resulted in widespread dissatisfaction with the science

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<sup>1</sup> The Curriculum Framework refers to the Western Australian curriculum document that is used as a guide by schools to develop and implement their teaching and learning programs.

curriculum (Fensham, 1988). Both the United States and the United Kingdom experienced a similar trend in dissatisfaction toward science (Fensham, 2007). Much of what is espoused in the curriculum of the United States and the United Kingdom is reflected in the curriculum of Australia. Thus at the end of the 1970s there was a wide range of science curricula, many of which were viewed as unsatisfactory for school students (Goodrum, Hackling, & Rennie, 2001).

During the 1980s, research into the dissatisfaction issues of the 1960s and 1970s resulted in the development of novel ideas and materials for school science to be inclusive of all students. A number of projects and research studies in many countries were developed that identified how science in schools would appeal to a larger audience. In New Zealand, *Learning in Science* explored students' conceptions about science, with the research focus moving from teachers and teaching to learners and learning. *The Secondary Science Curriculum Review*, in England and Wales, encouraged curriculum developers and teachers to identify how science could be presented to be more relevant to students and how science learning could be a deeper and more active process for students. Subsequently, in the Netherlands, the United States, Germany, Canada and Australia, projects that involved concepts in context were being developed to connect traditional science concepts with students' interest in the science in their everyday lives. This approach to science curriculum was strongly supported by research on how students learn and are attracted to science with a move away from the recipe-type laboratory experiments to the active participation learning of students. The focus of these projects was dominated by high school science as this area had been most affected by the content driven science of the 1960s (Fensham, 1997).

Research into the primary school science curriculum has shown that the more traditional methods of teaching primary science, focusing on the content and the processes of science, have failed to result in students acquiring scientific ideas about how to interpret the world around them. Students' conceptual understanding of science content and processes has been recognized as a fundamental aspect of the learning process (Skamp, 2004). The development of students' conceptual understanding of science can be enhanced when there is time to reflect on what is being learnt in the context in which the learning is being facilitated. In content-heavy curricula there is limited time for reflection and contextualization of the

science content, thus restricting students' understanding of science concepts (Goodrum, Hackling, & Rennie, 2001).

Additionally, it has been well documented in the literature that primary teachers believe they lack the confidence to teach science (Appleton, 2003). Several factors may contribute to this situation. Primary teachers must teach across all learning areas, so their time to develop understandings in science is limited (Parker, 2004). Many primary teachers have had no formal science lessons since junior high school (Appleton, 2003; Parker, 2004). A limited and perhaps negative exposure to science inhibits primary teachers' science content knowledge and pedagogical content knowledge (Hamm, 1992). These teachers may have well developed pedagogical skills, but they may flounder when teaching science or certain aspects of science if they move outside their area of content expertise (Jones & Moreland, 2005).

In the United States the unsuitability of the contemporary science curriculum resulted in over 300 reports describing the crisis in science education. One of these reports, *Project 2061: Science for All Americans* (American Association for the Advancement of Science, 1989), promulgated a vision for science that espoused scientific literacy as the basis on which the science curriculum should be built. The authors described a scientifically literate person as one who:

Is aware that science, technology and mathematics are inter-dependent human enterprises with strengths and limitations; understands key concepts and principles of science; is familiar with the natural world and recognises both its diversity and unity; and uses scientific knowledge and scientific ways of thinking for individual and social purposes. (p. 12)

There have been many views of scientific literacy expressed in numerous reports around the world (Bybee & DeBoer, 1994). In the Australian context, Goodrum et al. (2001) defined scientific literacy as

The capacity for persons to be interested in and understand the world around them, to engage in the discourses of and about science, to be sceptical and questioning of claims made by others about scientific matters, to be able to identify questions [, investigate] and draw evidence-based conclusions, and to make

informed decisions about the environment and their own health and well being. (p. 15)

The promotion of scientific literacy within the science curriculum can assist the movement from a traditional focus on student acquisition of scientific concepts and terminology to conceptual understanding of science that emphasizes the cognitive abilities, reasoning processes, commitment to a science worldview, and science communication skills (Prain & Hand, 2006). Scientific literacy can be promoted if primary school students begin to appreciate scientific ideas that help individuals to understand the science in the world around them.

### **Background to the Western Australian Science Curriculum Framework**

In Australia, a national curriculum was developed and released in June 1993 but not accepted for political reasons. However, each state used it as the basis for developing a new curriculum during the 1990s.

The Western Australian Curriculum Framework was completed in 1998 and introduced into Western Australian schools in 1999. The document was founded on the premise that learning is continuous and the essential purpose of education is to improve the learning and achievement of all students. The Curriculum Framework describes learning in terms of outcomes which aim to ensure that all students in Western Australia have the knowledge, understanding, skills and values necessary to participate in the community now and in the future. It was developed to be the guide, and therefore not a prescriptive document, for the curriculum in Western Australian schools. It was envisioned that implementation of the Curriculum Framework would mean that teachers and schools would design and develop learning and teaching programs to suit the needs of their students. Moreover, staff were to ensure that these programs included learning opportunities and enriching experiences for their students aimed at achieving the outcomes set out in the Curriculum Framework.

The Curriculum Framework divided the curriculum into eight learning areas: the Arts, English, Health and Physical Education, Languages other than English, Mathematics, Science, Society and Environment, and Technology and Enterprise (Curriculum Council, 1998).

The outcomes of the Science learning area were organized in two parts:

- Understanding Concepts Outcomes encompassed distinctive scientific understandings, theories, ideas and knowledge. Four outcomes drew from the traditional scientific disciplines of Natural and Processed Materials (chemistry), Energy and Change (physics), Earth and Beyond (geology and astronomy) and Life and Living (biology).
- Working Scientifically Outcomes addressed the skills of scientific inquiry and the ways people use scientific information. These outcomes were organised into five strands; Investigating Scientifically, Communicating Scientifically, Science in Daily Life, Acting Responsibly, and Science in Society.

In addition to the Curriculum Framework, eight separate documents named the Student Outcomes Statements (Education Department of Western Australia, 1998) were developed to reflect specific outcomes in each learning area. In these documents ideas were given of how the specific outcomes for a subject could be achieved. Once again, these ideas were not meant to be prescriptive but used as a guide for teachers when programming, implementing and assessing.

Implementation of the Curriculum Framework was far less successful than the ideals of the document. The documents were presented to teachers with few opportunities to understand and ask questions about the new framework which resulted in teachers having limited understanding of the way science could be taught to promote scientific literacy. To address this issue the Western Australian Department of Education and Training, in 2003, reviewed the Student Outcome Statements in all learning areas. As a consequence of this review, Progress Maps for each of the learning areas were developed. A working version of the Progress Maps was produced in 2003, with the hard copy version published in 2005. In 2005 the Curriculum, Assessment and Reporting Policy (2008) mandated the use of the Progress Maps now called the Curriculum Guides for the Outcomes and Standards Framework. Schools are required to use the framework to monitor and evaluate students' progress and achievement. With three documents in each of the learning areas teachers needed assistance to interpret and apply the current curriculum. These frequent changes to the document title together with at times limiting document availability to an online source have left many teachers confused about which document is the true working document.

Primary school teachers were facing not only mandated curriculum changes in science but in the seven other learning areas. Programs for professional development were organized by the Department of Education and Training in all eight learning areas, however, the main foci were those that addressed the aspects of literacy and numeracy. The KSS recognized that further professional development programs in science could assist primary school teachers to teach science in a manner that was commensurate with the outcomes of the current Curriculum Framework in Western Australia. Therefore, the KSS program expanded its offerings to meet the increasing professional development needs of teachers in Western Australian schools.

### **Purpose and Research Questions**

The purpose of this research was to investigate the effect of the KSS professional development program on the promotion of scientific literacy in primary school science through investigating the impact of the KSS professional development program on primary school teachers' attitudes, perceptions and understandings about science. The following four research questions addressed the purpose of this research.

1. What do primary school teachers understand by the term “scientific literacy”?
2. What are the factors determining the effectiveness of the KSS professional development program in;
  - a. developing primary science teachers' understanding of scientific literacy?
  - b. promoting the confidence of primary teachers when teaching science?
  - c. developing teachers' pedagogical skills to enable them to teach science?
  - d. developing teachers' knowledge and understanding of science to enable them to teach science?
3. In what ways do teachers' levels of confidence, pedagogical skills and science knowledge influence how they teach science to students to encourage the development of scientific literacy in schools?
4. In what ways can schools promote the longevity of the outcomes of the KSS professional development program?

### **Outline of the Research Design**

The research design for this two-part study involved four groups of participants. The first group was a purposeful volunteer sample of primary school

teachers, high school science teachers and the general public. This sample was used in the first part of the study to develop an understanding of what was typically understood by the term scientific literacy. Data were collected from the participants using Personal Meaning Mapping (Falk, Moussouri, & Coulson, 1998) interviews, which was the first time that this method had been used to elicit information about scientific literacy. Results from this group produced a baseline understanding of what scientific literacy meant to a variety of people. This information was then used to compare with the views of the primary school teachers in the three case study schools which formed the second part of the study.

Part two of the research involved three groups of participants from three primary schools in Western Australia. Each primary school was used as a case study to explore the outcomes of the KSS professional development programs in different school situations. The multi-site case study involved the use of several methods of data collection, which were used to triangulate the data so that a more complete picture of the situation was established.

Data collected included interviews with the KSS professional development program presenters, the principals, classroom teachers, and students; teacher and student questionnaires; observations of the professional development program and observations of classrooms during science lessons. The data from the schools related to teachers' perceptions of the KSS program in which they had been involved. The teachers were asked about their perceptions of the professional development program and how it impacted on their science teaching. In particular, the case studies examined how their confidence, knowledge and pedagogical skills in science had been affected by their participation in the professional development.

The data from three schools were analysed individually and the findings compared in a cross-case analysis. Various sections of the data from the school case study sites were able to be used to answer relevant parts of the four research questions. However, as this study investigated the impact of the KSS professional development program in only three metropolitan primary schools in Western Australia, the results may not be representative of a larger cohort of primary school teachers in other schools and the way in which they teach science.

## **Significance of the Study**

It has been well established in the literature that primary teachers' restricted understanding of scientific literacy, lack of confidence, and their limited content knowledge and pedagogical skills in science have restricted good quality science being taught in primary schools. The aim of this research is to contribute to understanding of, and consequently improvements in, these issues in five ways.

Firstly, research has shown that scientific literacy is not well understood by primary school teachers (Goodrum et al., 2001). However, it is not clear what primary teachers do understand by the term scientific literacy. This research represents a significant attempt to clarify primary teachers' understanding of scientific literacy so that efforts to increase their understanding can be more effectively focussed.

Secondly, the research makes a methodological contribution by exploring teachers' understanding of scientific literacy through the use of Personal Meaning Mapping interviews, an innovative qualitative technique that has not previously been used in this way.

Thirdly, the research explores how a professional development program may have an impact on teachers' knowledge, confidence and pedagogical skills in science that, in turn, may impact on the teachers' understanding of scientific literacy. This is achieved through teacher interviews and by observing primary teachers during the professional development program and teachers and their students in the classrooms.

Fourthly, this longitudinal study documents the changes in teaching following the professional development program. The research examines the longevity of the professional development to determine if any effects of the professional development program remain part of the teachers' regular science teaching repertoire. This research identifies aspects of the professional development program that will support and encourage teachers to sustain and progress in their science teaching in order to continually improve their students' learning.

Finally, the outcomes of this research form the basis for recommendations that can be used to guide professional development programs that will improve teachers' understanding of scientific literacy, increase primary teachers' confidence, knowledge and pedagogical skills that will improve the quality of science education for their students.



## **Location of the Researcher within this Research**

I am a secondary school science teacher who has worked in metropolitan and rural Western Australian schools for 17 years. I have taught general lower school science, upper school Chemistry, Physics, Human Biology and Senior Science during my career. I have had an interest in primary science education from an early stage in my career, having taught science in both the primary as well as the secondary areas in a rural school. Whilst at a secondary school, I also worked collaboratively with primary school staff and students from several feeder schools to develop effective transition programs between primary and secondary schools that enabled a smooth transition of students from Year 7 to Year 8. Although my interests in the transition program were more broad-based than science (I was also concerned with how students adapted to a new and larger school), the science that students purported to have experienced in primary school on their arrival to high school was a special area of note.

I was also keen to discover what the KSS professional development program was doing to support primary school teachers' efforts in relation to science education. A large project evaluating the KSS programs had been established and an opportunity for an Australian Postgraduate Award (Industry) (APA(I)) became available. The APA(I) enabled me to take leave from teaching for three years to develop a study in an area of interest to me – the impact of the professional development program offered by the KSS. In particular, I explored the way the KSS professional development program addressed scientific literacy, teacher confidence, teacher knowledge and teacher pedagogical skills.

A few years after the introduction of the Curriculum Framework in 1998, I had noticed that many science teachers were struggling with the Curriculum Framework in their area of speciality. Teachers noted that they did not understand what was expected of them and that they had issues with knowing how to assess students' learning in an outcomes-based framework. Consequently, many teachers did not engage fully with the implementation of the outcomes articulated in the Curriculum Framework. However for primary school teachers, assessment based on outcomes occurred much more quickly as implementation was mandated in the primary schools several years before the secondary schools. Informal conversations with primary teachers led me to understand the implementation of the Curriculum

Framework science curriculum was compounded in the primary school because they were working on understanding eight Curriculum Framework Learning Area documents, not just the ones for science.

As a teacher myself, I was aware of the influence of school culture and understood that it would be necessary to spend considerable time in the primary schools to understand their unique contexts. The common ground of teaching and learning provided a link with the teacher and student participants in this study. The extended time in the primary school allowed me to have my presence accepted by the staff at the school, allowing me to talk informally with many teachers to enhance my understanding of the context of the school. I collected a range of data from three different primary schools, enabling me to observe and interact with a variety of teachers to understand commonalities and differences.

From this point onward, I have chosen to call myself “the researcher” in this study in order to develop an outsider perspective, as I endeavoured to be an observer-participant rather than a participant in the research.

### **Overview of Thesis**

In Chapter 2, the development and the current views of scientific literacy in the science education literature will be reviewed, with particular reference to the Western Australian school context. Professional development in teacher education will be examined to identify a series of factors that can be attributed to successful professional development programs. The literature review, in the context of the aims of the KSS initiative, forms the basis for the development of the research questions.

In Chapter 3, the research design is explained and linked to the research questions. The selection of and information about the participants are described. Additionally, the description, use and analysis of instruments used to collect data are presented.

In Chapter 4, the Personal Meaning Mapping Interview instrument is described, data from the participants are analysed, findings presented and assertions are drawn. Chapters 5, 6 and 7 are devoted to the three case study schools, Fenchurch, Winchester and Knightsbridge, respectively. The research in each school is described and the findings presented.

In the final chapter, Chapter 8, the research questions are reviewed in the light of the synthesised findings for the Personal Meaning Map Interviews and the

three case study schools. The outcomes of the study and its conclusions are used to draw implications for professional development programs, for teachers and for further research.

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **Introduction**

This chapter presents a discussion of the concept of scientific literacy leading to a broad definition that has been developed in Australia. The definition of scientific literacy used in this research is then mapped against the Western Australian Curriculum Framework. Issues about scientific literacy in Australian schools, in particular Western Australia, are then reviewed. It is clear that some assistance in understanding and teaching for scientific literacy is required. The factors that could contribute positively to an effective professional development program are then derived from the literature to present a basis for determining the effectiveness of a current program for professional development.

#### **Scientific Literacy**

##### **The Development of Scientific Literacy in Education**

Paul de Hart Hurd was one of the first science educators to publish a discussion of the phrase “scientific literacy”, but the idea of this concept dates back to the beginning of the 20<sup>th</sup> century (Laugksch, 2000). According to Shamos (1995), scientific literacy was first introduced by Karl Pearson as a set of desirable thinking habits. In the 1920s, the educator, John Dewey, described these scientific habits of the mind as what should be the key to science education in schools (O'Neill & Ploman, 2004; Shamos, 1995). Dewey believed that the need for people to become scientifically aware was born out of the social concern regarding issues in science and technology that affected the public (Shamos, 1995). Unfortunately, only innovative educators became advocates for Dewey’s vision of accomplishing all students to think rationally about a variety of science concepts and, as attention dwindled towards the end of the decade, science became separated into specialised disciplines and education centred on other more significant developments. Then, in the early 1930s, the Progressive Education Association in the United States of America (USA) set up a committee that spent six years debating what should be included as the basic aspects of the science curriculum. They proposed that science should relate to personal living, immediate personal-social relationships, social-civic relationships, and economic relationships.

For the next 20 years innovation in science education lay dormant as the results of the depression and the events of World War II consumed the time and energy of the education systems in many countries (Fensham, 1997). Immediately after World War II, public attitudes toward science showed a great deal of respect and expectation of what was to come now the world was at peace. This was shortly followed by a period of disappointment and hostility about issues relating to hydrogen and atomic fuels, which finally gave way to a generally vague public viewpoint; everyday citizens found that they were not informed about scientific ventures and as a result lost interest (Shamos, 1995). Scientists had retreated from public scrutiny, not wanting to be criticised or to explain their experiments, decisions and choices concerning such issues as nuclear fuels and post war consequences. Soon scientists venturing out into the public domain were frowned upon by their colleagues (Miller, 2000). Furthermore, in countries relying on cultural traditions, like Japan and China, the community perceived modern science to be one of the chief threats to their culture and held negative opinions of science, scientists and science knowledge (Cobern, Gibson, & Underwood, 1995). Each of these factors contributed to stifling scientific communication between scientists and the general public, creating a 20 year stagnation in thinking about scientific literacy and, consequently, in the development of science education.

In 1949 Paul DeHart Hurd wrote a dissertation which analysed science education in the first half of the century and found it wanting regarding the outcomes for students (Eisner, Shavelson, & Atkin, 2004). Described by Oliver and Nichols (2001) as possibly “the most notable science educator of the 20<sup>th</sup> century” (p. 425), Hurd determined that teachers across all of the decades of the first half of the 20<sup>th</sup> century had been more concerned with their content objectives than with any other aspect of science teaching. He believed that science should have social relevance for all school students; he wanted science to be hands-on and minds-on and not the mere impartment of knowledge from master to novice (Hurd, 2000a; Oliver & Nichols, 2001). Hurd’s interest in science curriculum extended beyond the relevance of science to promoting the relationship between science, technology and society (Hurd, 2000b; Oliver & Nichols, 2001).

It was not until the late 1950s that the concept of scientific literacy as a goal of science education re-emerged under its current name (Jenkins, 1997; Shamos,

1995). Science education, driven by post war industrialisation, the USA's embarrassment that Russia successfully launched a satellite before the USA did, and increasing interest from academic scientists, was seen as a way to attract more students into the science field. In the early 60s the National Science Foundation in the USA and the Nuffield Foundation in the United Kingdom funded a number of projects to reform the curriculum of school science (Fensham, 2005; Kelly & Staver, 2005). In Australia, projects based on the USA's curriculum were developed providing materials for chemistry, physics and biology (Fensham, 1997). However, this focus in science education was mainly about recruiting more scientists and not about engaging all students in science. For this reason, the movement had lost impetus by the late 1970s, when it was realised that this approach to science had been geared for a specific science community and not for the general public (Jenkins, 1997; Shamos, 1995).

As interest in science and science education increased, many countries noted the inadequate state of school science and proceeded to devise solutions to rectify these problems. Thus what may have started as an attempt to produce more trained scientists showed promise to flourish into a means to provide students and the public in general with a broader understanding of science (Hurd, 1998; Shamos, 1995). In the early 80s, in an effort to improve the general public's scientific literacy, some scientists formulated lists of concepts, ideas, and phenomena that were deemed to be vital components of scientific literacy or things the public should know (Rennie & Stocklmayer, 2003). This attempt to improve scientific literacy involved the use of a one-way, top-down "deficit model" of the public's understanding, where the aim was to determine the science deficit of the public (i.e. what science its members did not know) and then to fill the knowledge vacuum of the "scientifically illiterate" general public with the facts and methods that were seen by science academia as vital components of the public understanding of science (Culliton, 1989; Miller, 2000). Understandably, the scientists themselves, being from different subject backgrounds, could not agree on the items that were suitable for general science knowledge of the public and as a result, the deficit model did not deliver what was expected (Fensham, 1992). Not only did scientific literacy have a unique meaning for scientists from different disciplines, it had different meanings for science educators, educators and the general public, because the term can mean different things to different people

(Laugksch, 2000; Symington & Tytler, 2004; Tytler, Smith, Grover, & Brown, 1999). Attention in schools then turned to making progress in understanding of the meaning of scientific literacy (Laugksch & Spargo, 1996; Miller, 2000).

However, developing a definition for scientific literacy could not be accomplished in isolation because it needed to be contextualised to reflect how people interact with science on a daily basis in their society. Thus, movements such as Project 2061: Science for All Americans (AAAS, 2004) in the USA (Fensham, 1997), the Public Understanding of Science (Thomas, 1997) in the UK, and variants of these programs in other countries, officially espoused scientific literacy as the purpose for school science. Although the development of definitions of scientific literacy was commonplace, there was still considerable debate and a generally accepted definition of scientific literacy remained elusive (Fensham, 1997; Solomon, 1997).

### **Current Views of Scientific Literacy**

As scientific literacy became recognised as a key purpose of science education for all students (Bybee, 1995; Laugksch, 2000; Millar & Osborne, 1998; The Association for Science Education, 2006), it became increasingly necessary to develop an agreed definition. The agreement of several countries to participate in the measurement of outcomes in formal schooling in the Organisation of Economic Cooperation and Development's (OECD) Program for International Student Assessment (PISA) and to provide a means to monitor students understandings using real-life contexts (Harlen, 2001) has resulted in a shared vision for science education. This vision represents and recognises the ability to think through real life problems as an essential aim of modern education. The OECD PISA report (2000) defined scientific literacy as:

The capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity.  
(p. 76)

A more recent OECD PISA report (2006) referred to scientific literacy as an individual's:

- Scientific knowledge and use of that knowledge to identify questions, acquire new knowledge, explain

scientific phenomena and draw evidence-based conclusions about science-related issues.

- Understanding of the characteristic features of science as a form of human knowledge and enquiry.
- Awareness of how science and technology shape our material, intellectual, and cultural environments.
- Willingness to engage in science-related issues and with the ideas of science, as reflective citizen. (p. 23)

In Australia, the authors of a government commissioned research report, *The Status and Quality of Teaching and Learning Science in Australian Schools* (Goodrum et al., 2001), argued that scientific literacy is seen as important for all Australian citizens. They developed a definition of scientific literacy that was consistent with the definition then used by PISA. The definition used in this research is the one used by Rennie, Goodrum & Hackling (2001). In their paper, reporting the results of a national study into science teaching and learning in Australian schools, they suggest a quality science education is one that promotes the development of scientific literacy by assisting citizens to be

interested in and understand the world around them, engage in the discourses of and about science, are sceptical and questioning of claims made by others about scientific matters, identify questions, investigate and draw evidence-based conclusions, make informed decisions about the environment and their own health and well being. (p. 466)

Goodrum et al. (2001) drew attention to widespread concern about the lack of science awareness, particularly in the community. The authors concluded that science educators, teachers and researchers believe that scientific literacy is the main purpose of science education in Australian schools but that its meaning is not well understood. Furthermore, data for their report indicated that the science curriculum implemented in schools is not likely to promote scientific literacy. This lack of understanding may be attributed to several factors. Firstly, the amount of information that teachers are expected to understand and remember, in addition to their teaching role, has greatly increased over the past twenty years. Secondly, new initiatives complete with new jargon and acronyms are constantly being imposed on schools and their staff in a



passive, non-reflective manner (Kahle, 1999; Tytler, Smith, Grover, & Brown, 1999). Thirdly, individuals draw upon science in a wide range of contexts, but the school curriculum cannot include details of the science content relevant to all of these contexts (Ryder, 2001) and thus knowledge must become subservient to the general issue of scientific literacy (Symington & Tytler, 2004). What is important for teachers is that they are able to make science accessible, relevant and meaningful for their students (Horowitz, 1996; Howitt, 2007; Lee, Hart, Cuevas, & Enders, 2004). Science that relates to and benefits aspects of students' daily lives may be an appropriate starting point if students are to make connections between science in school and science in the wider community (Haefner & Zembal-Saul, 2004; Rennie, 2005, 2006; Treagust, Jacobowitz, Gallagher, & Parker, 2001).

Developing a broad based knowledge and understanding about science and its relationships with society and individuals can lead to the development of scientific literacy. The idea is that when people develop a positive relationship with science, they become more scientifically literate (Martin-Dunlop & Fraser, 2005; Rennie & Williams, 2002). Habits of mind should form the basis for scientific literacy, because when science is second nature people will be able to identify it and utilise it (Reveles, Cordova, & Kelly, 2004). Both students and teachers must perceive science as a way of thinking, finding, organising and using information (Goodrum, Hackling, & Rennie, 2001; Rennie, Goodrum, & Hackling, 2001; Symington & Tytler, 2004). In particular teachers need to have the knowledge, skills and confidence to be able to prepare science lessons that will encourage students to understand science in ways that assist them to become life-long learners who can use science confidently. To do this, teachers must be familiar with the content of scientific literacy and how it can be developed.

Rennie (2005) has teased out the components of scientific literacy in a paper aimed at helping teachers to understand its meaning (see Figure 2.1). She argued that thinking differently about science involves not only learning new things, but becoming more aware of and interested in science. Once people are comfortable with, and can talk about and read about science, then they can begin to use it to answer questions, challenge information presented to them and make informed decisions about matters important to them.

This definition might not be familiar to most teachers; however, they will be familiar with the requirements of their science curriculum. If, as the Goodrum et al. (2001) report suggested, current science curricula do not promote scientific literacy then there is a need for scientific literacy to be clearly identified as a stated goal for students and teachers (Cobern, Gibson, & Underwood, 1995), and this must be both implicit and explicit in the school curriculum.

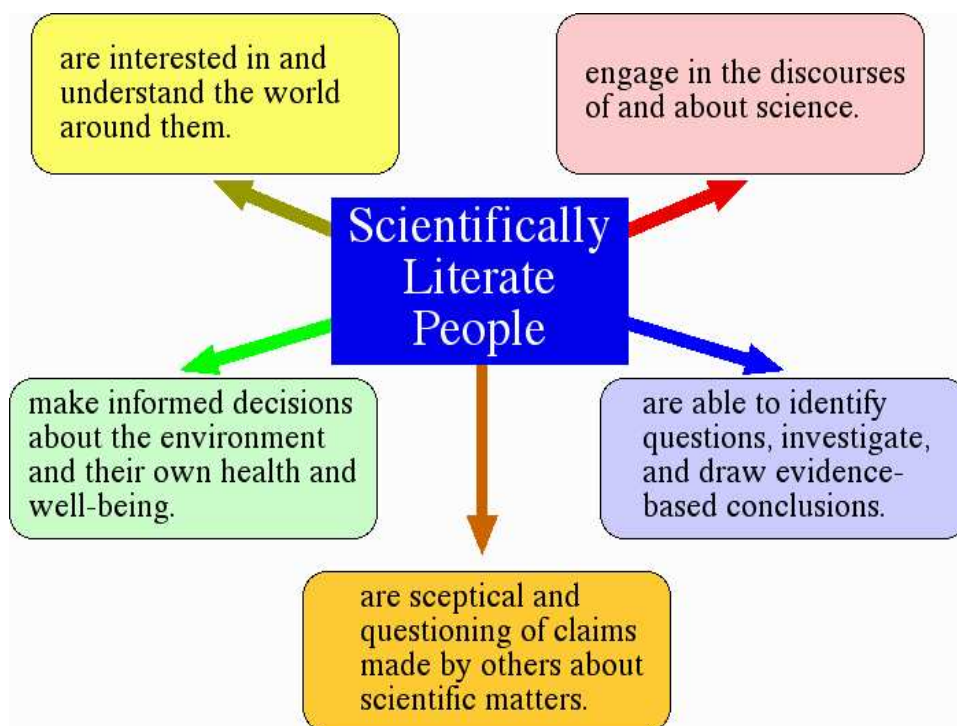


Figure 2.1. A definition of scientific literacy (from Rennie, 2005)

Clear links must be made between the components of the science curriculum and the components of scientific literacy. In Western Australia, the concept of Working Scientifically in the Science Learning Area of the Curriculum Framework is closely related to scientific literacy. The five outcome areas of Working Scientifically are described as science in daily life, communicating scientifically, science in society, investigating, and acting responsibly. These areas are defined in Table 2.1. The components of scientific literacy shown in Figure 2.1 can be mapped against the five outcomes that compose the Working Scientifically outcome, as shown in Table 2.2, columns 1 and 2. Additionally, in column 3, are suggested examples of what it means to be scientifically literate. These examples can provide

teachers with a guide to the kinds of skills that need to be developed in their students to achieve each aspect of scientific literacy.

Table 2.1 Definition of Working Scientifically from the Western Australian Curriculum Framework (Curriculum Council, 2005)

Working Scientifically	Western Australian Curriculum Framework Outcomes
Science in daily life	Applying and integrating science within our lives.
Communicating scientifically	Present and communicate science information, scientific language, access and organize information
Science in society	The nature and people of science, the impact of science.
Investigating	Planning, conducting, processing, evaluating
Acting responsibly	Impacts and ethics of science, decision-making processes

The information in Tables 2.1.and 2.2 demonstrates that the achievement of scientific literacy is not only a possible but an intended outcome of the WA science curriculum. Yet, as Goodrum et al. (2001) and other researchers (Fensham, 1997; Harlen, 2001; Jenkins, 1997) found, scientific literacy is not well understood and frequently not an outcome of the science curriculum. The implication is that teachers and their schools need assistance in both understanding what scientific literacy is, how their Curriculum Framework supports it as an outcome, and what skills their students need to develop to become scientifically literate. Such assistance might be provided by a professional development (PD) program that not only recognises the concept but develops a way that it can be presented in an effective manner. A PD program that promotes scientific literacy must allude specifically to the term “scientific literacy” in some way so that links between the term and effective science teaching are able to be made by both the PD presenter and the PD participants. If the term scientific literacy is incorporated into the regular repertoire of the PD, this will help teachers to become familiar and comfortable with the notion of scientific literacy being the focus of science education in schools. There should be a variety of ways that demonstrate the link between scientific literacy, everyday life and the curriculum. Further, development of the definition of scientific literacy needs to be

broken down for teachers and students if it is to be a part of the science education program.

Table 2.2 Mapping Scientific Literacy Against the Outcomes of Working Scientifically (Rennie, Mayne, Evans, & Sheffield, 2006)

Working Scientifically	Scientific Literate Persons	Underlying skills and abilities
Science in daily life	are interested in, and understand the world around them	Apply science knowledge and skills in daily life. Seek information to explain new phenomena or solve problems
Communicating scientifically	engage in the discourses of and about science	Feel comfortable to listen to, and to read, write and talk about science in everyday life
Science in society	are sceptical and questioning of claims made by others about scientific matters	Distinguish between fact and opinion. Assess quality of evidence
Investigating	are able to identify questions, investigate and draw evidence-based conclusions	Think through issues and identify, obtain and use needed information. Understand the meaning of “fair test”. Define an argument
Acting responsibly	make informed decisions about the environment and their own health and well-being	Recognise and cope with risk and uncertainty in decision making. Choose to act responsibly and ethically

### Professional Development in Teacher Education

In the following section, the nature of professional development is explored with a focus on the characteristics of effective professional development programs as established in research programs in Australia and internationally.

#### Defining Professional Development

There are many ways to define professional development (Bell & Gilbert, 1996; Guskey & Huberman, 1995; Hewson, 2007). Generally, PD involves a program to provide opportunities for individuals to grow both professionally and personally. Middlewood, Parker and Beere, as cited in Fraser, Kennedy, Reid and Mckinney (2007), defined professional development as “an ongoing process of reflection and review that articulates with development planning that meets corporate, departmental and individual needs” (p.156). Of late, the phrase “professional learning” has been used synonymously with a broader definition of

professional development. Loucks-Horsley (1998) referred to this broader definition of professional development as a “bridge”, that is, a vital link between where a person is and where they want to be (p. 1). Furthermore, Fishman, Marx, Best, and Tal (2003) believed that professional development “should fundamentally be about teacher learning: changes in the knowledge, beliefs, and attitudes of teachers that lead to the acquisition of new skills, new concepts, and new processes related to the work of teaching” (p. 645). These broader definitions of professional development focus on the individual as a learner, their personal growth and their pursuit of life-long learning (Fraser et al., 2007). In this research the term professional learning (PL) will be used when describing teacher outcomes, and the term professional development (PD) will be used when describing the programs that are implemented.

### **Types of Professional Development**

There are many forms of PD which may be offered to teachers. In her article, *Models of continuing professional development: a framework for analysis*, Kennedy (2005) outlined nine models that are often used by PD presenters.

1. Training - generally delivered to the teacher by the expert with the agenda determined by the deliverer; the participant is in a transmissive role.
2. Award-bearing - one that relied on or emphasised the completion of university or other award-bearing programs.
3. Deficit - one that has been designed to serve a perceived deficit in teacher performance.
4. Cascade - individual teachers attend training events and then disseminate the information to colleagues.
5. Standards-based programs - focus on standards formed by an external organisation, such as an educational jurisdiction and an externally formed accountability model.
6. Coaching/mentoring - a relationship between two teachers in order to assist the teacher with less experience. Coaching is more skills based and mentoring involves professional friendship and counselling. Professional learning needs to take place within the school context.
7. Community of practice - generally involves more than two people and depends on collaboration.

8. Action research - the study of a social situation involving the participants as researchers with a view to improving the quality of action.
9. Transformative - the professional development program recognises the range of different conditions required for transformative practice; it usually involves effective integration of a range of models.

These nine models, as listed, progress from a transmission approach through a transitional to a transformative approach in the way they engage participants. According to Kennedy (2005), professional autonomy is better developed with more transformative models.

Loucks-Horsley, Love, Stiles, Mundry and Hewson (2003) categorised these models of PD from the perspective of the PD presenters in terms of the types of strategies the participants would engage in during the program. Loucks-Horsley et al. group these strategies into six categories.

1. Aligning and implementing curriculum, e.g. curriculum alignment and instructional materials selection; curriculum implementation and curriculum replacement units.
2. Collaborative structures, e.g. partnerships with scientists and mathematicians in business, industry and universities, professional networks, study groups.
3. Examining teaching and learning, e.g. action research; case discussions; lesson study; examining student work and reflecting, and scoring assessments.
4. Immersion experiences, e.g. immersion in inquiry in science and problem solving in mathematics; immersion into the world of scientists and mathematicians.
5. Practicing teaching, e.g. coaching, demonstrating lessons, mentoring.
6. Vehicles and mechanisms, e.g. developing professional developers; technology for professional development; workshops, institutes, courses and seminars.

The choice of category and strategy will be dependent upon who the participants are and what information they are interested in to enhance their PL. Strategies can be used individually or bundled together, depending on the requirements of the participants. PD presenters need to identify which type, category and strategies will suit the teachers to ensure that the PD program is effective.

## **Models of Professional Development Programs**

There are two ways of modelling PD programs, firstly, from the teacher-participant perspective and secondly, from the facilitator perspective. Each of these perspectives is reviewed in the following section.

### ***The Teacher-Participant Perspective***

Through their work with science teachers during a PD program in New Zealand, Bell and Gilbert (1996) developed a model for achieving teacher PL that included the personal, social and professional development of the individual teacher. Bell and Gilbert's observations of and interactions with science teachers involved in their research found that teachers' personal development and social development are interrelated issues that impact on their PL. Bell and Gilbert developed nine categories based on teachers' beliefs and actions during their research. Figure 2.2 outlines their model of teacher development.

Dall'Alba and Sandberg (2006) described stage model PD as programs that endeavour to assist participants with skill acquisition from novice to expert by ensuring that the competencies required by each level are achieved before moving on to the next level of mastery. They argued that "a fundamental dimension of professional skill development – namely, understanding of, and in, practice - is overlooked in stage models" (p. 388).

Bell and Gilbert (1996) did not advocate a stage model for PD, so that one phase must be achieved before the next is developed. Rather, they recognised that "the nature of the learning that any individual achieves is influenced by their perceptions of the circumstances of their life" (p. 33). Their model describes nine main aspects which are a flexible sequence for each teacher with respect to time, where teacher learning activity may not indicate a movement forward but may indicate clarification of the nature of their teaching. They describe the processes as a facilitated progression in personal, social and professional development to aid PD presenters and teachers themselves to monitor change. Bell and Gilbert grouped the nine aspects into three categories for teacher development; personal, social and professional. Each of the aspects shows a progression; initial (1), second (2) and final (3) that was identified from the participants in their research. However, individual participant movement can occur in any direction. The following is a

description of the nine aspects; these aspects are also illustrated diagrammatically in Figure 2.2.

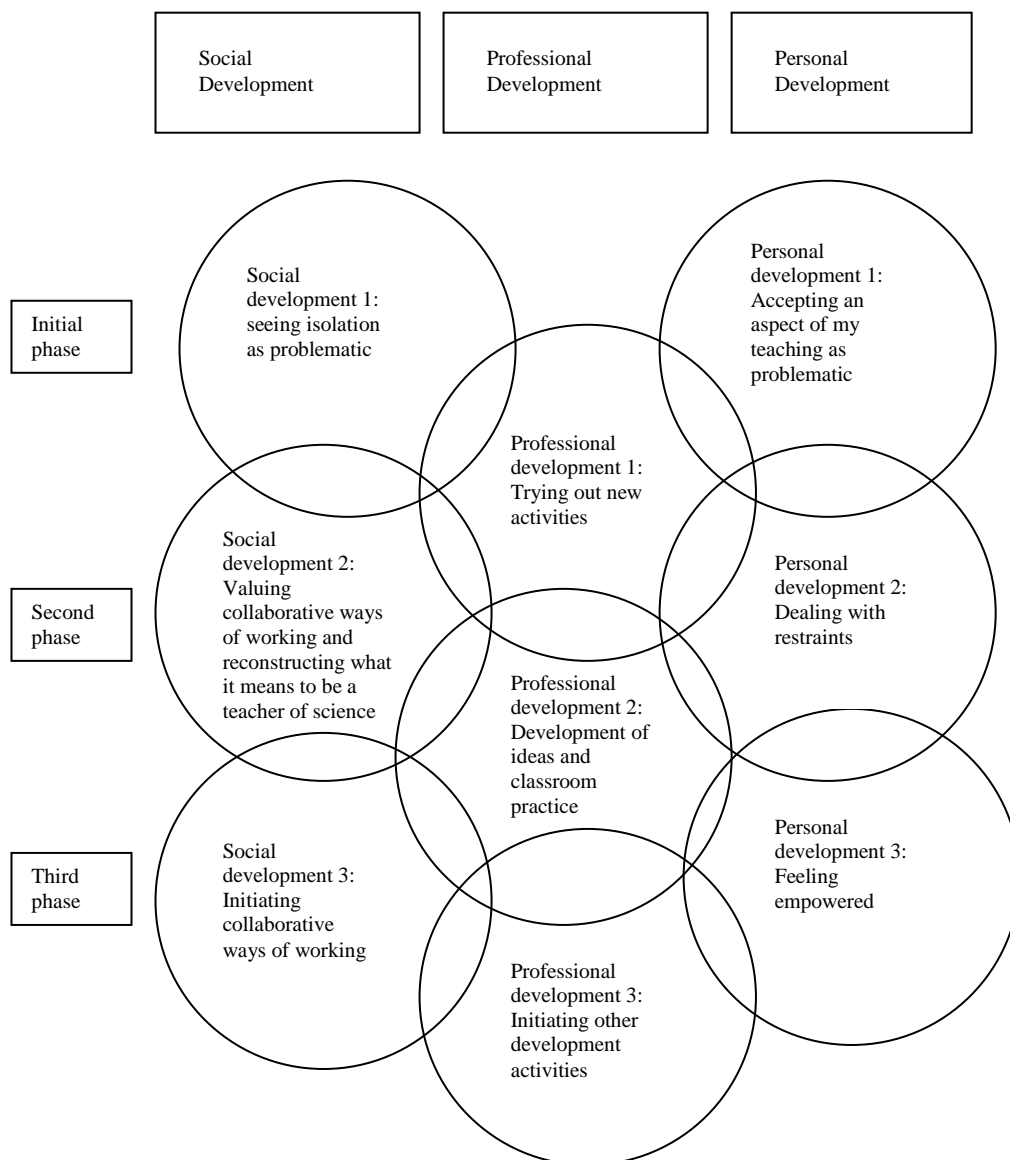


Figure 2.2. A model of teacher development (Bell & Gilbert, 1996, p. 16)

- Personal development 1: Accepting an aspect of teaching as problematic. Teachers note some dissatisfaction with an aspect of their teaching and make a decision to do something about it, like join a group or program.



- Social development 1: Seeing isolation as problematic. Teachers perceive a need for new ideas, support and feedback from others. Teachers believe the benefits of participating in a program outweigh the risks.
- Professional development 1: Trying out new activities. Teachers participate in the context of their own classroom, giving rise to teachers' ideas and professionalism being valued.
- Personal development 2: Dealing with restraints. Teachers are able to overcome the restraints inherent in teaching, such as the fear of losing control in the classroom, changing the amount of teacher intervention in their lessons, being able to cover the curriculum, their knowledge of the subject, meeting the assessment requirements, reevaluating their relationships with students and performance appraisal.
- Social development 2: Valuing collaborative ways of working and reconstructing what it means to be a teacher. The trust, support and credibility of the collaborator and peers are established and collegial relationships are developed.
- Professional development 2: Development of ideas and classroom practice. This is reflection-in-action, where there is reflection on classroom actions and reflection on classroom actions in relation to theoretical ideas.
- Personal development 3: Feeling empowered. Teachers become responsible for their own learning in the classroom and in collaborative work.
- Social development 3: Initiating collaborative ways of learning. Teachers seek out collaborative groups on their own volition.
- Professional development 3: Initiating other learning activities. Teachers move from the existing program by transferring their skills into other programs in the same or other areas.

Bell and Gilbert (1996) advocated that a participant's initial personal development requires the individual to enquire about the reasons a PD program is undertaken by accepting that an aspect of their own teaching requires assistance. In their study, the participants were mostly volunteers who had accepted an aspect of their teaching as problematic and were willing to explore other ways of teaching. The Bell and Gilbert (1996) study was not based on a whole-school PD program, but on the formation of a new group interested in improving their science teaching in an

educational jurisdiction. Although the impetus for whole-school PD program may be attributed to the dissatisfaction of a number of staff with a particular issue, this dissatisfaction may not be representative of all the staff at the school site.

Furthermore, the momentum behind the PD program selection may have arisen as a response to an educational jurisdiction or school initiative.

Bell and Gilberts' model was developed through observations of, and interviews with, teachers undergoing a voluntary PD, so therefore comes from the perspective of the willing participant rather than the perspective of the PD presenter or facilitator. In the current study, the perspective of the PD presenter is an important focus as this research aims to uncover factors about the PD implementation that effectively contributes to teachers' PL in schools.

For the PD presenter, it is imperative to know and understand why the PD program has been requested and who requested it. This information will enable the PD presenter to make a choice of model(s) that will be most suited to that particular situation (Kennedy, 2005).

### ***The Presenter Perspective***

The PD presenter may be a staff member at the school in which the PD will be delivered, a staff member of a local educational jurisdiction, a staff member of a state educational system or a member of a private organization. Loucks-Horsley et al. (2003) approached professional development from a PD presenter's point of view, which identified ways that the PD could be delivered most effectively to suit the requirements of the teachers. Loucks-Horsley and her team worked with PD presenters and teacher participants in many situations during the 1990s. This research culminated in the development of their model for PD in 1998, which describes PD from the presenter's perspective. Feedback from PD presenters, teachers and academics on this model allowed Loucks-Horsley and her team to refine this model or design framework into an effective implementation process, in 2003, as shown in Figure 2.3.

The planning process for any PD program needs several inputs; the knowledge and beliefs of the presenter(s) and the participants, the content, the context, the critical issues, the physical site and the strategies that will be used for the PD (Hewson, 2007). Loucks-Horsley et al. (2003) used an elaboration of these inputs as the design for the implementation process of their model, which may follow

the logical sequence of events as outlined in Figure 2.3 (commencing at Commit to Vision and Standards) or it may be necessary for some initial form of action to occur at some other stage of the cycle to foster the meaningful development of a PD program initiative.

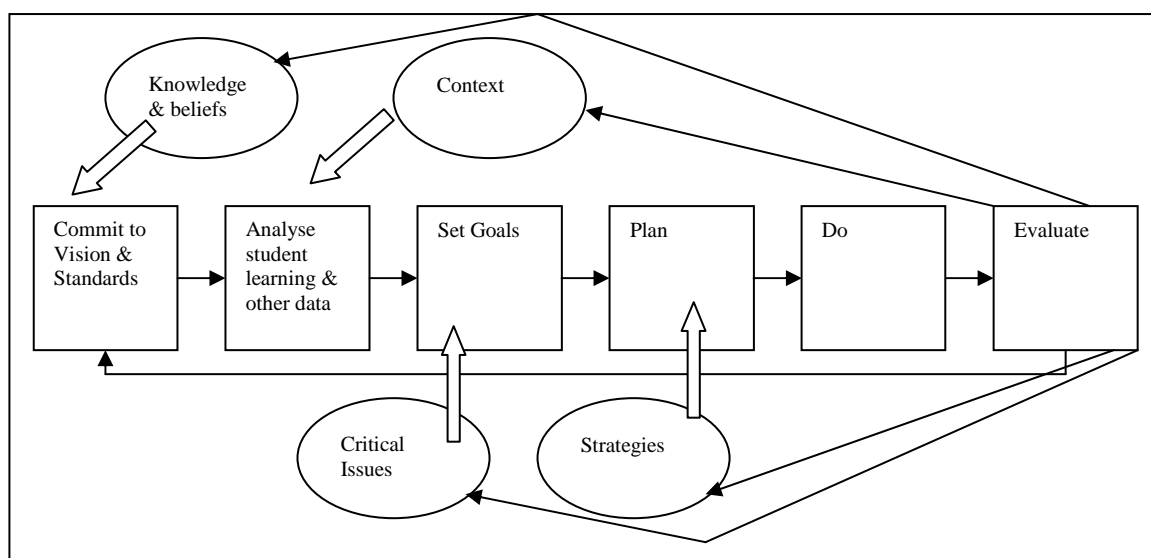


Figure 2.3. Design framework for professional development in science and mathematics. (Loucks-Horsley, et al., 2003, p. 2)

The Bell and Gilbert and the Loucks-Horsley et al. models form the basis of the following discussion about designing an effective PD program. The discussion will follow a chronological order of what should happen in effective and successful PD programs to promote teacher PL. From the discussion, various assertions of the key characteristics of what should be included in a PD program will be developed.

### Designing Professional Development

To design effective PD the presenter must take into account a number of factors relating to the school content as well as the nature and experiences of the participants. Ten factors are discussed in the following sections, drawing on both the Bell and Gilbert (1996) and the Loucks-Horsley et al. (2003) model, as well as other pertinent literature. Each section concludes with a statement synthesising the key factors that can lead to effective PD.

### ***Teachers' Attitudes and Beliefs***

PD presenters must understand the learners and learning, the teachers and teaching, the change process and the nature of the content area to be delivered (Loucks-Horsley et al., 2003). Firstly the PD presenter needs to have an understanding of why the school has afforded time and money for the PD program. Secondly, the PD presenter should determine “where teachers are” by finding out their perceptions and understanding. This can give the PD presenter an insight into what will restrict risk-taking actions and allude to some scaffolding that may assist teachers with their journey.

Thirdly, an effective PD program should be designed to take into consideration the knowledge and beliefs of the participants. The PD presenter will need to consider participants' past experiences, what content/concepts would be most beneficial for them, and if or why the participants wish to embark on this learning journey. If the PD presenter can assist teachers to understand the purpose of the PD, then it will greatly assist constructive feedback. Sparks (as cited in Loucks-Horsley et al., 2003) insightfully noted, “It’s been said that someone who has a ‘why’ can endure any ‘how’; few things are more important to motivation than purpose that is regarded as profoundly and morally compelling” (p. 15).

When dealing with a whole-school PD program that may not be welcomed unanimously by staff, PD presenters should plan proactively by anticipating constraining issues, confronting these issues and finding possible solutions that will assist the teachers in furthering their PL. Each participant will have their own agenda of what information they would like to know to enhance their PL learning. It is the PD presenter’s responsibility to obtain this information from all the participants to determine what type of program will best serve the participants to enhance their PL. Teachers’ knowledge and beliefs should not only be accounted for in the planning stages of the PD program, they should be delineated as they will be an important input at each phase of the implementation process (Loucks-Horsley et al., 2003). Furthermore, Abell and Roth (1994) have suggested that reform in science education will only be effective in the classroom if practitioners support and understand the innovations.

*In summary, then, the first key factor for effective PD is that the presenter should identify the attitudes, needs and beliefs of the teachers.*

### ***The School Context***

The context of the school plays an important part in how the PD is encountered, accepted and developed. The culture of the school will have an impact on the teachers and hence an impact on the professional learning of the staff (Abell & Roth, 1994; Tytler, 2007). Loucks-Horsley et al. (2003) identified a number of factors that may contribute to the school context: the students, the teachers, the curriculum, the learning environment, available resources, the history of organization, the organizational structure and leadership, and the national, state and local policies.

A PD program will only be effective if the presenter has an understanding of the school context. Kennedy (2005) identified the context through which the program is delivered and will subsequently be embedded as fundamental for successful implementation. PD presenters need to obtain information from the participants and the principal on the content and ways that the program should be delivered that would be most beneficial and appropriate.

*The second key factor for effective PD is that the presenter should identify the school context and develop the PD program according to the teachers' needs.*

### ***Teachers Valuing Professional Development***

For teachers to be able to identify areas of their teaching as problematic, they first need time to examine what may need assistance. If PD is a whole-school venture which is not voluntary for teachers, they need to know 'why' the PD program has been selected. The goals set by the school or educational jurisdiction need to be transparent to all teachers. In many schools a representative committee may have chosen a particular PD program in response to a staff, school administration or system need or initiative. If the whole staff have not been involved in the decision making process, it should be made clear why the PD was selected. Both the PD presenter and the teacher participants need to know the goals for students' learning, teachers' learning, teaching practice, and for the school (Loucks-Horsley et al., 2003).

Teachers need to know why and how the material in the PD program will assist them so that equity is assured for the whole school community. For teachers to change their current practice they must see a means to an end; teachers will not engage in what they perceive as risk taking behaviour if they cannot see the benefits

for themselves or their students. If the material presented in the PD program can be used with their classes in the near future, it gives even more meaning to the task. These activities should be an authentic reflection of the reality of current classroom practice; if teachers can see the relevance for themselves and their students then they will be more likely to incorporate the knowledge from the PD program into their regular classroom practice (Rodrigues, 2005a).

For PD presenters to engage teachers and encourage them to change their current practice, they must make their program activities workable, engaging and relevant to teachers. For PD to be effective, meaningful and successful, several factors related to the participant teachers need to be considered. Progressive PL outcomes occur when teachers undergo accommodative change. Teachers undergo accommodative change when they are intrinsically motivated to learn; become aware of their implicit ideas and practices and critically examine them; construct alternative knowledge, beliefs and practices; and resolve the conflicts between the prior set of ideas and practices and the new (Hashweh, 2003).

Effective PD programs should provide both human support and material resources, as these resources aid successful implementation (Rennie, Goodrum, & Hackling, 2001). If written and equipment resources are easily available from the PD presenter, on the internet or CD-ROM, within the school or locally, it will allow teachers easy access to the materials they need, thus encouraging them to make a start on an activity (Appleton & Kindt, 1999).

*The third key factor for effective PD is that the PD presenter should aim to include activities, strategies and provide resources that are of use to teachers.*

Primary teachers are the focus of this research and as such an understanding of their confidence, pedagogical skills and knowledge in science will be addressed in the following sections.

### ***Teacher Confidence and Skills***

Bandura's (1977) theory of social learning suggests that people develop a generalised expectancy concerning action outcome contingencies based on prior life experiences. In addition, people also develop specific beliefs concerning their own ability to cope. *Self efficacy* is the belief in one's own ability to perform a behaviour (Enochs & Riggs, 1990).

Primary teachers' personal beliefs about science and science teaching may affect whether or not they teach science and if they do, affect the way in which they teach it (Appleton & Kindt, 1999; Parker, 2004). Shallcross and Spink (2002) suggested that teachers see their own confidence as a measure of their competence. If teachers feel anxious about science they will not feel competent to teach it. Furthermore, Appleton (2003) found that if teachers lack the confidence to teach science they tend to use strategies that limit the scope of the science lessons resulting in didactic content-based learning experiences for students. PD presenters should be aware of potential "road blocks" that will limit primary teachers' desire to teach science and encourage ways to teach science effectively.

The development of science PD programs for primary school teachers should consider their attitudes to and confidence with science. It has been well documented, over a long period, that primary teachers consider their confidence to teach science limited (Appleton, 2003, 2006; Birse, 1996; Department of Education and Training, 1989; Ginns & Watters, 1996; Harlen & Holroyd, 1995). Lack of teacher confidence has been attributed to the following factors: lack of strong background in science content, inadequate facilities and equipment, a crowded curriculum, poor instructional leadership, and low priority ranking of science within the school curriculum (Appleton & Kindt, 1999; Peers, Diezmann, & Watters, 2003). As most primary teachers must teach across all of the learning areas, their time to develop understandings in science is limited (Appleton, 2006).

Many primary teachers have not participated in formal science lessons since high school; for some this may have been two years prior to their high school graduation (Appleton & Kindt, 1999). Their science experiences in high school may have been negative, confusing or limited to one science discipline, such as biology (Appleton, 2003; Parker, 2004; Shallcross & Spink, 2002). Teachers need to feel confident to teach science and have the skills to begin planning and implementing their own programs (Appleton & Kindt, 1999; Shallcross & Spink, 2002), and to be able to engage themselves and their students in meaningful science activities that reflect the curriculum guidelines, the needs of the students and address the themes of the classroom or school (Davis, 2003; Kelly & Staver, 2005; Shulman, 1986). Furthermore, teachers should have the ability to evaluate their programs in a constructivist manner to produce highly refined learning experiences for their students

(Parker, 2004; Shallcross & Spink, 2002). Consequently, PD presenters need to assess and address teachers' confidence and skills when preparing their program in order for PL to occur (Gregson, 2004). A PD program that gives teachers opportunities for active learning so that they are able to engage in hands-on activities, provides learning situations through inquiry and investigation, and allows teacher question time will be more effective at increasing teacher confidence and skills than a didactic approach (Garet, Porter, Desimone, Birman, & Kwang, 2001; Rodrigues, 2005a, 2005b). Bell and Gilbert (1996) suggested, in their aspect of initial professional development, that this should be developed by valuing what teachers have brought to the PD program and by encouraging teachers to build on their own expertise.

*In summary, the fourth key factor for effective PD is that the program should aim to increase teachers' confidence, and the fifth key factor is that a PD program should aim to increase teachers' pedagogical skills.*

### **Teachers' Knowledge**

Limited subject knowledge is sometimes blamed for primary teachers' low confidence levels leading to restricted classroom practices. Although these teachers may have well developed pedagogical knowledge (PK), they may find it difficult to teach science if they are unfamiliar with the content (Harlen, 1999; Harlen & Holroyd, 1995; Moreland & Jones, 2005). Appleton (2006) argued that content knowledge alone will not improve teachers' confidence. Pedagogical content knowledge (PCK) must also be improved for a teacher to perform effectively. Primary school teachers' limited, and perhaps negative, exposure to science may have inhibited both their science content knowledge (CK) and their science PCK (Hamm, 1992; Shulman, 1986). Appleton (2006) described PCK as the dynamic knowledge a teacher uses to construct and implement a science learning experience or a series of learning experiences. Teachers' understanding of the nature of the discipline, their personal CK, strongly influences their personal PCK. A teacher's PCK can determine what they highlight as important for particular students, in particular contexts. Sound CK appears to have a positive effect on teacher PCK, i.e. their planning, assessment, implementation of curriculum and curriculum development (Mulholland & Wallace, 2005).

Primary school teachers need to have a store of several unique, subject-specific CK and PCK (Appleton, 2006; Davis, 2003). In Western Australian



primary schools, science is often taught by the classroom teacher, who also conducts lessons in at least five other curriculum areas. By their own admission, many primary school teachers believe their knowledge and understanding of science is lacking. Most PD programs would have an implicit aim the endeavour to improve student learning, therefore these programs should start with the improvement of teachers' CK and PCK (Redman, 2005). Appleton (2003) found that teachers PCK can be observed through the demonstration of teachers' pedagogical skills.

*In summary, the sixth key factor for effective PD is that the program should aim to value teachers' past experiences and knowledge, and the seventh key factor is that a PD program should aim to increase teachers' content knowledge.*

### **Teacher Reflection and Collaboration**

PD initiatives must enable teachers to be reflective in the context of their own classroom. Teacher reflection should be an integral part of their PL, so that they have time to think about what they have done, examine what went right in the classroom and what they need to question or change. Without this time for reflection teachers will often continue with new methods that may need some fine tuning or, perhaps worse, consider that those new methods were problematic and resort to a method that may not be as effective but with which they are more comfortable (Loucks-Horsley, 1998; Tytler, Smith, Grover, & Brown, 1999). Bell and Gilbert's (1996) second professional development phase focused on the development of ideas and classroom practice. They referred to this as reflection-in-action, where there is a reflection on classroom action and a reflection on classroom actions in relation to theoretical ideas. Bell and Gilbert's (1996) second and third aspects of social development, which encourage valuing collaborative learning, emphasised that teachers should not only engage in self-reflection but should be encouraged to form groups for collaborative reflection. L'Anson, Rodrigues and Wilson (as cited in Rodrigues, 2005a) examined reflection at the personal and the collegiate levels, and considered three levels of reflection.

1. Pre-critical - where the reflection is largely technical and the teacher engages in practical trial and error of the strategies.
2. Internalised - where the strategy is put through a mentally rehearsed operation and outcome by the teacher.

3. Hypothetical - where the collegiate group through discursive actions assists in the construction and deconstruction of strategies.

Working in collegiate groups can enhance teachers' understanding of new content, new strategies and themselves (Rodrigues, 2005b). The PD presenter needs to be aware of any pre-existing collegiate groups within the school context so that collaboration can be effectively promoted.

Bell and Gilbert's model revealed that PL in schools is not an individual endeavour; there are times when social development with colleagues plays a significant role in teacher PL. Teaching is fundamentally a social activity through collaborative engagements in schools, departments or districts. Teachers' knowledge, beliefs and attitudes are formed interactively with all the people, events and changes that they are faced with at any given time. Teachers are communicators who thrive on the social aspects of situations. Teacher development is critically dependent on social interaction which can build learning communities so it is necessary to encourage and support teachers to collaborate (Horowitz, 1996; Kahle, 1999). Rodriguez (2005a) found that show and tell sessions of PD and the collegiality offered by school colleagues, experts and the wider school community not only supported the teachers in a risk-taking task, but encouraged them to take further risks with their practice in the future.

Successful PD should include activities that are extended across teacher learning communities in order to identify the processes and mechanisms that contribute to the development of these teachers' learning communities (Kahle, 1999; Yager, 2005) in order to develop and build a professional culture. To do this a common goal and shared vision must be sought by the PD presenter and all the participants. If teachers are involved in a collaborative learning environment where their peers and a support network are an integral part of the formula, teachers will feel empowered (Haefner & Zembal-Saul, 2004; Tytler, Smith, Grover, & Brown, 1999).

An effective strategy for teachers to engage in collaborative endeavours is Participative Inquiry, which involves planned and structured opportunities for teachers to reflect on their teaching in collegial groups situated in practice. By focusing on the changes to those practices, teachers develop solutions to problems and develop their own PL. Engagement in the development and implementation of

activities followed by critical reflection, by sharing ideas with colleagues, may help to challenge teachers to reconceptualise what they are teaching and view it from a different perspective resulting in the development of a new program that reflects the common goals of the school (Moulds, 2002; Rodrigues, 2005b). In their research, Roehrig, Kruse and Kern (2007) found that collegiate support was most effective when coordinated by a leader or administrator.

*In summary, the eighth key factor for effective PD is that the program should encourage and allow opportunities for reflection and collaboration.*

### **Longevity of Professional Learning**

Locks-Horsley et al. (2003) believed it is necessary to build into the PD a capacity for sustainability and to scale up the initiative in the future. Their work suggested that ongoing, sustained and intensive PD is more likely to have an impact than shorter PD. Activities that extend over time are more likely to allow teachers to try out new practices in the classroom; to have opportunities for in-depth discussions; and to obtain feedback on their teaching, student conceptions, misconceptions and pedagogical strategies. Furthermore, locating opportunities for PD within a teacher's regular work day and at the school site would alleviate the stress and strain on teachers' workloads (Bransford, Brown, & Cocking, 1999; Duggan & Gott, 2002).

Peers et al. (2003) found that "the time required to understand an innovation and to reflect and make changes to teaching practice" (p. 104) was the most significant issue in their study when introducing a curriculum innovation in a primary school. This indicates that longitudinal programs are needed. Unfortunately, this is not often viable as money and time are restricted in schools, universities and other interested organisations (Appleton, 2003). As funding is an issue in most schools, if materials can be obtained easily and cheaply in addition to ideas for the use of these material it would increase the success of implementation (Rodrigues, 2005a).

Roehrig et al. (2007), in their examination of a reform-based high school chemistry curriculum, found that teacher attitudes towards and implementation of curriculum were impacted by school site issues. They identified three aspects that influenced implementation: school-based leadership, school scheduling and concurrent district reform initiatives.

In terms of school-based leadership, Roehrig et al. (2007) found that if there were a “vacuum of leadership” (p. 904) teachers were left to make individual decisions resulting in limited implementation of the new curriculum. Hence, the lack of school-based leadership hindered the development of effective school based learning communities. For example, a change in the curriculum and its implementation may warrant a review of school scheduling to support the change. These scheduling changes may affect time spent on teaching the subject, or time set aside for teacher collaboration. If these scheduling changes are not made, the program will not progress as effectively as well as a program which is supported in the whole-school context. Multiple reform agendas compete for teachers’ time and with the goals of the new curriculum agenda. All reform agendas, at the school site, must be identified and teachers given time to implement programs and strategies that will assist in the reforms.

It is necessary for a PD presenter to work within the parameters of the imposed constraints. The PD presenter can facilitate the initial development of appropriate content, strategies, reflective practice and collaboration, but making the PD sustainable is a more complex matter that needs to be addressed by the school staff. Management teams need to devise strategies to facilitate effective working relationships in schools. Once the PD has been given momentum, it would be much easier for the management team to sustain that momentum by ensuring that the initiative is not forgotten and a meaningful future program for further teacher PL is devised with a contextual timeline and fitting strategies. PD that promotes continued PL should empower people to make informed decisions after the PD program has ceased (Redman, 2005).

*In summary, the ninth key factor for effective PD is that programs should aim to promote sustainability, progression, ownership and empowerment, and the tenth key factor is that a PD program should aim to assist schools in the development of leadership teams.*

The effectiveness of the PD program to develop teachers’ PL depends on allowing them enough time to implement strategies, engage in collaborative feedback and critically reflect on their practice both individually and collaboratively. This will result in more meaningful information about the success of the program and its longevity.

To summarise, and using the key factors of an effective PD program, it seems that PD presenters should

1. Identify the attitudes, needs and beliefs of the teachers to whom they will be providing the program.
2. Identify the school context and develop the PD program according to the needs of the teachers.

Further, the key factors of the PD program are that it should

3. Aim to include activities, strategies and provide resources that are of use to teachers.
4. Aim to increase teachers' confidence.
5. Aim to increase teachers' pedagogical skills.
6. Aim to value teachers' past experiences and knowledge.
7. Aim to increase teachers' knowledge.
8. Encourage and allow opportunities for reflection and collaboration.
9. Promote sustainability, progression, ownership and empowerment.
10. Aim to assist schools in the development of leadership teams.

### **Summary of Chapter**

The idea of scientific literacy in education has had a long history in its development. Scientific literacy today is seen as an important aspect for all citizens. The development of scientifically literate citizens must start in the school years with exposure to experiences that will promote scientific literacy for students. To do this, teachers must be able to effectively model these experiences to students.

Current research suggests that not only is scientific literacy not well understood by teachers, but, the science curriculum being delivered in schools is not providing opportunities for students to develop their scientific literacy skills. Although the current Western Australian school science curriculum is inclusive of the aspects of scientific literacy it seems there is a need for improvement. This improvement must begin with improving teachers understanding of the aspects of scientific literacy and providing them with opportunities that will allow them to promote scientific literacy to their students. To do this it is necessary to explore what teachers understand by the term scientific literacy.

Teachers need opportunities to engage and reflect on the aspects of scientific literacy if they are to be understood and used in appropriate contexts. For this to be

achieved some form of guidance must be employed to assist the teachers on their learning journey. In the primary school a PD program that addresses this issue must also address the reasons why primary school teachers may have not embraced all the aspects of scientific literacy. A successful PD program should aim to identify the prior knowledge, attitudes, needs and beliefs of primary teachers in the school context. It should also aim to include activities, strategies and resources that will be useful to primary teachers to improve their confidence, knowledge and pedagogical skills. Finally, PD programs should allow for opportunities for primary teachers to reflect, collaborate and promote the sustainability and progression through school-based leadership.

The literature reviewed in this chapter has demonstrated concern about teachers' understanding of scientific literacy. This chapter has also revealed several factors that may contribute to a successful PD program that could assist teachers with their development of scientific literacy. The aim of this research is to identify what teachers understand by the term scientific literacy, to determine if PD programs are successful in enabling teachers to develop their understanding of scientific literacy and to enhance the development of the skills of scientific literacy in their students.

## **CHAPTER 3**

### **RESEARCH DESIGN**

#### **Introduction**

This chapter begins with a restatement of the research questions, then turns to the research design of the study and describes the specific approaches that were taken in each stage of the research process. The final section of this chapter examines issues relating to trustworthiness of the data and the method the researcher used to ensure the research was carried out in an ethical manner. In essence, this research uses a multiple case study design incorporating an interpretive approach to data collection and analysis to examine the research questions. Table 3.1 provides an overview of the aspects of the research process and the approaches taken in this study. Each of the aspects presented in this table will be discussed in turn.

#### **Research Design**

##### **Research Questions**

The purpose of this research is to examine the impact of a professional development science program on primary school teachers' practice. It aimed to identify aspects of the PD program that were effective in providing primary teachers with the knowledge, confidence and pedagogical skills to teach science in a way that would promote scientific literacy. Specifically, the research was designed to answer the following research questions:

1. What do primary school teachers understand by the term "scientific literacy"?
2. What are the factors determining the effectiveness of the KSS professional development program in;
  - a. developing primary science teachers' understanding of scientific literacy?
  - b. promoting the confidence of primary teachers when teaching science?
  - c. developing teachers' pedagogical skills to enable them to teach science?
  - d. developing teachers' knowledge and understanding of science to enable them to teach science?
3. In what ways do teachers' levels of confidence, pedagogical skills and science knowledge influence how they teach science to students to encourage the development of scientific literacy in schools?

4. In what ways can schools promote the longevity of the outcomes of the KSS professional development program?

Table 3.1 Aspects of the Research Process and the Approaches Taken in this Study.

Aspects of the Research Process	Approach taken in this study
Research design	Multiple case study
Data collection	PD workshop feedback sheets (WFS) Teacher questionnaires Student questionnaires Observations PMM interviews Teacher interviews Student interviews
Data interpretation	Analysis of PD WFS Analysis of teacher questionnaires Analysis of student questionnaires Analysis of PMM Coding and categorisation of interviews Construction of case studies
Trustworthiness	Credibility Dependability Transferability Triangulation
Ethical issues	Anonymity Beneficence Informed consent Consideration



## **Research Paradigm**

An interpretive research paradigm was used in this study. The interpretive research paradigm aims to gain meaning or understanding through the involvement and interpretation of both the participant and the researcher (Cohen, Manion, & Morrison, 2000). Within this paradigm the researcher is the primary instrument in data collection and interpretation. In interpretive research the participants are able to share their views and multiple perspectives on reality with each other and the researcher.

Interpretive research data collection occurs most commonly through observations and interviews in case studies and ethnographies. Data collection within this paradigm is subjective, naturalistic, and generally non-statistical (Denzin & Lincoln, 2005). Design characteristics are normally small-scale research studies, which are non-random and purposeful, and where understanding actions and meaning is the general focus of the entire process. Interpretive research data collection and analysis aims to be comprehensive, expansive, holistic and richly descriptive (Willis, 2007). Interpretive research is generally the foundation of micro-sociological concepts: individual perspectives, personal constructs, negotiated meanings, and definitions of situations (Cohen et al., 2000).

The interpretive research methodology, according to Erickson (1986), focuses on the “immediate and local meaning of actions, as defined from the actors’ point of view” (p. 119). Thus, the researcher must be in a position where he or she is able to obtain this information. To do this the researcher must participate in observation in some way. LeCompte and Preissle (cited in Cohen, et al., 2000) define four degrees of participation for the researcher observing in a naturalistic setting:

1. Complete participant, where the researcher takes an insider role and may or may not declare that s/he is the researcher.
2. The participant-as-observer, where the researcher is known as a researcher and is part of the group life of the participants.
3. The observer-as-participant, where the researcher is known as a researcher but has less extensive contact with the participants.
4. The complete observer, where the researcher is not known to the participants and the participants do not know they are being observed.

The degree of naturalistic observation in case study research is dependent on the researcher's intention and position in the case study environment (Goetz & LeCompte, 1984). The focus of this interpretive research is the staff and students in a naturalistic primary school setting. The data gathered involved teachers' constructions of science concepts, pedagogy and meaning as a consequence of PD in this area. The researcher endeavoured to understand the situation as a whole, by discovering what is meaningful to her while simultaneously attempting to discover what is meaningful to the participants (Stake, 1988).

The creation of meaning within this situation was developed through the researcher as an observer-as-participant in three case studies. The case study observations in this research allowed teachers and students to continue to participate in their naturalistic settings. As observer-as-participant the researcher was part of the classroom life of the participants, documenting, recording and interpreting events, being mindful not to impose any views and opinions on the participants but interacting with the participants when appropriate.

### **Case Study Research**

This research included three case studies. Each case study was a unique entity; a metropolitan primary school involved in science PD. Because each case study contributed to the overall findings of the study, the research design can be described as a multiple case study (see Table 3.1). Case studies are uniquely bounded systems which rely on multiple sources of information that can be obtained by using multiple methods of data collection (Anderson, 1998). Case studies are both descriptive and inductive, while focussing on a particular aspect or experience in an authentic setting which is best understood in the social context of that setting (Merriam, 1988).

There are many types of case studies. The one selected for this research represented a sociological perspective as it was concerned with society and socialization in an educational classroom setting (Merriam, 1988). Merriam (1988) asserts that the interpretive case study not only collects thick descriptive data but uses these data to "develop conceptual categories or to support or challenge theoretical assumptions held prior to the data gathering" (p. 28). The research may also be described as inductive, as the researcher gives her interpretation of what happened; descriptive, as a description of what happened is provided; as

comprehensive, as information was recorded during the time in the classroom and compiled from other data sources; and as particularistic, because it was about a particular sample of Western Australian school teachers and their students engaged in the outcomes of the professional development program and who volunteered to participate in the research. Additionally, data were collected using Personal Meaning Mapping (PMM) interviews with a variety of educators, and these data assisted in providing content for the views about scientific literacy of the teachers in the case study schools. A description of how PMM were used in this research is presented in Chapter 4.

## **Participants**

Five groups of participants were involved in this research. Firstly, the four KSS Education Officers, Edith, Joy, Narelle and Anne (all names are pseudonyms) participated in various ways. Their involvement with the researcher included email correspondence, informal and formal discussions. Additionally, Edith and Joy also facilitated the PD workshops and provided the PD Workshop Feedback Sheet (WFS) data (described later) to the researcher.

The second, third and fourth groups of participants were the staff and students at the three metropolitan government schools, Fenchurch, Winchester and Knightsbridge Primary Schools (PS), that were involved in the case studies. Case study schools were selected based on two criteria: They were participating in the PD offered by the KSS, and they were willing to allow a researcher into their school to conduct research. Detailed descriptions of the schools, the participants and actual events will be reported in later chapters. Information relating to Fenchurch PS can be found in Chapter 5, Winchester PS in Chapter 6 and Knightsbridge PS in Chapter 7.

Fifthly, a further purposeful, volunteer sample of participants was involved in Personal Meaning Mapping (PMM) interviews during 2005, 2006 and 2007 which aimed to understand people's ideas about scientific literacy. Because this technique was to be used for the first time to examine people's understanding of scientific literacy, a small study was conducted to establish its potential for use and to provide some baseline data with which the views of the teacher participants in the case studies could be compared.

## **Data Collection and Analysis**

Multiple methods of data collection were used in this study to gain a deeper insight and provide evidence to construct meaningful propositions from the data analysis. Using multiple data sources and multiple collection methods enhanced the research findings through triangulation. Triangulation is a way of examining both convergent and discriminant data to control for possible bias on the part of the researcher or from using only one set of data (Mathison, 1988).

Table 3.1 provides an overview of the approaches taken in the data collection and analysis, procedures used to establish trustworthiness of the data and their interpretation, and ethical issues considered in this study. Data were collected from four major sources, the PMM interviews and three case studies at three Western Australian metropolitan primary schools. Methods of data collection included questionnaires, observations and interviews. Each of the instruments used in the case studies is discussed below, including the development, description, administration and analysis of data. The PMM interviews are discussed in Chapter 4.

Table 3.2 provides a summary of the number of participants in each case study, and the timeframe for data collection. The content of the teacher questionnaires varied slightly for each case study school as there was always discussion with the school to incorporate any of their suggestions about the instruments used. Table 3.3 presents a list of the data collection methods that were used and also shows the variations for each of the three case study schools.

Table 3.2 Number and Description of Participants in the Case Study Schools

School	Education Officer that facilitated the PD	Number of teachers					No. of students surveyed and observed in classes	Timeline for data collection	Duration of case study
		In the school	Completed WFS	Completed questionnaires	Interviewed	Observed			
Fenchurch	Edith	12	11-15	2	12	2	60	Jun 2005-Mar 2006	9 months
Winchester	Edith	16	9-14	1	8	1	28	Apr 2006-Jan 2007	10 months
Knightsbridge	Joy	37	34	25	7	2	58	Aug 2006-Jun 2007	11 months
Total		65	54-63	28	27	5	136	Jun 2005-Jun 2007	30 months

Note: The variation in the number of teachers that completed the WFS (column 4) was due to the addition of practicum students and to staff absences on the day of the Professional Development.

Table 3.3 Data Collection Methods for Each of the Three Case Study Schools

Data Collection Method	Fenchurch	Winchester	Knightsbridge
PD Workshop Feedback Sheet	3 PD WFS	3 PD WFS	1 PD WFS  Modified questions in second WFS to encompass Primary Connections
Teacher Questionnaire	Initial and Final Teacher Questionnaire	Initial Teacher Questionnaire	Questions modified at school request
Student Questionnaires	Toward end of the year	Initial and final, middle and end of year	Toward end of year
Teacher Interviews	Formal staff cluster meeting, based on school and researcher need	Formal interview protocol based on school and researcher need	Formal interview protocol based on school and researcher need
	Formal joint interview with two class observation teachers	Formal interview with one classroom observation teacher	Formal separate interviews with two classroom observation teachers
Informal Teacher Interviews	Informal conversations during the school day	Informal conversations during the school day	Informal conversations during the school day
Student Interviews	Informal interviews in conversations during class	Informal interviews in conversations during class	Informal interviews in conversations during class
		Formal interview protocol based on school need and researcher information	Formal interview protocol based on school need and researcher information
Observation of Lessons	Two Year 6/7 classes combined	Year 2/3 class	One Year 7 class and one Year 6 class

## **Nature of the Professional Development**

The KSS PD sessions are usually offered to teachers at their school or at Scitech, based on a fee-for-service principle. Teachers can choose from a range of workshops covering three main areas: planning and teaching technologies for science, Working Scientifically (specifically relating to the Western Australian curriculum area of Investigating), and developing conceptual understanding in science. In consultation with members of individual school staff the PD presenters develop programs that will be most suited to the requirements of the school.

At the beginning of each PD session, an activity book and support materials to assist in the follow-up implementation of ideas were provided to attending staff. The PD involved brainstorming, hands-on activities, content and resource information, and discussion time about the Western Australian Curriculum Framework and Science Curriculum Guide. The PD presenters aim to stay up to date with the current Western Australian science curriculum and plan on making their sessions as interactive as possible. The PD presenters are available to the participants by phone or email after all PD programs.

The PD sessions selected by Fenchurch, Winchester and Knightsbridge are outlined in Chapters 5, 6 and 7, respectively.

## **Professional Development Workshop Feedback Sheets**

The PD WFS were developed by the KSS Education Officers and are routinely used by them to obtain feedback on the PD workshops they present. The PD WFS had been used by the KSS since 2003 and a copy can be found in Appendix 1. Fenchurch and Winchester teachers both completed three WFS associated with the three PD sessions undertaken. However, only one WFS was completed by Knightsbridge because only one PD session was based on the KSS PD program.

The WFSs were collected by the Education Officers, as was their normal procedure, and the responses collated into a summary. These summary data sets for each school were provided to the researcher by the Education Officers. This had the advantage of ensuring confidentiality of the responses, but the disadvantage of not

knowing which responses were those of the teachers who were later observed as part of the case studies.

The first page of the WFS included demographic questions, an open-ended question about teachers' expectations of the workshop, and five items on which teachers were asked to rate their attitude and perceptions about their teaching of science in their classroom. These rating scale items employed a 4-point Likert scale: strongly agree, agree, disagree, and strongly disagree. The second page of the WFS contained the same five rating scale items, with small wording changes to capture the post-workshop context. Analyses of the workshop data rating scale items are reported as percentages for each response category. The WFS also contained three open-ended questions about teachers' responses to the workshop and subsequent actions the teachers planned to take in the classroom.

Before the workshop began, teachers completed the first page of the WFS. At the end of the workshop, teachers completed the second page of the WFS. As a means of analysis, the open-ended questions were categorised into several categories that reflected the teachers' responses. The data are reported using the percentage of teachers' responses reflecting a particular category. For a full list of the coding categories, see Appendix 2.

### **Teacher Questionnaire**

The Teacher Questionnaire used in this study was a pen and paper instrument designed to obtain teachers' ideas and perceptions about teaching science. The Teacher Questionnaire was used to collect both qualitative and quantitative data from the teachers. It was modified from one that had been used by Rennie (2004) in a previous survey of primary school teachers in 2003. For a copy of the original Teacher Questionnaire used in 2003, see Appendix 3.

During the refinement of the Teacher Questionnaire the researcher was involved in several discussions with a wide audience (university Science Education staff, Early Childhood specialists, a Statistical Package for the Social Sciences (SPSS) specialist, and post graduate science education students). The Teacher Questionnaire used in this study was revised to ensure that it reflected the contemporary primary science teaching



and curriculum and data required for this research. In summary, the changes made included the removal of the Western Australian Science content strands from the seven self-efficacy questions on the second page of the 2003 version of the questionnaire to ask about science in general, the addition of six more self-efficacy questions to ensure that all areas involved in this research were covered, and some small wording changes to ensure that the questions were suitable to the participants in this study.

The Teacher Questionnaires were administered towards the beginning of the case study period. Teachers were asked a variety of questions concerning their attitudes and perceptions about teaching science. Generally, the Teacher Questionnaire sought data about

- Teachers' backgrounds
- Science programming for the year
- Resources used in teaching science
- Teachers' interest, background knowledge, confidence and resource use in science
- Teachers' perceptions about why science should be taught in primary schools
- Teachers' pedagogical strategies when teaching science

The Teacher Questionnaire was used in this format with Fenchurch and Winchester and a copy can be found in Appendix 4. In the third case study at Knightsbridge, at the request of the Principal, the questionnaire was modified to align with feedback required by the staff at the school. The Principal wished to determine what PD programs his staff would like to be involved with in the future and what areas in science the staff believed would most benefit them with additional professional development. Thus, the science content strands were re-included. The modified Teacher Questionnaire used at Knightsbridge is provided in Appendix 5. The main reason the Principal at Knightsbridge wished to modify the Teacher Questionnaire was the opportunity to be involved in a new science initiative. At the time of the Knightsbridge case study many professional development providers, including the KSS, were being funded to provide professional development on a nation wide initiative called Primary Connections. This was a new curriculum that sought to teach science through language

literacy. The provision of funding meant that PD for Primary Connections was at no cost to primary schools across the state and consequently many schools, including Knightsbridge, took advantage of the free PD program.

Data from the Teacher Questionnaires were entered into spreadsheets using Microsoft Excel. The observed class teachers' responses to the demographic information from Fenchurch and Winchester were examined and notes were made about their background, experience and time for science programming. At Knightsbridge the school staff did not want to be identified by their Teacher Questionnaire so, as evident in Appendix 5, all demographic information was removed.

At Fenchurch and Winchester, the case study observational class teachers' attitudes about perceptions of teaching science, reasons to teach science and how teachers perceived they taught science were summarised by assigning each five-point rating scale item a number from 1 to 5. Data were examined individually for each teacher. All 25 teachers who responded to the Teacher Questionnaire were used in the analysis of the Knightsbridge data as the case study observational class teachers were unable to be identified without the demographic information. Means were calculated for the data representing teachers' attitudes and perceptions about science at Knightsbridge. Percentages were calculated for each response choice, for teachers' interest, background knowledge, confidence and resource use in the four science concept strands.

### **Student Questionnaire**

The Student Questionnaire used in this research was identical to a questionnaire used by Rennie in 2003, which was based upon one developed by Goodrum et al. (2001) in collecting data from primary school students. The Student Questionnaire was used to elicit students' perceptions of what was happening in their science classes. There were 31 four-point Likert scale questions and one open-ended question. Students were asked to respond to 18 items asking how often a range of activities happened in the classroom and another 13 items about their thinking and enjoyment in class. The open-ended item asked students "What do you like best about science?" The complete student questionnaire is shown in Appendix 6.

The Student Questionnaire in this research was used with students from Years 2 to 7. The Year 2 and 3 students whose first language was not English were assisted by teachers reading each of the items on the questionnaire. Although these students were younger than those for whom the questionnaire was originally developed, teachers were keen for them to complete the questionnaire. All other students responded to the questionnaire on their own. Table 3.2 provides the number of students completing the questionnaire in each school.

The questionnaires were administered by the classroom teachers of the students at Fenchurch and Winchester, and administered by the researcher at Knightsbridge. Any questions that students had regarding understanding of the items on the Student Questionnaire were answered by either the classroom teacher or the researcher.

Data from the Student Questionnaires were analysed using Statistical Package for the Social Sciences (SPSS) software. The 31 items were categorised into six themes, as related groups, and student responses to each item were calculated as percentages. These themes and the items they comprise are outlined in Table 3.4.

Table 3.4 Themes and Items of the Student Questionnaire

Theme	Items
Student activities in science lessons	1, 2, 3, 4, 7 and 9
Teacher- or student-centredness of the classroom	5, 6, 15, 16, 17 and 18
Using resources outside the classroom	8, 10, 11, 12, 13 and 14
Students' interest in science lessons	20, 27, 28 and 29
Students' perceptions of the easiness of science	19, 13 and 31
Students' thinking in science	21, 22, 23, 24, 25 and 22

The responses to the open-ended item on the questionnaire "What do you like best about science?" were categorised and coded. The categories were developed by Rennie (2004) in the earlier administration of the instrument. The categories included teaching and learning activities, management of learning, teaching and learning,

students' attitudes, resources, and grading and assessment. A complete list of the codes and categories used in this research can be found in Appendix 7.

## **Interviews**

The face-to-face interview is where at least one interviewer and one interviewee engage in some form of discourse about a topic of interest (Anderson, 1998). The formality of the discussion will depend on the interviewer's purpose, the interviewee's willingness to communicate and the nature of the relationship between the interviewer and the interviewee (Cohen et al., 2000). There are many different formats for interviews. For simplicity, interviews are categorized into four main types: informal conversational interview, guided approach interviews, standardized open-ended interviews, and closed quantitative interviews. Choice of type is dependent on the nature of the research (Kvale, 1996).

An interview shows that value is placed on the individual's ideas. Usually, few respondents refuse to be interviewed, leading to a high response and cooperation rate. Questions are asked one at a time; the pace is determined by the researcher, the interviewee or by both members, depending on the type of interview. Interviews allow for in-depth analysis and pursuit of details geared to each respondent, providing opportunities for the interviewer to clarify any answers given by the respondent. Furthermore, the interview provides information additional to what is actually said, because the interviewer and respondent may use direct observation to identify non-verbal facial expressions and other body language (Kvale, 1996). Each participant can be identified so the validity for the sample interviewed is high (Cohen et al., 2000).

In this study, formal and informal staff interviews, and formal and informal student interviews were used. Each of these is described below.

### ***Formal Staff Interviews***

Several teachers at each school site participated in formal interviews which occurred during school time at the beginning and the end of the case study period at each school. Interview protocols were used for formal interviews. These were different depending on the situation in which the interview was embedded. Formal interview questions were developed by the researcher in order to assist and validate interpretation

of the observations. Although interview protocols were similar in theme for teachers in all of the three case studies, it was necessary to adapt the protocol to reflect the wishes of the staff at each school.

### Fenchurch Primary School

Each of the teachers at Fenchurch participated collaboratively in one of three interviews which occurred during their regular Semester Two cluster meetings at the beginning of Term 3 (Week 2), 2005. These meetings covered all aspects of the curriculum and each lasted one full school day. A cluster was a group of teachers who taught similar grades. The three cluster groups were composed of teachers from: Kindergarten and Pre Primary, Years 1-3, and Years 4-7. One teacher who taught a combined Pre Primary/Year 1 class attended two of the cluster meeting sessions. A specialist Italian teacher, who was part-time, attended the Year 1-3 cluster meeting.

The researcher was invited to join each group for the science half hour (directly after lunch) where the researcher led a discussion about what teachers thought about the KSS PD and their feelings toward science. The researcher asked the questions outlined in Figure 3.1 during the interview.

- |   |
|---|
| <ol style="list-style-type: none"><li>1. What did you hope to get out of the PD?</li><li>2. What did you like best about the PD?</li><li>3. How are you going to utilise anything you have learnt in the PD?</li><li>4. How long does each of the science topics or themes run?</li></ol> |
|---|

Figure 3.1. Teacher cluster interview questions at Fenchurch PS

The general objective of these small group interviews was to establish the perceptions of the staff about the PD. The teachers' responses to the questions were scribed concurrently by the researcher as not all members of the staff were comfortable about being audio-recorded, and at a later time the researcher made additional field notes of the interview. The interview responses were divided into themes that were developed by the researcher from the responses. The themes included knowledge, confidence, pedagogical skills, resources, scientific literacy and future directions. Time was not

available for final staff interviews at Fenchurch Primary School due to end of term pressures.

#### Winchester Primary School

##### *Initial Staff Interviews*

Late in Term 1, 2006, three teachers, including the case study teacher, volunteered to participate in a one-to-one interview before the KSS PD sessions. The questions for the Initial Staff Interview are outlined in Figure 3.2.

- |  |
|--|
| <ol style="list-style-type: none"><li>1. Do you enjoy teaching science?</li><li>2. Is there anything you don't like about teaching science?</li><li>3. Why do you think that your school has science as a focus for Term 2 this year?</li><li>4. What do you hope to gain from the PD?</li><li>5. What would you like the PD presenter to present?</li></ol> |
|--|

Figure 3.2. Initial staff interview questions at Winchester PS

##### *Final Staff Interviews*

Eight staff members, including the case study teacher, volunteered to participate in the Final Staff Interviews. These were conducted individually early in Term 4, 2006. The questions for the Final Staff Interview are outlined in Figure 3.3.

- |   |
|---|
| <ol style="list-style-type: none"><li>1. How would you compare your confidence to teach science after the PD sessions to your confidence to teach science before the PD sessions?</li><li>2. Has your attitude toward science changed? Why/why not or if so how?</li><li>3. Were you able to reflect on your current practise? If so, what did you note?</li><li>4. How do you think your current students enjoy science compared with other groups of student in previous years?</li><li>5. What do you believe students should 'get out of' science?</li><li>6. How do you go about achieving this?</li><li>7. What do you understand by Scientific Literacy?</li><li>8. What did you think of the PD session on the last day of Term 1?</li><li>9. Do you think you need more assistance with science? If so, what would be valuable?</li><li>10. What improvements do you believe need to be made for science to move forward at Winchester PS?</li></ol> |
|---|

Figure 3.3. Final staff interview questions at Winchester PS

## Knightsbridge Primary School

### *Initial Staff Interviews*

Late in Term 4, 2006, seven teachers volunteered to participate in an individual interview. The questions for the Initial Staff Interview were identical to the final interview question used at Winchester (with school name changes) as outlined in Figure 3.3.

### *Final Staff Interviews*

Seven staff members, including the two case study teachers, volunteered to participate in the Final Staff Interviews. These individual interviews were conducted at the end of the case study period in May, 2007. The questions in the Final Staff Interviews were very similar to those used in the Initial Staff Interview. Question 7 was a new inclusion that related to Working Scientifically as the researcher noted that teachers were more familiar with this term when compared with the teachers' familiarity with the term scientific literacy. The questions for the Final Staff Interview are outlined in Figure 3.4.

1. How would you compare your confidence to teach science after the PD sessions to your confidence to teach science before the PD sessions?
2. Has your attitude toward science changed? Why/why not or if so how?
3. Were you able to reflect on your current practice? If so, what did you note?
4. How do you think your current students enjoy science compared with other groups of students in previous years?
5. What do you believe students should 'get out of' science?
6. How do you go about achieving this?
7. What do you understand by working scientifically?
8. What do you understand by Scientific Literacy?
9. What did you think of the PD session on the last day of Term 1?
10. Do you think you need more assistance with science? If so, what would be valuable?
11. What improvements do you believe need to be made for science to move forward at Knightsbridge Primary School?

Figure 3.4. Final staff interview questions at Knightsbridge PS

The questions posed to the teachers at Winchester and Knightsbridge were audio recorded and later transcribed by the researcher. The responses were grouped and categorised into themes similar to those in Fenchurch. The responses were used to gain a variety of perceptions from several members of staff.

### ***Interviews with Teachers of the Observation Classes***

All five teachers from the observation classes were interviewed about their beliefs and experiences about the PD, their confidence and attitudes toward science, the teaching and learning of science in their classroom, scientific literacy, and future directions of the science curriculum at their respective schools. An interview protocol was developed to reflect the information required in each case study.

#### **Fenchurch Primary School**

Early in 2006 (two months after the case study concluded) the two teachers from the observation class were interviewed together, about their beliefs and experiences about the KSS PD, their confidence and attitudes, science in their classrooms, scientific literacy, and future directions of the science curriculum at Fenchurch. The prepared questions are set out in Figure 3.5.

- |     |  |
|-----|--|
| 1.  | How would you compare your confidence to teach science after the PD to your confidence to teach science before the PD? |
| 2.  | Has your attitude toward science changed? Why/why not or if so how?  |
| 4.  | Were you able to reflect on your current practise? If so what did you note?  |
| 6.  | What do you believe students should ‘get out of’ science?  |
| 7.  | How do you go about achieving this?  |
| 8.  | What are your thoughts on scientific literacy?   |
| 9.  | What is working scientifically?  |
| 10. | How do you think students enjoyed science compared with other student groups in other calendar years?                  |
| 11. | Why do you think science is not a school priority in 2006?   |
| 12. | Is this a problem?   |
| 13. | What improvements do you believe need to be made for science to move forward at Fenchurch PS?                          |
| 14. | Any other comments you would like to make?   |

Figure 3.5. Interview questions for case study teachers at Fenchurch PS



## Winchester Primary School

1. What was the most significant part of the Professional Development (PD) for you?
2. Do you think the opportunities to ask questions and trial activities were important?
3. If you hadn't had the PD do you think you would have looked at the outcome science documents?
4. How easy was it for you to implement and use the ideas and strategies that you gleaned from the PD?
5. What was the most difficult part of changing your teaching practice to accommodate your new knowledge?
6. What do you think you will do next year for science?
7. Do you have the same year group in 2007?
8. How will you be programming in 2007?
9. Has the PD changed your attitude toward science?
10. Do you think you teach any of the science areas now or do you think what you have learnt is limited to the areas you looked at in 2006?
11. If you had to pick one of the other science learning areas such as Natural and Processed Materials, Earth and Beyond or Life and Living which one would you think would be the most difficult?
12. What things would you like to add to what you did this year?
13. If you had some more science PD what would be of most benefit to you?

Figure 3.6. Interview questions for case study teacher at Winchester PS

At the conclusion of Term 4, 2006 (after the case study concluded) the teacher from the case study class was interviewed about her beliefs and experiences about the PD, science in her classroom, and future directions of the Year 3 science curriculum at Winchester. The interview questions appear in Figure 3.6.

## Knightsbridge Primary School

In the middle of Term 2, 2007, after observations were completed, the two teachers from the case study classes were interviewed individually about their beliefs and experiences of the PD, their confidence and attitudes, science in their classroom, scientific literacy, and future directions of the science curriculum at Knightsbridge. The interviews were structured around the questions outlined in Figure 3.7.

All formal interviews were tape recorded and transcribed by the researcher. Each transcription was sent to the interviewees to member-check and several minor

corrections were completed (Lincoln & Guba, 1985a). The interview was grouped into themes based on the questions asked. The themes included scientific literacy, teachers' perceived confidence and knowledge gained from attending the PD, and teachers' impressions on what the future of science would be at their respective schools.

1. How would you compare your confidence to teach science after the PD sessions to your confidence to teach science before the PD sessions?
2. Has your attitude toward science changed? Why/why not or if so how?
3. Were you able to reflect on your current practise? If so what did you note?
4. What methods have you changed in your science teaching since the PD?
5. How do you think your current students enjoy science compared with other student other groups in previous years?
6. What do you believe students should 'get out of' science?
7. How do you go about achieving this?
8. What do you understand by working scientifically?
9. Do you think you or the school needs more assistance with science? If so what would be valuable?
10. What improvements do you believe need to be made for science to move forward at Knightsbridge PS?

Figure 3.7. Interview questions for case study teachers at Knightsbridge PS

### ***Informal Staff Interviews***

At all three schools the researcher informally interviewed teaching staff at the school. During this research it was sometimes necessary to further understand an idea or circumstance. In these instances, if the situation permitted, the researcher would approach a staff member and engage in a discussion about the issue. On other occasions a staff member would approach the researcher to ask a question or provide information about a particular issue.

Informal Staff Interviews occurred at various times through the case study periods. In the majority of cases, teachers were the initiators of the interaction. All staff members were invited to speak with the researcher at any time about any information

they felt would apply to the research. In these cases the researcher spoke with the staff member in an informal way and on most occasions the staff members wanted to tell the researcher about a particular aspect of science in the school. These interviews were documented as field notes at the earliest possible time. There was a wide variety of topics discussed, ranging from student learning to curriculum implementation and integration.

These informal interviews were recorded as field notes. As the case study progressed, themes and patterns that emerged from them were noted. The data from the interviews are reported, where relevant, in the discussion for each case study school.

### ***Formal Student Interviews***

At the first case study school, Fenchurch, time was not available for the students to be formally interviewed. However, much of the science class work was done in groups where the researcher was an observer-as-participant. This position allowed information to be collected about interactions between student and student, student and teacher, and student and researcher. Discussion topics, either with the researcher or that the researcher listened to, included how students enjoyed science, what they liked about science, and what was different between science lessons this year to last year. The researcher found that the informal information obtained in this way from the students at Fenchurch provided valuable insights. This led to the decision to include a formal interview session with the students in the other case study schools. Consequently, students at Winchester and Knightsbridge participated in formal student interviews. Interview protocols were developed based upon the information required for the research and the age of the participants.

At the conclusion of the interviews the notes were made into detailed records and read carefully by the researcher to identify themes and patterns in the responses. These themes were then presented in the findings.

#### **Winchester Primary School**

Nine students from the Year 2/3 case study class were interviewed individually during Term 3, 2006. The students were asked four questions (as outlined in Figure 3.8) which generated discussion.

1. What is your favourite subject?
2. Do you enjoy science?
3. Do you like science better this year than last year?
4. What science lesson did you like best this year?

Figure 3.8. Student interview questions at Winchester PS

### Knightsbridge Primary School

Ten students from the Year 7 and ten students from the Year 6 case study classes were interviewed individually during Term 2, 2007. The students were asked six questions, outlined below in Figure 3.9, which generated discussion.

1. What is your favourite subject?
2. Do you like science?
3. What is your most favourite part of science?
4. What is your least favourite part of science?
5. What has been your favourite part of science this year?
6. Do you like science better this year than last year?

Figure 3.9. Student interview questions at Knightsbridge PS

### ***Informal Student Interviews***

Informal student interviews occurred at various times at all three case study schools during the case study period. In the majority of cases, students were the initiators of the interaction. For example, students asked the researcher a question about the work they were doing which then developed into a discussion or sometimes the students mentioned an important point that the researcher noted. There were a wide variety of topics discussed with students from how the teacher instructs the class to group work with their peers.

These informal interviews were recorded as field notes at the earliest possible time. As the case study progressed themes and patterns emerged. The data were incorporated to amplify the other findings of the research reported in later chapters.

## **Observations of Lessons**

The observational descriptions were developed from Lincoln and Guba's (1985a) suggestions of ways to record field experiences. The diary entries were chronological, transcriptional and reflective.

The development of the science program, lessons and activities was undertaken by the teacher, who remained in control of the class at all times. Occasionally the researcher was asked, by the teacher or a student, to assist with an activity. Hence, the researcher's role can be described as observer-as-participant. During the science lessons the researcher recorded field notes about conversations, interactions and the structure of the lesson. The researcher kept a diary of field notes, and at the conclusion of each of the lessons the field notes were elaborated to include additional material that there had not been time to record earlier. The researcher's personal reflections were also added and stored as diary entries.

## **Fenchurch Primary School**

The two teachers who volunteered to be part of the case study each had a split Year 6/7 class of 30 students (i.e. two teachers and 60 students). The class teachers had chosen to combine the two classes and team-taught all subjects in one classroom. These two teachers had worked in a team teaching situation for several years, and found it successful for both the students and themselves as practitioners. The classroom was two regular rooms with the partition permanently removed. The front portion of the classroom was set up with a blackboard and student desks. The remaining half of the room had the teachers' desks, bookshelves, cupboards, and mat space. Desks along the back wall held eight computers. Over a period of nine weeks in Term 4, 2005 the researcher visited the Year 6/7 class for a period of 80 minutes each week during the scheduled science lesson. In addition, the researcher attended two excursions with the students, one to South Fenchurch Senior High School and the other to the Fenchurch Maritime Museum. In each situation the researcher made field notes of her observations.

### **Winchester Primary School**

The teacher who volunteered to be part of the case study had a split Year 2/3 class of 28 students. Over a period of 12 weeks in Terms 2 and 3, 2006 the researcher visited the Year 2/3 class for a period of 60 minutes each week during the scheduled science lesson. In addition, the researcher attended a full day activity (Helicopter Making Consistent Judgements<sup>2</sup> activity) with the students, and an additional science lesson that was required during one of the topics.

### **Knightsbridge Primary School**

The two teachers who volunteered to be part of the case study had a Year 6 class of 30 students and a Year 7 class of 28 students. The Year 6 class was combined with another Year 6 class not participating in the study for the science lessons. Over a period of 12 weeks in Term 4, 2006 and Term 1 and 2, 2007, each class was visited for a period of 60 to 90 minutes each week during the scheduled science lesson.

### ***Data Coding and Data Analysis***

During the primary science lessons the researcher recorded notes about conversations, interactions and the structure of the lesson. At the conclusion of each of the lessons the researcher made a report based on these notes with the addition of any material that the researcher recalled that had not been recorded. These reports were used to describe the researchers observations of both teacher and student perceptions of the science class and the science in which they participated. The field note reports were shown to the teachers after each of the observations in order to correct any misconceptions by the researcher.

### **Trustworthiness of Data**

All research needs to be accountable, that is it needs to be valid and reliable. Accountability in quantitative research relies on internal validity, external validity, reliability and objectivity. In qualitative research findings should reflect the reality of the experience in an attempt to establish the trustworthiness of the data. Lincoln and

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<sup>2</sup> Making Consistent Judgments is part of the Western Australian Department of Education and Training moderation policy. It is a component of the Curriculum, Assessment and Reporting: Policy and Guidelines 2006 where teachers engage in endorsed moderation processes within and between schools.

Guba (1985b) believe trustworthiness can be established by the researcher posing four questions to him/herself

1. “Truth value”: How can one establish confidence in the “truth” of the findings of a particular inquiry for the subjects (respondents) with which and the context in which the inquiry was carried out?
2. Applicability: How can one determine the extent to which the findings of a particular inquiry have applicability in other contexts or with other subjects (respondents)?
3. Consistency: How can one determine whether the findings of an inquiry would be repeated if the inquiry were replicated with the same (or similar) subjects (respondents) in the same (or similar) context?
4. Neutrality: How can one establish the degree to which the findings of an inquiry are determined by the subjects (respondents) and conditions of the inquiry and not by the biases, motivations, interests, or perspectives of the inquirer? (p. 290)

In qualitative research the naturalist equivalents of accountability measures are frequently used; credibility, dependability, confirmability and transferability (Lincoln & Guba, 1985b).

### **Credibility and Dependability**

Credibility and dependability were addressed in this research by prolonged engagement and persistent observation with the subjects in their contextual setting to provide scope and depth to the data collection (Lincoln & Guba, 1985a). This was further supported by the following information. During the observation of the classes the researcher made detailed field notes. That evening, or the following day, the researcher transcribed the notes into a reflective journal which identified

constructs/ideas about the confidence of teachers and what types of skills teachers had before and after the PD sessions. Data collection and analysis were chronological and ongoing. The researcher ensured that the categories developed remained congruent with the research goals. The participant teachers validated the transcriptions and categorisation which made the analysis an interactive process creating plausible interpretations of what was found (Stake, 1988).

The researcher used multiple sources of data, such as inspection of teachers' programs and worksheets, and students' portfolios, in addition to the data sources mentioned earlier in this chapter. The researcher asked for teachers' opinions and ideas about activities through informal and formal interviews. Teacher information about their perceptions of teaching science was also gathered using a questionnaire and student information was collected from a questionnaire and interviews. This approach allowed for triangulation through the use of multiple data sources and data collection methods to validate research findings, to help eliminate bias, and detect errors or anomalous discoveries (Anderson, 1998).

### **Confirmability**

Confirmability refers to the degree to which the results could be corroborated by others. Other researchers may validate or challenge the findings, or construct alternative arguments (Bassey, 1999). The researcher provided an audit trail which included raw data, field notes, transcriptions, construct development and formation, and categorisation and coding procedures. Verification of data gathered was achieved through triangulation. The types of information elicited from several sections of results were used to confirm, negate or complement themes or conclusions. Triangulation was used in this research to obtain a wider base of information (Lincoln & Guba, 1985a).

### **Transferability**

Transferability refers to the degree to which the results of qualitative research can be generalized or transferred to other contexts or settings (Trochim, 2006). The data collection involved a purposeful sample. It was necessary to provide thick descriptions of all the events. This was achieved by the development of a narrative style that contained "quotable quotes" (Roberts, 2006, p. 1) presenting a worthwhile story that



explores the significant features of the study. The resulting thick descriptions enhance the degree to which other researchers can judge the transferability of the results to other research situations.

### **Ethical Issues**

This research was approved in 2005 by the Human Research Ethics Committee at Curtin University of Technology, approval number HR 104/2005. The ways in which the researcher addressed the ethical issues of anonymity, beneficence, informed consent and consideration are outlined below.

#### **Anonymity**

Anonymity refers to concealing the identity of the participants in all documents resulting from the research. Confidentiality is concerned with who has the right of access to the data provided by the participants. As face-to-face interviews and case studies were conducted by the researcher confidentiality of the participants could be ensured. Likewise, in the area of reporting and publishing, anonymity was guaranteed to teachers and schools using deletion of identifiers (Cohen et al., 2000). Pseudonyms for all schools and the participants were used throughout this research. Any distinguishing features of a person or institution were also removed. The right to privacy of all documents was guaranteed to all participants and all personal information was protected. Access to data gathered was treated very carefully, being only available to persons necessary to the research (NHMRC, 2001a), in this case the researcher, her supervisors and the participants.

#### **Beneficence**

Beneficence is when research makes a positive contribution towards the field of knowledge in an area of interest by maximising the benefits and minimising the potential harm to ensure the welfare of all participants. The conduct of the research and the dissemination and communication of results from the research has been as unbiased, accurate and honest as possible. The researcher's personal and professional respect ensured that the rights, welfare and beliefs of the participants were adequately protected at all times (NHMRC, 1999). To guarantee justice the researcher attempted to see that the benefits of the research outweighed the burdens. The possible major benefits of this research are increased knowledge, improved service, greater understanding in relation to

the KSS PD program and the understanding of scientific literacy. Although the risks in this research were minimal, the researcher was mindful of the time constraints, privacy and confidentiality of the participants (NHMRC, 2001b).

The researcher-participant relationship is one of unequal power (AARE, 1998). The researcher's respect for persons emphasised the participants' self-determination, autonomy and individual choice (NHMRC, 2001b). To reduce the power imbalance, the researcher established relationships with the participants based on respect, negotiation and trust. The researcher achieved this by respecting participants' personal choice and promoting the conditions required to exercise their choices by developing and providing all the participants with information sheets and informed consent forms. Before the final version of any form was given to any staff member, cultural or academic considerations pertaining to the participants were addressed.

### **Informed Consent**

Informed consent is the written permission, without coercion, of the participants stating that they (or their dependent minor) agree to participate in a research activity. Informed consent is necessary because participants must be informed of the nature, purpose, risks and benefits of the research (Anderson, 1998). Following the acceptance by the Principal to participate, the researcher was able to contact individual teachers by letter or an informal meeting asking them to participate in the study.

The researcher made certain that teacher information sheets and consent forms and the parent/guardian information sheets and consent forms were at the reading level of the participants and that all participants (or their guardian) had the competence to read and understand the information (Cohen et al., 2000). The information sheet and consent forms were on Curtin University of Technology letterhead, contained the researcher's contact information, the researcher's supervisor's contact information and the Human Research Ethics Committee contact information (HREC, 2005). The information sheet included what was expected of the participants, a clear explanation of the purposes of the research and the procedures to be followed; a description of the risks and benefits that would be reasonably expected; an offer to answer any inquiries concerning the procedure; details of how privacy, confidentiality and anonymity would be assured; information explaining to

the participants that they have the right to see drafts, make amendments, and comment on final versions of any related papers reported; the estimated time that was involved in the research; and an instruction that the participant was free to withdraw consent and to discontinue participation in the project at any time without prejudice (Anderson, 1998; HREC, 2004). Additionally, the information sheet provided the participants with information on the nature and type of data to be collected, the means of collection and the way which data would be reported. This information was clearly described prior to consent being sought. There was no pressure on the participants to participate in activities. For a copy of the teacher information sheets and consent forms see Appendices 8 and 9.

Teachers explained the nature of the research to the students in their classrooms. The researcher was available to answer any questions from teachers, students or parents/guardians. Students were informed that participation was voluntary and that permissions slips were due back for either decision. The researcher made note of any students who were not to participate in the research and did not approach these students or use any of their work in any way.

Access to the schools was granted through the Department of Education and Training (see Appendix 10). Following this acceptance, the Principal of each school was contacted by telephone and subsequently sent an information letter (see Appendix 11) asking him/her to provide the researcher permission to enter the school site (Cohen et al., 2000). After consent was approved by the Principal, the researcher contacted the relevant District Office staff of each school to inform them of the study. It is not necessary to have informed consent from this body, so this information was given as a courtesy.

Paper data were stored in a locked cupboard on campus at Curtin University of Technology at the Science and Mathematics Education Centre. All data will be stored for a period of five years after the study is completed. Electronic information such as the transcriptions and the SPSS data will be stored on a USB thumb drive and a CD ROM in two different places at Curtin University of Technology. The key to the code for the data will be kept separate from the participant data (HREC, 2005).

## **Consideration**

The researcher was aware of the time constraints on the participants and endeavoured to make data collection involve as little disruption as possible to the normal state of school affairs. The PMM interviews (see next chapter) and formal interviews were completed during the school day. The teachers were provided with a relief teacher, at a cost to the ARC Grant, so they could leave their classes and be interviewed. Alternative arrangements were made for those teachers who did not wish to leave their class, where they were interviewed either before or after school at their request. Completion of the PMM interviews took each participant about thirty minutes at times that were negotiated between the researcher, the school administration and the participants to ensure a time that was mutually acceptable. Class observations were within the time frame of the school day, with the researcher being as unobtrusive as possible when in the classroom. However, if the teacher felt that it was appropriate for the researcher to assist in the classroom then this was done. When in the classroom the researcher negotiated with the teacher where she should sit, how involved she should be and what she was required to do. The researcher was mindful of the teacher's time, especially if discussions went beyond teaching time.

Participants had the rights to see drafts, make amendments, and comment on final versions of any reports. A high priority of this research was to give prompt and useful feedback to all the teachers and schools involved. Providing a report for each school at the end of the research period gave the staff the opportunity to reflect on events that had occurred during the research period. Each participant involved in the PMM interview was asked for clarification of their written responses to ensure the researcher ascertained the correct meaning of the responses. If any part of the research was unclear to the Principal or teachers involved in the research, the researcher ensured she answered any questions. The researcher also explained to the staff what would happen to the data in terms of storage and use for the thesis. Additionally, the researcher organised appropriate reports to the schools as soon as it was possible. The researcher made every effort to present the results in a manner that was not offensive to any participants.

### **Summary of Chapter**

This chapter discussed the research design used in this research together with the presentation of the research questions. It has given an overview of the data collection and analysis that was used at each of the three case study schools together with the trustworthiness of the data and the ethical issues that abounded the research. The data findings and analysis are presented in the following four chapters. The PMM interview description, methodology and data analysis are reported in Chapter 4. The data from the three case study schools are presented and analysed, in turn, in Chapters 5 through 7.

## **CHAPTER 4**

### **PERSONAL MEANING MAPPING INTERVIEWS**

#### **Introduction**

Examining different people's understandings of scientific literacy may assist in the exposure of why the meaning of scientific literacy is not well understood, as discussed in Chapter 2, although it is perceived in many countries to be a high priority for science education and an informed citizenry. This chapter reports an innovative attempt to elicit a wide range of adults' understandings of scientific literacy. Using a technique called Personal Meaning Mapping (Falk, Moussouri, & Coulson, 1998), interviews were collected from three participant groups: primary school teachers, high school science teachers and the general adult public. A broad selection of participants was sought in order to determine patterns in the responses that were general to the whole group and particular to the three participant groups. The results will not only provide evidence of whether or not Personal Meaning Mapping is a useful tool to explore perceptions of scientific literacy, but also provide a set of baseline data that can be used to compare the perceptions of the case study teachers about scientific literacy (reported in Chapters 5, 6 and 7).

#### **Personal Meaning Mapping**

Personal Meaning Mapping (PMM) is an interview-based technique that can elicit both cognitive and affective ideas (Falk et al., 1998). Research in both the cognitive and neurosciences increasingly supports the view that learning is a relative and constructive process (Appleton, 1997; Pope & Gilbert, 1983). PMM utilizes this relativist-constructivist approach to measuring learning (Falk et al., 1998). The PMM's foundations lie within the areas of mind mapping and concept mapping (Bennett & Rolheiser, 2001), with attention drawn to the construction of meaning of words rather than the interrelationships between concepts.

This technique was originally developed by Falk et al. (1998) for uncovering and measuring people's conceptions and perceptions of a word or stimulus phrase in an informal context. In their work they asked museum visitors, 40 randomly selected adults, to write words, ideas, images, phrases, or thoughts that came to mind related to

the stimulus phrase “gems and minerals”, using a pre-visit/post-visit approach to determine the visitor’s learning at a specific exhibit at the Smithsonian National Museum of Natural History in Washington, DC. Each individual’s pre-visit knowledge and feelings were compared with his or her post-visit knowledge and feelings. To determine the change, or learning of the visitor during the visit, the data were analysed in four dimensions; extent, breadth, depth and mastery.

The *extent* of a person’s knowledge or feelings were analysed by identifying the change in the use of appropriate language. The change scores were determined by counting the number of relevant words/phrases written down by a museum visitor on the pre- and post-PMMs and examining the difference.

The *breadth* of a museum visitor’s understanding was measured by identifying the change in quantity of conceptual understanding. Two researchers independently classified each visitor’s responses into conceptual categories. Inter-rater agreement was 95% and through discussion, terminology for categories and disputed classification were resolved. To determine the change in breadth, the researchers compared the number of conceptual categories that were used by the participants before and after the museum visit.

The *depth* of a museum visitor’s understanding was determined by the detail and complexity of their responses. Museum visitors were asked about some of their responses and the degree to which they could expand on their understanding (transcripts of the conversations were recorded). The two researchers independently scored the responses using a scale of 1-4 (1=no elaboration; 4=significant elaboration), and differences in scoring were resolved through discussion.

*Mastery* of a museum visitor’s understanding related to the overall way in which visitors’ described their understanding. Scoring was accomplished through holistic judgement, the PMMs were scored using a scale of 1-4 (1=simple, novice-like understanding to 4=highly detailed, expert like understanding). Once again, both researchers independently rated the PMMs and differences were resolved through discussion.

This method has been used in other informal learning institutions, such as the Challenge of Materials Gallery at the London Science Museum (Deneroff, Osborne, & Moussouri, 2005) and the National Aquarium in Baltimore (Falk & Adelman, 2003). When used in this way PMM does not assume that all learners enter with comparable knowledge and experience, nor does it require that an individual produce the right answer in order to demonstrate learning. Instead, PMM is designed to measure how a specified “educational experience” uniquely affects each individual’s personal, conceptual, attitudinal and emotional understanding (Falk, Moussouri, & Coulson, 1998).

### **Use of Personal Meaning Mapping in this Study**

This study reports the use of PMM in a more general context; the PMM was used as an exploration tool to determine participants’ understandings about the phrase “scientific literacy”. This qualitative approach to data collection allowed the researcher to focus on insight and discovery rather than the impact of an educational experience. In this way, the use of the PMM interviews might be considered as a modified approach compared to how PMM has been typically used by Falk and his colleagues. Here it was used only once in order to explore understanding of a concept, rather than twice to examine change as a result of a particular experience. In this study, the method was used to elicit ideas, words, images and conceptions that participants had acquired from their education and everyday life experience, thus enabling the researcher to identify what was known and understood by the participant at a particular time.

The PPM interviews were conducted by the researcher on a one-to-one basis with the participants. The participants were given an A4 sheet of paper with the phrase scientific literacy written in the centre of the page, as shown in Figure 4.1. Each participant was asked to think of some words, ideas, thoughts, images or phrases about scientific literacy. The researcher asked the question “What does scientific literacy mean to you?” The participants recorded their responses, in blue or black ink, on to the A4 sheet of paper. After allowing as much time as each person needed to complete their writing, the researcher sought verbal clarification of the ideas from each participant, and the participant’s responses were scribed, by the researcher, in red ink, onto the



participant's A4 sheet. At the conclusion of each of the PMM interviews the researcher made notes on what the participants had said in addition to what the participants had written and what the researcher had scribed. An example of a completed PMM is shown in Figure 4.2, where the participants' words are in blue ink and the researcher's scribing in red ink.

The average time taken by participants was 25 minutes. The participants spent 10 minutes, on average, writing their thoughts onto the sheet and an average of 15 minutes explaining the meaning of their written information to the researcher. All participants understood the task immediately. Several participants required encouragement to write as they believed they did not know any information about scientific literacy. However, after the researcher explained to them there were no right and wrong answers, participants became comfortable to record their ideas.

### ***Participants***

The PMM interview technique, focussing on scientific literacy, was used with 54 adults who were asked, and agreed, to participate in the research. This voluntary, purposeful sample was chosen to provide a diversity of perspectives from school teachers and the general public. The sample was divided into three participant groups, each of 18 people: teachers from primary schools; high school science teachers; and the general public.

The primary school teachers all worked in Western Australian metropolitan public or private primary schools. They were generalist teachers with one or two areas of expertise; none had expertise in the Science Learning Area. Their teaching experience varied from 5 to 30 years. The high school science teachers worked in public or private secondary schools in several countries. One teacher originally taught social studies but transferred to science when science teachers were in short supply. Another teacher commenced his career in a primary school and was later retrained as a science teacher. Both of these teachers majored in Biological Science. One other teacher had a background in Agricultural Science and lectured science at Training and Further Education College. The other teachers in this group had always been high school science teachers with seven having a major in Chemistry, seven having a major in

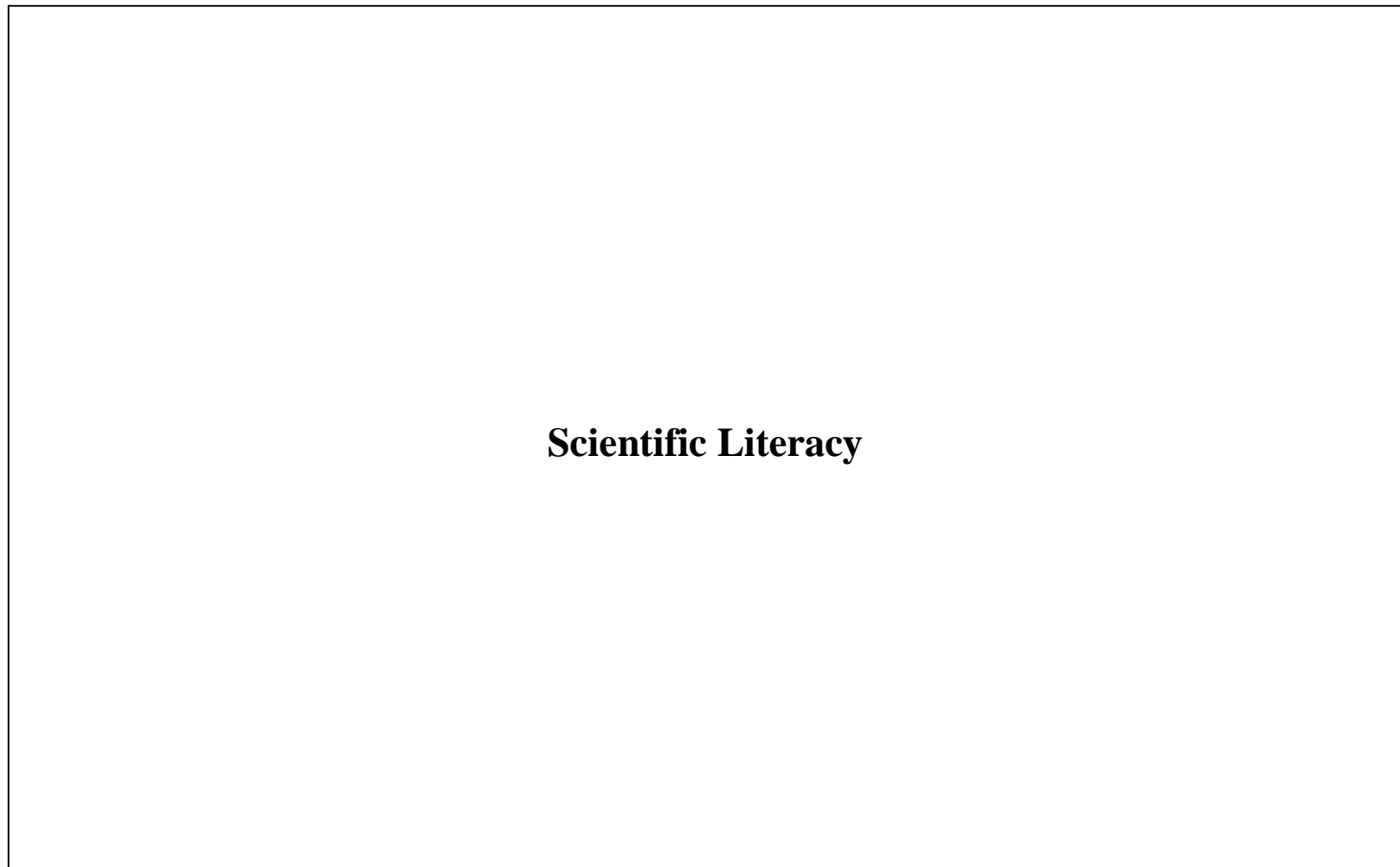


Figure 4.1. Representation of the PMM response sheet

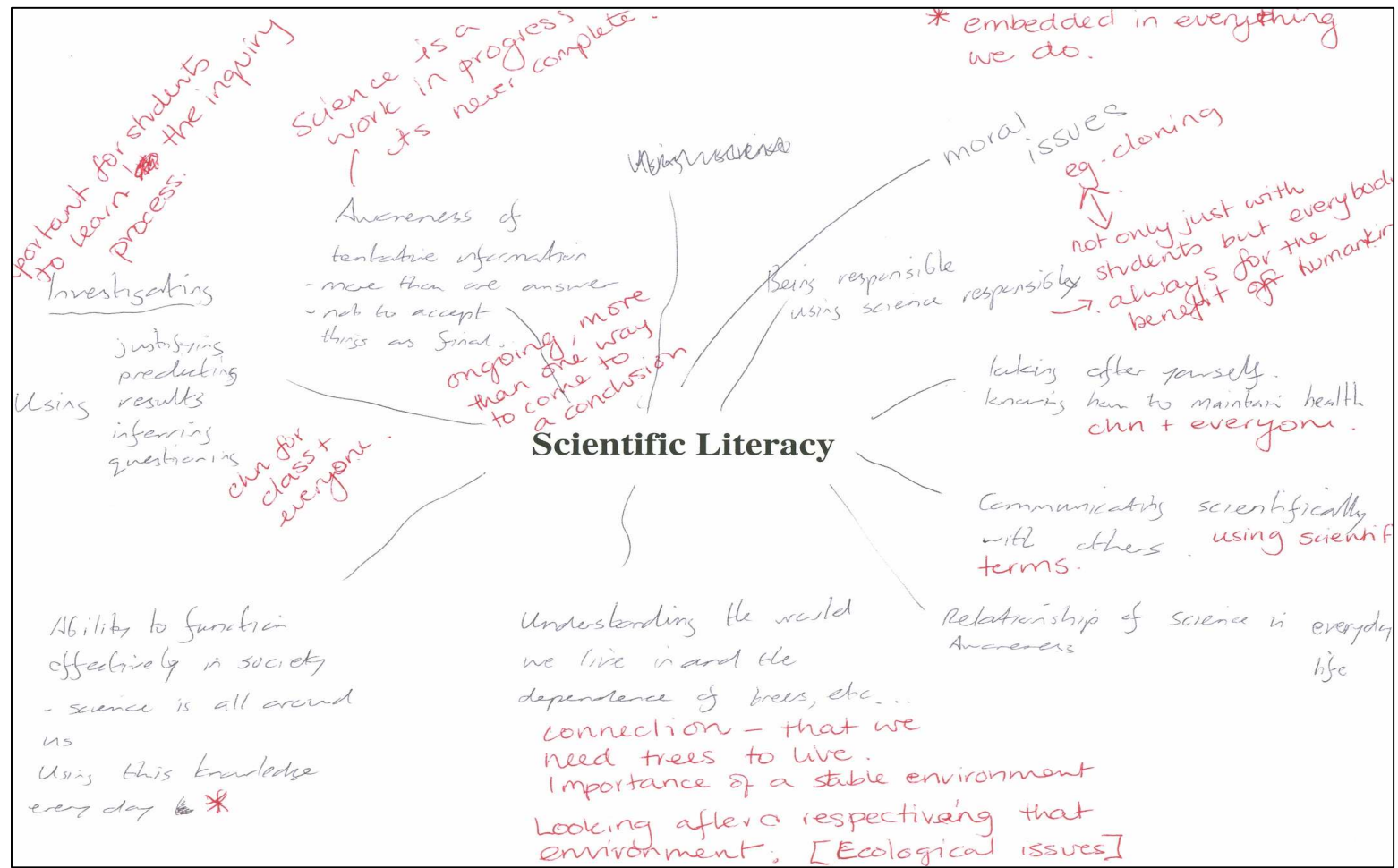


Figure 4.2. An example of a primary school teacher's PMM

Physics and one in Biological Science. Their teaching experience ranged from 5 to 40 years. The high school teachers' countries of origin included Australia, Germany, South Korea, Mozambique, Philippines, Lesotho, Indonesia, New Zealand and Malaysia. The 18 members in the general public also had varied educational and work backgrounds. The participants included a laboratory technician, postal services officer, nursing assistant, cabinet maker, police officer, landscaper, auto electrician, lecturer in the field of Business Marketing and Management, and a hair stylist. One of the general public participants was educated in Malaysia, one in India, one in South Africa while the remainder were educated in Australia. Table 4.1 shows the number of male and female participants in each group.

Table 4.1 Number of Participants in Each Group that responded to the PMM

Number of Participants	Primary School	High School	General Public	Total
Male	6	7	6	19(35%)
Female	12	11	12	35(65%)
Total	18	18	18	54
Percentage	(33%)	(33%)	(33%)	

### Analysis of the Personal Meaning Mapping Data

Several steps were involved with becoming familiar with the PMM data. This was important to determine a set of categories that were based on the participants' responses. The data from the participants' PMMs were recorded in a table using Microsoft word. The comments were printed and each participant's comments were separated by cutting the table into individual comments using scissors. The researcher became familiar with the participants' individual responses by reading them several times (Moustakas, 1994), and then developed categories based on the ideas that were represented in the participants' comments. Following this initial familiarisation with the data, a process, which Huberman and Miles (as cited in Kervin, Vialle, Herrington, & Okley, 2006) call "shuttling back and forth", was employed. In this process the

participants' responses were re-read several times to ensure that all comments were represented by a developed category. Sometimes the responses were broken into sections representing single concepts that related to one of the categories.

Each developed category was written on a separate index card and the cards placed at different positions on a table. The seven categories developed were science related to life, science communication, investigating, informed decisions, sceptical and questioning attitude, science content, and resources and strategies for teaching. Each developed category was assigned a code and the code was written on the index card.

The participants' responses were then sorted into one of the categories represented by the cards on the table. As each comment was sorted, the code that aligned with the card was written on the reverse of the participant's comment.

After one week, the researcher re-read and re-sorted the responses into the categories using the same method to check her reliability. Any discrepancies were noted and resolved through developing a clearer definition of the categories when necessary. Another sort was done in the same manner after a period of two weeks where the researcher found no discrepancies with her last set of results. The developed categories together with their explanations and examples are outlined in Table 4.2.

To further test the validity and reliability of the researcher's analysis, she explained to a colleague the process that she used to analyse the PMM data. She told her colleague how the categories were developed and what type of content was common to each of the categories. Any questions and issues brought up by the colleague were discussed and resolved.

The researcher and the colleague then performed the card sort independently for inter-rater reliability. This approach was used for each of the three participant groups. At the conclusion of each sort the researcher and colleague compared their data. Overall, there was 94% agreement and the remaining 6% of the data were categorised after discussion and consensus. After the consensus the total number of responses in each category was calculated for each participant group in addition to the total number of responses given by that group. The total number of responses for all groups and the number of responses for each category for all groups were calculated at the end of the

Table 4.2 Examples and Responses of the PMM Categories from the Participants

Scientific Literacy Category from this Research	Explanation of the category	Participant Example (what the participant wrote)	Participants' Explanation of example (what the researcher scribed)
Science related to life	Can identify the science in their daily life or in the life of others	Engagement with real world problems, investigations and projects.	Scientific literacy the person becomes aware in the real world context then they apply what they know/learn to the issue. (PST)#
Science communication	Can talk about, read about, write about, watch, hear and discuss science	Oral reports, diagrams, graphs, tables.	You need to be able to read and interpret a variety of information. (HSST)#
Investigating	Are able to follow and understand the steps of an investigation from the problem to the conclusion	Methodology	Processes like an experiment and/or activity. To be scientifically literate you should apply a strict methodology. (GP)#
Informed decisions	Can make informed decisions about their environment (local and global) and about their own self (personal)	Informed about current science issues and make judgements about current science issues	E.g. media information on TV etc. How can we efficiently use science in our everyday lives? (PST)#
Questioning and sceptical	Can be questioning and sceptical about claims by the media or other communicators about science issues	Ethical consciousness	Have your ethical standpoint, e.g. to clone. You have ethical thinking. (HSST)#
Science content	Knows the content of science that can relate to Chemistry, Biology, Physics, Geology etc.	Chemistry	Understanding chemical combinations and what that represents. (GP)#
Resources and strategies	Has the items required and knows the ways of assisting in the development of science education	Books	In the library I have just had some books purchased. (PST)#

#PST = primary school teacher, HSST = high school science teacher, GP = general public

card sort. Percentages of responses were also calculated for each group and the whole sample. It should be noted that, even though they were given as much time as they needed, what participants wrote may only be part of what they know, and therefore not the full complement of what they really understand, know or mean. As the following interview was explorative, aiming to elicit explanations from individuals about what they wrote, there was no redirection to the participant by the researcher to focus on missing aspects. For example, some participants may have remembered some ideas after the conclusion of the interview and these ideas were not able to be included. Additionally, participants may have wanted to conceal some of what they were thinking as they may have believed it was incorrect so did not mention these aspects. These possibilities must be kept in mind when interpreting the findings.

### **Findings**

From the PMM interviews with the 54 participants a total of 400 responses were isolated, which represents an average of just under 7 responses per participant. The number and percentage for each of the participant groups in each developed category of scientific literacy are shown in Table 4.3. Each of these categories is discussed in turn.

#### **Science Communication**

Primary school and high school science teachers' most common response was categorised as science communication (24% and 29% of their responses, respectively). Fifteen of the primary teachers' responses involved reading, writing and talking about science. For example, one primary teacher believed that scientific literacy included being able to "talk, read, view, do and write about science and scientific understandings". She explained this by stating that students have to know the "science genres such as procedures, reports, experiments." Ten of the responses were related to the terminology of science, for example, one primary teacher thought that scientific communication involved the "words in the science program that children would need to understand in order to complete a scientific experiment." Seven of the primary teachers' responses were devoted specifically to reading scientific material. For example, one primary teacher thought that students should be "comfortable and confident in reading scientific reports, documents and texts."

Table 4.3 Number (Percentage) of Responses for Each Group in the Seven PMM Categories

Category	Primary School	High School	General Public	Total
Science Communication	32 (24%)	40 (29%)	27 (21%)	97 (25%)
Science Content	24 (18%)	15 (11%)	34 (26%)	72 (18%)
Resources and strategies	17 (12%)	13 (10%)	35 (27%)	64 (17%)
Science related to life	22 (16%)	21 (15%)	20 (16%)	61 (15%)
Investigating	26 (19%)	21 (15%)	9 (7%)	56 (14%)
Questioning and sceptical	9 (7%)	17 (13%)	2 (<2%)	28 (7%)
Informed decisions	6 (4%)	9 (7%)	1 (<1%)	16 (4%)
Total n	136 (34%)	136 (34%)	128 (32%)	400 (100%)
%	100	100	100	100

Twenty (half) of the high school science teachers' responses in the science communication category were about terminology or vocabulary. For example, one high school science teacher believed that science communication should be the "vocabulary", where he stated that this included "understanding terminology involved, if you understand the terminology you increase the comprehension of the science that you are reading." Twelve of the responses were related to written and oral communications, for



example, one high school science teacher thought that scientific literacy was about “communication and comprehension” which he explained as “being able to communicate with other people. Students should be able to communicate in layman’s terms.” Eight responses were about reading information. For example, one high school science teacher thought it was about “reading texts and extracting information including statistics so that students could extract the information from the texts”.

Interestingly, science communication was the third most common response (21%) for the general public and not the first as it was with both groups of teachers. Nineteen participants of the general public sample thought that scientific literacy was about the terminology of science. For example, one member of the general public believed that it was the “language, the words used in literacy that related to science” and another thought it was about “understanding the terminology in science, what it is and what it does.” Eight members of the general public thought it represented the development of an understanding through general to specific language. For example, one person thought that it was about the “layman’s terms for science, so that when you explain something to someone who doesn’t know the jargon you break it down for them.”

### **Investigating**

The second most common response for both groups of teachers related to investigating (19% and 15% respectively). Interestingly every teacher had at least one comment in this response section. Fourteen of the responses from the primary school teachers mentioned some aspect of investigation. For example, one primary teacher believed that it was about “the investigation process and the variables needed for fair testing that students needed to understand.” Another eight of the responses related to experiments, for example, one primary teacher thought that students should be able to “design and carry out research and experiments to reach own conclusions, these are investigations.” Four of the responses included aspects of the scientific method, for example, a primary teacher said that scientific literacy was about the

scientific method, the hypothesis, aim, method, results, conclusion including changing and improvements to the experiment. You need to look at the problem and

investigate it in a logical fashion using a process that has been shown to work – the scientific method.

Ten of the high school science teachers' responses were classified as investigating related to the scientific method. For example, one high school science teacher believed that scientific literacy included "writing experiments, aim, hypothesis, method results, and conclusion. This is a way of setting up experiments; you need to use the correct scientific tabulation." Six of the responses for this group involved problem solving or inquiry skills. For example, a high school science teacher thought that "scientific inquiry skills including problem solving strategies should be employed and this is where scientists may have a deeper understanding than others." Five of the responses related to fair testing and variable manipulation. One science teacher thought that scientific literacy included the "ability to identify variables in a situation, know what to control and know how to change the variables."

The responses for investigating (7%) were not as common for the general public as they were for the teachers. None of the general public's responses contained the word investigate. All nine comments for this group related to experimentation. For example, one person wrote "the methodology the processes, like an experiment or activity. When you do an experiment you should apply a strict methodology."

### **Science Content**

As shown in Table 4.3, science content was a common comment (26%) with the general public. This was also a noted response by the primary school teachers (18% of comments). The most common content idea for the general public (18 of 34 responses), related to a specific subject. For example, one person thought that scientific literacy would include "physics, understanding the equations, laws and other things in the physics subjects." Ten responses were about science concepts, for example, one member of the general public believed the "study of concepts, know the concept not the application of it" was important for scientific literacy. Six responses were about a combination of subjects, for example one person wrote that scientific literacy involved "science, chemistry, physics, biology, all things science."

Primary teachers' most common response involved knowledge about the history of science (14 comments). For example, a primary school teacher believed that to be

scientifically literate you needed to “know about important scientific discoveries, the history and development.” Six of the primary teachers’ comments related to general science facts. For example, one primary school teacher thought that it was about “facts, the knowledge base of the topic.” Four responses were about science concepts, for example, a primary school teacher thought it was important to “understand of the content of science to have a knowledge bank of concepts.”

Only 11% of the high school science teachers’ comments were representative of science content, which was lower than the number of comments from the general public and the primary school teachers. Eight responses related to science content in general. For example, one high school science teacher believed that scientific literacy should include “scientific knowledge so that you have a scientific basis.” Seven comments were about specific science subjects, for example, one high school science teacher thought you had to have a “fundamental knowledge about physics, chemistry, biology, geology and technical issues because our world is full of technical devices”.

### **Resources and Strategies**

Perhaps surprisingly, the general public’s most common response related to resources and strategies (27%, see Table 4.3). This group’s responses were about resources rather than strategies. The most common response (n=21) involved books about science. For example, one person thought that there should be “lots and lots of books available in the science classroom. Interesting ones not just boring science books” to support scientific literacy. Thirteen responses were about the equipment that was required for science, for example, one person believed that “unless you have some hands-on stuff related to scientific literacy the edges would get blurred. The actual factual stuff doesn’t get conveyed; e.g. an anatomy display and literature about the room should be available to schools.” One response related specifically to higher order science reading “journals regarding the literature of science.”

For primary school and high school science teachers there were fewer responses about resources (12% and 10% respectively), and teachers described with what and how they were going to inform the students about science. The most common response for primary teachers (nine responses) was related to obtaining information. For example, one primary school teacher wrote that you need to “understand where the information

can be obtained from, where to go to find stuff, e.g. the library, the internet, etc.” Six responses related to how they were going to teach the science. One primary teacher thought that to “teach science in an interesting way you need to be motivational especially with the junior primary.” Two responses were about the acquisition of resources. For example, one primary teacher believed, “You need books. I have just purchased some for the library.”

Ten of the high school teachers’ responses involved acquisition of resources by obtaining information, for example, one high school science teacher thought that scientifically literate people needed to know how to “search websites to extract information.” Three responses were simply about teaching; one high school science teacher thought that you could improve scientific literacy simply through “teaching”, and another teacher thought that the “syllabus was a way of breaking the information down into manageable parts”.

### **Science Related to Life**

Science related to life obtained almost the same number of responses from all three of the participant groups, about 15% (see Table 4.3). For the teachers, many examples were given about how they would relate the science to their students by using ideas with which students might be familiar. The most common idea, fifteen responses for high school teachers, related directly to everyday life. For example, one high school science teacher thought that to be scientifically literate you needed to “describe life in a scientific way, for example, when you are teaching electricity, talk about what the students know about it in their own life.” Five comments involved linking science in the classroom with everyday life, for example, one science teacher believed, “you need to relate to real life not just lab life.” One response represented the awe of everyday science “the content is fascinating and amazing and all around us. If you can see this you have the wow of science!”

Twelve of the primary school teachers’ responses in this category involved making links with science and everyday life. For example, one primary teacher thought that it was necessary to “make links between everyday life and science. Science is integrated with everything in our life.” Eight of the responses were about world issues, for example, one primary teacher thought that the “engagement of real world problems

should be the focus of investigations and projects. A scientifically literate person becomes aware in a real world context then applies what they know of have learned to the issue.” Two of the responses related to the relevance of science, for example, “science should be relevant to every day experiences.”

Nine of the general public’s comments were related to real world experience. For example, one person thought it was about “linking theory to the real world, applying the science to your own life”. The public offered examples of their daily experiences in seven of the responses, for example one said, “knowing about all the chemicals you need to make beer.” Four of the responses were about science and the environment; for example, one person wrote “recognising science in our environment.”

### **Questioning and Sceptical Attitude**

The category relating to being questioning and sceptical attracted 17 responses (13%) from high school science teachers. Seven comments related to understanding how to interpret the validity of science work. For example, one science teacher thought “you need to have enough information to be able to determine the validity of your own work and the work of others.” Six comments involved being able to be critical about the science students read. For example, one teacher believed they needed “the ability to read, understand and critique science related articles in the media.” Four comments were about the value of evidence in scientific endeavour, for example, one teacher thought that “to have scientific literacy that you accept that there are different opinions [views] and you can make your own view based on evidence not on people. It is a more objective view”.

Being questioning and sceptical and making informed decisions were uncommon responses for primary teachers and the general public. Four responses from primary school teachers related to being critical of scientific information. For example, one teacher said scientific literacy required a person being “critical of information, not taking on science as blind faith, look at the evidence behind the statement”. Three of the responses were about being sceptical about information, for example, a primary teacher thought that you needed to have “scepticism having the skills to view scientific finding objectively.” Two responses referred to making judgements about scientific issues. For example, one teacher thought you needed to be “informed about current scientific issues

and make judgments about current issues.” The comments from the general public were about finding out the truth about current science, for example, one person thought they needed to know “what is the truth?”

### **Informed Decisions**

All three participant groups had the lowest number of comments in the informed decisions category. Four of the high school science teachers’ responses involved global environmental issues, for example, one teacher believed you should have a “global awareness especially of environmental issues.” Three comments referred to ways in which to act about environmental issues. One teacher wrote that it was important to have “an awareness of what we can do now to (hopefully) help the future.” Two responses involved the ethics of science; one teacher thought that you needed to have an “ethical consciousness.”

Four of the primary school teachers’ responses related to environmental issues. One teacher believed it was about “understanding that we need to look after and respect the environment”, and another wrote “how science is helping or ruining the environment.” Two of the responses related to the ethics of science, as one teacher wrote, it was about “the moral issues using science responsibly.”

### **Comparison of Responses with the Definition of Scientific Literacy**

Following the analysis the categories developed in this research were mapped against the definition of scientific literacy (Rennie et al., 2001) used in this study to determine similarities and differences. Examination of the data in Table 4.4 reveals that many of the aspects of scientific literacy from the definition are reflected by the PMM categories developed in this study. In addition to the five categories that were mapped to the definition of scientific literacy, two additional categories were identified. The first of these, identified by all three participant groups in the PMM interviews, related to the “science content”, as they believed that scientific literacy required some knowledge of science. The science content category was not subsumed under the category science related to life as the participants were very specific about limiting their responses to specific subject areas of science that they recalled from their prior education. It does, however, have some overlap with the aspect “are interested in and understand the world

around them”. The other additional category identified in this research, by all of the participant groups, was “resources and strategies” needed for teaching science.

Table 4.4 Relationships Between and the PMM Categories and the Definition of Scientific Literacy

Scientific Literacy Category from this Research	Scientific Literacy aspect from definition (Rennie et al., 2001)
Science related to life	Are interested in and understand the world around them
Science communication	Engage in communication of and about science
Investigating	Are able to identify questions, investigate and draw evidence based conclusions
Informed decisions	Make informed decisions about the environment and their own health and well being
Sceptical and questioning	Are sceptical and questioning of claims made by others about scientific matters
Science content	
Resources and strategies	

### People’s Views of Scientific Literacy

As a way of summarising what was learned about people’s views of scientific literacy, the following three assertions were developed. They were a result of the researcher’s reflection on her field notes and examination of the results of the PMM interviews.

#### *Assertion 1: People’s understanding of scientific literacy is based on both formal and informal learning experiences*

Participants seem to have based their interpretation of scientific literacy on what they have read or on an influential person’s views to which they have been exposed. For example, Brian, a primary school teacher and recent graduate, verbalised as he wrote his list of aspects onto the A4 sheet of paper. During his PMM interview he said, “now I

remember these from uni [university], now which one am I missing...oh...um...what was that lecture all about again?" Thus, he demonstrated that he was trying to remember a list rather than having an understanding of scientific literacy that was meaningful.

An individual may be scientifically literate in their actions and behaviours, but when faced with the phrase in isolation from a contextualised situation may report understandings that suggest a lack of knowledge about scientific literacy. For example one of the general public participants, Maeve, chose to look at the terms "scientific" and "literacy" as separate entities, while another participant revealed his/her knowledge of the content of science and referred to science in isolation with no mention of literacy. Further, a person may be scientifically literate but have a misconception of the phrase. For example, several participants believed it was about the literature of science, or limited only to reading and writing in science. Hence, the level of education of the participants, both formal and informal, also plays a role in their understanding of scientific literacy. The researcher was able to identify aspects of scientific literacy that participants did not mention in the PMM interviews through examination of their actions in their daily lives. For example, one participant, who appeared to have a limited understanding of scientific literacy from the PMM interview, discussed at length several current environmental issues.

Perceptions based in past traditions or norms can be biased and simplistic. For example, Paul, a Business Marketing graduate, believed that "if you want to be a scientist, the study of the physics, chemistry and biology are important because these are the most important science subjects – they have all the basic fundamentals". He stated that he did not believe it was important for everyone to understand science, only those who engaged in science occupations. Interestingly, another aspect that Paul mentioned was about "technology" where he thought the "application of science – used for a specific purpose or application e.g. IT application of physics/engineering. When it comes to technology you need to combine all of the above physics, chemistry, biology so these people in IT need to know about science."

Participants who have not had the opportunity, or do not feel that they are able to question scientific issues may be limited in their understanding. The advent of the internet and similar technologies that allow fast and easy access to a myriad of



information, in addition to the increased openness of debates and discussion in a variety of accessible media, may not ensure a more informed or a more sceptical and questioning public.

*Assertion 2: Self-efficacy in science plays a central role in what participants understand, believe and are willing to share about scientific literacy*

Fifteen of the 18 participants from the primary school group were reluctant to explain what they thought scientific literacy meant to them. They believed that they did not know the answer to “What does scientific literacy mean to you?” and needed to be supported into writing anything down. When they did, many of the participants wrote words/phrases that related to at least some of the aspects of scientific literacy in the currently accepted definition, especially the aspects of science communication and investigating. Interestingly, they consistently made negative comments about their own ability to complete this task. For example, Lisa, who had been teaching in primary schools for seven years, thought aloud, “this isn’t right, I’m not sure what I am saying”, and Melanie, a primary teacher of 20 years, stated “I don’t know about this, I am just guessing”. These issues are reflected in the amount of science taught by many primary school teachers. If primary school teachers teach only minimal science there is less opportunity to engage in thinking about the aspects of scientific literacy with their students. Furthermore, if primary teachers are teaching science in their classrooms they need to be informed of what is required of them to promote scientific literacy among their students if this is the goal.

High school science teachers were much more confident about their ideas. They were told, as were all other participants, that the researcher was interested in *their* interpretation of scientific literacy. Six of the 18 participants immediately interpreted this request as the researcher developing a definition and they must present the researcher with ideas that will be included. For example, Matthew had been teaching science for over 35 years and he thought “what you need to know is that there should be a lot of reading, not just text books but other books from the library”, and Scott, a science teacher for 15 years, stated “[scientific literacy] should include all the language skills in science, all the spelling words and how to write up a lab report.” However, high

school science teachers' greater confidence compared to primary teachers did not ensure their increased number of responses in all of the categories of scientific literacy. Rather, it suggested that they were more willing to respond because they felt confident about the subject of science.

The general public's most common responses related to resources and strategies (27%) and science content (26%). The researcher observed that the participants in this group showed similarities in the way they responded to the primary teachers, where they believed they were not qualified to answer the question. For example, Gerry, a postal officer, said "I don't know what I am supposed to do here, I am just making suggestions, I don't know if they are right," and he asked, "Can you tell me if I am right?" Susan, a science laboratory technician in a high school asked, "Isn't this for the teachers to know? I know about the lab equipment and how to set up some experiments but I don't really know about scientific literacy."

The participants' attitudes and explanations in the PMM interviews revealed that they could be placed on a confidence continuum, ranging from some of the almost overconfident high school science teachers, to those that lacked confidence like primary teachers and the general public. Hence, self-efficacy may have an impact on the way understanding of scientific literacy will be interpreted by these groups.

*Assertion 3: Cultural backgrounds and social interactions are important in the development and understanding of scientific literacy*

Esther, a high school science teacher from Mozambique, believed that scientific literacy should include "multiscience" (to be able to make choices). She explained this to the researcher as when students would "have knowledge about alternative ways not just the scientific ones. Spiritual, indigenous, religious alternatives", when dealing with decisions that involve science.

The understanding and interpretation of science and scientific literacy through the eyes of a particular culture is an important factor when addressing understanding. For some cultural groups, science is about how they can blend traditional beliefs with Western science. In many countries with indigenous populations, such as Australia, Africa and New Zealand, indigenous persons view their science through the cultural

landscape of their heritage (Clandinin & Connelly, 1996). How science is taught and learnt by cultural and social groups is important when developing the understanding of scientific literacy. Traditional cultural history is tenaciously defended in many countries, and the juxtaposition of modern science has been perceived as one of the major threats to their cultural heritage. Consequently, the development of negative opinions of science, scientists and science knowledge may have impacted on both the understanding and interpretation of scientific literacy (Cobern et al., 1995).

Heather, a New Zealand Māori and a high school science teacher of Māori students, stated in her PMM that “understanding concepts and behaviours” was an important aspect of scientific literacy. This meant to Heather that students could see the relationship between natural life and science taught in schools so that they could “understand why we group things together into ideas, therefore students know that science isn’t just for them. Māori students need to understand that science concepts and the things that occur [in our daily life] are related”. Lilly, a primary teacher in Australia, revealed that

catering for children in this multicultural school needs  
careful attention when you are planning anything,  
sometimes children are not permitted to participate in  
certain activities or discussions. These are the wishes of  
their parents so we must respect them and work around  
them to be inclusive of the kids.

### **Summary of Chapter**

This chapter looked the ways PMM interviews could be used to understand people’s views of scientific literacy and examined how the method was used in this study. The meaning of scientific literacy, based on categories developed through the reading of participants’ responses, showed similarities to those that were developed in previous definitions. An examination of the findings revealed that the three participant groups, primary school teachers, high school teachers and the general public, showed some commonalities in their responses to the scientific literacy. The most common responses for all three participant groups were those that related to science

communication. The least common aspect of scientific literacy for all three groups was making informed decisions.

Through using participants' comments in the PMM, and other comments and observations during the PMM interviews, the researcher was able to produce three assertions which related to factors that may impact on participants' understanding and expression of scientific literacy. These assertions related to participants' learning experiences, their self-efficacy and cultural and social interactions.

## **CHAPTER 5**

### **FENCHURCH PRIMARY SCHOOL**

#### **Introduction**

This chapter describes the findings from data collected from the students and teachers of Fenchurch Primary School. It provides a background to the PD program, along with an overview of the workshops presented to the staff. The chapter then presents the data collected from the school, in a chronological order, together with their analysis.

#### **Background to Fenchurch Primary School**

Fenchurch, a metropolitan state school, is over 100 years old. The school is situated 25 km from Perth city in a mixed socioeconomic area (middle and high income earners) and had, during the time of the study, a staff of 12 teachers. There were 10 female teachers and 2 male teachers, a male deputy principal and a female principal, giving a total of 14 staff. At the time of the data collection the school had 230 students from Kindergarten (4 years of age) to Year 7 (12 years of age). Science was taught in each class by the class teacher. Some teachers were specialists (e.g. Art, Italian) and some were part-time, so not every teacher in the school taught science.

Fenchurch selected Science as an education priority at the end of 2004, following a school-based and initiated survey completed by the whole staff. The results revealed that staff felt that their knowledge, confidence and pedagogical skills were most limited in the areas of Science and Technology and Enterprise, specifically in the areas of planning and assessment. The deciding factor that made the school staff select Science, rather than Technology and Enterprise, was attributed to data received as feedback from a non-school based student survey late in 2003 (Rennie, 2004) which indicated that students' learning in and attitudes toward science in the school were sound but could be improved. In 2005, Fenchurch staff selected two school priorities; Science and the new Western Australian state-wide assessment system. As part of their Science priority the staff decided that PD sessions in science would be a suitable starting place to improve their PL.

The principal, in consultation with the whole staff, reviewed the PD options available to primary school teachers and selected the KSS PD program because it was flexible in

terms of content and delivery and could be designed to meet staff needs. After consultation with an Education Officer from the KSS, Fenchurch selected three PD workshops: Working Scientifically; Developing Conceptual Understandings in Science with specific reference to the content area of Earth and Beyond; and Planning and Assessing with an emphasis on Earth and Beyond. The staff believed that these PD workshops would be most beneficial for their PL as they covered both school priorities at the same time. Three half-day PD sessions took place in the first semester of 2005 with half of the staff attending the morning sessions and the remainder attending a repeat session in the afternoon. All teachers and administrators participated in the PD program. At the beginning of each PD session, an activity book and support materials to assist in the follow-up implementation of ideas were provided to all attending staff.

### **Overview of the Fenchurch Workshops**

The three Science PD workshops are outlined below.

*Workshop 1 (March 15, 2005): The Beyond of Earth and Beyond (Astronomy)* covered the Western Australian curriculum science content area of Earth and Beyond focussing on Astronomy. This workshop offered materials and ideas about Astronomy that aimed to assist teachers in their conceptual understanding of the topic. It included various hands-on activities for teachers.

*Workshop 2 (May 2, 2005): Working Scientifically Through Open Investigations* covered the Western Australian curriculum science area of Working Scientifically paying particular attention to Investigating and how Investigating could be used in Astronomy. It explored the Earth and Beyond outcomes with activities in Astronomy, and looked at strategies to incorporate Investigating as part of the teachers' programs.

*Workshop 3 (June 27, 2005): Planning and Assessing* covered the area of planning and assessing incorporating Investigating and the content area of Earth and Beyond. This workshop took teachers through a planning process using the Western Australian Curriculum Framework (Curriculum Council, 1998), Curriculum Guides and the Outcomes and Standards Framework/Progress Map (Curriculum Council, 2005).

## Findings

Data were collected from seven sources as outlined in the methodology section: PD WFS, Teacher Questionnaires, Student Questionnaires, PMM Interviews, Formal and Informal Teacher Interviews, Informal Student Interviews and Observations of Classroom Lessons. Table 5.1 shows the timeline for administration of the data collection methods.

### **Professional Development Workshop Feedback Sheet**

The WFS is a survey routinely used by the KSS PDP staff to obtain feedback on their workshops (see Appendix 1), and is completed in two stages. Before the workshop, teachers completed five demographic questions (these are not analysed), an open-ended question about their expectations of the workshop, and five items on which teachers were asked to rate their attitude and perceptions about their teaching of science in their classroom. A 4- point rating scale, with response choices from “strongly agree”, “agree”, “disagree”, “strongly disagree” was used.

At the end of the workshop, teachers completed the second page of the WFS. They rated five items similar to those used in the pre-professional development WFS (with small wording changes to capture the post-workshop context), and completed four open-ended questions about their responses to the workshop and subsequent actions they planned to take. The number of participants for each of the workshops varied (11 to 15) due to staff absences and attendance of a pre-service teacher.

### ***Teachers’ Attitudes and Perceptions about Confidence and Pedagogical Skills Before and After the PD Workshops***

The first part of the Pre- and Post-Professional Development WFS contained five items for which teachers were asked to rate their attitude and perceptions about their teaching of science in their classroom before and after attending the PD workshop. The results are analysed by workshop.

Table 5.1 Data Collection Timeline for Fenchurch

Data	Mar 2005	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan 2006	Feb
Professional Development & Workshop Feedback Sheets	√		√	√								
Teacher Questionnaire							√					
Personal Meaning Mapping Interviews							√					
Teacher interviews -Cluster Group					√							
-Case study class teachers												√
-Informal				√	√	√	√	√	√	√		
Student Questionnaire									√			
Informal Student Interviews								√	√	√		
Observation of lessons								√	√	√		



### Workshop 1: The Beyond of Earth and Beyond (Astronomy)

Table 5.2 presents a comparison of pre- and post-workshop teachers' attitudes and perceptions about science teaching in Workshop 1. The results for Item 1 show that before the workshop, 92% (12 teachers) responded agree or strongly agree to having a positive attitude toward teaching science. The corresponding post-workshop item revealed that teachers remained positive about science, with several teachers responding more positively. Before the workshop, 92% (12 teachers) agreed that they needed adaptable pedagogical skills and ideas to use in the science class (see Item 2). After the workshop, all teachers were satisfied that they had been given pedagogical skills and ideas to use in the classroom. Interestingly, two teachers moved from strongly agree to agree in their response after the workshop. One possible reason for this might be that these teachers believed they needed to acquire more practical and adaptable pedagogical skills than what the workshop offered.

Table 5.2 Fenchurch Teachers' Pre- and Post-workshop Attitudes and Perceptions about Teaching Science in Workshop 1 Astronomy (%)

Wk shop	Item Pair no.	Item Content	SA	A	D	SD
Pre	1	Currently I have a positive attitude towards teaching science	54	38	8	0
Post		I have a positive attitude toward teaching science	70	30	0	0
Pre	2	Currently I need adaptable skills and ideas to use in the classroom	70	22	8	0
Post		I have been given adaptable skills and ideas to use in the classroom	54	46	0	0
Pre	3	Currently I am confident in planning effective science programs	8	54	30	8
Post		I could confidently plan effective science programs	62	30	8	0
Pre	4	Currently I can confidently deliver effective science programs	8	54	30	8
Post		I could confidently deliver effective science programs	62	30	8	0
Pre	5	Currently I feel confidently able to facilitate student achievement in science outcomes	8	46	46	0
Post		I could confidently improve students learning in science outcomes	46	46	8	0

Note: N=13

The remaining three item pairs related to teacher confidence. Generally, the results from Table 5.2 illustrate an increase in teachers' confidence after the PDP workshop; 62% (8 teachers) were confident in planning effective science programmes before the workshop compared with 92% (12 teachers) after it (Item pair 3). Similarly, 62% were confident of delivering effective science programmes before the PDP workshop, increasing to 92% (12 teachers) after the workshop (Item pair 4). The final item pair, relating to confidence in facilitating student achievement, revealed that only 54% (7 teachers) were confident in this aspect before the workshop, compared with 92% (12 teachers) in the post-workshop response (Item pair 5).

The overall results reflect that teachers already had a positive attitude toward science and were amenable to new ideas. The post-workshop results for the first two item pairs show that teachers agreed they needed and were provided with adaptable pedagogical skills and ideas to use in the classroom. The results in Table 5.2 show positive outcomes of the PDP workshop, in the area of teacher confidence, with most teachers' gaining confidence as a consequence of the PDP workshop.

### **Workshop 2: Working Scientifically Through Open Investigations**

Table 5.3 presents a comparison of pre- and post-workshop teachers' attitudes and perceptions about science teaching in Workshop 2. As for Workshop 1, there was little change before and after the PD workshop in Items 1 and 2. Ninety three percent of teachers had positive attitudes toward teaching science before the PD experience, with 100% responding positively after the PD program. The pre- and post-workshop sections of the survey for Item 2 showed a small movement from agree to strongly agree in the complementary post PD program item. Teachers agreed they needed, and were given, adaptable pedagogical skills and ideas to use in the classroom.

The data in Table 5.3 also illustrate that teachers were more confident in the planning and delivering of effective science programs, and facilitating student achievement, as a consequence of completing the PD workshop. Prior to the workshop only 53%, 54% and 47% respectively of teachers were confident in planning, delivering and facilitating before the workshop (Items 3, 4 and 5), In contrast, all teachers were confident after the PD workshop.

**Table 5.3 Fenchurch Teachers' Pre- and Post-workshop Attitudes and Perceptions about Teaching Science in Workshop 2 Working Scientifically (%)**

Wk shop	Item Pair No.	Item Content	SA	A	D	SD
Pre	1	Currently I have a positive attitude towards teaching science	33	60	7	0
Post		I have a positive attitude toward teaching science	47	53	0	0
Pre	2	Currently I need adaptable skills and ideas to use in the classroom	33	67	0	0
Post		I have been given adaptable skills and ideas to use in the classroom	47	53	0	0
Pre	3	Currently I am confident in planning effective science programs	0	53	40	7
Post		I could confidently plan effective science programs	33	67	0	0
Pre	4	Currently I can confidently deliver effective science programs	7	47	47	0
Post		I could confidently deliver effective science programs	27	73	0	0
Pre	5	Currently I feel confidently able to facilitate student achievement in science outcomes	0	47	53	0
Post		I could confidently improve students learning in science outcomes	33	67	0	0

Note: N=15

### **Workshop 3: Planning and Assessing**

Table 5.4 reports the comparison of pre- and post-workshop teacher attitudes and perceptions about science teaching in Workshop 3. Similar to Workshops 1 and 2, there was little change in Item 1, with teachers generally positive toward teaching science before the workshop, with every teacher responding positively after the workshop. The results from Item 2 also showed a positive trend, with all teachers agreeing they needed and were given adaptable pedagogical skills.

As in Workshops 1 and 2, the results in Workshop 3 for Items 3, 4 and 5 revealed a positive movement in teachers' attitudes and perceptions after the PD workshop. The pre-workshop survey showed 45% (5 teachers) were confident in planning effective science programmes, 54% (6 teachers) were confident of delivering effective science programs and 46% (5 teachers) were confident to facilitate student achievement. After

the PD workshop all participants' reported that they were confident to engage in these three aspects.

Table 5.4 Fenchurch Teachers' Pre- and Post-workshop Attitudes and Perceptions about Teaching Science in Workshop 3 Planning and Assessing (%)

Wk shop	Item Pair no.	Item Content	SA	A	D	SD
Pre	1	Have a positive attitude towards teaching science	45	45	10	0
Post		I have a positive attitude toward teaching science	64	36	0	0
Pre	2	Need adaptable skills and ideas to use in the classroom	45	55	0	0
Post		I have been given adaptable skills and ideas to use in the classroom	64	36	0	0
Pre	3	Currently I am confident in planning effective science programs	18	27	55	0
Post		I could confidently plan effective science programs	64	36	0	0
Pre	4	Can confidently deliver effective science programs	18	36	45	0
Post		I could confidently deliver effective science programs	45	55	0	0
Pre	5	Feel confidently able to facilitate student achievement in science outcomes	10	36	55	0
Post		I could confidently improve students learning in science outcomes	45	55	0	0

Note: Due to rounding not all rows add to 100 (N=11)

In summary, the majority of teachers came to the PD workshops with positive attitudes toward science, and maintained or improved their attitudes after the PD workshops. Teachers believed that they need and were given adaptable pedagogical skills in all three of the PD workshops. For each workshop, the data show that all teachers believed they were more confident with planning, delivering and facilitating science lessons by the conclusion of the workshop. Interestingly, at the commencement of the second and third workshops, the data showed that teachers appeared to be less confident than at the conclusion of the previous workshop. This is understandable as the three PD workshops related to three different areas of science: the content of Earth and Beyond (Astronomy); Working Scientifically through Open Investigations; and Planning and Assessing in Earth and Beyond. Each workshop represents a unique aspect of

science for the teachers and although all are related to teaching and learning in science there seemed to be disparity between teachers' confidence levels about these three areas.

### *Teachers' Attitudes and Perceptions about Knowledge, Pedagogical Skills and Confidence, Resources and Leadership through Open-Ended Responses*

The results of the four open-ended questions on the WFS are presented below. The content of teachers' responses were analysed, as described in Chapter 3, and clustered into six categories; knowledge, pedagogical skills, confidence, resources, leadership/collaboration and reflection. In this section the open-ended questions are analysed across the three workshops.

Question 1 (see copy of the WFS in Appendix 1) was answered before the Workshops began. Teachers were asked "What would you personally like to achieve as a result of attending this workshop?" Table 5.5 presents the percentage of comments that fell into the categories of knowledge, pedagogical skills, confidence, resources and leadership/collaboration.

The largest percentage of comments, in all three workshops, related to acquiring pedagogical skills (see Table 5.5). Examples of such comments included "improved teaching skills" (Workshop 1), "new strategies to help teach science" (Workshop 2), "proformas and rubrics" (Workshop 3) and "greater organisational and programming skills" (Workshop 3). Whilst all these comments relate to pedagogical skills, teachers often referred to the skills most likely to come from that particular workshop.

The next most common response related to knowledge. Examples of such responses included "knowledge to use in the classroom" (Workshop 2), and "knowledge to incorporate science as a fun and inspiring classroom activity" (Workshop 3).

Two teachers made comments relating to teacher confidence. In Workshop 1 one teacher stated she wanted to achieve "have a more specific idea of what I am meant to be doing", while in Workshop 2 one teacher wanted "confidence and ideas to implement successful scientific learning experiences in the classroom". There were no comments relating to confidence at the start of the third Workshop.

Two additional responses were obtained from Question 1, one relating to resources and one relating to leadership/collaboration (see Table 5.5). The responses about resources occurred in Workshop 3 where one teacher wanted "more hands-on

activities”. The leadership/collaboration response that occurred in Workshop 1 stated that the teacher wanted to be “able to support the school better”.

Table 5.5 Fenchurch Teachers’ Responses to the Question, “What would you personally like to achieve as a result of attending this workshop?”

Comment category	% of comments		
	Workshop 1 Earth and Beyond	Workshop 2 Working Scientifically	Workshop 3 Planning and Assessing
Knowledge	9	15	6
-need a better understanding of science and outcomes			
Pedagogical Skills	76	76	88
-help with planning and programming			
-teach science to young children			
-ideas for task and activities			
Confidence	9	9	-
-increased confidence to do science			
Resources	-	-	6
-resources that can help			
Leadership/collaboration	6	-	-
-to support staff			
Number of comments	19	23	16
Number of teachers	13	15	11

After the Workshops teachers were asked three additional open-ended questions. Question 1 asked teachers “What actions do you plan to take following today’s session?” Table 5.6 presents the percentage of comments that fell into the categories of knowledge, pedagogical skills, confidence, resources, leadership/collaboration and reflection.

The largest number of responses from Workshops 1 and 3, (76% and 57% respectively) were related to pedagogical skills (see Table 5.6). Examples of these comments included “plan a theme around Astronomy” (Workshop 1) and “plan science for next term” (Workshop 3).

Table 5.6 Fenchurch Teachers' Responses to the Question "What actions do you plan to take following today's session?"

Comment category	% of comments		
	Workshop 1 Earth and Beyond	Workshop 2 Working Scientifically	Workshop 3 Planning and Assessing
Knowledge	8	-	-
-look at the science content			
Pedagogical Skills	76	10	57
-design own activities			
-enthuse students			
Confidence	-	10	-
-have fun with science			
Resources	8	70	43
-refer to and use material			
Leadership/Collaboration	8	-	-
-work with others			
Reflection	-	10	-
-review current practice			
Number of comments	13	21	14
Number of teachers	13	15	11

In Workshops 2 and 3, many comments were related to acquiring or using resources (70% and 43% respectively). For example "incorporate planning sheet box" (Workshop 2), "use the planning documents" (Workshop 3), and "familiarise myself with planning notes" (Workshop 3). Additionally, one comment in Workshop 1 described how the teacher believed s/he would collaborate by writing as s/he wished to "participate in a whole school science program".

Question 4 (see Appendix 1) asked teachers: "Has this workshop affected your views about teaching science?" The largest number of comments in Workshops 1 and 3 related to knowledge. Examples of such comments included "having the handbook with all the definitions [of Astronomy] will be most helpful to me" (Workshop 1) and "a greater understanding of outcomes based planning and activities" (Workshop 3).

Another frequent response to this question related to confidence, with 35% of the comments from Workshop 2 and 26% from Workshop 1. For example, in Workshop 1 one teacher wrote that the PD had “made me not so scared to talk about issues I don’t understand”. In Workshop 2 one teacher thought that the PD had made her/him “more confident to develop a science program”. In Workshop 3 one teacher simply wrote the words “very positive”.

Nine other responses related to pedagogical skills. In Workshop 1 one teacher thought that the PD had “made it easier to plan”, in Workshop 2 a teacher wrote that “it [the PD] has given me ideas to extend, experiment and to also provide children with a structure when completing experiments.” Additionally, after Workshop 3 a teacher explained “I now know you can apply science to any real-life situation such as ‘Which paper is most appropriate to soak up a liquid?’”. Seven respondents stated that the workshop had affected their views about teaching science but did not elaborate how their views had been affected.

Table 5.7 Fenchurch Teachers’ Responses to the Question “Has this workshop affected your views about teaching science?”

Comment category	% of comments		
	Workshop 1 Earth and Beyond	Workshop 2 Working Scientifically	Workshop 3 Planning and Assessing
Knowledge	36	24	41
- given a better understanding of content and concepts			
Pedagogical Skills	16	24	17
-I have found that there are alternative approaches and new ideas			
Confidence	26	35	17
-it has increased my confidence			
Resources	11	6	-
-resource materials are useful			
Yes, gave no reason	11	11	25
Number of comments	19	17	12
Number of teachers	13	15	11



Question 5 (see Appendix 1) asked teachers: “What was the main message you gained from today’s workshop?” Table 5.8 shows the largest number of comments in Workshop 3 related to pedagogical skills. For example, in Workshop 3 one teacher thought that the main message was to “use the available ideas to make it [science] easier”. Additionally comments about pedagogical skills were also common in Workshop 2, for example, one teacher thought that the main message was that “science can be hands-on and applicable to life”.

The most frequent responses in Workshops 1 and 2 related to confidence. In Workshop 1 one teacher thought that the main message was that “science is easy and enjoyable”. In Workshop 2 a teacher thought the message was to “have a go and find science in everything”. Other responses about resources and knowledge were also identified. For example in Workshop 2 one teacher thought that the main message was about the resources when they wrote “a simple activity can provide a wealth of learning”.

Table 5.8 Fenchurch Teachers’ Responses to the Question “What was the main message gained from today’s workshop?”

Comment category	% of comments		
	Workshop 1 Earth and Beyond	Workshop 2 Working Scientifically	Workshop 3 Planning and Assessing
Knowledge	-	5	-
- It has given me a clearer perspective			
Pedagogical skills	38	30	77
-science can be integrated			
Confidence	62	45	8
-increased my confidence			
Resources	-	20	15
-help is available			
Number of comments	13	20	13
Number of teachers	13	15	11

In summary, analysis of the open ended responses showed that, in anticipation of all three workshops, the staff's highest priority was to gain pedagogical skills. From Workshops 1 and 3 the most common action that staff planned to take after the PD workshops related to their use of newly acquired pedagogical skills. The staff believed they had a repertoire of science activities to use and that they had the pedagogical skills to teach science. After Workshop 2, the teachers' most common expected action was to use the resources made available to facilitate their planning, programming and students' learning. In this workshop, the staff's views had been most affected by giving them increased confidence to teach science, while in Workshops 1 and 3 the most common response related to a better understanding of the Astronomy content and how to plan and assess, respectively. Most staff found the main message of Workshops 1 and 2 was about their increased confidence, while in Workshop 3 the most common response related to the pedagogical skills teachers had acquired for planning and assessing in science.

A follow-up discussion with Edith, the Education Officer, revealed that she was pleased by the WFS data from Workshop 3. In Edith's words, her previous experience of the teachers' understanding of the Planning and Assessing workshops

had always been OK but they [the teachers] definitely found this workshop the most challenging. So I was really surprised and happy that the Fenchurch teachers were so positive about the Planning and Assessing workshop. (Field notes, 10<sup>th</sup> August, 2005)

Further discussion with Edith drew attention to the presentation order of the workshops. As the Planning and Assessing Workshop was possibly the most challenging workshop for teachers it may be best to have this workshop scheduled as the final one. This would enable teachers to have time to become familiar with other aspects of science and have more knowledge, confidence and skills before embarking on planning and assessing.

## **Teacher Interviews**

### ***Staff Cluster Meetings***

All staff were interviewed in one of three cluster meetings which took place a month after the third PD workshop. The interviews were based around the four questions outlined in Figure 5.1.

- |  |
|--|
| <ol style="list-style-type: none"><li>1. What did you hope to get out of the PD?</li><li>2. What did you like best about the PD?</li><li>3. How are you going to utilise anything you have learnt in the PD?</li><li>4. How long is each science topic or theme?</li></ol> |
|--|

Figure 5.1. Interview questions used at Fenchurch staff cluster meetings

A themed summary of the responses to the questions is outlined below in relation to knowledge, confidence, pedagogical skills and resources.

### ***Knowledge***

Before the PD program, teachers wanted to increase their knowledge base of the Earth and Beyond content and teachers believed that they had achieved this goal. This increased knowledge base was evident through teacher engagement in the Astronomy topic (a few teachers brought some examples of their students' work to the cluster meeting). Some teachers also noticed that because more time was spent during the school day talking about science, this had resulted in students doing science at home and taking science-based books out of the library for the students' own enjoyment.

### ***Confidence***

Before the PD program the teachers wanted to increase their confidence in the teaching of science. The aspects of the PD that teachers believed assisted in their improved confidence related to the PD presenter. The teachers believed that because the presenter was patient, made connections to aspects of life that they knew, and valued their ideas and opinions, it promoted their confidence. As Penny said, she "showed us how we learn" and encouraged the participants. Furthermore, the teachers felt that because the presenter valued their ideas they found the confidence, as Merv explained, "to let kids extend themselves" (26<sup>th</sup> July, 2005).

### ***Pedagogical Skills***

Prior to the PD workshops, the teachers believed that the PD should be able to give them ideas on how to do "hands-on", interesting and relevant activities related to student outcomes, especially in early childhood education. Specifically, teachers wanted to know how to introduce a science topic and how to make it relevant and easier for

them to teach. From their participation in the workshops they knew that the activities worked and could be transferable to other areas of the science curriculum, Sigrid informed the researcher that “I have used the organisational skills I learnt in the PD to allow students to do a variety of small group activities”. They also believed that they had the pedagogical skills to be able to modify some of the resources. As Mark explained, “I can modify the activities we did quite easily to use with my Year 4s”.

### **Resources**

In anticipation of the workshops, teachers also wanted the PD to provide easy to come by, inexpensive, relevant and novel resources and ideas. Teachers believed this was achieved as the resources, both those provided on paper and ideas suggested, were very good. For example, teachers believed that they were already using the investigating and planning proformas from the PD program successfully. They felt that the resources suggested in the workshops could easily be purchased in a local store and would be affordable within their science budget. Additionally, many teachers believed they would be able to adapt them to use with their particular year level. However, an Early Childhood teacher thought that many of the resources and strategies presented in the PD would need to be modified for the Early Childhood level as they teach science in an integrated manner, and this would take considerable time.

Generally, teachers were positive about the outcomes of the PD program in relation to knowledge, confidence, pedagogical skills and resources. However, teachers felt that they still needed time to engage and reflect on the knowledge they had gained and resources they were given at the workshops. They believed this would eventuate as they implemented more science in their classrooms. Further, the results of the cluster interviews were consistent with the findings from the open-ended questions relating to the WFS. This suggests that since the workshops the teachers have taken some of the actions they foreshadowed earlier.

### **Teacher Questionnaire**

The two case study teachers, Katorina and Emily, were given the Teacher Questionnaire to complete during an individual teacher/researcher interview, three months after the third PD Workshop. Both teachers chose to engage in discussions with the researcher during their completion of the Teacher Questionnaire. These discussions

involved the teachers asking the researcher for clarification of some items and teacher explanations of their item response choices, increasing the researcher's understanding of the responses supplied by the teachers in the Teacher Questionnaire. Results from the Teacher Questionnaire are presented in terms of the teachers' background and experience, science programming in 2005, attitudes and perceptions of teaching science, reasons for teaching science, and teachers' pedagogical strategies.

### ***Teachers' Background and Experience***

Katorina and Emily team-taught 60 Year 6 and 7 students in most subject areas which included science. They had attended all three PD sessions in 2005. Both were experienced primary school teachers. Katorina had a Bachelor of Education and had been teaching for 21 years. Emily had a Diploma of Teaching and had been teaching for 23 years.

### ***Science Programming in 2005***

Katorina and Emily reported that, in their classroom, science was taught in an integrated manner for 120 minutes per week, which is higher than the national average of 59 minutes in 2001, as stated by the DETYA report (Goodrum et al.). Science was usually taught in the afternoon. Reported science topics for the year included Frogs, Mini-experiments, Electronics and Earth and Beyond.

Both Katorina and Emily used a variety of resources in planning their science programs, with the most popular being children's interests, PD materials, Curriculum Framework Science Guide (2005), the Internet, Primary Investigations (a nationally prepared primary science publication), and their previous experiences.

### ***Attitudes and Perceptions about Teaching Science***

The Teacher Questionnaire included a variety of questions about attitudes and perceptions about teaching science. Teachers were asked to respond to a five-point rating scale (scored 1 to 5). Katorina's and Emily's responses are shown in Table 5.9.

#### **Interest and Confidence**

The first four items in Table 5.9 relate to teachers' perceived interest about and confidence to teach science. Katorina's and Emily's responses revealed that they are both very interested and believe they are confident to teach science.

## Knowledge

Items 4, 5 and 6 in Table 5.9 relate to teachers' perceived knowledge of science. Katorina's responses reveal that she believes that her background knowledge of science is intermediate; consequently she finds students' questions are not often easy to answer (Item 6). Emily believed her knowledge was extensive (Item 4), and not surprisingly, she believed that she does not find it difficult to explain to students the science behind the activities they do (Item 5).

## Pedagogical Skills

Items 2, 3, 7 and 12 in Table 5.9 relate to teachers' perceived pedagogical skills when teaching science. Katorina's and Emily's responses reveal that they both believe they have the pedagogical skills to teach science effectively, with responses at the positive end of the scale for all items.

## Resources

Items 9 and 10 in Table 5.9 relate to teachers' perceived availability of resources. Katorina's and Emily's responses to these items were also very positive with Katorina even writing a comment next to item 9 saying that the resources were "much improved" and commented that "the availability of resources had increased recently".

The results in this section of the Teacher Questionnaire show a commonality with those from the larger cohort of teachers in the cluster meetings. Both situations identified that teacher confidence had been increased and that teachers' pedagogical skills were good. The resources provided by the PD and the impetus to purchase further resources had been a positive outcome. Both Katorina and Emily felt that they had the required knowledge necessary to teach primary science, however, Katorina did show signs of some limitations in the Teacher Questionnaire regarding limited background knowledge.

Table 5.9 Katorina's (K) and Emily's (E) Attitudes and Perceptions about Science at Fenchurch

	Teachers' attitudes and perceptions about science	Score 1	Score 5	K	E
<i>Interest and Confidence</i>					
1.	My own interest in teaching science is best described as	Not interested	Very interested	4	5
8.	My confidence in teaching science is	Not very confident	Confident	5	5
11.	When teaching science, I welcome students' questions	Rarely	Always	5	5
13.	I am enthusiastic about teaching science	Rarely	Always	4	5
<i>Knowledge</i>					
4.	My own background knowledge for teaching science is best described as	Limited	Extensive	3	5
5.#	I find it difficult to explain to students the science behind the activities they do	Rarely	Always	5	2
6.	Students' science questions are easy for me to answer	Rarely	Always	2	5
<i>Pedagogical Skills</i>					
2.#	Compared with other subjects I find it difficult to teach science	Rarely	Always	5	5
3.	I am effective in monitoring children doing science activities or experiments	Rarely	Always	4	4
7.	My skills in teaching science are best described as	Limited	Extensive	4	5
12.	I am continually searching for better ways to teach science	Rarely	Always	5	4
<i>Resources</i>					
9.	The resources available to me for teaching science are	Limited	Extensive	4	4
10.	I use outside resources (such as the internet) and/or people (such as a local expert) in my classroom	Rarely	Often	5	5

Note. 5-point scale. # Item statement is negatively worded but not negatively scored.

### **Why Teach Science?**

Katorina and Emily were asked to rate the level of importance they gave to 13 possible reasons for teaching science to their students. Teachers were asked to respond to a five-point rating scale (coded 1 to 5), with 5 the most positive response. Their results are presented in Table 5.10. The items ranked most highly by Katorina and Emily are located at the top of the table.

Table 5.10 Katorina's and Emily's Reasons for Teaching Science at Fenchurch

Item No.	Possible reasons for teaching science to students	Katorina	Emily
1.	To interest children in science	5	5
6.	To demonstrate the importance of making decisions based on information	5	5
7.	To show that decisions made in science have social consequences	5	5
8.	To practice problem-solving skills	5	5
10.	To show how science is related to everyday life	5	5
11.	To integrate science with other school subjects	5	5
12.	To develop social skills (such as cooperation)	5	5
13.	To develop self-discipline and independence	5	5
2.	To provide scientific knowledge	4	4
4.	To develop communication skills – verbal	4	4
5.	To develop communication skills – written	4	4
3.	To practice manipulative skills	4	3
9.	To prepare students for science later on	4	3

Note. Responses given to a 5-point scale

The results suggest that Katorina and Emily have many high priorities for teaching science. They both gave equal highest importance to 8 of the 13 items, many of which referred to several aspects and relevance of science and development of independent skills for students. All of these reasons presented in Table 5.10 relate to aspects of scientific literacy, as discussed in Chapter 4.

Items 4 and 5, which are also directly related to literacy, are ranked in the second group (scored 4 by both teachers) by Katorina and Emily. A category identified by exploring adults' perceptions of scientific literacy using PMM interviews (see Chapter 4) was the content of science. Item 2 encompasses this reason for teaching science, and was scored in the second group in Table 5.10 by Katorina and Emily. Another category developed in Chapter 4 related to resources and strategies that may be used for teaching science. Items 3 and 9 are representative of this category and were scored in the third



group. Thus many of the aspects of scientific literacy were recognised by the teachers as important reasons to teach students science. For example, the item that represented making informed decisions being of great importance (Item 7) had both teachers ranking it 5, together with their seven other top priorities.

### ***Teachers' Pedagogical Strategies***

The final page of the Teacher Questionnaire asked teachers to report the kind of strategies most often used in their classrooms. Katorina and Emily both reported that in nearly every lesson children researched their own choice of assignment or project and used the computers and the internet for researching science. Emily and Katorina believed that the children also planned their own experiment in at least half the lessons, and that children worked in small groups for about half of the science time. Students working on written work alone, teacher-led question and answer sessions, teacher demonstrations, teacher-directed experiments and lessons involving the use of audiovisual media were infrequent activities. Understandably, as these teachers team-taught, they agreed on many of the ways in which they believe they teach.

Overall, the data from the teacher questionnaire reveal that Katorina and Emily believe they have the interest, confidence, knowledge and pedagogical skills to teach science effectively. Both teachers believed that the resources in the school were good, with Katorina believing that they had improved. Both teachers also believed they teach science to their students in a manner which engages the students and promotes scientific literacy. Nevertheless, Katorina showed somewhat less confidence than Emily when asked about her perceptions about teaching science.

### **Personal Meaning Mapping Interviews**

The teachers' scientific literacy was further investigated through the Personal Meaning Mapping (PMM) Interviews. Emily and Katorina completed a PMM using the method described in Chapter 3, and their comments were sorted into the categories of scientific literacy developed by the researcher from the data described in Chapter 4. Table 5.11 shows how the teacher responses were categorised according to the aspects of scientific literacy. Katorina gave 10 responses in the PMM interview which were placed into five scientific literacy categories. Emily gave 7 responses which were

placed into six scientific literacy categories. In total, there were 17 responses from both teachers.

Table 5.11 indicates that the most common responses reported by Katorina and Emily were those that related to Investigating and Resources and Strategies. This is not surprising as Investigating was a main focus of PD Workshop 2 and is an assessable component of the Science curriculum. Likewise, resources and strategies were also important aspects of all three PD workshops. Katorina made three references to having the resources and strategies to teach science (30%) while Emily made only one. This may be because Katorina does not feel as confident about her own ability in science as Emily, therefore gave more responses that were categorised as resources and strategies. Science content and communication were two other response categories that were common. It was interesting to note that both teachers made a comment about being able to make informed decisions. Only Emily made a comment about science being related to life and neither teacher made any comment that could be related to being sceptical and questioning about science.

Table 5.11 Fenchurch Teachers' Responses in Categories of Scientific Literacy

Scientific Literacy Category	Katorina's responses (n=10)	Emily's responses (n=7)	Total number of responses (n=17)
Investigating	2 (20%)	2 (29%)	4 (23%)
Resources and strategies	3 (30%)	1 (14%)	4 (23%)
Science content	2 (20%)	1 (14%)	3 (18%)
Science communication	2 (20%)	1 (14%)	3 (18%)
Informed decisions	1 (10%)	1 (14%)	2 (12%)
Science related to life	-	1 (14%)	1 (6%)
Questioning and sceptical	-	-	-

Teacher examples and explanations of each of the categories are given in Table 5.12. The teacher examples (column 2, Table 5.12) are the words or phrases that the teachers wrote to describe their own ideas on scientific literacy. The teacher

explanations (column 3, Table 5.12) are researcher's notes of the teachers' responses to clarification elicited by the researcher.

Table 5.12 Fenchurch Teachers' Examples and Explanations of Scientific Literacy

Category	Teacher Example (what the teacher wrote)	Teacher Explanation (verbal explanation by the teacher, scribed by the researcher)
Resources and strategies	Resources (K)	You have to have some
	Understanding science is integrated into all other areas of learning (E)	Integrate into the learning areas of the Curriculum Framework
Science content	Understanding concepts (K)	Knowledge base
	Connection to traditional scientific activities/subjects i.e. physics, chemistry, biology (E)	How can we relate our primary science to the high school
Science communication	Science 'speak', introducing vocabulary that is subject specific (K)	Starting to use the vocabulary correctly e.g. terminology when writing procedures
	Language (E)	Of scientific words
Investigating	Investigation (K)	Children chose an area to do using all resources
	Planning an investigation (E)	Using the correct format and being able to do the investigation
Informed decision	Re-evaluate information (K)	Re-evaluate by gaining more information
	Ability to follow a pathway to answer a question (E)	Being logical and critical
Science related to life	Understand that science is integrated into all other areas of learning (E)	Learning areas of the curriculum framework can relate science to the everyday
Questioning and sceptical	-	-

K=Katrina, E=Emily

## Student Questionnaire

The Student Questionnaires sought to determine how students perceived their science lessons. The Student Questionnaire was completed by 54 students from Years 6 and 7 in the case study class. The class had a 50:50 ratio of boys to girls. The Student Questionnaire was completed five months after the final PD Workshop. A copy of the Student Questionnaire is available in Appendix 6.

Students were asked to respond to 18 items on the Student Survey asking how often a range of activities happened in their classroom during science, and another 13 items about their thinking and enjoyment in class during science. In the following section, the items are clustered to aid description (but still retain their original item numbers). The clusters related to students' activities in science lessons, teacher-or student-centredness of the classroom, using resources outside the classroom, students' interest in science lessons, students' perceptions of the easiness of science, students' thinking in science and what students liked best about their science lessons.

### ***Students' Activities in Science Lessons***

The results in Table 5.13 give some examples of the activities students reported in their science lessons.

Table 5.13 Students' Activities in Science Lessons at Fenchurch

Item Content	% Responses			
	Never	Some Science Lessons	Most Science Lessons	Nearly Every Science Lesson
In my science lessons:				
1. I copy notes from the teacher	26	70	4	0
2. I make up my own science notes with friends or by myself	18	48	32	2
3. I can talk to others about my ideas	8	23	52	17
4. I read a science book	36	53	11	0
7. We have class discussions	0	18	42	40
9. We do our work in groups	0	28	52	20

Class discussions (Item 7), working in groups (Item 9) and children talking to each other (Item 3) were the most common activities reported by students. Approximately 70% of students reported these occurring in most or nearly every lesson. Note-taking (Items 1 and 2) happened less frequently with over 65% of children indicating that this only happened in some lessons or never. Reading science books (Item 4) was another uncommon science activity.

### ***Teacher-or Student-Centredness of the Classroom***

Table 5.14 summarises the students' perceptions of the teacher- or student-centredness of science lessons. The students believed that experiments are common in the science lesson however they tend to be teacher-directed (Item 6) rather than student-directed (Item 17). The students were encouraged to investigate and find out things (Item 18). Consequently the students believed they seldom watched the teacher doing experiments as a demonstration only (Item 5).

Table 5.14 Teacher- or Student-Centredness of the Classroom at Fenchurch

Item Content	% Responses			
	Never	Some Science Lessons	Most Science Lessons	Nearly Every Science Lesson
In my science lessons:				
5. I watch the teacher do an experiment	13	52	28	8
6. We do experiments the way the teacher tells us	0	22	52	26
My teacher				
15. Listens to my ideas	13	43	35	9
16. Talks to me about my work in science	9	53	38	0
17. Lets us do our own experiments	24	34	28	14
18. Asks us to investigate and find out things	2	22	46	30

### ***Using Resources Outside the Classroom***

Table 5.15 presents the students' perceptions of the use of resources outside the classroom. Students sometimes used resources beyond the classroom. Over 65% of students believed that they went outside of the classroom to do activities/experiments

(Item 10) and had visiting speakers (Item 12) at least some of the time. Almost 75% of students felt that they were given the opportunity to learn about scientists (Item 8) in their science lessons at least some of the time. Over 65% of students felt that they had used computers (Item 13) or the internet (Item 14) during at least some science lessons.

The students believed that most of their science lessons were activity-based with the teacher taking the lead. Some lessons were outdoor and to a smaller extent students used the internet and computers.

Table 5.15 Using Resources Outside the Classroom at Fenchurch

Item Content	% Responses			
	Never	Some Science Lessons	Most Science Lessons	Nearly Every Science Lesson
In my science lessons				
8. We learn about scientists and what they do	24	55	19	2
For science				
10. We do activities outside in the playground, at the beach or in the bush	22	72	6	0
11. We have excursions to the zoo, museum, Scitech, or places like that	22	69	7	2
12. We have visiting speakers who talk to us about science	33	54	9	4
13. We use computers to do our science work	32	59	7	2
14. We use the internet at school for science	21	57	20	2

### ***Students' Interest in Science Lessons***

Table 5.16 summarises the students' interest in science lessons. The information in Table 5.16 shows that the Year 6/7 class students were rarely bored in science (Item 29), with the students enjoying (Item 20), getting excited (Item 27) and being curious about science (Item 28) in at least some of their lessons.

Table 5.16 Student Interest in Science Lessons at Fenchurch

Item Content	% Responses			
	Almost Never	Sometimes	Often	Nearly always
The science we do at school is::				
20. Enjoyable	9	29	33	29
During science lessons I am:				
27. Excited	14	41	31	14
28. Curious	20	30	33	17
29. Bored	22	52	11	15

### ***Students' Perceptions of the Easiness of Science***

Table 5.17 summarises the students' perceptions of the easiness of science. The results show that 60% of students believed that they learnt a lot in science (Item 31) most or every lesson, with a further 30% believing that they learn a lot in some science lessons. Students were rarely confused in science lessons (Item 30) with 48% of students reporting they were only confused in some lessons and a further 35% believing that they were almost never confused in science. Consequently, over 70% of students reported that they found the science they did at school easy to understand (Item 19).

Table 5.17 Fenchurch Students' Perceptions of the Easiness of Science

Item Content	% Responses			
	Almost Never	Sometimes	Often	Nearly Always
The science that we do at school				
19. Is easy to understand	0	29	42	29
During science lessons I				
30. Am confused	35	48	9	8
31. Learn a lot	10	30	43	17

### ***Students' Thinking in Science***

Table 5.18 summarises the students' thinking in science. The results revealed that students felt challenged in science lessons. The response patterns to these items are quite similar. Seventy two percent of students believed that often or nearly always they

were made to think (Item 21), with 69% believing that they needed to be able to think and ask questions in science (Item 22). Additionally, 78% of students believe they needed to understand science ideas (Item 24) and 62% of students believed they needed to be able to recognise the science in the world around them (Item 26). Students thought they needed to remember facts (Item 23) less often.

Table 5.18 Students' Thinking in Science at Fenchurch

Item Content	% Responses			
	Almost Never	Sometimes	Often	Nearly always
The science that we do at school:				
21. Makes me think	11	17	53	19
In science we need to be able to:				
22. Think and ask questions	0	31	42	27
23. Remember lots of facts	5	39	37	19
24. Understand science ideas	5	17	48	30
25. Explain things to each other	4	33	48	15
26. Recognise the science in the world around us	8	30	38	24

### ***What Students Liked Best About Their Science Lessons***

The last question on the survey was open ended, asking what students liked best about their Science lessons. Nearly all students (52 of the total 54) wrote a response. There were a total of 89 ideas given in the 52 responses. Each response was read and given a code according to the ideas expressed (Appendix 7 shows the coding categories). Some students included more than one reason for what they liked best about science lessons so their response was assigned more than one code.

Table 5.19 provides a summary of the results for the case study class. The ideas expressed are clustered in three main themes: teaching and learning activities, students' attitudes/feelings and science content. Table 5.19 reports the percentage of ideas that fell into each cluster. The most popular cluster from students was that they liked the activity work, with 47% of the responses falling into this cluster. One Year 6 student mentioned that he liked "doing the experiments and playing with all the cool stuff".



Eleven percent of student responses related to science being fun, interesting and enjoyable (see Table 5.19). Nine percent of students' responses mentioned a specific activity they did. For example, a Year 7 student mentioned that he liked "we experiment with stuff such as putting half a tablet of Berocca and water in a film cannister [sic] and shaking it and letting it explode like a rocket!!!". Students also liked learning about new things. A Year 6 student wrote "I like science lessons where we go on excursions and find out new and exciting things".

Table 5.19 What Years 6 and 7 Students at Fenchurch Like Best About Science Lessons

What students liked best about science lessons	% of ideas
Teaching and Learning Activities	
Hands on experiments/activities/investigations/ making things	47
Like outdoor activities and excursions	3
Like library research projects	3
Student Attitude/Feeling	
Fun, interesting, enjoy	11
Content	
Specific like/topic, lab activity	9
Like learning new things/doing new things/we learn a lot/educational	7
Like challenge – make us think/experiments	6
Unpredictable/weird/unusual	6
Other ideas	8

The results of the Student Questionnaire illustrate that students believed they learnt a lot in science and were engaged in their work. They reported that they enjoyed the science and felt challenged in the work. The data collected suggest that students appear to be doing science on a regular basis with the main format for lessons being hands-on group activities (investigating). Students believed that they needed to recognise the science in the world around them (science related to life) and they needed to discuss and think in science (science communication). Investigating, science related

to life and science communication, which are aspects of scientific literacy, were highly ranked by students in their responses. The activities that students reported they were engaged in are commensurate with those reported by their classroom teachers in the Teacher Questionnaire. Although the data reported by the teachers and the students are complementary, the researcher believed for a more complete picture of what was happening in the science classes a field work component was important. Field work observations are important because the observer-as-participant can see the dynamics of the classroom and distinguish between what may be an idealised teacher or student situation as suggest by the data, and what is happening in the classroom.

### **Observations of Lessons in the Year 6/7 Case Study Classes**

#### ***Context for Lesson Observations***

Katorina and Emily were each assigned one class of 30 Year 6/7 students which they chose to combine together to form a team-teaching situation. Katorina and Emily team-taught the 60 Year 6 and 7 students in two classrooms that could be separated by concertina doors. However, as these doors were permanently open the two rooms made a double sized classroom for the two classes of students. The room was divided into two sections; one half housed all the students' desks while the other half housed six computers, teachers' desks, two bookcases, equipment storage section and space on the floor where students could work.

The researcher observed the class during its regular science program in Term 4, 2005, four months after the last PD Workshop. Science was taught each week for the nine weeks of Term 4. The topic for the term was Electricity, which is part of the Energy and Change Outcome Area of the Western Australian science curriculum. The researcher was unable to participate in observations that involved the content base of Earth and Beyond as the volunteer teachers, Katorina and Emily, had completed this content area in third term when the cluster meeting, interview and questionnaires were being conducted by the researcher, as per the agreement with the school principal.

The classes started their new science topic of Electricity at the commencement of Term 4, and it was integrated with the Learning Area of Technology and Enterprise. For the first four weeks of the term science lessons were scheduled on Monday afternoons. After lunch there were 15 minutes for silent reading followed by the start of the science

lesson that ran until approximately 10 minutes before home time. Thus, the period allocated for science was 120 minutes per week. Due to a timetabling change during the final five weeks of the term, science was scheduled on Mondays between recess and lunch; a time period of 70 minutes. Thus the total time spent on Science integrated with Technology and Enterprise in Term 4 was 830 minutes (almost 14 hours).

Katorina and Emily had deliberately integrated Science with Technology and Enterprise in Term 4 because linking the two seemed appropriate with the electricity topic. The rationale was that Science and Technology and Enterprise could be easily incorporated into the topic of Electricity, with the outcomes from two Learning Areas being achieved from the one project. The Technology and Enterprise aspect of the project was to design and decorate the wooden part of the circuit board (the technology process). The Science component of the topic included understanding the electrical circuit itself.

Teachers devised a program that allowed the students to work in a variety of ways and at a range of paces to reflect the students' abilities and circumstances. There was a variety of science activities in which students participated throughout the term. These are outlined chronologically in Table 5.20.

### ***Lesson Observations***

Students were introduced to the topic of electricity by their teachers directing their attention to some of the things they already knew about electricity. The topics "static electricity" and "safety with electricity" were used as the introductory lessons. This initial lesson involved examples of static electricity using equipment in the classroom, such as a scarf made from synthetic material, a hair comb and a balloon. The teachers also included examples that students were familiar with from home, such as trampolines, plastic slides (slippery dips), walking across carpet then touching a metallic door handle and combing hair.

Table 5.20 Outline of Year 6/7 Science Program in Term 4 2005 at Fenchurch

Week(s)	Activity	Nature of Activity	Pedagogical grouping
1	<ul style="list-style-type: none"> <li>• Introduction to electricity/Students prior knowledge/Class brainstorm</li> <li>• Static electricity and electrical safety</li> <li>• Individual mind maps on electricity</li> </ul>	<p>Teachers introduced the topic by asking students to tell them what they knew about electricity.</p> <p>Students worked on their own to develop their own understanding of electricity.</p>	<p>Teacher led whole class discussion</p> <p>Individual student work</p>
2	<ul style="list-style-type: none"> <li>• Introduction and advance organizer and review of previous lesson</li> <li>• Completion of mind maps on electricity</li> <li>• Student search of library for appropriate books for a class set</li> </ul>	<p>Teachers direct students into groups and encourage them to discuss last week's lesson.</p> <p>Students complete their work from last week and/or go to the library to find books about electricity.</p>	<p>Teacher facilitated small group work</p> <p>Individual student work</p>
3	<ul style="list-style-type: none"> <li>• Introduction, review and advance organiser</li> <li>• Booklet on electrical circuits containing activities and worksheets</li> <li>• Equipment names, drawing circuits, using the electricity equipment to make circuits</li> <li>• Review of previous lessons by small group communication with researcher</li> </ul>	<p>Teacher reviews previous lesson by asking students questions. Teacher introduces equipment and circuit diagrams to the students and presents students with a workbook. The workbook has activities about electricity that students do and answer relevant questions. Students are given time to work on their booklets the classroom.</p>	<p>Teacher led whole class discussion</p> <p>Whole class teacher demonstration</p> <p>Individual or small group practical work</p>
4	<ul style="list-style-type: none"> <li>• Introduction, review and advance organiser</li> <li>• Making electrical circuits to form a circuit board</li> <li>• Student development of an idea for the circuit and the design of the board and a time line</li> <li>• Student description of the circuit and what it would do.</li> <li>• Equipment supplied to each student: MDF board, light globe, socket and some wire</li> <li>• Review: Students were told where to get additional equipment if required</li> </ul>	<p>Teachers explain to the students that they will be building a circuit board over the following six weeks. The teachers explain what is expected of the students and let the students know that the work will be self paced and students will need to manage their own time.</p> <p>Students draw up a timeline for the following weeks to ensure that they get their circuit boards completed on time. Students work on their activity book.</p>	<p>Whole class teacher explanation and demonstration</p> <p>Individual</p> <p>Individual or small group</p>
5-9	<ul style="list-style-type: none"> <li>• Introduction, review and advance organiser</li> <li>• Student practical assessment on making simple, series and parallel circuits</li> <li>• Students making and trialling the circuits for their circuit board</li> <li>• Students drawing, painting, drilling and gluing the MDF for their circuit board</li> </ul>	<p>Teacher reminds students of the activities they should be doing.</p> <p>Students do practical activity tests.</p> <p>Students work on circuit board or on work booklet.</p>	<p>Teacher explanation</p> <p>One-on-one teacher/student</p> <p>Individual or small group</p>

When the teachers were asked why they chose these two topics as an introduction, Emily responded that, based on her prior discussions with students

many students appeared to have the most real life  
experience with electrical safety or with static  
electricity so it was something they knew a little about  
to get things moving. (Field notes, 11<sup>th</sup> October, 2005)

This relates to the teacher using science in everyday life to assist students in understanding science and hence promoting scientific literacy. The researcher's further conversations with the teachers revealed that the teachers were not aware that science related to life could be regarded as an aspect of scientific literacy. However, the teachers believed that science should be taught by relating to what children have seen or know because, as the teachers explained, the science in the PD workshops had been demonstrated to them in a way that they could make links to their everyday life experiences. Katornina and Emily believed that this link to students' everyday understanding was important for students to have an understanding of science that would be useful to them in the future.

This introductory lesson was mostly teacher directed; the remainder of the lessons were student centred with the teachers acting as facilitators. For the following lessons the teachers generally started the lessons with a brief review of the previous week's lesson and handing out of any work that needed to be returned to the students. This was followed by the use of an advance organiser (Ausubel, 1968) of what the students would be doing for the day. As time progressed, the advance organiser also covered what the students would be doing for the rest of the term so that they would be able to organise their time effectively. All information was documented on the board for students to refer to during that lesson. The students were encouraged to make their own time lines and be responsible for their own time management.

Teachers acted as facilitators, assisting with equipment and science content, and providing important pieces of information, such as how to draw circuit diagrams and the names of circuit equipment. Teachers also wrote this information on the board so the students could refer to it. Katornina made the following comment to the researcher.

Working in this type of environment did not come naturally. We have developed a framework of how to work like this, which was developed at the beginning of the year and took students about a term to master it at a satisfactory level. Split classes made this job a little easier the following year as half of next year's students would already know the procedure. (Field notes, 31<sup>st</sup> October, 2005)

Katorina and Emily believed that some of the pedagogical skills that assisted with effective science lessons (and other practical subject areas) were developed by learning through experience. The teachers also believed that they had been given some new pedagogical skills at the PD sessions which assisted with their science lessons. These allowed the students to conduct their own investigations in a way that was meaningful to them – another aspect of scientific literacy. Students would often be involved in a variety of different tasks at their own pace within the parameters of the time line. The tasks included

- Individual “electricity” mind maps
- Completion of a work booklet which included definitions, making circuits, testing items for conductivity
- Organising their timeline
- Working on their individual circuit board (which included drawing the plan of their circuit, drawing the design of their circuit board, testing their circuit board, making an equipment list, developing a time line that would map their progress over the next six weeks, circuitry, painting and drilling)
- Demonstrating their ability to make simple, series and parallel circuits
- Exploring an electricity kit
- Using a class set of library books as a reference when required
- Drawing circuit diagrams

Katorina and Emily explained that they were interested in students exploring and asking questions and thinking through these questions themselves rather than telling the students the answers. In this way the teachers encouraged students to communicate scientifically, with one another verbally, and communicate with their teachers both verbally and in written form. This represents another aspect of scientific literacy.

Katorina believed that her improved confidence from the PD sessions had made her comfortable to teach in this way although she did not feel that she was at a mastery level of the content. As Katorina pointed out, “students need to find out things for themselves and not be told exactly what to do, otherwise they do not think for themselves. This is a strategy that we have always used and it was great to have it confirmed at the PD sessions” (Field notes, 24<sup>th</sup> October, 2005).

Teachers rarely told students which groups to go in or how many students should be in the group, as Emily explained that

Sometimes students need to work in a group because of the amount of equipment needed but other times they can either work by themselves, with a partner or in small groups it is up to them. What we expect is that they chose other students they believe they can work with effectively. (Field notes, 7<sup>th</sup> November, 2005)

As the series of lessons progressed, teachers were observed to spend less time going through the day’s instructions as the students’ own plans dictated what was required. Students were allowed to go to the library or use the computers at the back of the room so the level of information available was always high. Katorina and Emily said that because the PD presenter showed the teachers how to access content of Earth and Beyond, through books, internet, and other resources, rather than just providing them with a series of hard facts, it had enabled them to increase their knowledge base with Electricity using the same pedagogical skills. Katorina thought that this benefited the students because, as she explained

we were able to access lots of resources from the internet, books in the library and other resources from within and outside the school. It all went together to form an excellent self-paced activity package for the students that we used for the Electricity topic in fourth term. (Field notes, 14<sup>th</sup> November, 2005)

However, Emily mentioned that

Although we start out with good intentions to ensure that the student booklet was monitored regularly, it was one of those things that as the momentum got going we forgot all about

that part of science. The hands-on activities take priority over everything else. We know we do this all the time and we know that we should be more consistent with the consolidation and encouraging students to get all the work done in their activity book, but it's our weakness. What we usually end up doing is getting the kids to rush through everything at the end, which is not the best thing for the students or for their science. (Field notes, 14<sup>th</sup> November, 2005)

Interestingly, in relation to the Working Scientifically PD Workshop and while reviewing the Working Scientifically component of the Science curriculum document, Emily thought that sometimes limitations are due to the focus on what is to be assessed in the curriculum. She explained

We are very focussed on Investigating. This was a large part of our first PD because we have to have the Levels right [correct] so that we are giving the students the correct grades. I have never really looked at the other parts of WS before, but they all make sense and I do a lot of those things [the other aspects of WS] with my kids. (Field notes, 11<sup>th</sup> October, 2005)

Although Katorina and Emily believed they had the knowledge, confidence and the skills from the PD program to access resources and provide students with a stimulating and engaging learning environment, this did not ensure that appropriate assessment occurred. As Emily reported

It wasn't that we didn't know how to assess, it was the time. It just got away from us and we did not get everything finished and therefore it was more difficult to properly assess the students. (Field notes, 5<sup>th</sup> December, 2005)

Overall Emily and Katorina provided a learning environment that was conducive to their students being involved in science communication, participating in investigations and relating science to daily life, albeit not realising all these aspects were those of scientific literacy. They were able to provide such an environment to



their students through having the knowledge, confidence, pedagogical skills and resources that had been provided by the PD workshops.

### ***Informal Student Interviews***

Students were interviewed informally during the scheduled science lessons. Students were very confident when speaking with the researcher, possibly because she had been seen often by the time the students' interviews began. They spoke about what they had been doing so far and what they were going to do with their circuit board or what they had been doing at home. One student told the researcher that they "liked science because they always had good projects and did fun things" (Field notes, 21<sup>st</sup> November, 2005). Another student mentioned that she "did not know anything about electricity before the lessons and had learnt a lot this term" (Field notes, 21<sup>st</sup> November, 2005).

One student told the researcher that although she enjoyed this topic she did not feel very confident with the concepts. The researcher asked how she and her group members could become more confident and they said if they could "do more hands-on stuff with the equipment, like we have been doing" (Field notes, 21<sup>st</sup> November, 2005). After working with the circuits for 10 minutes the student told the researcher that it was easier than she thought.

Students helped each other with their work and for the most part their communications were about the work. In a conversation with a group of students, one girl said that she

loves science at Fenchurch PS because at my other school no one was allowed to touch the science equipment and here [at Fenchurch] you can. (Field notes, 21<sup>st</sup> November, 2005)

Some students were a little slow to bring in some equipment that they were asked to bring from home. Not being able to complete some of their work made several students more careful the following week about bringing their equipment and the majority of students were prepared, especially in the last weeks of term.

Towards the end of the term, students started bringing in extra equipment from home and talking about how they were going to extend their ideas. One student said that they were going to get some more wires "to make some circuit boards for Christmas" (Field notes, 5<sup>th</sup> December, 2005). Another said that they would like to

“build a toy car and attach one of the motors to it to see how fast it would go” (Field notes, 5<sup>th</sup> December, 2005).

During the last two weeks there was a greater focus on the completion of the written booklet. It was noticed by the researcher that the equipment became more and more neglected and worn every week. It was also not returned to the right places by the students as time needed to be spent on the learning rather than the packing up. The pedagogical skills of equipment collection and distribution are unique to practical subjects such as Science, Technology and Enterprise and Art. This pedagogical skill was not covered in the PD workshops. So unfortunately, not until the teacher wishes to use the equipment at a later date, will this issue be understood and possibly rectified.

Students clearly enjoyed making something that they were going to be able to take home and use/show to their family and out of school friends. As it was near Christmas time many of the students were talking about decorations. They talked about the lights on the Christmas tree and the houses and whether they would be parallel or series circuits. Some of the students got the equipment and tried out their ideas. The open-ended self-paced lesson format allowed students to explore their own ideas in an environment that allowed time for developing a bigger picture about how electricity related to everyday life.

In general, students appeared to enjoy the integrated Science and Technology and Enterprise topic of Electricity as it was hands-on and provided opportunities for students to work in small groups and choose activities that they could relate to their everyday life. Students did not complain about the written components of their tasks but understandably favoured the practical investigations.

Teachers gave the impression that they were not only enjoying teaching the Electricity topic but were impressed with their students and how well they attended to the tasks asked of them. Teachers were constantly assisting students in one way or another which produced a deeper understanding of what the students required of them as teachers. This, in turn, facilitated better learning.

### **Interview with Case Study Teachers**

The following section describes an interview with Katorina and Emily, the two classroom teachers from the observation class, which occurred at Fenchurch on the 22<sup>nd</sup> February 2006, eight months after the final PD workshop and almost three

months after the conclusion of observations. The teachers were interviewed concurrently in the staff room during their DOTT (Duties Other Than Teaching) time. The theme of the interview was the impact of the PD program on their classroom practice.

### ***Impact of the PD Program on Teacher Knowledge***

In terms of the knowledge provided by the PD, Emily believed

Some of the science content and other information about planning and investigating we could use and some of it we needed to put away or modify for the year level. So we did a lot of packing stuff away and discarding things until we had what was good for us.

Katorina thought that the PD had assisted her to understand that “it’s not just about science content; it is knowing where to go to find out about the content.”

### ***Impact of the PD Program on Teacher Pedagogical Skills***

Emily thought that the PD program had provided her with some “good strategies” for science lessons that she had since used in her teaching. Katorina believed that you could “use the strategies from the PD and implement them into your class without too many modifications to them”. However, Emily thought that “the assessment documents and ideas were not the sort of thing that someone outside the school could provide” and chose not to use the suggestions on the way she assessed in the classroom.

### ***Impact of the PD Program on Teacher Confidence***

Katorina, felt that the PD had “helped with my confidence, especially the content and resources” and, in addition, it changed her attitude toward science. In the past Katorina had

really steered clear of science but now in the team teaching situation...now with the PD and the resources that we have...I would approach science a lot differently...I would have avoided it before but I feel comfortable to do it now.

Yet, according to Emily, the other classroom teacher, the PD had not improved her confidence in science teaching as it was already high. However, the PD had provided her with “a better focus and resources for Earth and Beyond that have been very helpful in my teaching”.

### ***Impact of the PD Program on Resources***

Emily believed that, as the science purchasing officer, the PD had encouraged her to buy more science resources for Fenchurch PS to “make science more accessible for the students”. Katorina believed that, “with all the new resources we have, students are able to stimulate their brains and really develop an interest in science. We are now able to offer a more challenging science program”.

In relation to the resources and ideas provided by the PD, Katorina liked that they could “go straight from the PD and use some of the resource activities with your class” and Emily felt that they did “a lot of packing away and discarding. Some ideas from the PD we could use and others we couldn’t. We came away from the PDP and thought about what was relevant to us and what would work with our students”.

### ***Impact of the PD Program on Science Learning and Scientific Literacy***

Emily stated that the outcomes she wanted students to achieve when learning science were “extending and understanding science vocabulary, integrating science into other learning areas, cooperative learning, teamwork, the content, the interest of students”. Emily wanted students to develop a natural curiosity about the subject. The teachers believed their students had achieved this curiosity by providing a more student-centered environment. As Katorina put it, “we immerse students in the topic, we pose questions to the students and they have to find out answers to the *why* questions”.

In a more student-centered, inquiry-based learning situation there are always possibilities that students would ask questions not anticipated by the teacher. Consequently, the teacher may not immediately be able to answer the questions at hand. However, as Emily pointed out, “we have never had a situation where we [the whole class] could not find the answer to a question”. What is important, in Katorina’s opinion, is that “our students know that we don’t know everything and we tell them this straight out. We encourage them to find out things that we *all* don’t know”. Furthermore, “it’s not just about the content of science, it’s about *how* to find out what you want to know”.

When examining what was taught in science Katorina believed that Working Scientifically involved letting “the kids doing the hands on learning, the language of science and how to use it [the language] appropriately”. Emily believed that

Working Scientifically also involved “a process that you need to follow, the inquiry process – investigating”. Katorina added “it is more than a writing base, it’s an activity base”. In Emily’s view Working Scientifically also involves “hypothetical situations, safety issues and equipment”.

For Katorina, Scientific Literacy brought to mind the writing genres of science where she believes that “kids don’t get a lot of practise at the language of science, we try to integrate it, but previously it did not get that much attention. But it still ends up being not well developed”. Emily interjected and added that this was not the only area of Scientific Literacy, stating that “there are moral issues, values (transplants, cutting up rats), the content base, safety, science language, science terms and science behaviours” that are included in Scientific Literacy. Katorina mentioned that “unfortunately when teachers hear the word ‘literacy’ they all focus on language due to the constant push in this area over the last decade or so”.

The two teachers could not make any specific links between Working Scientifically and Scientific Literacy however they did feel that there was a connection. As Emily explained, “I think there are links but we have not had time to explore them but if you asked if we were teaching all the components we would be, we just don’t know all the labels.”

### ***Impact of the PD Program on Success of Science at School in 2005***

Emily felt that what made science such a great success at Fenchurch in 2005 could be attributed to “a combination of the PD program, the new resources and science being a school priority”. Katorina believed that one of the best outcomes attributed to the school science focus and the PD workshops was “the overflow from having this science priority year is now that we have done the science PD in Earth and Beyond we can transfer these pedagogical skills to other aspects of science”.

### ***Impact of the PD Program on Fenchurch Primary School’s Future Directions***

Science was not a priority for Fenchurch in 2006; the teachers did not feel that this was a problem. As Emily stated

we have sustainability as a whole school emphasis.

The Western Australian Literacy and Numeracy

Assessment (WALNA) test results revealed that

there were problems with spelling so this is now a

priority but we still have sustainability and solar cells project starting up this year for the whole school. Science doesn't need to be pushed so hard this year as everyone is motivated about science, science is a semi-priority.

As for the future directions of science at Fenchurch, Katorina would like to see "better organization of the resources by further development of the science storeroom, there are two days allocated this year to continue resourcing the science room". Emily mentioned that the school is also doing

Robotics this year, we have the IT person running this and some [Robotics] kits are being purchased. The main aim is to train the older students so they can teach the younger students. Additionally, we are linking with the high school science program again. So there is still a lot of science going on.

### **Summary of Chapter**

From the first Science PD workshop, teachers at Fenchurch were interested in Science, had positive attitudes toward science, and welcomed new ideas about how to teach Science. Teacher confidence increased after all three PD workshops. The main reason for this increase was the hands-on experiences in the workshops that were easy to do and understand and adaptable to the classroom. The increase in teachers' confidence in planning, delivering, facilitating student achievement and assessing science outcomes was achieved through teachers increased knowledge, pedagogical skills and access to resources provided by the PD program.

Katorina and Emily emphasised many aspects of scientific literacy in both their responses to questionnaires/interviews and when observed in the classroom teaching science. These encouraged their students to be scientifically literate by engaging them in investigations that involved real life situations that required students to communicate scientifically.

Students enjoyed and were engaged in their science lessons which challenged them by making them think and allowed them to investigate using their own ideas. Katorina and Emily thought that their improved pedagogical skills, increased

confidence and knowledge had allowed the students more autonomy with their activities.

Although the PD sessions had finished, the two case study teachers still felt that they were “unpacking” the pedagogical skills, the Earth and Beyond content knowledge and resources. They believed it would take time to modify and sort through every idea that had been given out during the PD workshops. Both teachers believed that they needed time to reflect and digest the information presented at the PD workshops, and change it in a way that suited both them and their class.

## **CHAPTER 6**

### **WINCHESTER PRIMARY SCHOOL**

#### **Introduction**

This chapter describes the findings and their analysis at the second case study school, Winchester Primary School. It provides the background and overview of the PD program followed by the data collection and analysis in chronological order.

#### **Background to Winchester Primary School**

Winchester is a small metropolitan primary school located eight kilometres south east of the city of Perth in a low socio-economic area. Winchester classrooms were terraced but had no doors connecting other classrooms. All rooms were positioned around an outdoor sporting area which was common to Western Australian schools that had been in operation since the early 1960s. The school had a separate onsite kindergarten with the main building catering for just over 200 students from Pre-Primary to Year 7. Winchester had a staff of 14 female teachers and 2 male teachers, a female Deputy Principal and a male Principal, a total of 18 teaching staff. Science was not necessarily taught by the class teacher as some teachers are specialists only (e.g. Art, Language Other Than English). Further, some teachers are required to teach other classes in their specialisation, and consequently do not teach their own class science. Some teachers were also part-time. Consequently, not all teachers at Winchester taught science.

Science became an educational priority at Winchester for Term 2, 2006. After engaging in discussions with several staff members in Term 4, 2005, the Principal realised that PL needed to be enhanced in several areas of the Western Australian school curriculum. In Western Australia it is common for a school to maintain a priority for at least one year. However, in this case the Principal felt that it was necessary to facilitate the PL of the school staff in four areas, one each school term. The other areas included Literacy, Numeracy, and Technology and Enterprise. As part of their science priority the staff suggested that some PD sessions in science would be beneficial.

The Principal had received a letter containing information about the KSS, and after reading the information about the PD workshops that the KSS offered he contacted Scitech. After consultation with an Education Officer from the KSS, the



Principal selected three PD workshops that he thought would be suitable for his staff. The three workshops were: Working Scientifically through Open Investigations; Developing Conceptual Understandings in Science with specific reference to the content areas of Energy and Change - Forces and Natural and Processed Materials; and Planning and Assessing with an emphasis on Energy and Change (Forces). The principal believed that these three sessions would provide a broad range of content and strategies that could be used by the staff.

Both teachers and administrators attended the three full-day sessions that took place in the second term of 2006. The first PD session occurred on a scheduled school PD day, and the other two PD sessions were scheduled on a Saturday. At the beginning of each PD session an activity book and support materials to assist in the follow-up implementation were provided to attending staff.

### **Overview of the Winchester Workshops**

The content of the three science PD workshops is outlined below.

*Workshop 1 (May 1, 2006): Working Scientifically through Open Investigations* covered the Western Australian curriculum science area of Working Scientifically, paying particular attention to Investigating and how Investigating could be used in Energy and Change (Forces) and Natural and Processed Materials. It explored the Natural and Processed Materials outcome and Energy and Change outcome with activities about forces and kitchen chemistry and looked at strategies to incorporate Investigating as part of the teachers' programs.

*Workshop 2 (May 13, 2006): Energy and Change (Forces) and Natural and Processed Materials* covered the Western Australian curriculum science content areas of Energy and Change (Forces) and Natural and Processed Materials. This workshop offered further materials and ideas about forces and kitchen chemistry that aimed to assist teachers in their conceptual understanding of the topic. It included some hands-on activities for teachers.

*Workshop 3 (May 27, 2006): Planning and Assessing* covered the area of planning and assessing incorporating Investigating and the content areas of Energy and Change and Natural and Processed Materials. This workshop took teachers through a planning process using the Western Australian Curriculum Framework, Curriculum Guides and the Outcomes and Standards Framework/Progress Map.

Table 6.1 Data Collection Timeline for Winchester

[illegible]

## Findings

This section describes the findings from the data collected from the students and teachers at Winchester. The data were collected from seven sources as outlined in the methodology section in a similar manner to that at Fenchurch, discussed in Chapter 5. Table 6.1 presents the data collection methods and their timeline. In the following sections each of the methods and their results are described in chronological order.

### Initial Teacher Interviews

The Initial Teacher Interviews were conducted with eight teachers before the KSS PD sessions. As was noted in Chapter 3, the initial teacher interview responses were based around four questions which are reproduced in Figure 6.1.

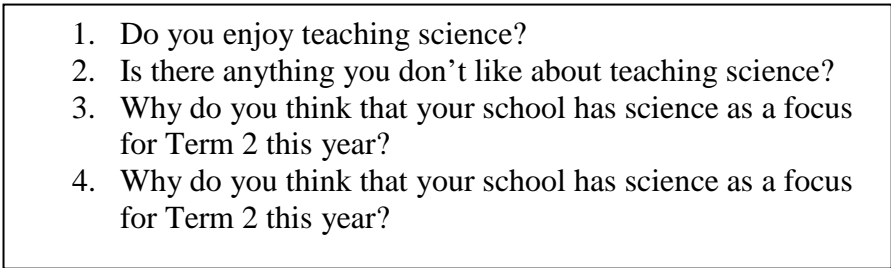
- 
1. Do you enjoy teaching science?
  2. Is there anything you don't like about teaching science?
  3. Why do you think that your school has science as a focus for Term 2 this year?
  4. Why do you think that your school has science as a focus for Term 2 this year?

Figure 6.1. Initial teacher interview questions at Winchester

The interview responses were grouped into the same four themes as for Fenchurch, that is, knowledge, confidence, pedagogical skills and resources.

### **Knowledge**

The teachers thought that they needed help with their science as it had been a few years since they had looked at the science curriculum and the way in which it should be taught. They believed that they needed some ideas for Energy and Change and some simple reminders about any of the content that they would be teaching would be helpful. In fact, teachers appeared to have so little science background they wanted any information that the PD presenter could provide about any science content.

### **Confidence**

Most teachers enjoyed teaching science. However, they believed that they needed to get back into science as it had been neglected. They wanted to become better science teachers by feeling confident that they could engage their students in science. They

also wanted to feel confident that their science teaching was consistent with the current science curriculum in Western Australia.

### ***Pedagogical Skills***

The teachers wanted ways of teaching science that could tie in with the themes in their classrooms. They wanted to be able to set up an efficient, workable and stimulating science program in the school. They thought they needed to rethink and refresh their approaches to science that would make their lessons easier and more fun for the students. Teachers enjoyed the hands-on aspect of science and hoped that the PD presenter would be able to assist in their development of this area by providing them with simple ideas to engage their students, especially in small group work.

### ***Resources***

The teachers enjoyed teaching science but they felt it was difficult to get all the equipment and materials organised for their lessons. They did not like the time it took to look for and collect the equipment and materials. They often had to pay for the materials they purchased with their own money and reimbursement was slow. Essentially, they wanted to see any new ideas or resources.

Generally, teachers agreed that they needed the science PD to increase their knowledge, confidence, pedagogical skills and resources in their science learning area. The results suggest that teachers believed that science had been neglected for some time and although they taught science they knew that they could improve their lessons.

### ***Teacher Questionnaire***

The case study teacher, Laticia, was given the Teacher Questionnaire to complete during an individual teacher/researcher interview. Laticia chose to engage in discussions with the researcher during her completion of the Teacher Questionnaire. She asked the researcher for clarification of some items and explained some of her item response choices. This increased the researcher's understanding of the responses supplied by Laticia in the Teacher Questionnaire.

### ***Teacher's Background and Experience***

Laticia taught a split Year 2/3 class in most subject areas except for Art and Languages Other Than English. She attended all three PD sessions in 2006. Laticia

was an experienced primary school teacher with a Bachelor of Education degree and 32 years teaching experience.

### ***Science Programming in 2006***

Laticia reported that in her classroom science was taught as a separate subject for 60 minutes a week. This matches the national average of 59 minutes reported by Goodrum et al. (2001). Science was usually taught in the afternoon, and her reported science topics for the year, so far, were Air and Water. Laticia used a variety of resources when planning her science program with the most popular being children's interests, thematic integration, and Primary Investigations.

### ***Attitudes and Perceptions about Teaching Science***

The Teacher Questionnaire included a variety of questions about attitudes and perceptions about teaching science. Teachers were asked to respond to a five-point rating scale (scored 1 to 5). Laticia's responses are shown in Table 6.2.

#### **Interest and Confidence**

Laticia's responses to Items 1, 8, 11 and 13 in Table 6.2 revealed that she was moderately interested in teaching science. However, she was quite confident in her ability to teach science, especially in responding to children's questions.

#### **Knowledge**

Laticia's perceived knowledge of science was measured by Items 4, 5 and 6. The data in Table 6.2 shows that she believed that her background knowledge of science was sound. As she was completing the questionnaire, Laticia said that she was very comfortable with her knowledge of science at the Year 2/3 level (the year that she was teaching) but may not have the science knowledge she thought appropriate for Years 6 and 7 students.

#### **Pedagogical Skills**

Items 2, 3, 7 and 12 in Table 6.2 relate to perceived pedagogical skills when teaching science. Laticia's responses revealed that she thought she had the pedagogical skills to teach science effectively. However, she did not believe she was as confident with teaching science as she was with other subjects (Item 2).

#### **Resources**

Laticia's responses to Items 9 and 10 were quite positive. As Laticia explained "I have easy access to the resources I need for the Year 2/3 class. I have

been teaching the same split year group for about five years now and I have the resources in my classroom”.

Table 6.2 Laticia’s Attitudes and Perceptions about Science at Winchester

Teachers’ attitudes and perceptions about science	Score 1	Score 5	Laticia
<i>Interest and Confidence</i>			
1. My own interest in teaching science is best described as	Not interested	Very interested	3
8. My confidence in teaching science is	Not very confident	Confident	4
11. When teaching science, I welcome students’ questions	Rarely	Always	5
13. I am enthusiastic about teaching science	Rarely	Always	4
<i>Knowledge</i>			
4. My own background knowledge for teaching science is best described as	Limited	Extensive	4
5.# I find it difficult to explain to students the science behind the activities they do	Always	Rarely	5
6. Students’ science questions are easy for me to answer	Rarely	Always	5
<i>Pedagogical Skills</i>			
2.# Compared with other subjects I find it difficult to teach science	Always	Rarely	3
3. I am effective in monitoring children doing science activities or experiments	Rarely	Always	4
7. My skills in teaching science are best described as	Limited	Extensive	4
12. I am continually searching for better ways to teach science	Rarely	Always	5
<i>Resources</i>			
9. The resources available to me for teaching science are	Limited	Extensive	4
10. I use outside resources (such as the internet) and/or people (such as a local expert) in my classroom	Rarely	Often	4

Note. 5-point scale. # Item statement is negatively worded but not negatively scored

### **Why Teach Science?**

Laticia was asked to rate the level of importance she gave to a number of possible reasons for teaching science to her students. Her results are summarised in Table 6.3.

Laticia gave equal highest importance (rank 5) to 11 of the 13 items, many of which referred to the relevance of science and development of independent skills for

her students. She had many high priorities relating to the aspects of scientific literacy, discussed in Chapter 4. Items 3 and 7, which are directly related to investigating and making informed decisions, are ranked in the second group (scored 4) by Laticia. This is not surprising as these skills would be the most difficult to teach to young children and may therefore be given a lower ranking. Nevertheless, all aspects were recognised by Laticia as important reasons to teach students science from a young age.

Table 6.3 Laticia's Reasons for Teaching Science at Winchester

Possible reasons for teaching science to students	Laticia
1. To interest children in science	5
2. To provide scientific knowledge	5
4. To develop communication skills – verbal	5
5. To develop communication skills – written	5
6. To demonstrate the importance of making decisions based on information	5
8. To practice problem-solving skills	5
9. To prepare students for science later on	5
10. To show how science is related to everyday life	5
11. To integrate science with other school subjects	5
12. To develop social skills (such as cooperation)	5
13. To develop self-discipline and independence	5
3. To practice manipulative skills	4
7. To show that decisions made in science have social consequences	4

Note. Responses given to a 5-point scale

### ***Teachers' Pedagogical Strategies***

The final page of the Initial Teacher Questionnaire asked teachers to report the kind of strategies most often used in their classrooms. Laticia reported that “teacher explaining the science content to children” was the most common way children work in science in her class, with this occurring in nearly every lesson. Teacher-led class discussion and teacher demonstrations, along with students working outside and/or in small groups were also very common with the Year 2/3 students. Laticia believed that her students participated in teacher-directed activity, used the internet for science, planned and conducted their own experiments or activities, or worked alone on written work in about half of their science lessons. As might be expected with

this age group, students doing their own choice of assignment or their own experiment were less frequent activities

The results in this section of the Teacher Questionnaire show a commonality with those from the Initial Teacher Interviews. The interviews and the Teacher Questionnaire identified that teachers were comfortable in teaching science but that the science they had been teaching over the last few years had not changed. Laticia also showed some limitations in the content areas of science which impeded on her confidence to teach science, especially to another year group. Laticia appeared to have combated the issue of resources in her classroom by having collected resources over the past five years. Because the Principal had foreshadowed Laticia would be teaching Year 5 the following year, when the researcher asked Laticia if these would be suitable if she were to older students, she responded by saying, “they are really only for this age level, so I guess I would have to look for some other things and start over again”.

### Personal Meaning Mapping Interviews

Laticia’s ideas about scientific literacy were investigated through a Personal Meaning Mapping Interview. Laticia completed a PMM and her comments were sorted into the categories of scientific literacy by the researcher. Table 6.4 shows Laticia’s responses categorised according to the aspects of scientific literacy.

Table 6.4 Laticia’s Responses to the PMM for Scientific Literacy at Winchester

Scientific Literacy Category	Laticia’s responses (n=10)	Percentage of responses (%)
Resources and strategies	2	20
Science content	1	10
Science communication	1	10
Investigating	6	60
Informed decisions	-	-
Science related to life	-	-
Questioning and sceptical	-	-

Laticia gave 10 responses in the PMM Interview which were placed into four scientific literacy categories. The most common responses reported by Laticia were those that related to Investigating followed by Resources and Strategies. This is not surprising as Investigating was a main focus of and an assessable component of the



science curriculum. Laticia made one reference to science communication and one reference to science content.

Laticia's examples and explanations of each of the categories are given in Table 6.5. Laticia did not provide any responses relating to making informed decisions, science related to life or being questioning and sceptical. However, the data from the responses to the Teacher Questionnaire suggest that Laticia believed that all aspects of scientific literacy, with the exception of making informed decisions, were important to her science teaching. It may be possible that Laticia did not think of these aspects of scientific literacy at the time of the interview or that she did not think of these aspects as scientific literacy. Additionally, as Laticia works with young children who were beginning to learn science, she may believe it is more important to introduce science in any manner as it is a new experience for her students.

Table 6.5 Laticia's Examples and Explanations of Scientific Literacy at Winchester

Category	Example of what the Laticia wrote	Laticia's Explanation of example (scribed by the researcher)
Resources and strategies	Knowledge gained from literature	Know how to look for websites, books etc. So that what you read would spark the children's interest
Science content	Terminology	Find out the technical names to use with the students
Science communication	Recording information	Usually in written form worksheets/charts etc
Investigating	Observation	Looking, using observing skills by teacher direction first e.g. observe an experiment something that is given to them
Informed decisions	-	-
Science related to life	-	-
Questioning and sceptical	-	-

## **Professional Development Workshop Feedback Sheets**

The WFS were administered by the PD presenter and they were analysed in a similar way to those for Fenchurch described in Chapter 5. The number of participants for each of the workshops varied (9 to 14) due to staff absences.

### ***Teachers' Attitudes and Perceptions about Confidence and Pedagogical Skills Before and After the Professional Development Workshops***

The WFS contained five items for which teachers were asked to rate their attitude and perceptions about their teaching of science in their classroom before and after attending each of the PD workshops.

#### **Workshop 1: Working Scientifically through Open Investigations**

Table 6.6 presents a comparison of pre- and post-workshop teachers' attitudes and perceptions about science teaching in Workshop 1. The results for Item 1 show that before the workshop, all teachers responded agree or strongly agree to having a positive attitude toward teaching science. The complementary post-workshop item revealed that teachers remained positive about science after the PD responses with several teachers responding more positively after the workshop. The Item 2 data show that before the workshop, all teachers agreed that they needed adaptable pedagogical skills and ideas to use in the science class. After the workshop, all teachers were satisfied that they had been given pedagogical skills and ideas. The remaining three item pairs related to teacher confidence. The results in Table 6.6 reveal a positive movement in teachers' attitudes and perceptions after the PD workshop. The pre-workshop WFS showed 83% (10 teachers) agreed that they were confident in planning effective science programmes compared with all teachers, (five of whom moved to strongly agree), after the PD workshop (Item pair 3). Similarly, the results revealed that all teachers were confident of delivering effective science programmes after the workshop (Item pair 4) with 42% (5 teachers) becoming more confident as shown by the movement of responses to strongly agree. The final item pair, relating to confidence in facilitating student achievement (Item pair 5), also revealed a movement in confidence with five teachers responding to strongly agree after the workshop.

Table 6.6 Winchester Teachers' Pre- and Post-workshop Attitudes and Perceptions about Teaching Science in Workshop 1: Working Scientifically (%)

Wk shop	Item Pair no.	Item Content	SA	A	D	SD
Pre	1	Currently I have a positive attitude towards teaching science	25	75	-	-
Post		I have a positive attitude toward teaching science	67	33	-	-
Pre	2	Currently I need adaptable skills and ideas to use in the classroom	50	50	-	-
Post		I have been given adaptable skills and ideas to use in the classroom	67	33	-	-
Pre	3	Currently I am confident in planning effective science programs	-	83	17	-
Post		I could confidently plan effective science programs	42	58	-	-
Pre	4	Currently I can confidently deliver effective science programs	-	92	8	-
Post		I could confidently deliver effective science programs	33	67	0	-
Pre	5	Currently I feel confidently able to facilitate student achievement in science outcomes	-	75	25	-
Post		I could confidently improve students learning in science outcomes	42	50	8	-

(n=12)

The overall results reflect that teachers already had a positive attitude toward science and that these attitudes improved after the PD workshop. The results in Table 6.6 also show positive outcomes of the PD workshops in the area of teacher confidence, with most teachers' perceptions about their confidence becoming more positive after the PD workshop.

## Workshop 2: Energy and Change (Forces) and Natural and Processed Materials

Table 6.7 presents a comparison of pre-workshop and post-workshop teachers' attitudes and perceptions about science teaching in Workshop 2. As for Workshop 1, there was little change in Item 1 with the teachers generally positive toward teaching science, before and after the workshop. Similarly, the pre-workshop and post-workshop sections of the survey for Item 2 showed some movement (two teachers) from agree to strongly agree in the complementary post PD item. Teachers agreed they needed, and were given, adaptable pedagogical skills and ideas.

The three items relating to teacher confidence all revealed both a positive and a negative movement in teachers' attitudes and perceptions after the PD workshop.

Some teachers were more confident in planning and delivering effective science after the PD workshop, while other teachers were less confident about these aspects. The final item pair relating to confidence in facilitating student achievement also revealed this trend. As the researcher attended this workshop with the participants she noticed that there was a large amount of content for the participants to absorb on the day and perhaps that information overload had caused some of the teachers to feel less confident.

Table 6.7 Winchester Teachers' Pre-and Post- workshop Attitudes and Perceptions about Teaching Science in Workshop 2: Energy and Change and Natural and Processed Materials (%)

Wk shop	Item Pair No.	Item Content	SA	A	D	SD
Pre	1	Currently I have a positive attitude towards teaching science	22	88	-	-
Post		I have a positive attitude toward teaching science	44	66	-	-
Pre	2	Currently I need adaptable skills and ideas to use in the classroom	44	66	-	-
Post		I have been given adaptable skills and ideas to use in the classroom	67	33	-	-
Pre	3	Currently I am confident in planning effective science programs	-	100	-	-
Post		I could confidently plan effective science programs	11	78	11	-
Pre	4	Currently I can confidently deliver effective science programs	-	100	-	-
Post		I could confidently deliver effective science programs	22	56	22	-
Pre	5	Currently I feel confidently able to facilitate student achievement in science outcomes	-	100	-	-
Post		I could confidently improve students learning in science outcomes	11	67	22	-

(n=9)

### Workshop 3: Planning and Assessing

Table 6.8 presents a comparison of pre-workshop and post-workshop teacher attitude and perceptions about science teaching in Workshop 3. The results of Item pairs 1 and 2 show that all teachers had the same positive attitude toward science teaching before and after the PD workshop, and teachers believed they were provided with adaptable pedagogical skills and ideas.

The last three item pairs showed a more positive trend than that of Workshop 2, with all teachers feeling confident about the three aspects of planning, delivering and

facilitating after the PD workshop. The pre-workshop survey showed 86% (12 teachers) were confident in planning effective science programmes and confident of delivering effective science programs. After the PD all participants reported that they were confident to engage in these three aspects. Item pair 5 revealed that all teachers were responded positively to the pre-workshop item, with five teachers moving from “agree” to “strongly agree” in their responses.

Table 6.8 Winchester Teachers’ Pre-and Post- workshop Attitudes and Perceptions about Teaching Science in Workshop 3: Planning and Assessing (%)

Wk shop	Item Pair no.	Item Content	SA	A	D	SD
Pre	1	Have a positive attitude towards teaching science	43	57	-	-
Post		I have a positive attitude toward teaching science	43	57	-	-
Pre	2	Need adaptable skills and ideas to use in the classroom	43	57	-	-
Post		I have been given adaptable skills and ideas to use in the classroom	43	57	-	-
Pre	3	Currently I am confident in planning effective science programs	-	86	14	-
Post		I could confidently plan effective science programs	21	79	-	-
Pre	4	Can confidently deliver effective science programs	-	86	14	-
Post		I could confidently deliver effective science programs	36	64	-	-
Pre	5	Feel confidently able to facilitate student achievement in science outcomes	-	100	0	-
Post		I could confidently improve students’ learning in science outcomes	36	64	-	-

(n=14)

Looking collectively at the results of these three WFS reveals that teachers already had a positive attitude toward science before the PD workshops. This positive attitude remained after the PD workshops and may have made the PD workshops more beneficial for many teachers as they were already enthusiastic about teaching science.

For Workshops 1 and 3, the data show that teachers believed they were more confident with planning, delivering and facilitating science lessons by the conclusion of workshop. Workshop 2 showed a different trend for some staff with their

confidence decreasing at the conclusion of the workshop. Interestingly, at the commencement of the second and third workshops, some data showed that teachers appeared to be less confident than at the conclusion of the previous workshop. This may have occurred because of the different composition of participants in the three PDP workshops. It could also be attributed to the workshops being related to three different areas of science: Working Scientifically through Open Investigations; the content of Energy and Change (Forces) and Natural and Processed Materials; and Planning and Assessing in Energy and Change (Forces). Each workshop represents a unique aspect of science for the teachers and although all are related to teaching and learning in science, there seemed to be disparity between a teacher's confidence levels about these three areas. The results of the complementary items also revealed that staff felt that they needed pedagogical skills and that these skills were provided in the workshops.

### ***Teachers' Attitudes and Perceptions about Knowledge, Pedagogical Skills and Confidence, Resources and Leadership through Open-Ended Responses***

More detailed information was available from responses to the four open-ended questions on the WFS. The content of teachers' responses were analysed, and clustered into seven categories as described in Chapter 3. In this section, the analysis of the open ended questions is reported across the three workshops. It should be noted that several teachers chose not to answer certain open ended questions.

Question 1 (see copy of WFS in Appendix 1) was answered before the Workshops began. Teachers were asked "What would you personally like to achieve as a result of attending this workshop?" A summary of these categories is provided in Table 6.9, together with the percentage of the comments that fell into each category.

Table 6.9 shows that the largest number of comments in all three workshops related to acquiring pedagogical skills. In Workshop 1, a teacher wrote about wanting "ideas for making science learning enjoyable". In Workshop 2, a teacher wanted to know about "some new ideas for Year 1". In Workshop 3, one teacher simply wanted "planning skills". Whilst all these comments relate to pedagogical skills, teachers often referred to the skills most likely to come from that particular workshop.

Several other responses related to knowledge. In Workshop 1 one teacher believed “an awareness of the process of teaching science using outcomes” was needed, and another in Workshop 2 wanted “a better understanding of science”. One teacher in each workshop made comments related to teacher confidence, for example, in Workshop 3, a teacher needed “confidence in planning”. Additionally, two responses related to leadership, and these teachers wanted to assist other staff members with their PL goals.

Table 6.9 Winchester Teachers’ Responses to the Question “What would you personally like to achieve as a result of attending this workshop?”

Comment category	% of comments		
	Workshop 1 Working Scientifically	Workshop 2 EC & NPM	Workshop 3 Planning and Assessing
Knowledge	23	36	9
-Better understanding of science			
Pedagogical Skills	69	45	55
-improved skills			
-teach science better			
-ideas for making science enjoyable			
Confidence	-	9	9
-confidence to present science			
Resources	8	9	9
-planning documents			
Leadership/collaboration	-	-	18
-improve teaching and learning across the school			
Number of comments	13	11	11
Number of teachers	12	9	11

Note: Because of rounding all columns may not add to 100

EC – Energy and Change; NPM – Natural and Processed Materials

After the Workshops teachers were asked three more questions. Question 1 (see WFS in Appendix 1) asked teachers: “What actions do you plan to take following today’s session?” A summary of these categories is provided in Table 6.10, together with the percentage of comments in each category.

Table 6.10 shows that the largest number of comments after Workshops 1, 2 and 3 (46%, 75% and 67%, respectively) related to pedagogical skills. After Workshop 1, a teacher wrote that s/he could “adapt some of my planned lessons”; in Workshop 2, one teacher was going to “try some of the activities”; and in Workshop 3, one teacher thought that s/he could “plan a unit of work for this term”. In Workshop 1, about a third of the comments were also related to acquiring or using

resources (38%). One teacher wrote about using the “plan, conduct, process and evaluate format”. Additionally, three comments described how the teachers believed

Table 6.10 Winchester Teachers’ Responses to the Question “What actions do you plan to take following today’s session?”

Comment category	% of comments		
	Workshop 1 Working Scientifically	Workshop 2 EC & NPM	Workshop 3 Planning and Assessing
Knowledge	-	-	11
-greater understanding of outcomes			
Pedagogical Skills	46	75	67
-write a science program			
-planning skills			
Confidence	8	12	22
-keep my positive attitude			
Resources	38	12	-
-check out the website			
Reflection	8	-	-
-look carefully at my lessons			
Number of comments	13	8	9
Number of teachers	11	8	8

Note: Because of rounding all columns may not add to 100

EC – Energy and Change; NPM – Natural and Processed Materials

they had increased confidence. One of these teachers commented “keep my positive attitude toward science”.

Question 4 (see Appendix 1) asked teachers: “Has this workshop affected your views about teaching science?” The results in Table 6.11 show that the largest number of comments in Workshops 1, 2 and 3 related to confidence. In Workshop 1 one teacher believed that they were “more confident about creating open-ended investigations” and in Workshop 2 a teacher simply thought they were “more positive”. After Workshop 3 one teacher wrote that s/he had “gained more confidence”.

Another frequent response in Workshops 1 and 3 pertained to pedagogical skills, represented by 30% of the comments in Workshop 1 and 20% of the comments in Workshop 3. For example, after Workshop 1, one teacher wrote that the PD presenter had shown him/her some “good ideas”. In Workshop 3 one teacher thought that the content of the PD had given him/her “effective strategies to incorporate more science into my programming”. Two respondents stated that the workshop had affected their views about teaching science but did not elaborate how



their views had been affected and three respondents said that their views about science had not been changed, just been reinforced.

Table 6.11 Winchester Teachers Responses to the Question “Has this workshop affected your views about teaching science?”

Comment category	% of comments		
	Workshop 1 Working Scientifically	Workshop 2 EC & NPM	Workshop 3 Planning and Assessing
Knowledge	10	-	-
-made it clearer in my mind			
Pedagogical Skills	30	-	20
-I have effective strategies			
Confidence	40	50	60
-science is fun			
-I am more confident			
Yes, gave no reason	10	25	-
No, just reinforces it	10	25	20
Number of comments	10	4	5
Number of teachers	10	4	5

EC – Energy and Change; NPM – Natural and Processed Materials

Question 5 (see Appendix 1) asked teachers: “What was the main message you gained from today’s workshop?” Table 6.12 shows that, overall, the largest number of comments from the seven teachers related to pedagogical skills. For example, in Workshop 1 one teacher thought that the main message was to “work toward more open ended activities”, and in Workshop 3 one teacher thought the main message was to “keep planning simple”. Comments about pedagogical skills were also common in Workshop 2. For example, one teacher from Workshop 2 thought that the main message was that “simple ideas can generate a wide range of learning in many areas”. Additionally in Workshop 1, many participants commented on their confidence. For example, one teacher stated that “It is really easy to involve children in science activities”.

The most frequent responses in Workshop 2 related to knowledge. In Workshop 3 one teacher thought that the main message was “how to apply energy and force to science experiments”, and another response about resources was also identified.

Table 6.12 Winchester Teachers' Responses to the Question "What was the main message gained from today's workshop?"

Comment category	% of comments		
	Workshop 1 Working Scientifically	Workshop 2 EC & NPM	Workshop 3 Planning and Assessing
Knowledge - I have a better understanding	14	43	-
Pedagogical skills -hands-on methods	43	29	50
Confidence -science can be easy and fun	43	29	25
Resources -new science books look fantastic	-	-	25
Number of comments	7	7	4
Number of teachers	7	7	4

Note: Because of rounding all columns may not add to 100

EC – Energy and Change; NPM – Natural and Processed Materials

In summary, analysis of the open ended responses showed that, in anticipation of all three workshops, staff's highest priority was to gain pedagogical skills, which was also a common theme of the Initial Teacher Interviews. For all three workshops the most common action that staff planned to take after the PD workshops related to their use of newly acquired pedagogical skills. Staff believed that they would be able to use the science activities from the PD and put into practice their newly developed pedagogical skills to teach science in their classrooms.

Another common anticipated action in Workshop 1 was to use the resources made available to teachers to facilitate their planning, programming and students' learning. In Workshops 1, 2 and 3, the staff's views had been most affected by giving them increased confidence to teach science. Most staff found the main message of Workshops 1 and 3 was about their increased pedagogical skills while in Workshop 2 the most common response related to the increased knowledge of the staff.

The results from the pre-PD WFS items show a commonality with the Initial Teacher Interviews and Laticia's Teacher Questionnaire responses. Teachers again appeared to be positive and enthusiastic about teaching science and they believed that they needed the pedagogical skills and confidence to teach science effectively in their classrooms. This was evident in all three workshops. Interestingly, the data

from the Initial Teacher Interviews focused largely on the need for resources, whereas the main focus in the WFS was pedagogical skills.

The researcher's observations of the second PD Workshop, where the staff learned about the content areas of Energy and Change (Forces) and Natural and Processed Materials, suggest that it involved too much information for the staff over a short period of time. One of the Winchester PS staff members said

I really like all the activities but there are so many now I think I am getting them all mixed up and I am getting tired. The one I will remember for sure is the coloured water with detergents – that's great.

It was also noted by the researcher that what the teachers wanted was to understand the student outcomes in science. The first and third PD sessions addressed this concern, as opposed to the second PD which was more content based.

### **Observations of Lessons in the Year 2/3 Case Study Class**

#### ***Context of Lesson Observations***

Laticia taught the Year 2/3 class at Winchester and had taught this age group of students for the last five years. In 2006, her class comprised 8 Year 2 students and 20 Year 3 students. Laticia's classroom had a blackboard and whiteboard set alongside storage cupboards at the front of the room. Students' desks, clustered to cater for groups of six to eight students were in the centre of the room. The back of the room housed four desks, each with its own computer for student use, some storage space and Laticia's desk and computer.

The researcher observed the class during its regular science program during part of Terms 2 and 3, 2006. The observation of the lessons commenced directly after the first PD session in the third week of Term 2 and continued until three weeks before the end of Term 3. Science was taught each week for the 14 weeks for a period of 60 minutes per week. One extended lesson took place in Term 3 which required most of the school day, thus the total time spent on science during the observation period was 1020 minutes (17 hours). An overview of the lessons, activities and pedagogical grouping are presented in Table 6.13.

Laticia explained that with younger children she found it easier to do three topics a term, with each topic lasting for 3-4 weeks. This enabled the children to be engaged without having to remember 10 weeks of work. Laticia said that she

incorporated science, as she did other subjects, with a classroom theme. The topics for the observation period were Investigating, Push and Pull (both covered during the PD sessions) and Teeth (part of the Year 3 Health curriculum). During the observation lesson Laticia also mentored two practicum students. One of the practicum students was completing her final practicum and Laticia allowed for the practicum student's creativity and enthusiasm in three of the science lessons to do Silk Worms, which became the fourth topic during the observation period.

### ***Lesson Observations***

Laticia originally wanted to “do something related to balloons” at the start of Term 2, but after she saw the EO from Scitech's ‘Introduction to investigations through observing and classifying Living and Non-living things’, Laticia thought

I can easily adapt this activity from the booklet to make it appropriate for my year level and it would teach the students how to make observations and classify at the same time.

(Field notes, 18<sup>th</sup> May, 2006)

The first lesson was teacher directed with the students encouraged to contribute and ask questions when necessary.

The second lesson continued ‘investigating’ with students focused on observation using all five senses and making predictions. This lesson was integrated with the theme of foreign countries and their food; hence food samples were used as the observational matter. Again the lesson was teacher directed, but with ample time for students to express ideas or opinions and ask questions.

The third lesson incorporated the whole school theme which was decided by the staff at the final PD session. All classes, Pre Primary to Year 7, looked at forces through the topic of Push and Pull from the Primary Connections resource book. This lesson was also integrated with investigating and the students looked at predicting and testing their predictions about what type of force is required to move certain objects.

Table 6.13 Outline of Laticia's Year 2/3 Term 2 and 3 Program at Winchester

Lesson	Activity	Nature of Activity	Pedagogical Grouping
Term 2 1 Observations 1	<ul style="list-style-type: none"> <li>Living and Non-Living</li> <li>Observing the attributes of living and non-living things</li> </ul>	Teacher explains to the students the attributes of living and non-living things. The teacher then asks the students to classify some objects they can see. Students complete a classification worksheet.	Whole class teacher explanation Teacher-led whole class discussion Individual student work
2 Observations 2	<ul style="list-style-type: none"> <li>Making predictions</li> <li>Using the five senses to observe various foods</li> </ul>	Teacher explains the activity to the students. The students use their five senses to observe the various foods on their tables. Teacher consolidates what the students have found through a discussion session.	Whole class teacher explanation Student in groups of 4 Teacher-led class discussion
3 Push and Pull 1	<ul style="list-style-type: none"> <li>Forces</li> <li>The difference between a push and a pull force</li> </ul>	Teacher explains to the students the difference between a push and a pull. Students are given various small toys and asked to classify them as toys that work on a push or a pull or both. Teacher discusses the students' findings.	Whole class teacher explanation Small group work Teacher-led class discussion
4 Teeth 1	<ul style="list-style-type: none"> <li>Story about teeth</li> <li>Types of teeth, canines, molars etc</li> <li>Discussion</li> </ul>	The teacher reads a large picture book story about teeth. The teacher asks the students what they know about teeth. Students are told about the different types of teeth and how humans use their teeth to eat different foods.	Teacher reads book about teeth to the whole class. Whole class teacher explanation. Teacher-led class discussion
5 Teeth 2	<ul style="list-style-type: none"> <li>Care of your teeth</li> <li>Personal hygiene</li> <li>Diet</li> </ul>	Teacher reminds students about the work they have been doing on teeth. The teacher asks the students about their experiences with the school dental van. Teacher tells students about what they can do to protect their teeth; brushing and diet. Teacher puts a tooth in Coca Cola ® to see what happens to the tooth.	Whole class teacher explanation. Teacher-led class discussion. Teacher demonstration
6 Teeth 3	<ul style="list-style-type: none"> <li>Life and Living ,Teeth Assessment</li> <li>assessment</li> </ul>	Teacher shows the students what has happened to the tooth. Students are assisted through the test by the teacher reading out the questions.	Teacher led class discussion. Individual student work on test with assistance from teacher
Term 3 7, 8&9 Silk Worm 1, 2 & 3	<ul style="list-style-type: none"> <li><i>Practicum Teacher arrival</i></li> <li>Introduction to silk worm book and diagram. Explanation of activity and observations</li> </ul>	Teacher explains silk worms and shows students the larval form they are in today. The teacher draws and put notes on the board. Students copy work from board then look at books and the silk worms.	Teacher-led discussion. Teacher written explanation and drawing on board. Individual student work
10 & 11 Push and Pull 2 & 3	<ul style="list-style-type: none"> <li>How do things move? What is gravity?</li> <li>Predictions and observations</li> </ul>	Teacher explains to the students how things move and asks students what they know about gravity. Students are given a worksheet to make prediction and then some equipment to make observations on how different objects work.	Teacher-led class discussion. Small group work
12 Push and Pull 4 <i>Whole day activity</i>	<ul style="list-style-type: none"> <li>Helicopter assessment</li> <li>Variables in investigations</li> <li>Predictions</li> <li>Patterns</li> </ul>	Teacher gave the student background information about helicopters. Teacher asks the students what they know. Students are told about the task of making a paper helicopter and trialling it to see how long it stays in the air. Teacher demonstrated what may be done and then the students work in groups to test their helicopters and then wrote the results onto their worksheets.	Teacher explanation and teacher-led discussion to whole class. Teacher demonstration. Small group and individual student work
13 Push and Pull 5	<ul style="list-style-type: none"> <li>Fantastic Forces</li> <li>Describing forces through writing and diagrams</li> </ul>	The teacher used a previous lessons on how some of the forces were classified as push or pull to get students to write about some forces they viewed by diagram. After the teacher explanation students worked on their own to write about the forces.	Teacher explanation to whole class. Individual student work
14 Push and Pull 6	<ul style="list-style-type: none"> <li>Review of helicopter and change of another variable</li> </ul>	Teacher reminded students about their previous helicopter lesson and demonstrated what variables might be changed and then the students work in groups to test their helicopters and then wrote the results onto their worksheets.	Teacher explanation to whole class. Small group work

As the Primary Connections books had not arrived at the time of the final PD session, there was some debate about which of the activities from the Push and Pull book would be used for the common assessment task<sup>3</sup>. As the term had been disrupted by several events and Primary Connections books were not available, Laticia decided to integrate the Teeth for Oral Hygiene with Teeth for science. In Year 3, as part of the Health curriculum, Laticia incorporated 'Teeth Hygiene'. Laticia explained

I usually pick science topics that go with the whole theme for the term but this term there have been a few themes as everything has been so hectic with the WALNA<sup>4</sup> testing, the new reporting system and International Cultural Day.  
(Field notes, 14<sup>th</sup> June, 2006)

The next three lessons, 4 to 6, were about teeth, but instead of the focus only on the health and hygiene, Laticia encouraged the students to develop an understanding about the types of teeth in the human mouth and what types of chewing actions are made with each type of tooth. Laticia used the students' familiarity with and affinity for the television program "Myth Busters" to encourage them to carry out an investigation, like those seen on Myth Busters, in class with a tooth being placed in Coca Cola® for a two week period. Students were required to formulate the procedure and make predictions. In the sixth lesson students were exposed to thinking about changing variables and fair testing, by placing a piece of marble into a glass containing Coca Cola®. The students were shown a piece of marble and they were told that this marble is used for flooring; many of the students believed they have seen the marble at some time on the floor of expensive buildings. Laticia stated that

I teach Oral Hygiene every year to Year 3 students, but what I have done differently this year is I have integrated

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<sup>3</sup> Common Assessment Tasks are activities that are used by all year group or a number of year groups in a school to observe the progression of students in the Western Australian Outcomes and Standards Framework. In this case the activity was used to identify what aspects of Investigating were identified as typical of each year level.

<sup>4</sup> WALNA is the Western Australian Literacy and Numeracy non-school based test that is given to all students in Years 3, 5, 7 and 9 during the school year. Teachers take time out of their regular program to prepare students for the test and to administer the test.

health with science and given it a science focus. For example, I would have never done the investigations before when I was teaching this topic. Normally if I were teaching investigations in science I would have given students all the answers and told them what they were going to do, but I spent much more time on seeing if the students knew what they were doing – so these parts are different and something I learnt from the PD session. (Field notes, 21<sup>st</sup> June, 2006)

Laticia was also not familiar with the other areas of Working Scientifically before she attended the PD workshops. She stated

Investigating is the only other thing you have to do in addition to the content areas, and all I have to do is make sure I do the Investigating with my class because in the Early Childhood that is all I have to report. (Field notes, 21<sup>st</sup> June, 2006)

The Primary Connections books had still not arrived at the beginning of Term 3 and a practicum student had arrived at the school in the Year 2/3 class for the term. The practicum student had organised some silk worms for the students to have in their classroom. The following three lessons, lessons 7, 8 and 9, were dedicated to the introduction and the setting up of the silk worms in the classroom.

In the interim the researcher received a copy of the Primary Connections books and loaned the books to Laticia and the practicum student. Laticia and the practicum student developed a program, implementing the ideas from the PD, with a theme of Forces.

In the second introductory lesson to forces, lesson 10, students were given a range of toys and asked how they could make them move. The ideas covered in this lesson were contact and non-contact forces, gravity and size of the force applied. The teacher's questions were derived from the students' observations, expressions and ideas. The following lesson, lesson 11, was about air and its relationship with force where the investigating aspect of prediction was integrated into the activity. During the last two lessons the students started to write a science journal about some of their activities for reflection.

The whole-school “Helicopter” activity was run over a whole day for the Year 2/3 class, lesson 12. The teacher was only constrained by two other classes that the students needed to attend, Art and Language Other Than English. The remainder of the day was for the science “Helicopter” activity. The teacher conducted a brainstorming session to find out what students knew about helicopters. The students appeared to be familiar with what a helicopter looked like. They knew helicopters were used for flying, for police chases and by the media. They could also describe a helicopter. They noted that there was a set of propellers on the top of a small sized body (when compared with an aeroplane) in which two to four people could be transported. The teacher had printed out three colour photos of helicopters she found on the Internet. These photos showed a helicopter similar to the one the students had described and a larger helicopter used by the armed forces. The students noted that the one used by the armed forces was much larger than the ones they had seen and that both helicopters had a propeller on the tail. Students were also shown some toy helicopters; these were passed around along with the pictures so students could have a closer look. Students were asked if they knew how the helicopter flew. One student said “it flies because the top propeller goes around fast enough to lift it off the ground.” Another student said “It can fly straight up and not like a plane that needs to run along the ground first.” The teacher asked the student if they had ever made a paper helicopter, one student had but some of the other students had only made paper planes. The teacher asked the students how they might make a helicopter (asking the student that had made one before to answer last). One student quickly suggested using “two paper strips, which could be joined together with sticky tape, like a cross” and another student thought “the cabin could be made out of a small Choc-milk carton [300mL rectangular waxed cardboard carton].” Laticia asked her students to think of a way to make the helicopter out of only paper. The students thought for a while and then the student who had made a paper helicopter before suggested that the helicopter could be made from “half a piece of paper with the tops cut like rabbit ears.” Laticia then demonstrated how to make the paper helicopter from half a piece of A4 paper.

Students made their paper helicopters from the templates that had been made by Laticia. They were asked how they could test their paper helicopters. One student responded that they could “measure the time it took for it to drop to the



floor.” Laticia asked where they should drop the paper helicopter and a student thought that it should be dropped from “one metre.” The students suggested what equipment they would need and a list was compiled on the whiteboard that included A4 paper template, scissors, metre ruler and stop watch. Students wrote a prediction of the time they thought the paper helicopter would take to reach the ground from one metre. Each student was assigned to a group of three and the group performed three trials, recorded their results and then they were directed back to the floor to discuss their results. The children were able to perform the task successfully, although there were discrepancies between the results of individual groups. Laticia asked the students how they could change their paper helicopters or make another one to make the flight time longer or shorter. Children’s suggestions included; make the propellers longer, make the propellers shorter, make the base of the helicopter shorter, make the whole helicopter bigger, make the whole helicopter smaller. Students were then asked to choose one of the variables and to make another helicopter and test its flight time. Children tested their two paper helicopters with their group, recorded their results and wrote a sentence to compare the results of the two paper helicopters.

The same Common Assessment Task investigation was performed by Years 1 to 7 students in the school. Consequently, the Year 2/3 class needed assistance with parts of the investigation such as determining variables that may affect the investigation, deciding on which variable to change and evaluating their investigation. The aspects of the investigation which students completed independently were the predicting, the recording of the data and determining the pattern in their results. Interestingly, Laticia stated that the averaging activity would be too difficult for her class. Only four students in the class were able to follow the procedure for finding the average of the three trials.

The following lesson, lesson 13, reinforced what the students had done in the Common Assessment Task by integrating this prior experience with the other previous “push and pull” lessons to incorporate and consolidate all the terminology such as “gravity” and “pressure” when they discussed their paper helicopters. The final lesson, lesson 14, looked at changing a variable that students did not change in their original Common Assessment Task investigation.

## Student interviews

Five girls and four boys were interviewed toward the end of Term 3 and were individually asked the questions in Figure 6.2.

- |    |   |
|----|---|
| 1. | Do you enjoy science?                               |
| 2. | Did you like science better this year or last year? |
| 3. | What was your favourite science lesson this year?   |
| 4. | What is your favourite school subject?              |

Figure 6.2. Students interview questions at Winchester

Students' responses showed they all enjoyed science. One student said "quite a bit, it's fun for me. I like the experiments and I can do them with my family later at home".

Six students said that they had enjoyed science better this year than last year. Two of these students thought it was more fun, another two students said that they had not done science before; one student believed that he did not do very much science before and another student mentioned that he liked it this year because "now it is not boring". One student pointed out that she had always liked science. Interestingly, two students who thought science was better last year had attended different schools in 2005.

The students' favourite science lesson was the helicopter (chosen by eight of the nine students), which reflects the level of engagement demonstrated by the students during this topic. Students had a wide variety of favourite subjects with only one of the nine students selecting science as their favourite subject. Other students chose Art, writing, Mathematics, and Society and the Environment as their favourite subjects. This information suggests that science does not have to be the student's favourite subject to be enjoyed.

In general, students' responses confirmed what the researcher had observed. Students were very interested in and enjoyed science. Many students reported that they were doing more science now than before. Furthermore, traditionally Laticia had reported that students were only able to engage in a science topic for approximately 4 weeks (4 hours). The Forces topic was well received by the

students, which included a common favourite activity – the helicopter. This topic was extended over many weeks due to the issue with the resource book arrival. In spite of this the students remained engaged and interested in the Forces topic even during the extended activity.

### **Student Questionnaires**

The Student Questionnaire and its data analysis were the same as those used at Fenchurch (Chapter 5). For a copy of the Student Questionnaire refer to Appendix 5. The questionnaire was completed by the 21 members (52% boys and 48% girls) of the Year 2/3 case study class. The other seven students were absent on the day of administration.

The survey was designed for primary school students in Year 4 and above, but the class teacher believed the students could do it with some assistance and was keen for them to do so. So it was necessary for the researcher, the class teacher and the teacher assistant to work together when the surveys were administered to this class. This ensured that students understood each question and knew how to respond in a valid manner. The researcher read each question to the students, explained each of the alternative responses, then waited for the students to answer before moving on to the next question. The classroom teacher worked with students who had difficulty with following instructions and the Education Assistant worked with two students who experienced difficulty with English.

### ***Students' Activities in Science Lessons***

Some examples of the activities students reported in their science lessons are reported in Table 6.14. Class discussion (Item 7) is the most frequently reported science activity with 55% of students believing this occurred in most or nearly every lesson. Making up their own science notes (Item 2), reading a science book (Item 4) and working in groups (Item 9) were other common responses.

Table 6.14 Students' Activities in Science Lessons at Winchester

Item Content	% Responses			
	Never	Some Science Lessons	Most Science Lessons	Nearly Every Science Lesson
In my science lessons:				
1. I copy notes from the teacher	4	76	10	10
2. I make up my own science notes with friends or by myself	14	52	24	10
3. I can talk to others about my ideas	10	61	10	19
4. I read a science book	24	33	29	14
7. We have class discussions	10	30	35	25
9. We do our work in groups	10	55	25	10

***Teacher- or Student-Centredness of the Classroom***

The results in Table 6.15 show that watching teacher demonstrations (Item 5) and doing experiments are common, but with students performing them as instructed by their teacher (Item 6) rather than their own choice (Item 17).

Table 6.15 Teacher- or Student-Centredness of the Classroom at Winchester

Item Content	% Responses			
	Never	Some Science Lessons	Most Science Lessons	Nearly Every Science Lesson
In my science lessons:				
5. I watch the teacher do an experiment	0	29	48	23
6. We do experiments the way the teacher tells us	0	19	43	38
My teacher				
15. Listens to my ideas	0	35	45	20
16. Talks to me about my work in science	5	70	20	5
17. Lets us do our own experiments	20	65	0	15
18. Asks us to investigate and find out things	0	45	50	5

The students thought they were encouraged to participate by their teacher asking them to investigate and find out things (Item 18) most of the time. The results also revealed that the students believed their teacher was willing to listen to their ideas (Item 15) in most lessons.

### ***Using Resources Outside the Classroom***

According to the results in Table 6.16 students sometimes used resources beyond the classroom. Over 90% of students believed that they learn about scientists and what they do (Item 8) and have visiting speakers (Item 12) at least some of the time. Approximately 70% of students felt that they go outside of the classroom to do activities/experiments (Item 10) and used computers (Item 13) in at least some of their science lessons.

Table 6.16 Using Resources Outside the Classroom at Winchester

Item Content	% Responses			
	Never	Some Science Lessons	Most Science Lessons	Nearly Every Science Lesson
In my science lessons				
8. We learn about scientist and what they do	5	70	15	10
For science				
10. We do activities outside in the playground, at the beach or in the bush	29	71	0	0
11. We have excursions to the zoo, museum, Scitech, or places like that	43	52	5	0
12. We have visiting speakers who talk to us about science	0	95	0	5
13. We use computers to do our science work	30	60	5	5
14. We use the internet at school for science	40	55	5	0

### ***Students' Interest in Science Lessons***

The data in Table 6.17 suggest that the Year 2/3 students are rarely bored in science (Item 29), and that they enjoy (Item 20) and get excited (Item 27) about science in at least some of their lessons. Students were curious (Item 28) a little less often.

Table 6.17 Student Interest in Science Lessons at Winchester

Item Content	% Responses			
	Almost Never	Sometimes	Often	Nearly always
The science we do at school is::				
20. Enjoyable	5	25	25	45
During science lessons I am:				
27. Excited	0	26	21	53
28. Curious	26	42	16	16
29. Bored	60	40	0	0

### ***Students' Perceptions of the Easiness of Science***

According to the information in Table 6.18, 90% of students believed that they learnt a lot in science (Item 31) most or every lesson, with a further 10% believing that they learnt a lot in at least some science lessons. Students reported that they found science easy to understand (Item 19) often or nearly always 65% of the time. Students were rarely confused in science lessons (Item 30) with 37% believing that they were never confused in science and 53% of students thought they were confused in only some lessons.

Table 6.18 Students' Perceptions of the Easiness of Science at Winchester

Item Content	% Responses			
	Almost Never	Sometimes	Often	Nearly Always
The science that we do at school				
19. Is easy to understand	5	30	30	35
During science lessons I				
30. Am confused	37	53	5	5
31. Learn a lot	0	10	30	60

### ***Students' Thinking in Science***

Lastly, the results in Table 6.19 show that students felt challenged in science lessons. Approximately 75% of students said they were made to think often or nearly always (Item 21) and believe that they need to be able to think (Item 22). Additionally, 70% of students believed they need to understand ideas (Item 24) and

50% of students believed they needed to be able to recognise the science in the world around them (Item 26) and needed to remember science facts (Item 23).

Table 6.19 Students Thinking in Science at Winchester

Item Content	% Responses			
	Almost Never	Sometimes	Often	Nearly always
The science that we do at school:				
21. Makes me think	0	20	15	65
In science we need to be able to:				
22. Think and ask questions	0	25	35	40
23. Remember lots of facts	10	40	30	20
24. Understand science ideas	0	30	35	35
25. Explain things to each other	5	37	26	32
26. Recognise the science in the world around us	0	50	25	25

### ***What Students Liked Best About Science***

Over 95% of students (20 of the total 21) wrote a response to the final, open-ended item on the Student Questionnaire. The responses were read and coded as they were at Fenchurch PS (Chapter 5). The 20 responses from students were assigned a total of 24 ideas.

An outline of the results for the Year 2/3 case study class is shown in Table 6.20. Three main themes were expressed through the students' ideas from their responses. The most popular theme from students was that they believed science was fun, interesting and enjoyable; one Year 3 boy stated that "They [the science lessons] are exciting and fun and I am never bored".

Other students' responses were that they liked learning about new things; a Year 3 girl wrote "My most favourite part of science this year is learning new things". Students also liked the experiments or activities they did. For example, a Year 3 boy wrote that he liked "me doing science experiments".

Table 6.20 What Year 2/3 Students at Winchester Like Best About Science Lessons

What students liked best about science lessons	% of ideas
Teaching and Learning Activities	
Hands on experiments/activities/investigations/ making things	17
Liked group work	5
Student Attitude/Feeling	
Fun, interesting, enjoy	38
Content	
Like learning new things/doing new things/we learn a lot/educational	25
Specific like/topic, lab activity	8
Other Ideas	16

In general, students believed that they participated in various science activities. They reported that they watched teacher demonstrations followed by doing activities in small groups as the teacher has instructed. This would be expected at the Early Childhood level as students were beginning their exposure to investigating in science. Students enjoyed science and usually found it easy to understand. Students felt that they needed to recognise the science in the world around them (science related to life) at least some of the time. Students were also beginning to discuss and think in science (science communication). Investigating, science related to life and science communication, which are aspects of scientific literacy, were prevalent in students' responses. The activities that students reported reflected those of their teacher in the Teacher Questionnaire.

### **Final Staff Interviews**

The responses of six staff to 14 questions about their science teaching after the PD program (see Appendix 11) were coded and categorised into themes. The following description highlights the major ideas and themes from the analysis of the data.

#### ***Knowledge***

Most teachers were positive about the PD. According to five of the six teachers, the most beneficial aspect of the PD was that it gave teachers direction and understanding of how science should be planned, taught and assessed. Teachers



believed that the information provided in the PD sessions had given them a better understanding of the curriculum materials in science and how they would be able to use them to complement and/or update their programs.

### ***Confidence***

Four teachers believed they were already positive about science before the PD program and two teachers felt that the PD had made them more positive toward teaching science. All of the teachers believed that the PD had increased their confidence. Four teachers believed that because of their increased confidence science was now a more regular part of the classroom schedule.

### ***Pedagogical Skills***

The most popular follow up actions that teachers took after the PD were sharing and discussing ideas with colleagues and seeking out additional resources. Reviewing and trying out the new activities were also popular follow up actions. However, two teachers mentioned that the PD could have been more inclusive of the junior primary level when addressing the needs of teachers.

### ***The Meaning of Science and Scientific Literacy***

In relation to what science meant to them, two teachers thought that science was about the understanding of the natural world and the other four teachers believed that science was about hands-on discovery type learning for the students. In terms of scientific literacy, five teachers said that it was about the language of science, with two teachers mentioning that it was about communication, understanding the methods and procedure of science. One teacher thought it was about knowing how to access science information about science.

### ***Impact of the PD Program on Students' Learning***

Teachers' primary belief about what students should "get out of science" was enjoyment. Teachers believed they were doing more science in their classroom and as a consequence students were starting to look forward to science. As one teacher put it, "the impact on students was that children have enjoyed the science they were doing".

In general, the teachers were positive about the outcomes of the PD program in relation to knowledge, confidence, and pedagogical skills. Interestingly, two teachers that had not attended all the PD sessions remarked that they realised in hindsight that it would have been beneficial to attend the full complement of the PD.

Many teachers who attended the PD said that they had initiated a collaborative relationship with another member of staff. They worked with their partner to prepare programs, share ideas or just to discuss issues. This collaboration was highlighted by one teacher, Brigid, who stated

Now that I am working with Antoinette they [science lessons] have been much easier. We come up with ideas together and it is fun to do it. Even when we work on our own we can still share ideas from time to time. This reduces our total workload for science and provides us with each other's feedback as a critical friend.

The results of the Final Teacher Interviews were consistent with what teachers said they would do on the WFS completed directly after the PD programs. The interview responses suggest that teachers were taking the follow-up actions that they had planned, and also expanding their experience to work collaboratively.

### **Interview with the Case Study Teacher**

The following section describes an interview with Laticia, the case study teacher. The meeting was scheduled, at Laticia's request, after the school year, and was held at a café near the school on the 11<sup>th</sup> December, 2006. The theme of the interview was Laticia's reflection about the impact of the PD program on her classroom practice.

### ***Impact of the PD Program on Teacher Knowledge***

On reflection, Laticia found that the PL had not completely overhauled her way of teaching science but made her aware of what she was teaching and that her focus on the outcomes was important for what she intended the students to achieve. Laticia thought

The way you teach and explain things to students doesn't change that much. But now you are more focused on an outcome as a teacher. You're more aware of the outcomes you're teaching, rather than just saying, 'oh this will do, this looks like a good lesson', now you are looking for a specific outcome.

In 2007 Laticia intended to continue with her modified science approach, and had already started planning with outcomes, because

I think the children enjoyed it...that was the confirmation, the reason I would do it. I think if the children had not liked it I would have found other alternatives. The fact that the children loved it, learnt from it and I found it easy to teach was important. So I think I would follow the same type of structure next year.

### ***Impact of the PD Program on Teacher Pedagogical Skills***

Laticia did not feel that the PL had changed her attitude toward science (as it was already positive), but it had changed the way she viewed it should be taught.

I think before I thought that it was too hard to prepare and organize, I didn't have a real problem with the content. I now know how to lay my hands on lots of the different items more easily. So you're not looking for difficult-to-source items that are specific to a science topic. Additionally, if the school had already purchased specific science items they often became lost or were not available from the science room when you wanted them. From my experiences with the PD, I now know you can use things from home, the classroom and the local shop.

Laticia believed that she was confident to try areas of science other than the ones the staff had dealt with in the PD, as "the area that we looked at was set out in a way that it was accessible and understandable so I am sure that the other areas are the same."

### ***Impact of the PD Program on Teacher Confidence***

Laticia believed that the most significant part of the PD program was Being able to feel comfortable, becoming more familiar with it [the science curriculum]. Up until then I had really only glanced at it. This gave me the chance to have an in depth look and understand it...So I think that was probably the best part. And that I got the time to spend and to understand what I was actually supposed to do.

Laticia also felt that the opportunities to ask questions and trial activities were very important because you not only receive “feedback from the presenter but others’ opinions as well.”

### ***Impact of the PD Program on Resources***

Laticia believed that because the staff, including the Principal, had seen some of the resources available to teachers at the PD sessions it had encouraged the Principal to purchase some much needed current science books. The set of Primary Connections books that the staff had wanted had been purchased and the Principal had made funds available to purchase other resources. The Science Coordinator was currently reviewing science resource books for the school staff to use in the future.

### ***Impact of the PD Program on Science Learning and Scientific Literacy***

After the PD sessions, Laticia was more passionate toward relating science to everyday life as she believed it was an important application of science. Laticia became more aware that she needed to build on the students’ prior knowledge. After her implementation of the outcomes in her class, Laticia found her students asked more questions and believed that their opinions were valued.

The researcher brought Laticia’s original PMM to the interview. The researcher showed the PMM to Laticia and asked if she had anything that she would like to add about scientific literacy. Laticia looked at the PMM and read each of her responses and explanations that had been written by the researcher. Laticia said that her understanding of scientific literacy had not changed and that she did not want to add or remove any information.

### ***Impact of the PD Program on the Success of Science at School in 2006***

Laticia believed that the ideas and strategies from the PD were easy to implement because

It was still fresh and I did it very soon after the PD – that made a difference. If I had left it too long it may have been put on the back burner and I may have forgotten it all.

On a more practical note, for the Early Childhood class in 2007 Laticia would like to extend her repertoire to

do more work in small groups, especially for the activity work as organizing the whole class at one time is very

difficult in the junior primary. I would have some group activities and have the students rotating around so that I can actually work with one group at a time and have the other groups doing some sort of preparation or writing the report so I can focus on specifics with a small group. That would be a more effective way of teaching science.

Another post-PD focus for Laticia was that she was planning to adopt a more student-centred approach to science in 2007. When the researcher asked Laticia what she thought the impact of the PD was for the whole school she said

Everyone is talking a lot more about science now. We did an activity together and looked at how we would mark it to check if we are all on the right track. We have some things planned for science as a whole staff next year, more PD and more collaboration.

Laticia believed that although the PD was “great” that you could not do everything in a short space of time, as she revealed

You have to have time to go back to your classroom and do one thing [activity] and then think about it, decide whether it is worth doing again, if it needs to be modified for your kids and if it fits with the curriculum.

After further reflection Laticia thought

You know, I really would like to have someone to work with, someone to bounce ideas off from time to time, that’s one of the reasons I like to have prac students. Sometimes in a small school like this one you don’t have another [teacher] teaching exactly the same year as you so you don’t spend as much time talking about what you are doing, as everyone else is doing something different.

### ***Impact of the PD program on Winchester's Future Directions***

When the researcher asked Laticia about what might be expected in science at Winchester in the future, she explained that

Although science was only a priority for one term, this year there has been considerable focus on the follow-up of the PD that we will continue with next year. The reason for this is that the science Making Consistent Judgements is a focus for all Western Australian primary schools in 2007, especially in Years 3, 5 and 7. So as a school we have decided to keep working with science, particularly in the area of assessment for next year at least. We decided that we all [staff members] should be involved because we all may be involved if not next year then some time in the future.

### **Summary of Chapter**

Before the PD workshops, teachers at Winchester believed they would most benefit from better resources and pedagogical skills to assist in their science teaching. The staff's main focus for the school was that it lacked resources. Interestingly, the staff's responses in the Final Staff Interviews revealed that resources were no longer an issue and that they had moved forward from believing that the schools limited resources for science was a problem. They had moved onto thinking about how and what they could do to improve their science teaching. It seemed that the lack of resources had been used as an excuse not to do science, but now they had a more positive and confident view about science.

Laticia found that on her own PL journey she was constantly reflecting on what she had achieved in terms of pedagogical skills, increased confidence and resource acquisition. Laticia was working to achieve this sense of accomplishment in other areas of science that were not included in the PD session. She believed that she was able to do this successfully by applying the pedagogical skills and strategies from the PD experience to other areas of science. Students enjoyed science, were engaged and were doing a lot of science at an early age. Laticia thought that her increased confidence and pedagogical skills had allowed her to extend herself further

than she had in the past. This enabled her to try new activities in science and she was able to encourage her own students to be more autonomous.

Although the PD sessions were over in quick succession and the school appointed only a term to science as a priority, Laticia believed that, as did other teachers, their PL had just begun. The teachers had been given the grounding to improve their science teaching and they were using this foundation to progress at their own rate. Laticia thought that teachers would be able to continue their PL at Winchester through “in-house collaboration and reflection”.

## **CHAPTER 7**

### **KNIGHTSBRIDGE PRIMARY SCHOOL**

#### **Introduction**

This chapter describes the collection and analysis of the data for Knightsbridge Primary School. It first provides some background information about the school and of the PD program offered there, followed by the findings chronologically. In this school only one PD was based on the KSS PD program because the Principal required a move to the Primary Connections program. Consequently the data collection was adapted to the different circumstances.

#### **Background to Knightsbridge Primary School**

Knightsbridge, a metropolitan state school, had a staff of 37 teachers some of whom were part-time; there were 32 female teachers and 5 male teachers, two female deputy principals and a male principal. The school is located in a predominantly middle socio-economic area and has 585 students from Kindergarten to Year 7. The school, located 16 km south west of Perth, Western Australia, celebrated its 30<sup>th</sup> anniversary in 2007. Knightsbridge is an open plan school with groups of four classrooms adjoining a common area. In recent years the school student population had increased and four transportable classrooms were placed at the rear of the school to cater for the temporary increase in student numbers. Science is generally taught by the class teacher. However, some teachers are part-time, and hence not every teacher in the school teaches science.

Knightsbridge's educational priorities were determined by the whole staff, and in 2006 and 2007 the school had chosen science as an area of need following the results of the Monitoring Standards in Education student data. As part of their science priority the staff came to the consensus that some PD sessions in science would be beneficial. The Principal, who had recently moved to Knightsbridge, suggested the KSS as an organisation to deliver the PD program. The Principal had a prior successful experience with the KSS at another school, he knew the Education Officer and the variety of professional development programs that could be provided to his staff. Additionally, the Principal chose the KSS to deliver the PD because he knew that it was flexible in terms of content and delivery and therefore suited the staff's needs.



The two half-day, whole-school workshops were: Working Scientifically through Open Investigations (2006) and Introduction to Primary Connections (2007). All teachers and administrators participated in these two workshops. Both whole school PD sessions occurred on scheduled school PD days. At the beginning of the first PD session, an activity book and support materials to assist in the follow-up implementation were provided to attending staff. Resources for the Primary Connections were purchased by the school's science coordinator prior to the PD session, however, the PD Education Officer also brought copies of the books for teachers to use during the PD.

The first whole-school PD workshop occurred in May, 2006 and the second whole school PD workshop on Primary Connections occurred almost a year later in April, 2007. Other small group or in-class PD sessions were conducted by the Education Officer during the first term. Knightsbridge also requested and received a further half-day, whole-school PD session which occurred in Term 4, 2007 after the research period. There was a large time span between the first two PD sessions as the Knightsbridge staff had other concurrent priorities for which the staff participated in PD sessions. Late in 2006, government primary school teachers were able to receive the Primary Connections PD at no cost. The Australian Government organised funding for educators from all Australian states and territories to be trained in the delivery of PD relating to Primary Connections. The KSS Education Officers were trained to deliver Primary Connections PD and thus were able to offer it as part of their service. As the Primary Connections PD involved no fee for service to government primary schools, the requests to the KSS for the Primary Connections were greater than those of the KSS regular workshops. Consequently, their workshops in 2007 focussed on Primary Connections. After the researcher observed the Primary Connections PD session she found that the aims of the KSS PD were not reflected by Primary Connections and hence these data were not used in this case study. It is important to note that the Primary Connections resource books began to be used by the KSS as a resource in their general PD sessions because the books were becoming more readily available.

## **Overview of the Knightsbridge Workshops**

The two science KSS PD sessions are outlined below.

*Workshop 1 (May 1, 2006): Working Scientifically through Open*

*Investigations* covered the Western Australian curriculum science area of Working Scientifically specifically relating to Investigating and how Investigating could be integrated with the content areas of Natural and Processed Materials and Energy and Change. It explored the Investigating, Natural and Processed Materials, and Energy and Change outcomes by showing teachers how these outcomes related to specific activities.

*Workshop 2 (April 5, 2007): Introduction to Primary Connections* explored the initiative linking the teaching of science and English language literacy (not scientific literacy). The curriculum resource had a Working Scientifically focus which spanned all years of primary school. The workshop explored the Primary Connections books, which were developed around the four conceptual outcomes of Earth and Beyond, Energy and Change, Life and Living, and Natural and Processed Materials.

## **Findings**

This chapter describes the findings from the data collected from the students and teachers of Knightsbridge. As for Fenchurch and Winchester Primary Schools, the data were collected from the seven sources as outlined in the methodology section: PD Workshop Feedback Sheets, Initial Teacher Interviews, Teacher Questionnaire, Personal Meaning Mapping Interviews, Observation of Lessons, Student Interviews, Student Questionnaires, Final Staff Interviews, and Interviews with Case Study Teachers. Table 7.1 presents the timeline for the data collection at Knightsbridge.

Table 7.1 Data Collection Timeline for Knightsbridge

Data	2006 May	Nov	Dec	2007 Jan	Feb	Mar	April	May	June
Professional Development & Workshop Feedback Sheets	√						√*		
Teacher Questionnaire		√							
Personal Meaning Mapping Interviews		√							
Teacher interviews									
- formal initial		√							
- formal final								√	
- case study class teachers								√	√
- informal		√	√		√	√	√	√	
Student Questionnaire								√	
Informal Student Interviews								√	
Observation of lessons		√	√		√	√	√	√	√

Note: \*Primary Connections PD

### ***Professional Development Workshop Feedback Sheet***

There were 34 teachers who responded to the PD WFS which were the same WFS as those administered at the Fenchurch and Winchester Primary Schools.

#### ***Teachers' Attitudes and Perceptions about Confidence and Pedagogical Skills Before and After the PD Workshop***

Table 7.2 presents a comparison of pre- and post-workshop teachers' attitudes and perceptions about science teaching in the Workshop.

Table 7.2 Teachers' Pre- and Post- workshop Attitudes and Perceptions about Teaching Science in Workshop 1: Working Scientifically (%) at Knightsbridge PS

Wk shop	Item Pair no.	Item Content	SA	A	D	SD
Pre	1	Currently I have a positive attitude towards teaching science	29	71	0	0
Post		I have a positive attitude toward teaching science	44	56	0	0
Pre	2	Currently I need adaptable skills and ideas to use in the classroom	32	59	6	3
Post		I have been given adaptable skills and ideas to use in the classroom	32	68	0	0
Pre	3	Currently I am confident in planning effective science programs	9	53	38	0
Post		I could confidently plan effective science programs	21	79	0	0
Pre	4	Currently I can confidently deliver effective science programs	6	68	26	0
Post		I could confidently deliver effective science programs	24	76	0	0
Pre	5	Currently I feel confidently able to facilitate student achievement in science outcomes	3	35	56	6
Post		I could confidently improve students learning in science outcomes	15	85	0	0

(n=34) Note: Due to rounding not all rows add to 100

The results in Table 7.2 reveal that teachers remained positive about science after the PD, with several teachers responding more positively after the PD. The Item 2 data show that before the workshop, 91% (31 teachers) agreed that they needed adaptable pedagogical skills and ideas to use in the science class. After the workshop, all teachers were satisfied that they had been given pedagogical skills and ideas.

The results relating to teacher confidence show a positive shift in teachers' attitudes and perceptions after the PD workshop. The pre-workshop WFS showed 62% (21 teachers) believed that they were confident in planning effective science programs (Item pair 3) compared with all teachers after the workshop. Likewise, all teachers were confident of delivering effective science programs teachers after the workshop, with six of the teachers moving their response from agree to strongly agree. The fifth item pair, confidence in facilitating student achievement, revealed that only 38% (13 teachers) were confident in this aspect before the PD workshop, compared with all teachers in the post-workshop survey.

In general, the results reflect that teachers already thought positively about science and that these attitudes were improved by the PD workshop. The post-workshop data for the second item pair revealed that teachers thought they were provided with adaptable pedagogical skills and ideas to use in the classroom. Interestingly, three teachers who did not think that they needed pedagogical skills before the workshop reported that they had been given them after the workshop. A comparison of teachers' perceptions about their confidence before and after the PD workshop reveals favourable outcomes.

### ***Teachers' Attitudes and Perceptions about Knowledge, Pedagogical Skills and Confidence, Resources and Leadership through Open-Ended Responses***

Four open-ended questions for one workshop were analysed. As at Fenchurch and Knightsbridge, the content of teachers' responses were analysed, as described in Chapter 3, and clustered into seven categories: knowledge; pedagogical skills; confidence; resources; leadership; collaboration; and reflection.

Question 1 (see copy of WFS in Appendix 1) was answered before the PD Workshop commenced. Teachers were asked "What would you personally like to achieve as a result of attending this workshop?" Table 7.3 shows a summary of these categories, together with the percentage of the comments that fell into each category.

The largest number of comments, in the PD workshop, related to acquiring pedagogical skills. For example one teacher wrote that they wanted "activity ideas with simplicity and assessment ideas" and another teacher wanted "new practical activities for PP [Pre Primary]".

Ten responses (26%) related to knowledge. One teacher believed “information on evaluating” was needed, and another wanted to “gain a better understanding of the investigating strand”. Four comments related to teacher confidence, for example, a teacher needed “increased confidence in teaching science”. Additionally, one response related to resources; this teacher wanted improved access to resources.

**Table 7.3** Knightsbridge Teachers’ Responses to the Question “What would you personally like to achieve as a result of attending this workshop?”

Comment category	% of comments
	Workshop 1 Working Scientifically
Knowledge	26
-understand science more	
Pedagogical Skills	60
-more hands-on experiments that can be taught to children	
-better evaluation skills	
Confidence	11
-increased confidence in teaching science	
Resources	3
-awareness of and access of resources	
Number of comments	38
Number of teachers	31

At the conclusion of the PD workshop teachers were asked three more questions. Question 1 asked teachers: “What actions do you plan to take following today’s session?” Table 7.4 presents a summary of these categories, together with the percentage of comments in each category. The largest number of comments after the workshop related to pedagogical skills. For example one teacher wrote about being able to “write up and teach [a program] using the investigation principles”, and another teacher was going to “use simpler and greater value lessons.”

Six comments were related to acquiring or using resources. One teacher wrote: “Try some of the activities in the green book [Primary Connections Life and Living]”. Additionally, five comments described how teachers believed they had increased confidence. One of these teachers wrote that s/he would “Try more science activities with an emphasis on language.”

Table 7.4 Knightsbridge Teachers' Responses to the Question "What actions do you plan to take following today's session?"

Comment category	% of comments	
	Workshop 1	Working Scientifically
Knowledge		9
-found out more information		
Pedagogical Skills		47
-use the investigating process		
Confidence		16
-try some of the activities		
Resources		19
-go to the website		
Reflection		9
-review my planning		
Number of comments		32
Number of teachers		22

Question 4 asked teachers: "Has this workshop affected your views about teaching science?" Table 7.5 shows the most comments after the PD Workshop related to confidence. One teacher believed that the PD "made it [the science activities] look easy", and another teacher simply stated that s/he was "more enthusiastic".

Another frequent response pertained to pedagogical skills, represented by 26% of the comments. For example, one teacher wrote that the PD had given him/her some "great ideas for lessons", and another teacher believed that s/he was introduced to "many approaches". Seven responses were about knowledge, for example, one teacher referred to a "greater understanding of the outcomes". Five teachers said that their views about science had not been changed, just reinforced.

Table 7.5 Knightsbridge Teachers' Responses to the Question "Has this workshop affected your views about teaching science?"

Comment category	% of comments	
	Workshop 1	Working Scientifically
Knowledge		23
-it clarified ideas and concepts		
Pedagogical Skills		26
-learning can take place in simple activities		
Confidence		35
-its fun and less stressful		
-it is not hard		
No, just reinforces it		16
Number of comments		31
Number of teachers		24

Question 5 asked teachers: "What was the main message you gained from today's workshop?" Table 7.6 indicates the largest number of comments in

Workshop 1 related to pedagogical skills. For example, one teacher thought that the main message was to “keep science simple”, and another thought the main message was that “science needs to be relevant to children’s lives”. The second most common response related to teacher confidence. For example, one teacher thought that the main message was that “science is not that scary to tackle” and another teacher believed that “It’s easy to investigate”. Additionally, eight responses related to knowledge, for example, one teacher stated that the PD had “clarified some levelling issues”.

Table 7.6 Knightsbridge Teachers’ Responses to the Question “What was the main message gained from today’s workshop?”

Comment category	% of comments
	Workshop 1 Working Scientifically
Knowledge	18
-clarified some levelling issues	
Pedagogical skills	46
-keep activities simple	
-focus on the relevant skill level	
Confidence	32
-the activities are simple and lots of fun	
Resources	4
-excellent planning and resources for lessons	
Number of comments	44
Number of teachers	28

In summary, analysis of the open ended responses showed that, in anticipation of the workshop, the staff’s highest priority was to gain pedagogical skills. The most common action that staff planned to take after the PD workshops related to their use of newly acquired pedagogical skills. Staff believed that they would be able to use the science activities from the workshop in their classrooms during science lessons. Staff also believed that their newly developed pedagogical skills would be of benefit to both themselves and the students. Most staff found that the main message of the PD workshop was to have increased confidence to use their new skills in their classrooms.

### Initial Teacher Interviews

Seven teachers were individually interviewed six months after the first PD workshop. This meant that teachers had considerable time to reflect on the PD and to try out some of the ideas they were given in the PD. As was noted in Chapter 3,



the Initial Teacher Interview responses were based around 13 questions. The questions asked of each participant are shown in Figure 7.1.

14. What was the most significant part of the PD for you?
15. Do you think the opportunities to ask questions and trial activities were important?
16. If you hadn't had the PD do you think you would have looked at the outcome science documents?
17. How easy was it for you to implement and use the ideas and strategies that you gleaned from the PD?
18. What was the most difficult part of changing your teaching practice to accommodate your new knowledge?
19. What do you think you will do next year for science?
20. Do you have the same year group in 2007?
21. How will you be programming in 2007?
22. Has the PD changed your attitude toward science?
23. Do you think you teach any of the science areas now or do you think what you have learnt is limited to the areas you looked at in 2006?
24. If you had to pick one of the other science learning areas such as Natural and Processed Materials, Earth and Beyond or Life and Living which one would you think would be the most difficult?
25. What things would you like to add to what you did this year?
26. If you had some more science PD what would be of most benefit to you?

Figure 7.1. Initial interview questions at Knightsbridge

The following summary was developed from the interview responses of the seven teachers. Knowledge, confidence, pedagogical skills, resources, impact on students, understanding of science and further science PD were the themes used to construct the summary.

### **Knowledge**

The teachers felt that they had a better understanding of how to teach science especially in the area of Investigating; as Katy explained “the PD has improved my knowledge of the outcomes and the investigating process”. They all believed they had been able to use their new found knowledge immediately. Further, the teachers thought that after attending the PD they felt more comfortable with science. This made them more involved with science and as a result they believed they were teaching science more regularly.

### ***Confidence***

Six of the seven teachers were positive about the PD program. Two teachers mentioned that the program made the science look easy, a further two teachers mentioned that the investigations information was invaluable, and one teacher remarked that s/he was ready to get going as soon as the Primary Connections book arrived. One teacher already felt positive about science before the PD program and the other six teachers felt that the PD had made them more positive toward teaching science. Six of the seven teachers believed that the PD had increased their confidence; the other teacher claimed to already be confident about science.

### ***Pedagogical Skills***

According to two of the seven teachers, the most beneficial aspect of the PD program was that it gave teachers direction about how science should be planned, taught and assessed. Most teachers thought the PD was “right on track” with where they were in terms of their learning. Planning, implementing and trying out the new activities were the most popular follow up actions. However, one teacher mentioned that some techniques for managing groups would have been helpful and another teacher stated a wish for some more direction about ideas or sources of ideas.

### ***Resources***

Popular follow up actions that teachers took after the PD program were seeking out additional resources, mentioned by four of the seven teachers, and sharing and discussing ideas with colleagues, mentioned by three teachers.

### ***Impact on Students***

The teachers believed that the impact of the PD program had filtered through to the students, and they emphasised that what students should “get out of science” was enjoyment and understanding.. They thought that the children were more enthusiastic about science than they had been previously, had a clearer picture of what science was about, were more involved with their science lessons and enjoyed the science they were doing.

### ***Understanding of Science***

In relation to what science meant to them the teachers provided a variety of answers. Two teachers thought that science was about the understanding of the natural world, three teachers believed that science was the empirical pursuit of

knowledge and three teachers believed that science was about hands-on discovery learning for the students.

### ***Further Science PD Programs***

The teachers believed that they required further assistance in terms of PD. One teacher wanted “more hands-on PD sessions like the last one, it really helped me to learn”, and another teacher said that he really wanted to “get into the new books [Primary Connections] and understand them.”

Teachers were happy with the science PD they had received earlier in the year. Generally, the first PD session had increased teachers’ knowledge, confidence, and pedagogical skills. The PD program had also given them some new resources to practice in their science teaching. However, teachers believed they required more PD to ensure that they were keeping up to date with the current methods and resources. The results from Initial Teacher Interviews have many similarities to the data from the WFS from the PD workshop in terms of knowledge and pedagogical skill acquisition. Also, the results from the Initial Teacher Interviews are consistent with teachers’ responses to the post-PD WFS items.

### **Teacher Questionnaire**

The Teacher Questionnaire was modified, at the request of the Principal, to be more inclusive of the information that he and the school’s science committee might use to improve science in the school. The main changes to the questionnaire involved removing any demographic information about the teachers to ensure confidentiality, this included information about teachers’ science programming in 2006, and the inclusion of a second section about teachers’ interest, background knowledge, confidence and resource use, with responses separated into the content areas of Western Australian science curriculum. Additional changes included the removal of the last two pages of the questionnaire about why teachers taught science and the pedagogical strategies teachers used when teaching science. In its place questions were included on the effectiveness of the first PD workshop on Investigating, what teachers would like the following PD sessions to address, and whether or not they knew Primary Connections. A copy of the Knightsbridge Teacher Questionnaire is in Appendix 5. The following analysis examined all the data but reports only the findings that are relevant to this research.

Twenty five teachers volunteered to participate in the Teacher Questionnaire and the Principal chose to administer the questionnaire to the staff 6 months after the initial PD workshop. The results below reflect these teachers' responses.

### ***Teachers' Background and Experience***

Information from the school website informed the researcher that all teachers were fully qualified with an average of 22 years teaching experience. All teaching staff met the professional requirements to teach in Western Australian schools and registration with the Western Australian College of Teaching.

### ***Attitudes and Perceptions About Teaching Science***

The Teacher Questionnaire included a variety of questions about attitudes and perceptions of teaching science. Teachers were asked to respond to a five point rating scale (scored 1 to 5). The confidentiality of the Teacher Questionnaires resulted in the researcher not being able to identify the two case study teachers in the sample. Hence, the mean responses were calculated for all 25 teachers and presented in Table 7.7.

#### **Interest and Confidence**

Items 1, 8, 11 and 13 in Table 7.7 relate to teachers' perceived interest about and confidence to teach science. The results reveal that, on average, teachers were interested in science, and were reasonably enthusiastic about teaching science. Teachers' confidence to teach science was generally high and they welcomed children's questions.

#### **Knowledge**

Teachers' perceived knowledge of science was determined by Items 4, 5 and 6 in Table 7.7. On average, teachers' background knowledge of science was about the scale midpoint. Mean scores for explaining the science behind the activities they do with their students and answering students' questions were also close to the midpoint.

#### **Pedagogical Skills**

Teachers pedagogical skills (Items 2, 3, 7 and 12) were sound but teachers believed that they did not teach science as well as they taught other subjects.

#### **Resources**

Teachers' perceived availability of resources were sought through responses to Items 9 and 10. Teachers believed that the resources available to them were

adequate, with resource materials within the school being more accessible than those outside the school.

**Table 7.7 Teachers' Attitudes and Perceptions about Science at Knightsbridge**

Teachers' attitudes and perceptions about science	Score 1	Score 5	Mean
<i>Interest and Confidence</i>			
1. My own interest in teaching science is best described as	Not interested	Very interested	3.8
8. My confidence in teaching science is	Not very confident	Confident	3.4
11. When teaching science, I welcome students' questions	Rarely	Always	3.8
13. I am enthusiastic about teaching science	Rarely	Always	3.6
<i>Knowledge</i>			
4. My own background knowledge for teaching science is best described as	Limited	Extensive	2.9
5.# I find it difficult to explain to students the science behind the activities they do	Rarely	Always	2.5
6. Students' science questions are easy for me to answer	Rarely	Always	3.1
<i>Pedagogical Skills</i>			
2.# Compared with other subjects I find it difficult to teach science	Rarely	Always	2.3
3. I am effective in monitoring children doing science activities or experiments	Rarely	Always	3.1
7. My skills in teaching science are best described as	Limited	Extensive	3.3
12. I am continually searching for better ways to teach science	Rarely	Always	3.4
<i>Resources</i>			
9. The resources available to me for teaching science are	Limited	Extensive	3.1
10. I use outside resources (such as the internet) and/or people (such as a local expert) in my classroom	Rarely	Often	2.7

Note. # Item statement is negatively worded but not negatively scored

### ***Teaching the Science Content Strands***

Teachers were asked a series of questions relating to their attitudes and perceptions about teaching each of the concept strands. Their percentage responses are reported in Table 7.8. The results show that teachers are most interested in, have an adequate background for teaching science, and are the most confident with Life and Living (Items 1, 2 and 4 respectively). Nearly all teachers felt their skills in teaching science were reasonable or competent, but about a quarter felt not very confident (Item 3).

Table 7.8 Knightsbridge Teachers' Interest, Background Knowledge, Confidence and Resource Use in Each of the Four Science Concept Strands (% Responses)

Item	Earth and Beyond	Energy and Change	Natural and Processed Materials	Life and Living
1. My own interest in teaching science is best described as				
Highly interested	29	29	16	41
interested	62	62	70	50
Not interested	8	8	12	8
2. My own background knowledge for teaching science is best described as				
extensive	12	12	8	8
adequate	70	70	75	83
Extra preparation needed	16	16	16	8
3. My skill in teaching science is best described as				
competent	20	20	16	20
reasonable	75	75	79	75
I'm not too sure of my ability	4	4	4	4
4. My confidence in teaching science				
Very confident	8	12	4	12
confident	75	62	70	70
Not very confident	16	25	25	16
5. The resources available to me for teaching science are				
extensive	4	8	8	8
adequate	75	75	66	75
limited	20	16	25	16
6. I use outside resources (such as the internet)				
Very often	12	12	8	8
often	33	29	33	37
sometimes	54	58	58	54
7. I use outside resources and people (such as a park ranger)				
Very often	0	4	4	0
often	8	8	8	12
sometimes	91	87	87	87
8. When teaching science, I usually				
Design my own activities	12	8	16	20
Adapt ideas from resources	70	62	62	62
Follow a given course	16	29	20	16

Most teachers thought there were adequate resources available for science teaching, but about a fifth thought resources were limited (Item 5). Internet and outside resources were used infrequently and teachers usually designed or adapted ideas when teaching science (Items 6, 7 and 8 respectively).

### Personal Meaning Mapping Interviews

Jasmine and Justine, the two case study teachers, were interviewed using the PMM interview technique during an individual teacher/researcher interview. The PMM investigating the teachers' scientific literacy was administered six months after the initial PD workshop. Both teachers completed a PMM using the method described in Chapter 3, and their comments were sorted into the categories of scientific literacy by the researcher. Table 7.9 shows how Jasmine's and Justine's responses were assigned to these categories. Justine gave 12 responses in the PMM interview which were categorised into four scientific literacy categories. In contrast, Jasmine only provided four responses which were categorised into three categories. The two teachers produced a total of 16 responses. Table 7.9 indicates that the most common response reported by Jasmine was science content and for Justine it was science communication

Table 7.9 Teachers' Responses Categorised into Aspects of Scientific Literacy at Knightsbridge

Category	Jasmine's responses (n=4)	Justine's responses (n=12)	Total number of responses (n=16)
Resources and strategies	1 (25%)	2 (17%)	3 (19%)
Science content	2 (50%)	1 (8%)	3 (19%)
Science communication	1 (25%)	7 (58%)	8 (50%)
Investigating	-	2 (17%)	2 (12%)
Informed decision	-	-	-
Science related to life	-	-	-
Questioning and sceptical	-	-	-

Jasmine was reluctant to write her responses down as she did not believe she knew the "correct answer". After further clarification by the researcher that responses were not classified as correct or incorrect, Jasmine wrote her four

responses to the phrase. Some of Jasmine's and Justine's examples and explanations of each of the categories are given in Table 7.10.

Table 7.10 Teachers' Examples and Explanations of Scientific Literacy at Knightsbridge

Category	Teacher Example (what the teachers wrote)	Teacher Explanation (verbal explanation by the teachers, scribed by the researcher)
Resources and strategies	Subject (Jasmine)	You can put science across all subject areas
	Just using computers (Justine)	Computer skills for research
	Famous scientists (Jasmine)	About their discoveries
Science content	Understanding the facts, maybe tests (Justine)	For assessment and understanding
	Language variables (Jasmine)	All the words of science and the type of language you use and all the equipment
Science communication	Journal writing (Justine)	Reporting on what they have done and learnt
Investigating	Write up of experiment (Justine)	How to do this in a scientific manner
Informed decision	-	-
Science related to life	-	-
Questioning and sceptical	-	-

Jasmine and Justine did not provide responses that could be categorised into making informed decisions, science related to life, or being questioning and sceptical. Justine was particularly focussed on the literacy aspect in her responses, as some of her responses that were categorised as investigating or content by the research retained a communication focus. Jasmine's ideas were also classified in terms of what could be written, read or spoken.

Jasmine was apprehensive to communicate her ideas and this was illustrated during the administration of her PMM interview when she explained

I don't know exactly what this means, so I don't have the correct answer. You probably need to know about famous scientists and their discoveries so I will put that down, but I am not sure.



## **Observations of Lessons in Case Study Classes**

### ***Context of Lesson Observations***

Jasmine and Justine were approached by the Principal to participate in the case study research. The context of each class is outlined below. The research period did not commence until late in 2006 as the researcher continued to conduct research at the previous case study school, Winchester, until late 2006. There was some overlap of the research period, however, the observation lessons at Winchester would often coincide with the science lesson times at Knightsbridge, making visits to both schools during the same period difficult.

#### **Jasmine's Classes**

Jasmine taught in a demountable classroom that had a fixed blackboard at the front of the room, storage drawers on both sides of the room, and students' desks set in groups of six to eight towards the front of the room. A movable whiteboard, the teacher's desk and a computer station were at the back of the room.

Jasmine explained that she chose science topics that were in the assessment schedule for the semester and she could relate to a theme in her classroom. A topic usually ran for the duration of the term with some exceptions being the lead up to special events such as Christmas.

The observation of the lessons commenced six months after the first PD session. The researcher observed Jasmine's split Year 4/5 class during the regular science program for the last two weeks of Term 4, 2006. Jasmine's class consisted of 31 Year 4/5 students (17 boys and 14 girls). Science was taught for 60 minutes each week, usually in the afternoon. The total time during this observational period was 120 minutes (2 hours). The theme for the two week period was the science of toys, covering the science areas of Investigating and Energy and Change strands.

Unexpectedly, Jasmine was required to teach a Year 7 class in 2007. There are many Australian public holidays on Monday in Term 1, which resulted in the one science topic theme extending to Term 2. This class was observed by the researcher during all of Term 1 (7 lessons) and the first four weeks of Term 2, 2007 (3 lessons). Science was taught once in each practicable week over these 14 weeks for a period of 60 to 90 minutes per week. The total time spent on science during this observation period was 735 minutes (12 hours 15 minutes) or just over 73 minutes per week. Jasmine's class comprised 28 Year 7 students (15 boys and 13 girls). During the

2007 observation period Jasmine mentored one practicum student who did not instruct any science lessons. Marvellous Micro-organisms, from Primary Connections, was the theme during the observation period engaging in the Investigating and Life and Living strands.

### Justine's Class

The researcher observed Justine's Year 6 class during its regular science program during Terms 1 and 2, 2007. The observation of the lessons commenced nine months after the first PD session early in Term 1, 2007 for Justine. Science was taught each week for 9 weeks for a period of 55 to 90 minutes per week. The total time spent on science during the observation period was 700 minutes (11 hours 40 minutes) or almost 78 minutes per week.

Justine's 2007 class comprised 30 Year 6 students (16 boys and 14 girls). Justine mentored a practicum student during the observation period but the student did not teach any science lessons.

Justine team taught with another Year 6 teacher, Barbara. The two classrooms were open plan but generally students from each class stayed on "their" side of the room, even during activities. Both classrooms had a fixed blackboard at the front of the room, storage drawers on the sides of the room nearest the windows, and students' desks set in groups of four to six toward the front of the room. The teachers' desks and eight computer stations were located at the back of the room. The researcher only observed Justine's class, as the other teacher did not volunteer for the research.

Justine explained that she chose topics that were in the assessment schedule for the semester and, where possible, she related science to students' everyday experiences. A topic usually ran for the duration of the term. During the observational period Justine and Barbara team-taught the Primary Connections topic of Marvellous Micro-organisms which incorporated aspects of Investigating and Life Living strands. At the onset of the observational period, Jasmine usually taught the lesson first to her Year 7 class and passed information, including helpful hints, to Justine and Barbara.

## **Lesson Observations**

### **Jasmine's Year 4/5 Class**

The last two science lessons of the 2006 school year conducted by Jasmine were integrated into the class theme of the tradition of toys and Christmas. The activity that Jasmine used was one from the Scitech PD sessions that had been done in May, 2006. Jasmine said she chose this activity because

It was readily available from the resources from the PD  
and it highlights investigation skills, such as variables  
and fair tests which are really important for science  
activities. I like the students to do hands-on activities  
in science, they enjoy them and learn a lot from them.

(Field notes, 29<sup>th</sup> November, 2006)

**Table 7.11      Outline of Jasmine's Year 4/5 class's Term 4 (2006) Science Lessons at Knightsbridge**

Lesson	Activity	Nature of Activity	Pedagogical Grouping
1	<ul style="list-style-type: none"><li>• Making toy cars</li><li>• Car launcher activity</li><li>• Variables and fair test</li></ul>	Teacher asks students what they remember about variables and fair tests. Students decide what variables they will test with their cars and write their methodology and perform a trial run.	Teacher led whole class discussion Small group work Individual written work
2	<ul style="list-style-type: none"><li>• Car launcher activity</li><li>• Variables and fair test</li><li>• Investigation planner</li></ul>	Students use the investigation planner to test one or two variables with their car (different surfaces, tension in elastic, gradient). Students record their results. Class discussion about results and ideas for further investigations.	Small group work Teacher led whole class discussion

Table 7.12 Outline of Jasmine's Year 7 Term 1 and 2 (2007) Marvellous Micro-organisms Program at Knightsbridge

Lesson	Activity	Nature of Activity	Pedagogical Grouping
Term 1			
1	<ul style="list-style-type: none"> <li>• Micro-organisms and bread</li> <li>• Brainstorm of what children know</li> <li>• Brainstorm chart</li> <li>• Investigation of different breads</li> </ul>	<p>Teacher asks students what they know about micro-organisms. Students give a variety of responses about what they believe to be micro-organisms.</p> <p>Students construct their own chart from the brainstorm.</p> <p>Teacher explains the bread activity to the students and writes what is contained in each of the breads on the board.</p> <p>Students record information, perform the investigation and record results.</p>	<p>Teacher led brainstorm and class discussion</p> <p>Individual student work</p> <p>Small group work</p>
2	<ul style="list-style-type: none"> <li>• Micro-organisms and bread</li> <li>• Introduction to flow charts</li> <li>• Construction of making bread flow chart</li> </ul>	<p>Teacher explains how to construct a flow chart and does an example of making toast on the board with the students' assistance. Teacher asks the students what they know about making bread. Students write a flow chart for making bread from the information discussed and prior knowledge.</p>	<p>Teacher explanation</p> <p>Individual student work</p>
3	<ul style="list-style-type: none"> <li>• Integration of science with reading</li> <li>• Background on micro-organisms</li> </ul>	<p>The teacher selects students to read the passage about micro-organism and asks the students questions at the conclusion to evoke discussion.</p> <p>Students write in their own words what they understood from the passage.</p>	<p>Teacher led student reading and comprehension</p> <p>Individual student work</p>
4	<ul style="list-style-type: none"> <li>• What happens when yeast is mixed with sugar and water?</li> <li>• Investigation</li> </ul>	<p>Teacher explains what the students will be investigating and reads the instructions with the students. Students perform the investigation and record the initial results and begin to write the investigation into their notebooks. Teacher engages students in whole class discussion about their results.</p>	<p>Teacher explanation</p> <p>Small group work</p> <p>Teacher led class discussion</p>
5	<ul style="list-style-type: none"> <li>• What happens when yeast is mixed with sugar and water? (cont)</li> <li>• Investigation (cont)</li> </ul>	<p>Teacher reminds the students what they are investigating and reads the instructions with the students. Students perform the investigation and record the initial results and write the investigation into their notebooks. Teacher engages students in whole class discussion about their results.</p>	<p>Teacher explanation</p> <p>Small group work</p> <p>Teacher led class discussion</p>
6	<ul style="list-style-type: none"> <li>• What temperature of water is best for yeast?</li> <li>• Investigation</li> </ul>		
7	<ul style="list-style-type: none"> <li>• How do you make dough?</li> <li>• Why does dough rise?</li> <li>• Pizza making Investigation</li> </ul>	<p>The last five lessons follow the same format as outlined below.</p>	<p>Teacher explanation</p> <p>Small group work</p> <p>Teacher led class discussion</p>
Term 2			
8	<ul style="list-style-type: none"> <li>• Looking at and describing mould</li> <li>• Investigation</li> </ul>	<p>Teacher explains what the students will be investigating and reads the instructions with the students. Students perform the investigation and record the initial results and begin to write the investigation into their notebooks. Teacher engages students in whole class discussion about their results.</p>	
9	<ul style="list-style-type: none"> <li>• Making mould</li> <li>• Integration with reading</li> <li>• Investigation</li> </ul>		
10	<ul style="list-style-type: none"> <li>• Observations of mould</li> <li>• Investigation</li> </ul>		

## Jasmine's Year 7 Class

The first lesson was an introductory lesson where the students were encouraged to explain what they knew about micro-organisms and to investigate different breads. The lesson progressed well and the children were attentive and involved, but after the lesson Jasmine expressed some concerns saying

I think one of the aims of the lesson will be to see the difference between yeast breads and non-yeast breads...but I am not one hundred percent sure at the moment. That is the one problem I have with the Primary Connections book, they don't have an ending. When you have prac students you often tell them that they should have consolidated the lesson by asking students what they have done. With this book [Primary Connections] they want you to just do some of the activities and not tell the students the answers or sum up what you have done. You have to wait until later in the book. Maybe that's the way the book is supposed to be? (Field notes, 19<sup>th</sup> February, 2007)

The second lesson integrated flowcharts with science. In this lesson students needed to think about how bread would be made and the steps taken to make the bread. Students worked collaboratively in small groups to put this information into a flow chart. Most of the students had the right idea of how to make bread and their consensus was reached quite easily. Jasmine still felt uneasy about the Primary Connections books, as "they don't seem to have an ending to sum up what you have done in the lesson you have to wait for that somewhere down the track" (Field notes, 26<sup>th</sup> February, 2007).

The third lesson integrated science with comprehension and writing. Jasmine included a discussion on the history of science relating to micro-organisms. Word origins and definitions were also discussed. After the lesson Jasmine mentions that she

doesn't know how anyone can teach science in 40 minutes, you need at least one hour to an hour and a half and sometimes 2 hours a week to teach science effectively. Science needs to be

integrated in with language to make this happen. (Field notes, 6<sup>th</sup> March, 2007)

Lessons 4 to 6 were investigations about yeast. The investigations were presented in such a way that they gave students appropriate instructions without directing the students towards a narrow conclusion. The teacher-directed discussions were designed to make the students think about why the events the students observed occurred. The following teacher-directed series of questions provides an example.

Jasmine: Why does the balloon inflate? Why does bread rise?  
S1: It might produce hot air  
Jasmine: Mmm sort of  
S2: It might produce a gas  
Jasmine: Yes, what gas?  
S3: It might produce oxygen  
Jasmine: It's not oxygen. Any other ideas on what the gas might be?  
S4: Carbon dioxin  
Jasmine: Nearly – it's carbon dioxide  
(Field notes, 13<sup>th</sup> March, 2007)

To increase the engagement of the students, Lesson 7 involved a modification of the Primary Connections program to make pizza rather than bread. When asked what they learnt in this lesson some students' responses were

Student 1: Learnt that you need oil to make dough  
Student 2: Learnt that you shouldn't stir yeast too much in the water  
Student 3: Learnt that you have to let dough rise  
Student 4: Learnt that you can put salt in dough  
(Field notes, 28<sup>th</sup> March, 2007)

Lessons 8 to 10 involved a set of investigations about mould. Jasmine's foci on these investigations were fair testing, variables and learning about the mould. Jasmine mentioned

I now understand how the Primary Connections books work.  
They give the students some information and then the students need to think about this information and bring it all together to make a complete picture which they did in the last couple of lessons. (Field notes, 8<sup>th</sup> May, 2007)

#### Justine's Year 6 Class

Justine's program was very similar to that of Jasmine's due to the collaborative nature of the Year 6 and 7 teachers. As Justine put it,

Because we are working together on this new Primary Connections program and Jasmine is going first she gives her worksheets and ideas to me and then I modify my lessons a little, if necessary for my students, it's a good way to work. Another time it will be my turn to go first and give my material to others. (Field notes, 23<sup>rd</sup> February, 2007)

Because Justine collaborated with Jasmine, her sequence of lessons was almost the same. As shown in Table 7.13, however, Justine covered this content in 9 lessons rather than 10. Justine also worked collaboratively with Barbara, one of the other Year 6 teachers, in every lesson. Both Justine's and Barbara's students would be given instructions together, share the same resources and join in the plenary sessions. Justine was the key teacher in the science lessons with Barbara acting as a support. Justine thought this arrangement was very effective because

we share things for some other subjects where the other teacher takes the lead role. I really like teaching science and although the other teacher enjoys science too it gives us some time to work on an area of interest and put more time into it and do some new things like introducing this Primary Connections book. (Field notes, 2<sup>nd</sup> March, 2007)

After the first four lessons Justine voiced some concerns over the Primary Connections book

There aren't many hands-on activities in the book and the book seems to jump around a lot. (Field notes, 16<sup>th</sup> March, 2007)

However, toward the end of Term 1 Justine realised that the foundations of the topic were many hands-on activities for the students. As Justine reflected

You need to immerse the students in the science so they can start making their own connections about what you are doing. It's not about giving the answers to the students, it's about how the students engage and make sense of the activities. I think they [students] learn much

more the way I am teaching now. (Field notes, 30<sup>th</sup>  
March, 2007)

Although Justine had participated in the Primary Connections PD workshop she thought

Being shown what to do and trying it for yourself are two very different things. It is more meaningful when you have to actually teach it and you need to have a handle of what's going on. (Field notes, 11<sup>th</sup> May, 2007)

In general, the focus for both teachers was on testing variables and fair testing when students were doing investigations, which was the focus of the first PD session. Both teachers put in considerable time and effort to make the students' learning experiences reflect situations that they may face in real life, e.g. why dough rises and how to prevent mould on your food.



Table 7.13 Outline of Justine's Year 6 Term 1 and 2 (2007) Marvellous Micro-organisms Program at Knightsbridge

Lesson	Activity	Nature of Activity	Pedagogical Grouping
Term 1			
1	<ul style="list-style-type: none"> <li>• Marvellous micro-organisms</li> <li>• Brainstorm of what children know</li> <li>• Brainstorm chart</li> <li>• Preparation for next lesson's investigation</li> </ul>	<p>Teacher asks students what they know about micro-organisms. Students give a variety of responses about what they believe to be micro-organisms.</p> <p>Students construct their own chart from the brainstorming session.</p> <p>Teacher explains the bread activity to the students and writes what is contained in each of the breads on the board.</p> <p>Students record information, perform the investigation and record results.</p> <p>Teacher explains what the students will be investigating in the next lesson and reads the instructions with the students.</p>	<p>Teacher led brainstorm and class discussion</p> <p>Individual student work</p> <p>Small group work</p>
2	<ul style="list-style-type: none"> <li>• Investigation of different breads</li> </ul>	<p>Teacher reminds the students what they will be investigating and reads the instructions with the students. Students perform the investigation and record the initial results and begin to write the investigation into their notebooks. Teacher engages students in whole class discussion about their results.</p>	<p>Teacher explanation</p> <p>Small group work</p> <p>Teacher led class discussion</p>
3	<ul style="list-style-type: none"> <li>• Introduction to flow charts</li> <li>• Construction of making bread flow chart</li> </ul>	<p>Teacher explains how to construct a flow chart and does an example of making toast on the board with the students' assistance. Teacher asks the students what they know about making bread. Students write a flow chart for making bread from the information discussed and prior knowledge.</p>	<p>Teacher explanation</p> <p>Individual student work</p>
4	<ul style="list-style-type: none"> <li>• Word wall – micro-organism</li> <li>• Integration of science with reading</li> <li>• Background on micro-organisms</li> </ul>	<p>Teacher asks students about all the words they have learned that relate to micro-organisms over the last few lessons. The teacher writes each word on a separate piece of paper and pins it to a board in the room.</p> <p>The teacher selects students to read the passage about micro-organism and asks the students questions at the conclusion to evoke discussion.</p> <p>Students write in their own words what they understood from the passage.</p>	<p>Teacher led student information collection.</p> <p>Teacher led student reading and comprehension</p> <p>Individual student work</p>
5	<ul style="list-style-type: none"> <li>• Investigation: What happens when yeast is mixed with sugar and water?</li> </ul>		
6	<ul style="list-style-type: none"> <li>• What temperature of water is best for yeast?</li> <li>• Investigation</li> </ul>	<p>The next five lessons follow the same format.</p>	<p>Teacher explanation</p> <p>Small group work</p> <p>Teacher led class discussion</p>
Term 2			
7	<ul style="list-style-type: none"> <li>• How do you make dough?</li> <li>• Why does dough rise?</li> <li>• Pizza making Investigation</li> </ul>	<p>Teacher explains what the students will be investigating and reads the instructions with the students. Students perform the investigation and record the initial results and write the investigation into their notebooks. Teacher engages students in whole class discussion about their results.</p>	
8	<ul style="list-style-type: none"> <li>• Test micro-organisms</li> <li>• Making mould</li> </ul>		
9	<ul style="list-style-type: none"> <li>• Observations of mould</li> <li>• Investigation</li> </ul>		

## Student Interviews

Twenty students were selected on a random basis and interviewed, ten students from each of the case study classes. Five boys and five girls from each of Year 6 and 7 were interviewed individually, toward the end of Term 2, 2007 and were asked the six questions outlined in Figure 7.2.

- |    |   |
|----|---|
| 1. | What is your favourite subject?                         |
| 2. | Do you like science?                                    |
| 3. | What is your most favourite part of science?            |
| 4. | What is your least favourite part of science?           |
| 5. | What has been your favourite part of science this year? |
| 6. | Do you like science better this year than last year?    |

Figure 7.2. Student interview questions at Knightsbridge

Students' responses showed they all enjoyed science. Eighteen students explained that the best part of science was the experiments. One Year 6 girl thought that group work was the part of science she liked the best, because she liked working with others, and another Year 6 student thought there was a lot of variety in science this year.

Fourteen students stated that the part they liked least about science was the writing. Two students said they did not like sitting and listening, one student did not like it that "there wasn't any chemistry this year" and one Year 7 student did not like "the hard work we have to do in science".

Two students explained that they liked everything about science. Seventeen students said that they had enjoyed science better this year than last year. Two of these students thought it was more fun, another two students believed that they had not done very much science before. A Year 6 boy mentioned that he liked science this year because "we are doing the more advanced subjects", while a Year 7 boy believed "science is more interesting and there is more variety this year". One Year 7 girl pointed out that she had always liked science. The three students who thought science was better last year had really enjoyed their science lessons last year because of the particular topics.

The students' favourite science lesson was the pizza making which was chosen by eleven of the twenty students. Other favourite lessons included the yeast experiments (5 students) and the mould experiment (4 students).

Seven of the twenty students chose sport as their favourite subject. There were many other favourite subjects reported by students, including; Art, spelling, language, Mathematics, English and Technology and Enterprise. Only three of the twenty students selected science as their favourite subject, suggesting science can be enjoyed by students with a variety of interests.

Overall, the researcher's observations were confirmed by the students' responses. Students were very interested in their science classes and they enjoyed participating in all their science lessons. Many students reported that they were doing more science now than they had in the previous year and looked forward to their regular science lesson each week.

### **Student Questionnaires**

The Student Questionnaire was identical to the one used at Fenchurch and Winchester Primary Schools. It was completed by 14 boys and 11 girls from Justine's Year 6 case study class and 16 boys and 11 girls from Jasmine's Year 7 case study class. A copy of the student questionnaire is available in Appendix 5. Generally, the results of the Student Questionnaire were similar for both classes. However, after a closer examination of the data, the researcher thought that the individual results of each class should be presented, as in some items the responses varied widely from one class to the other.

### ***Students' Activities in Science Lessons***

Table 7.14 summarises the students' activities in science lessons. Class discussion (Item 7) was the most common science activity with 80% of students in Year 7 and 96% of students in Year 6 reporting this occurred in most or nearly every lesson. Students in Year 7 believed that they made up their own science notes (Item 2) more often than the Year 6 students. Conversely, students in Year 6 believed they copied notes from the teacher more often than they Year 7 students (Item 1). Talking to others about their ideas (Item 3), having class discussions (Item 7) and working in groups (Item 9) were common responses for both classes.

Table 7.14 Students' Activities in Science Lessons at Knightsbridge

Item Content		Year	% Responses			
			Never	Some science lessons	Most science lessons	Nearly every science lesson
In my science lessons:						
1.	I copy notes from the teacher	7	18	78	4	0
		6	8	44	40	8
2.	I make up my own science notes with friends or by myself	7	0	14	60	26
		6	16	60	16	8
3.	I can talk to others about my ideas	7	4	22	44	30
		6	0	20	20	60
4.	I read a science book	7	44	52	0	4
		6	36	48	46	0
7.	We have class discussions	7	0	4	22	74
		6	8	12	40	40
9.	We do our work in groups	7	0	8	44	48
		6	0	8	36	56

Note: Year 7, n=27; Year 6, n=25

### ***Teacher- or Student-Centredness of the Classroom***

Table 7.15 summarises students' perceptions of teacher- or student-centredness in science lessons. The results in Table 7.15 reveal that watching teacher demonstrations (Item 5) were more common in Year 7 than in Year 6. Teacher directed experiments were common in both classes (Item 6). Students in Year 7 had more opportunity to do experiments of their own choice (Item 17) than the Year 6 students. The students were encouraged to participate by teachers asking them to investigate and find out things (Item 18) in over half of the lessons in both classes most of the time. The results reveal that students believe the teacher was willing to listen to their ideas (Item 15) in most lessons.

Table 7.15 Teacher- or Student-Centredness of the Classroom at Knightsbridge

Item Content	Year	% Responses			
		Never	Some science lessons	Most science lessons	Nearly every science lesson
In my science lessons:					
5. I watch the teacher do an experiment	7	18	41	37	4
	6	44	36	8	12
6. We do experiments the way the teacher tells us	7	0	22	52	26
	6	0	12	24	64
My teacher					
15. Listens to my ideas	7	0	41	37	22
	6	16	28	32	24
16. Talks to me about my work in science	7	18	41	22	18
	6	32	20	32	16
17. Lets us do our own experiments	7	18	26	33	22
	6	76	12	4	8
18. Asks us to investigate and find out things	7	0	22	30	48
	6	12	36	16	36

Note: Year 7, n=27; Year 6, n=25

### ***Using Resources Outside the Classroom***

Table 7.16 summarises students' beliefs about the resources outside the classroom. Students infrequently used resources beyond the classroom according to the results in Table 7.16. In both classes over 50% of students believed that they learned about scientists and what they do (Item 8) at least some of the time. Having visiting speakers (Item 12), going on excursions (Item 11), using computers (Item 13) and using the internet (Item 14) were infrequent activities for both Year 6 and 7 students. In Year 7 approximately 50% of students felt that they go outside of the classroom to do activities/experiments (Item 10) while in Year 6 84% of students believed this never happened. The students believed that most of the case study class' science lessons are a combination of teacher demonstration and student-centred activities with the teacher

taking the lead. Lessons were rarely outdoors and guest speakers and computer use were uncommon activities. These results about the lack of excursions or outdoor work reflect those given by the teachers in the larger staff population. The researcher also noted that most lessons were inside the classroom, computers were used occasionally and there were no guest speaker lessons during the observation period.

Table 7.16 Using Resources Outside the Classroom at Knightsbridge

Item Content		Year	% Responses			
			Never	Some science lessons	Most science lessons	Nearly every science lesson
In my science lessons						
8.	We learn about scientist and what they do	7	15	63	18	4
		6	40	52	4	4
For science						
10.	We do activities outside in the playground, at the beach or in the bush	7	48	52	0	0
		6	84	16	0	0
11.	We have excursions to the zoo, museum, Scitech, or places like that	7	89	11	0	0
		6	92	8	0	0
12.	We have visiting speakers who talk to us about science	7	74	26	4	4
		6	60	24	8	8
13.	We use computers to do our science work	7	67	26	4	4
		6	80	20	0	0
14.	We use the internet at school for science	7	52	48	0	0
		6	72	28	0	0

Note: Year 7, n=27; Year 6, n=25

### ***Students' Interest in Science Lessons***

Table 7.17 summarises the students' interest in science lessons. The information in Table 7.17 shows that students in both the Year 6 and 7 classes were rarely bored in science (Item 29). Students enjoyed science (Item 20) and were excited (Item 27) about science a little more often in Year 7 than in the Year 6 class. Students were not particularly curious in science (Item 28) in either class.

Table 7.17 Students' Interest in Science Lessons at Knightsbridge

Item Content		Year	% Responses			
			Almost Never	Sometimes	Often	Nearly always
The science we do at school is:						
20.	Enjoyable	7	0	16	46	38
		6	4	36	24	36
During science lessons I am:						
27.	Excited	7	4	22	33	41
		6	8	44	28	20
28.	Curious	7	0	41	41	18
		6	12	36	28	24
29.	Bored	7	48	44	8	0
		6	32	52	4	12

Note: Year 7, n=27; Year 6, n=25

### ***Students' Perceptions of the Easiness of Science***

Table 7.18 summarises the results of students' perceptions of the easiness of science.

Table 7.18 Students' Perceptions of the Easiness of Science at Knightsbridge

Item Content	Year	% Responses			
		Almost Never	Sometimes	Often	Nearly always
The science that we do at school					
19. Is easy to understand	7	0	12	44	44
	6	0	12	64	24
During science lessons I					
30. Am confused	7	37	52	7	4
	6	32	52	16	0
31. Learn a lot	7	0	11	33	56
	6	8	12	32	48

Note: Year 7, n=27; Year 6, n=25

The results in Table 7.18 show that, in both Year 6 and 7, 80% or more of students believed that they learn a lot in science (Item 31) most or every lesson. Eighty

percent of the students reported that they found science easy to understand (Item 19) often or nearly always in both classes. Students were rarely confused in science lessons (Item 30), with 52% of students responding that they were only confused in some lessons with over 30% in each class believing that they were never confused in science.

### ***Students' Thinking in Science***

The results in Table 7.19 revealed that students felt challenged in science lessons. Almost 90% of students in Year 7 and 68% of Year 6 students say that often or nearly always they are made to think in science (Item 21).

Table 7.19 Students' Thinking in Science at Knightsbridge

Item Content	Year	% Responses			
		Almost Never	Sometimes	Often	Nearly always
The science that we do at school:					
21. Makes me think	7	0	11	50	39
	6	0	32	28	40
In science we need to be able to:					
22. Think and ask questions	7	0	22	41	37
	6	0	20	32	48
23. Remember lots of facts	7	4	11	63	22
	6	4	24	44	28
24. Understand science ideas	7	0	15	48	37
	6	0	28	32	40
25. Explain things to each other	7	0	26	37	37
	6	0	20	44	36
26. Recognise the science in the world around us	7	4	41	37	19
	6	12	50	25	12

Note: Year 7, n=27; Year 6, n=25

Approximately 80% of students in both classes believed that they needed to be able to think (Item 22). Additionally, over 70% of students in each class believed they needed to understand ideas (Item 24) and 85% of students believed they needed to be able to recognise the science in the world around them (Item 26) at least some of the time. Over 70% of students in each class believed that they often needed to remember science facts (Item 23).



### **What Students Liked Best About Science**

Almost every student (50 of the total 51) offered a written response to the open-ended question on the survey which enquired what students liked best about science. A total of 82 ideas were given in the 50 responses. The responses were coded using the same method that was used at as Fenchurch and Winchester.

Table 7.20 provides an outline of the results for the two 2007 case study classes. The data in Table 7.20 shows the two main themes which were inclusive of the student ideas together with the percentages of students whose responses were included in these ideas. The most popular theme from students was that they liked the hands-on activities and investigations in science, one Year 7 girl stated that “I like to watch the experiments grow and react” and a Year 6 boy stated simply “I like experimenting”.

Table 7.20 What Year 6 and 7 Students Like Best About Science Lessons at Knightsbridge

What students liked best about science lessons	Year 7 % of ideas	Year 6 % of ideas	Ave % of ideas
Teaching and Learning Activities			
Hands on experiments/activities/investigations/ making things	49	31	40
Liked group work	9	10	10
Student Attitude/Feeling			
Fun, interesting, enjoy	14	21	17
Content			
Specific like/topic, lab activity	7	13	10
Challenging	21	15	18
Other ideas	2	10	5

Other student responses were that they thought that science was fun, interesting and enjoyable. For example, a Year 6 girl wrote “I like having fun and learning” and a Year 7 boy wrote “the experiments are really interesting”. Students also liked it when they did group work. For example, a Year 6 girl wrote “I like it when we can go with our friends because we can cooperate easier.”

Overall, students believe that they engaged in a variety of activities in science. However, students did not experience many activities outside the classroom. They reported that they watched teacher demonstrations followed by doing activities in small

groups as the teacher instructed, with the Year 7 students progressing to being able to do their own activities. The students enjoyed and got excited about science, especially the Year 7 students. Students believed they need to understand science ideas and thought they were encouraged to think in science, concepts which relate to scientific literacy. Other examples that reflect scientific literacy presented in the data included students needing to recognise science in the world around them (science related to life), explain things to each other (science communication), and that students did many activities in science (investigating).

### **Final Teacher Interviews**

Seven teachers participated in the Final Teacher Interviews which occurred at the conclusion of the case study period, one month after the second whole school PD workshop. Each teacher was interviewed independently. The Final Teacher Interview responses were based around 10 questions as outlined in Figure 7.3.

11. How would you compare your confidence to teach science after the PD sessions to your confidence to teach science before the PD sessions?
12. Has your attitude toward science changed? Why/why not or if so how?
13. Were you able to reflect on your current practice? If so what did you note?
14. What methods have you changed in your science teaching since the PD?
15. How do you think your current students enjoy science compared with other student other groups in previous years?
16. What do you believe students should “get out of” science?
17. How do you go about achieving this?
18. What do you understand by working scientifically?
19. Do you think you or the school needs more assistance with science? If so what would be valuable?
20. What improvements do you believe need to be made for science to move forward at Knightsbridge PS?

Figure 7.3. Final teacher interview questions at Knightsbridge

The interviewees’ responses to the ten questions were grouped into six themes. The following section presents the teachers’ responses about knowledge, confidence, pedagogical skills, scientific literacy, impact of the PD program on students’ learning, and the impact of the PD program on the future direction of science at Knightsbridge.

### ***Knowledge***

Six of the seven teachers were positive about the two PD workshops. According to these six teachers, a fundamental aspect of the PD was that it gave teachers an understanding of how science could be taught effectively in the primary classroom. The teachers believed that the information provided in the PD sessions had given them a better understanding of the new curriculum materials for science. For example, one teacher believed that they would need to “make allowances as there is more emphasis on language in the curriculum resource [Primary Connections] itself”. One teacher reported “I have increased my understanding of the outcomes and standards framework” and another mentioned that he could “understand how to assess science better”.

### ***Confidence***

Five of the seven teachers believed that the PD had increased their enthusiasm and confidence. After the second PD workshop one teacher said that they had “a more positive attitude toward science” while another thought that the PD had given her a “boost of enthusiasm”. One teacher believed that they had always been confident in terms of science and another thought that he needed more information to make an informed decision about how he felt about the PD program. Three teachers reported that they were already trying some new ideas in their classroom because of their increased confidence. As one teacher pointed out “I am now giving science a higher priority by putting in more of my time into planning science lessons”.

### ***Pedagogical Skills***

Six of the seven teachers felt that they used their new found pedagogical skills since the time of the second PD. One teacher noted “I am bringing the ideas from the PD into my planning and teaching” and another said “I am giving students more input into science”. In general, teachers thought they were being more student-centred by giving students more open-ended questions, providing students with more opportunities to work cooperatively in groups and encouraging their students to have inquiring minds. Six of the seven teachers believed that they had become more focussed on what was important to be teaching in science as a consequence of the PD program. Two of the teachers had worked on integrating the literacy aspect of the new curriculum materials into their science lessons.

### ***Scientific Literacy***

When asked to describe scientific literacy teachers offered several comments. One teacher thought that it was “understanding the mechanics of technology and integrating science with technology”. Another teacher thought that to encourage scientific literacy you would need to “encourage inquiry, teach students to be critical and get students to work like a scientist”. “Being scientifically literate to become an informed adult” was given as the reason by one teacher for why scientific literacy should be important. Other teacher responses included modelling inquiry to encourage students to explore everyday phenomena and teaching students to be critical. The teachers encouraged students to communicate scientifically and to investigate by getting students to work together in groups to safely investigate everyday problems that were often integrated with technology. Teachers believed that investigating this way developed students’ understanding of science in their everyday life and showed the values in science and society.

### ***Impact of the PD Program on Students’ Learning***

The teachers’ primary belief about what students should “get out of science” was enjoyment. Teacher believed that the students’ enjoyment in science had improved because they were more aware of what was happening in science and had more ownership of the science they did in the classroom. The teachers considered that this was a result of students having more choice in the science curriculum as teachers were negotiating the curriculum with the students and therefore getting them more involved in the science lessons.

### ***Impact of the PD Program on the Future Direction of Science at Knightsbridge***

In general, the teachers were positive about the outcomes of the two whole-school PD workshops in relation to knowledge, confidence, pedagogical skills, and the impact the program had on their classroom teaching. All of the teachers believed that they required some additional PD to consolidate what they had learned and to develop other skills, especially assessing in science. A further PD session had been organised by the Principal for all teachers to attend early the following term (Term 3, 2007). Four teachers were interested in organising collaborative groups within the school that would assist in their future PL. Two teachers had already developed collaborative relationships with other teachers who taught the same age group. These teachers reported that the

collaboration had assisted with their understanding of ideas presented in the workshops and had increased their confidence so that they could implement new ideas into their programs. The collaboration allowed the teachers' time for reflection, as Casey explained

It's great to talk with someone else who knows what you are trying to do. If you can't work something out, just talking it through seems to help. Even if you cannot work it out yourself you can brainstorm until you start to think outside the square.

Three teachers wanted to ensure that all staff members were heading in the same direction. They thought this could be achieved by refocussing and mapping out where they had been and where they wanted to go with science. They wanted to make sure that everyone was "up to speed" and maintain science as a priority in the school for a further two years. Two teachers believed that more resources needed to be made available to all teachers.

Two of the seven teachers believed they needed more support to become competent with Primary Connections. These teachers were not part of the trial and one of the teachers had missed one of the PD sessions. They were both keen to become more engaged with science in the near future and they believed that the PD would assist with their goals. The two teachers also hoped that the more experienced mentoring teachers within the school would also be able to assist them with their goals. The other five teachers felt that they had made a considerable amount of progress with their science lessons over the last year and they had seen the positive results in their classrooms. All of the teachers would like some additional PD in the area of assessing in science and five of the teachers were very keen to "move forward" by working with their colleagues.

The results of the Final Teacher Interviews were consistent with the findings from the WFS completed directly after the first PD workshop. However, as almost a year had elapsed between the two PD sessions, all but a few teachers (who had participated in the extra PD session, which included the case study teachers) were at different stages of their implementation. These responses suggest that some teachers were taking follow-up actions but others had not felt confident enough to commence without the appropriate resources. Teachers' believed that further PD in assessing in science and Primary Connections combined with a more collaborative structures within

the school would assist in the progression of teachers' PL in science at Knightsbridge PS.

### **Interviews with the Case Study Teachers**

The following section describes the interviews with Justine and Jasmine, the two classroom teachers from the observation classes. The interviews occurred after school at the teachers' request. The teachers were interviewed separately as they taught different classes. The theme of the interviews was the impact of the PD program on classroom practice.

#### **Interview with Jasmine**

The following section describes an interview with Jasmine, the second case study teacher. This interview also occurred in the staffroom at Knightsbridge on the 13<sup>th</sup> June, 2007.

#### ***Impact of the PD Program on Teacher Knowledge***

Jasmine believed that the PD had increased her knowledge of the Science Learning Area by providing her with opportunities to ask questions during the PD. She thought that

Because the PD was presented in such a way that you could stop the Education Officer and ask questions, I really started to understand what was meant by the outcomes. It was really good to actually be using the document that we use in the classroom during the PD, it made everything more meaningful.

#### ***Impact of the PD Program on Teacher Pedagogical Skills***

The practical ideas and strategies that the Education Officer used in the PD sessions were very helpful to Jasmine as she used them immediately with her class without modifying them to determine if they were successful. Jasmine found

They [the ideas and strategies] worked with my kids.  
They [the students] did the activity and we got a lot out of them, they really made them think.

#### ***Impact of the PD Program on Teacher Confidence***

Jasmine felt that the PD had increased her confidence to teach science, as she explained

Before the PD I avoided science like the plague. I would always try to swap with another teacher. I would take their Art, Music, anything as long as they would take my science. When I did have to teach it, it was always the first to go if things were busy. Now I teach science for at least an hour every week, sometimes two!

### ***Impact of the PD Program on Resources***

Jasmine explained that many resource books and science equipment had been purchased in the past year. Jasmine believed that the Science Coordinator, Wilma, had done a great job organising all the equipment into plastic crates for many of the activities from the PD program. Jasmine found that “you just pick up the crate, take it to your class and off you go. All you have to do is make sure any consumables are replaced”.

### ***Impact of the PD Program on Science Learning and Scientific Literacy***

Jasmine was given her PMM and asked to read it at this point in the interview. The researcher asked Jasmine if there was anything that she would like to add to or remove from the PMM. After a couple of minutes reading and thinking about the question Jasmine stated that she did not want to change anything about the PMM. However, when asked by the researcher about what she believed was important to teach her students in science that would prepare them for the future Jasmine said

“We [teachers] need to teach science in a contextual way. We [teachers] can use things that are topical, in the news maybe, so they know what is going on. I cannot teach them everything about science so I guess they should know how to get information for themselves so that they become young adults that understand what is going on in the world.

### ***Impact of the PD Program on the Success of Science at School in 2007***

In Jasmine’s view, the PD had made a great impact on her teaching of science and an impact on science at a whole school level because, as she put it, it is “great to be involved with something that was so understandable and practical”. However, Jasmine believed some teachers were more confident than others as she explained “not all staff members are on the same page and some more PD is necessary for everyone”.

### ***Impact of the PD Program on Knightsbridge's Future Directions***

Jasmine hoped that Science would remain a priority at Knightsbridge for at least another year. This would ensure that further PDP would be undertaken by all staff and that collaborative structures would be developed within the school to ensure that the PL continues.

### ***Interview with Justine***

The following section describes an interview with Justine, the case study teacher. It occurred in the staffroom, at Knightsbridge on the 24<sup>th</sup> May, 2007.

### ***Impact of the PD Program on Teacher Knowledge***

For Justine the PD came “just at the right time.” She had team taught her Year 6 class with another teacher who always took the leading role in science lessons. Justine explained

I have taken a back seat in science for a while now. I felt that I didn't know much about any of the content areas in science. The PD was what I needed to improve my knowledge of the content and understanding of the Curriculum Framework.

### ***Impact of the PD Program on Teacher Pedagogical Skills***

The PD had enabled Justine to try some activities with other teachers before she used them with her students. Justine thought that

Doing the science activities as a student prepared me to be able to see what would work and what could go wrong. These skills you learn as you go in the classroom. It was great to make any mistakes in the PD rather than in my classroom.

### ***Impact of the PD Program on Teacher Confidence***

Justine believed she was able to lead the science lessons this year because she had been given a “confidence boost.” She went on to explain, “I know I can still improve but I am well on my way to tackle all aspects of science. What is different is I now have the courage to try”.

### ***Impact of the PD Program on Resources***

During the PD program, Justine remembered the Education Officer showed staff how resources could be cheaply and easily purchased, “it was a matter of knowing what you had in the school and knowing where it was and how to access it”. Justine had



assisted Wilma, the Science Coordinator, in preparing the plastic crates containing equipment for the upper primary classes. Justine thought that this was an invaluable experience. She explained

If you are prepared for science the lesson is a lot easier to think through. Working with the crates gave me an insight into the organisation before the lesson that is required. You know where things are, it makes it easier and the lesson goes like clockwork.

### ***Impact of the PD Program on Science Learning and Scientific Literacy***

Justine was shown the record of her scientific literacy PMM by the researcher. The researcher asked her if she would like to amend it. After some consideration Justine declined. The researcher asked Justine what practical understanding of science she would hope children in her class would have as young adults. Justine replied

They would need to understand the science that they were involved with...Like electricity for an electrician, plants for a gardener and chemicals for a hairdresser. They also need to make sure they understand the impact what is going on globally and locally, Kyoto, global warming, soil salinity, water restrictions.

Her answer implied other aspects of scientific literacy, such as science related to life and making informed decisions that her PMM did not include.

### ***Impact of the PD Program on the Success of Science at School in 2007***

Justine thought that the PD program had been well accepted by many teachers and had brought the teachers together to share ideas and resources. She believed that the PD had provided her with a more confident way of teaching science that was engaging her students. In relation to the whole school, Justine believed that there was scope for improvement with further PD in the near future.

### ***Impact of the PD Program on Knightsbridge's Future Directions***

In Justine's opinion, science was very important to Knightsbridge and should remain so for at least another year. Justine explained

We are just getting started. We have done a lot but we need to continue. I think we are only half way there. We will need some more PD, more resources and more time

to collaborate and reflect with our colleagues. Maybe if we set some time into the timetable for collaboration and reflection in science next year we can keep the ball rolling.

### **Summary of Chapter**

Before the initial PD workshop, teachers at Knightsbridge believed they would most benefit from pedagogical skills to assist in their science teaching. Pedagogical skills were still being sought at the end of the case study period. The funding that allowed teachers from Western Australian government schools to engage in free Primary Connections PD, accompanied with the ability of the KSS Education Officers to deliver the Primary Connections PD program, changed the focus of the KSS PD program. This change in focus altered the way the staff at Knightsbridge acquired and used knowledge, pedagogical skills and resources, making it more specifically related to the Primary Connections materials.

Nevertheless, staff believed that they had been given knowledge, pedagogical skills and resources from the PD program, and in particular, from the first PD workshop. However, the teachers believed they required more assistance, especially in the area of Primary Connections. Staff believed they could continue on their PL journeys. Several staff thought they could continue to the next level involved by setting up collaborative structures within the school to allow for collegial interactions. Teachers who were interviewed thought that collaboration and reflection were the next step to enhance their own PL journeys, as well as those of other teachers.

The PD sessions for Knightsbridge were spread over a year. Because there was a considerable time when only some staff were involved in their PL in the science area, a disparity of PL experiences occurred among the staff. All staff were keen to continue their own science PL journey. However, some members of the staff made it clear that they felt that the time between subsequent PD sessions had been too long, and for some, this meant that they had forgotten much information of the initial information presented in the first PD session. On the other hand, staff that had been actively involved with the individual and small group PD sessions that reflected the content of the first PD workshop felt sufficiently confident to say that they would be able to transform their practice to reflect any science program.

## **CHAPTER 8**

### **DISCUSSION AND IMPLICATIONS**

This chapter gives an overview of the research undertaken in this study and then a summary of the findings from the PMM interviews (Chapter 4) and the case study schools, Fenchurch, Winchester and Knightsbridge Primary Schools (Chapters 5, 6 and 7 respectively). Using a cross-case analysis, the findings are drawn together to provide answers to the research questions. Finally, implications that evolved from the research are drawn for professional development presenters, teachers and other researchers.

#### **Introduction**

As discussed in Chapter 2, scientific literacy is viewed globally as a key purpose of science education. The definition of scientific literacy used in this research, which reflected the Australian context, described scientific literate persons as those who:

are interested in and understand the world around them, engage in the discourses of and about science, are sceptical and questioning of claims made by others about scientific matters, identify questions, investigate and draw evidence-based conclusions, make informed decisions about the environment and their own health and well being. (Rennie et al. 2001, p. 466)

Goodrum et al. (2001) concluded from their review that, although the various state and territory curricula supported the development of scientific literacy, there was little evidence that it was widely understood. Mapping aspects of scientific literacy to the Western Australian school science curriculum demonstrated a close correspondence to the Working Scientifically outcome, confirming that scientific literacy was an intended outcome of the Western Australian science curriculum. However, it was clear that teachers required assistance to understand scientific literacy and how the Western Australian Science Curriculum Framework is supportive of it as an outcome.

It was suggested in Chapter 2 that such assistance may be part of a PD program. In this research, the impact of the KSS PD program was investigated to determine how it assisted teachers to understand scientific literacy, and how they, in turn, assisted their students to develop scientific literacy.

This research focussed on the following research questions.

1. What do primary school teachers' understand by the term "scientific literacy"?
2. What are the factors determining the effectiveness of the KSS PD program in

- a. developing primary science teachers' understanding of scientific literacy?
  - b. promoting the confidence of primary teachers when teaching science?
  - c. developing teachers' pedagogical skills to enable them to teach science?
  - d. developing teachers' knowledge and understanding of science to enable them to teach science?
3. In what ways do teachers' levels of confidence, pedagogical skills and science knowledge influence how they teach science to students to encourage the development of scientific literacy in schools?
  4. In what ways can schools promote the longevity of the outcomes of the KSS PD program?

### **Overview of Research Design**

This research used a mixed-method approach based upon a multiple case study research design. Firstly, the PMM interviews were used to examine primary school teachers', high school science teachers', and the general public's understanding of scientific literacy. This section of the research provided a framework about people's perceptions of scientific literacy with which to compare the views of a smaller sample of primary teachers in the following case studies.

Research in the three case study schools, Fenchurch, Winchester and Knightsbridge, provided information about the impact of the PD workshops on teachers, in terms of their understanding of scientific literacy, pedagogical skills, knowledge and confidence in teaching science in primary schools, from the perspective of the case study teachers and other staff members in the schools who were interviewed or completed the teacher questionnaire. Additional information from surveys and interviews with the students in the case study classes was also used to inform the research.

This chapter synthesises the results from Chapters 4, 5, 6 and 7 to provide answers to the research questions. In this chapter the findings will be discussed across the four research situations; the PMM and the three primary schools.

### **Summary of Findings**

#### **Research Question 1: What do primary school teachers understand by the term scientific literacy?**

The first research question was examined by comparing the views of the five case study primary school teachers with the views of the three other groups, each of 18 participants, gained from the PMM interviews. The responses to the PMM interviews

gave an insight to a broader range of views of scientific literacy by examining the views of three groups of participants; primary school teachers, high school science teachers and the general public. The responses provided by each participant group were reviewed, and patterns in their perceptions were identified. Table 8.1 shows the response patterns of the four groups.

Table 8.1      Categorised Responses (%) of Primary Teachers, High School Science Teachers, the General Public and Case Study Teachers to the Scientific Literacy PMM

Categories	Primary School Teachers (n=18)	High School Science Teachers (n=18)	General Public (n=18)	Case Study Teachers (n=5)
Science communication	24	29	21	28
Science content	18	11	26	16
Resources and strategies	12	10	27	21
Science related to life	16	15	16	2
Investigating	19	15	7	28
Questioning and sceptical	7	13	2	0
Informed decisions	4	7	1	5
Total percentage	100	100	100	100
Total number of responses	136	136	128	43

### ***Science Communication***

A common category of responses for all four groups was science communication. The word “literacy” in the phrase “scientific literacy” drew the participants’ attention, especially those of the teachers, to ideas about an accepted understanding of the word literacy, which related to reading, communicating, writing and speaking. The participants adapted this idea to include science as an appendage to the related aspects of reading, writing, communicating and speaking. The teachers at the case study schools were able to provide further insight into why the term literacy directed teachers to this way of thinking. Katorina, one of the case study class teachers at Fenchurch, believed that

Unfortunately when teachers hear [the word] literacy they all focus on language due to the constant push in this area in the last decade or so. (Teacher Interview, 22<sup>nd</sup> February, 2006)

Laticia, the case study teacher at Winchester, concurred with this opinion by stating

We spend half of our time on literacy and numeracy, usually more on literacy. About 30% of our day is involved with

literacy, so when we hear the word literacy anywhere we revert back to what we do so often and do not view it in any other context. (Field notes, 14<sup>th</sup> August, 2006)

This pattern was exemplified by Justine, one of the case study teachers from Knightsbridge, half of whose responses to the stimulus “scientific literacy” were categorised as science communication (see Table 7.9).

### ***Science Content***

Science content received the second highest number of comments from the general public in the PMM interviews, and also by Jasmine, one of the case study teachers from Knightsbridge. This may relate to the participants’ confidence to offer ideas on their PMM. The general public, and several primary school teachers, were reluctant to write down their ideas without additional coaxing by the researcher. When they did many of the comments were related to the word “science” rather than the whole phrase “scientific literacy”, and consequently they wrote about scientific discoveries or mentioned the disciplines of science. This apprehension was well illustrated during the administration of Jasmine’s PMM interview when she explained that she didn’t know exactly what scientific literacy meant, so she would not be correct in her answer (see Jasmine’s PMM interview, Chapter 7).

### ***Resources and Strategies***

Resources and strategies are an integral part of the delivery of any curriculum, so it might be expected that teachers would write responses that reflect this category. Surprisingly, the comments relating to resources and strategies were the most common among the general public, with their responses relating to resources such as books and scientific models, rather than strategies. The responses of the case study teachers revealed that resources and strategies were more common responses for them than for the larger primary school teacher cohort.

### ***Science Related to Life***

Science related to life, which is an important aspect of scientific literacy, received a similar percentage of responses across the three participant groups (15-16%) in the PMM interviews. However, in the case study teachers’ PMM interviews, only Emily (Fenchurch) gave a comment that was representative of this category.

### ***Investigating***

Responses relating to investigating were common among the three teaching groups, particularly those involved with primary teaching. Two of the case study teachers, Emily (Fenchurch) and Laticia (Winchester), provided responses mostly related to Investigating. The frequency of teachers' responses in this area can be explained in terms of the structure of the Western Australian science curriculum. Table 2.1 demonstrated that all aspects of scientific literacy could be mapped to the Working Scientifically element of the Western Australian science curriculum. Although all five aspects of scientific literacy are included in the Western Australian science curriculum, Investigating is the only easily assessable component and hence may get the most attention.

Emily, while reviewing the science curriculum document, explained that as a result of the PD program she now understood the full extent of the Working Scientifically component of the curriculum document and could use it effectively in the classroom (Chapter 5). Laticia, the Year 2/3 case study teacher, was also not familiar with the other areas of Working Scientifically and she believed that her understanding of this component was important for the Early Childhood children whom she taught (Chapter 6). These comments reflect that teachers' attention has been focussed on Investigating as they are required to assess in this area of science and not in the other four areas of Working Scientifically.

### ***Questioning and Sceptical Attitude***

Having a questioning and sceptical attitude was a more common response from high school science teachers than the other two participant groups in the PMM interviews. The general public and primary teachers did not have many responses assigned to this category. None of the case study teachers wrote any responses in this area.

### ***Informed Decisions***

The category about informed decisions was not a common response category for any of the participant groups in the PMM interviews. Interestingly, only Katorina and Emily (Fenchurch) each made one comment assigned to this category. The responses from the case study teachers match closely those of the primary school teacher group.

### ***Trends in views of Scientific Literacy***

The three assertions made about the findings in Chapter 4 are revisited here to identify trends between the case study teachers and the larger cohort of participants described in Chapter 4.

Assertion 1 suggested that people's understanding of scientific literacy is based on both formal and informal learning experiences. This research has shown that primary teachers' learning experiences have been entrenched in a language literacy focus for a considerable time. Thus, a large part of their understanding of scientific literacy, revealed in their PMM interview, was based on their tenacious understanding of the word literacy. Similarly, Investigating was also a common primary school teacher response, possibly based on recent, topical and continued exposure to this easily assessable part of the Science Curriculum.

The primary teachers in this research appeared to have only limited exposure to and understanding of scientific literacy, furthermore, their understanding was focussed on one or two areas; science communication and Investigating. Given this, it is not surprising that the Goodrum et al. (2001) report found that the understanding of scientific literacy was not well understood, as teachers in Western Australia spend considerable time with other aspects of literacy and assessable aspects of the science curriculum.

The research findings agree with the views of Appleton (2003), who argued that primary school teachers' limited background knowledge was a result of limited science exposure in their formal science education which resulted in a low confidence level. Furthermore, Parker (2004) suggested that primary school teachers' prior formal educational science experiences may have lacked both breadth and depth. In Western Australia, as with other educational jurisdictions, primary teachers usually teach in at least six of the eight Learning Areas; consequently their time to develop understandings in science is limited (Appleton, 2006).

Assertion 2 proposed that self-efficacy in science plays a central role in what participants understand, believe and are willing to share about scientific literacy. The interactions in the interviews suggest that primary school teachers, and some of the general public, were uneasy to respond to an area in which they believed they were not confident in providing suitable answers. The findings suggest that if teachers do not feel comfortable with science then they may be inhibited in the development of their science



programs. This idea was examined by Enoch and Riggs (1990), who suggested that teachers who have a low self-efficacy in science or science teaching may avoid teaching science as they believe it is beyond their capabilities. PD program presenters should be aware of this issue and provide opportunities for primary teachers to improve their level of self-efficacy.

Assertion 3 purported that cultural backgrounds and social interactions are important in the development and understanding of scientific literacy. The findings from the PMM interviews in Chapter 4 revealed that three high school science teachers identified issues that related to groups of indigenous students they had taught. None of the five case study teachers made any reference to how a particular student or group of students impacted on their understanding of scientific literacy. Although cultural diversity was mentioned by one Western Australian primary school teacher in her PMM interview (Chapter 4), it did not appear to be an issue for teachers in the case study schools. The researcher identified that the four case study classes catered for students with a diverse range of cultural backgrounds and the three case study schools embraced and celebrated their school's multiculturalism in special events.

In general, the case study teachers' responses were similar to those of the larger cohort of primary teachers in the areas of science communication, science content and making informed decisions. The case study teachers' PMMs included more responses in the categories of Investigating and resources and strategies than those of the larger primary teacher group, but were still quite similar. Comments that expressed science as being related to life and being sceptical and questioning were not as common for the case study teachers as for the larger primary teacher group. However, as a general trend the responses showed similarities in the ranking of responses in each of the seven categories.

The findings showed that science communication and investigating were primary teachers' main categories of responses reflecting their understanding of scientific literacy. Knowing the content of science was also a common response among all the primary school teachers, as was having some resources and strategies, especially for the case study teachers. PD programs should aim to cover these aspects of scientific literacy to confirm teachers' understanding.

Although science related to life was a common response for the primary school teacher cohort, it was not for the case study teachers. Having a questioning and

sceptical attitude and making informed decisions were not common among the primary school teachers' responses, thus identifying these aspects as not being inclusive of primary teachers' understanding of scientific literacy. PD programs should aim to address these aspects in greater detail to develop primary teachers' understanding of these aspects of scientific literacy.

### **Research Question 2: What are the factors determining the effectiveness of the KSS PD program?**

In Chapter 2 a review of the literature on teachers' professional learning and professional development programs led to the identification of a number of factors that characterised effective PD programs. These factors are used in the context of the findings of the research to critique the effectiveness of the KSS PD program. In Chapter 2, two key factors were identified that the PD presenters should consider before the program is commenced at a school.

1. Identify the attitudes, needs and beliefs of the teachers to which they will be providing the PD program.
2. Identify the school context and develop the PD according to the needs of the teachers.

In relation to the first factor, information from each of the three principals of the case study schools suggested that the staff had been involved in the decision about, and were willing to participate in, the science PD. The principals had also been in contact with the PD presenter to negotiate a series of suitable workshops that would cater for the needs of their staff. The data from teacher interviews confirmed that all teachers were willing and believed they needed the PD to improve their science teaching, an important factor contributing to effectiveness of engaging teachers in a PD program according to Bell and Gilbert (1996). Furthermore, in all three case study schools, data from the WFS revealed that all teachers had positive attitudes towards science at the onset of each PD workshop.

The second pre-professional development program factor suggested that before the commencement of a PD program the presenter should consider the context of the school. The PD presenters in this research both had a background in education and considerable teaching experience in Western Australian schools which allowed them to understand the school context in general, including what Loucks-Horsley et al. (2003) identified as the national, state and local policies. More importantly, before the program

began, the PD presenters spent considerable time communicating with each of the principals at the case study schools, to understand the immediate school context.

The review of the literature in Chapter 2 also identified an additional eight key factors that should be considered during the implementation of the PD program. The PD program should

3. Aim to include activities, strategies and provide resources that are of use to teachers.
4. Aim to increase teachers' confidence.
5. Aim to increase teachers' pedagogical skills.
6. Aim to value teachers' past experiences and knowledge.
7. Aim to increase teachers' knowledge.
8. Encourage and allow opportunities for reflection and collaboration.
9. Promote sustainability, progression, ownership and empowerment.
10. Aim to assist schools in the development of leadership teams.

These additional eight factors refer directly to how the PD is developed and presented. Interviews with the KSS PD presenters and observations of the PD workshops indicated that the PD presenters prepared resources in alignment with what Loucks-Horsley et al. (2003) described as the students, the teachers, the curriculum, the learning environment, available resources, the history of the primary school and the organisational structure and leadership.

The effectiveness of the PD was investigated through the second research question in this research. To repeat, this research question asked:

2. What are the factors determining the effectiveness of the KSS PD program in;
  - a. developing primary science teachers' understanding of scientific literacy?
  - b. promoting the confidence of primary teachers when teaching science?
  - c. developing teachers' pedagogical skills to enable them to teach science?
  - d. developing teachers' knowledge and understanding of science to enable them to teach science?

***Research Question 2a: What are the factors determining the effectiveness of the KSS PD program in developing primary science teachers' understanding of scientific literacy?***

The following section outlines the informal promotion of scientific literacy during the PD workshops. Each aspect of the definition of scientific literacy is discussed.

## Interested in and Understand the World Around Them

The PD presenter showed how science is related to the world around teachers by demonstrating that they themselves are positive and passionate about science, providing relevant, real-life explanations of their own personal experiences and the activities that are included in their workshops. An example of Edith's personal experience was given when she spoke about the presence of fresh fruit stopping jelly from setting to explain aspects of solutions and dissolving.

The PD presenter also assisted teachers to further their own knowledge by explaining and modelling how they found information from websites and other teaching resources. The Education Officers also left their contact details with the participants so they could be contacted if assistance was required. The teachers at all three case study schools were interested in the websites and resources shown to them during the PD program. As Rachel, a participant from Knightsbridge, explained, "knowing where to go or to be able to contact someone that could help me is important if I want to find out more science about the things I am interested in" (Field notes, 23<sup>rd</sup> February 2007).

At Fenchurch, Emily and Katorina commenced the Electricity topic with a teacher-led discussion about "real-life experiences with electrical safety and static electricity" (Emily, Field notes, 11<sup>th</sup> October, 2005). They chose this approach because they had learnt in the PD that links to their own every day life experience had worked successfully when they were the learners. Laticia at Winchester had a similar experience. She explained

the PD encouraged me to use something the students were familiar with to get them thinking about forces. I chose toys because we were looking at push and pull. I thought the students would probably have played with these toys and they might have idea of how they work. The students not only enjoyed the lesson but they really understood the difference between push and pull immediately. (Field notes, 25<sup>th</sup> May, 2006)

However, the findings at Knightsbridge could not be as clearly attributed to a direct result of their PD experience. Although Jasmine and Justine both mentioned science related to life as an aspect of scientific literacy in their final teacher interviews, and they both involved their students with real-life activities in their lessons, there was no

reference by either teacher to these behaviours as a result of participation in the PD program. The staff at Knightsbridge received only one session of the initial KSS PD program, the other two sessions presented to staff were based on the Primary Connections PD program. Hence, the lessons the teachers taught that were related to life were prescribed by the Primary Connections text that the teachers were following.

### Science Communication

Science communication includes opportunities for participants to engage in the discourses of science. The PD presenters encouraged the use of many forms of communication in their activities and documentation to engage in the discourse of and about science. Teachers were encouraged to discuss science in the news, journals, and other media. Additionally, they were encouraged to explore the possibilities for lessons, arising from their own interests when preparing their science lessons. At Fenchurch, the researcher observed Katorina and Emily modelling science communication to their students by letting the students explain what they had learnt in a previous lesson to a small group of students. When asked why they did this, Katorina answered

In the PD we were able to talk and ask questions about what we were doing and what it meant. This allowed me to clarify little bits of information along the way. I found that I understood what was going on and I didn't get confused. If it worked for me I am sure it works for many of our students. (Field notes, 7<sup>th</sup> November, 2005)

Justine at Knightsbridge reached a similar conclusion about reviewing and writing in science. When the researcher asked why she spent the last ten minutes of most science lessons devoted to students' journal writing, she reasoned that

One of the activities in the PD, had us [the teachers] going hell for leather on four different experiments that had to be finished in under 10 minutes. Then we had to pack up, it was too fast and I didn't remember a thing. Even now I can't remember what the activities were about. The PD presenter showed us what we do to our students, we ask too much in a very short period of time. So I decided at the end of each lesson to get students to think about what they did by writing down what they did

in a journal. This helps them consolidate what they learn  
in the lesson. (Field notes, 9<sup>th</sup> March, 2007)

Laticia (Winchester) thought that for her younger students it was important to expose them to science books. Laticia expanded this view to include reading age-specific science books to her students. Laticia explained

I always have lots of books in the class but one of the  
things I particularly liked that Edith suggested in the PD  
was reading the large picture books about science to my  
class, like the one about the giraffe<sup>5</sup> she showed us.  
(Field notes, 21<sup>st</sup> June, 2006)

These three examples show that different aspects of science communication may be favoured by different teaching styles and that teachers adapted the forms of science communication to students' ability levels.

### **Sceptical and Questioning of Claims Made by Others**

Being sceptical and questioning of claims made by others was encouraged by the PD presenters during the KSS PD program. They did this by encouraging teachers to think through and review what they had read or heard about scientific matters. Teachers were encouraged to be well informed by extending the information presented to them through searching for further information. The PD participants agreed that this was an important aspect of Working Scientifically, and hence of scientific literacy. However, none of the teachers interviewed in the three case study schools referred to this aspect of scientific literacy in any way. Furthermore, throughout the observation period, in each of the case study classrooms, the researcher did not find any evidence of this aspect of scientific literacy enacted.

### **Investigating**

To be able to identify questions, investigate and draw evidence based conclusions are skills of scientific literacy covered by the Investigating outcome of Working Scientifically in the Western Australian science curriculum. As mentioned previously, this related aspect of scientific literacy is required to be assessed and each of the case study schools participated in one PD workshops specifically about this aspect (Working Scientifically for Open Investigations). With this increased focus, it is not surprising that

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<sup>5</sup> Andreae, G & Parker-Rees, G. (1999). *Giraffes can't dance*. Orchard Books. London

the teachers in the case study schools have a considerable understanding about this aspect. At Winchester, Investigating was the main focus of their Common Assessment Task about helicopters. Winchester developed the Common Assessment Task to be inclusive of all aspects of Investigating; planning, experimenting, recording and evaluating. Students, especially the older ones (Years 5-7), were able to successfully achieve these outcomes beyond their teachers' expectations. Margaret, the science leader at Winchester, believed this was an outcome of the PD program because

the CREST<sup>6</sup> proforma we used in the PD was a good starting point. I modified it to suit our activity and I developed one for the junior primary that was easier than the standard one. (Field notes, 27<sup>th</sup> July, 2007)

Katorina and Emily (Fenchurch) provided their students with a booklet of activities that allowed students to work on self-paced investigations for the majority of Term 4, 2005. However, minimal time was afforded to evaluating both by the teachers and the students, hence limiting the impact of this aspect of scientific literacy. Justine and Jasmine (Knightsbridge), through their use of the Primary Connections resource book on micro-organisms, believed they were able to allow their students more time to immerse themselves in the problem and more time to evaluate what they had done than in their previous science lessons. Jasmine explained

It's not about everyone coming to the same conclusion, it's about how you got there and what you found out along the way and using your evidence to back you up. (Field notes, 12<sup>th</sup> March, 2007)

It appears that the PD program about Primary Connections is particularly effective for the Investigating outcome of Working Scientifically in the Western Australian science curriculum.

### **Make Informed Decisions**

Making informed decisions about the environment and their own health and well being was encouraged in the PD sessions by the presenters suggesting that teachers use their own local environment or their own special interests in concert with the knowledge, pedagogical skills and ideas acquired at the PD workshop. Martin, a participant in the PD

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<sup>6</sup> CREST: Creativity in Science and Technology is a project-based program managed by Commonwealth Scientific and Industrial Research Organization (CSIRO) Education.

program at Fenchurch, approached the researcher and explained that he had put the idea about special interest into practice. He explained

I asked my [Year 5] students if they thought that the money spent by the US government on the NASA space program could be better spent in other areas. They had to look at the amount of money spent and then look out the outcomes of the space program and the impact on the environment. It worked really well as they critically evaluated the evidence and then we had a debate. (Field notes, 24<sup>th</sup> October, 2005)

The PD presenter's encouragement of making informed decisions resulted in a more localised approach from the PD participants at Winchester. Mary and Derek organised a local recycling expert to do a waste audit of all the rubbish bins one afternoon to show students what could and could not be recycled in metropolitan Western Australia. Mary and Derek believed that knowing about what can be recycled should be "developed at an early age" (Field notes, 3<sup>rd</sup> November, 2006). Conversely, there was little mention and no enactment of this aspect of scientific literacy in any of the case study classes that could be linked to the PD program.

In the KSS PD program scientific literacy is presented through Working Scientifically as this document is familiar to teachers. Teachers' engagement and understanding of three of the aspects of scientific literacy – science related to life, science communication, and investigating – showed a significant increase as a result of the PD. Teachers' ability to model informed decision making was encouraged as a result of the program. There was evidence that this occurred at Fenchurch and Winchester shown by the stories of Martin, Mary and Derek. However, no examples were seen in the lessons observed in the case study classrooms.

***Research Question 2b: What are the factors determining the effectiveness of the KSS PD program in promoting the confidence of primary teachers when teaching science?***

The rating scale data in the WFS for all individual PD workshops, undertaken at the three case study schools, showed that teachers believed that their confidence had increased after attending each of the workshops. Teachers' reported that their confidence



had increased in planning and delivering effective science programs, and believed that they were more confident to facilitate student achievement in science outcomes.

The responses to the pre-PD workshop open-ended question, “What would you personally like to achieve as a result of attending this workshop?” showed that improved confidence was not a high priority for teachers. Similarly, many of the actions that teachers planned to take following the workshops were not attributed by them to increased confidence (Question 3), however, some teachers said they would do things they otherwise might not. This is commensurate with the findings from the Teacher Questionnaire from the case study teachers at Fenchurch (Table 5.9) and Winchester (Table 6.2) and the cohort of teachers at Knightsbridge (Table 7.7). The teachers’ responses revealed that teachers generally believed they were confident to teach science. Additional information from the Knightsbridge Teacher Questionnaire (Table 7.8) revealed that these teachers were more confident to teach Earth and Beyond and Life and Living than Energy and Change and Natural and Processed Materials.

The Initial Teacher Interview with Laticia (Winchester) was the only interview to occur before all three of the school’s PD workshops. This revealed that the area in which she would like to increase her confidence pertained to the science curriculum. She wished to increase her confidence in this area in order to teach science consistently within the Western Australian Science Curriculum Framework. Laticia stated

I am not really sure what this [the science curriculum] is all about. I look at the document [shows the researcher the science curriculum document] and it overwhelms me. (Interview, 6<sup>th</sup> April, 2006)

It is of note that the document Laticia showed the researcher had been revised and was no longer used as another science curriculum document had been given to schools at the beginning of that year. In her Final Interview at Winchester, Laticia stated that the confidence she required was provided through the PD program.

Teachers at Fenchurch were asked, during the staff cluster meetings, to retrospectively think about what they had wanted from the PD experience. On reflection, the teachers believed that to increase their confidence to teach science was a factor that they hoped would be influenced by the PD program. Further, the response patterns to Question 4 on the WFS, “Has this workshop affected your views about teaching science?”

were indicative of teachers' improved confidence at Fenchurch. In fact, improved confidence was the most common response from participants in Workshop 2 and second most common in Workshop 1. At Winchester it was the most common response across all three workshops, and was also the most frequent response for the Knightsbridge participants. Science being enjoyable, fun, and easy to teach were common themes in teachers' responses that related to their improved confidence after the PD program.

Data from teacher interviews after the PD sessions at Fenchurch revealed that because the PD presenter was patient when explaining concepts and respected the staff and their opinions the teachers felt more confident to teach science. Kelly, a participant at the workshops explained

She [Edith, the PD presenter] was very good  
with everyone. She did not make you feel silly  
no matter what questions you asked. (Cluster  
meeting, 26<sup>th</sup> July, 2005)

One of the characteristics of effective PD was that the PD program should value the teachers' past experience and knowledge. The cluster meeting interviews at Fenchurch revealed that the PD presenter had valued the teachers' ideas and opinions and, in turn, promoted their confidence. The responses from the Teacher Initial Interviews at Knightsbridge, which occurred six months after the first PD workshop, revealed that six of the seven teachers interviewed believed that the workshop had increased their confidence. The second set of Teacher Interviews at Knightsbridge occurred one month after the second PD workshop. The findings reflected those of the previous interviews, with teachers generally maintaining their level of confidence about teaching science. Even so, two of the interviewees believed that they required this second PD as they needed a form of motivation.

The two case study teachers at Knightsbridge both believed the PD program had increased their confidence to teach science. For Justine, not only had her confidence increased but she had the courage to continue to improve. She felt that this had happened as she had been encouraged by the PD presenter to extend herself. Jasmine believed her confidence had increased to such a point that she now embraced science lessons rather than trying to "avoid them like the plague" (Interview, 13<sup>th</sup> June, 2007).

During the case study teacher interview at Fenchurch, Katorina said that an outcome of the PD was that she was able to team-teach science more confidently than

before. Emily, on the other hand, had always been confident to teach science, and she noted that her confidence had not been affected by the PD program.

In response to Question 5, “What was the main message gained from today’s workshop?” confidence was the most frequent response to Workshops 1 and 2 at Fenchurch and equal most frequent at Winchester for Workshop 1, indicating that increased confidence was a contributory factor to the success of the PD program. A closer analysis at the school site, through researcher observation, was required to understand how this increased confidence impacted on classroom teaching. The researcher found that teachers in all three case study schools were very enthusiastic, well prepared and engaged in their science lessons. All teachers showed a high level of confidence when working with their students. However, in comparing the five case study teachers the researcher noticed there was a range of confidence levels amongst them.

After the PD program, Emily (Fenchurch) was the most confident teacher and this impacted somewhat negatively on her team-teaching partner Katorina’s confidence, as Katorina allowed Emily to take charge of the science lessons most of the time. Justine (Knightsbridge) was also very confident and she also taught with a team-teaching partner. This impacted positively on Justine’s confidence as she was the teacher who took the lead in the science lessons. Jasmine (Knightsbridge) and Laticia (Winchester) appeared to have similar confidence levels. It is noteworthy that the researcher observed that Jasmine’s and Laticia’s confidence levels increased more over the observational period than did those of the other case study teachers.

During the observation period the researcher noted that the two teachers from Fenchurch and Justine from Knightsbridge were very comfortable to have an observer in their class and it was “business as usual”. However, although the researcher was welcomed into their classrooms, Jasmine (Knightsbridge) asked that if she needed help with any of the explanations would the researcher assist. The researcher explained that she did not know everything about science, but agreed to assist if required. Interestingly, Jasmine did not require the researcher’s assistance with any science explanations. Laticia (Winchester) asked if the researcher would be a sounding board for her ideas as she explained, “I like to talk things through so that I can get them clear in my own mind” (Field notes, 13<sup>th</sup> May, 2006). The researcher agreed to this request but found that as Laticia had a student teacher in the classroom for a large proportion of the observation period, the student teacher inherited this role.

As discussed in the literature in Chapter 2, two significant factors hinder teachers' confidence to teach science; limited or negative prior science experiences (Appleton, 2003; Appleton & Kindt, 1999; Parker, 2004; Shallcross & Spink, 2002) and an overburdened curriculum with a low priority given to science (Appleton & Kindt, 1999; Peers, Diezmann, & Watters, 2003). The factors that made the PD program effective in developing teachers' confidence were that the presenters considered the attitudes and prior experiences of the participant teachers at the onset of and throughout the PD experience. The PD presenters also removed the "road blocks" by allowing teachers to have an opportunity to try and ask questions about the activities that were completed in the session. Collaborative work among pairs of teachers and time for collaboration also allowed teachers to believe they were more confident.

***Research Question 2c: What are the factors determining the effectiveness of the KSS PD program in developing teachers' pedagogical skills to enable them to teach science?***

In general, the results of the rating scale data in the WFS showed that teachers believed that they required, and were given, adaptable pedagogical skills across all workshops in all three case study schools. The open-ended responses given prior to the PD workshops revealed that in each of the workshops, at each of the case study schools, pedagogical skills was the most common response to the question, "What would you personally like to achieve as a result of attending this workshop?"

Similarly, pedagogical skills were an important factor for the teachers interviewed at Winchester prior to the PD program. They hoped they would be provided with "simple, hands-on activities that would engage their students" (Winchester Teacher Interview, 6<sup>th</sup> April, 2006). Additionally, the need for resources was also important, as teachers believed their resources had aged and required updating. However, according to her Teacher Questionnaire responses, Laticia believed the resources were more than adequate as all the resources she needed were in her classroom.

Using the pedagogical skills provided in the workshop was also a common response after the PD workshops when teachers were asked "What actions do you plan to take following today's workshop?" At Winchester it was the most common response for all three workshops; similarly at Knightsbridge it was the most common response for their workshop and at Fenchurch it was the most frequent response to Workshops 1 and 3. In Workshop 2, at Fenchurch, the use of provided resources was the most common

response category; and resources was also the second highest response category in Workshop 1 at Winchester. It is noteworthy that these two workshops were about Investigating and many resources for this area were provided. Knightsbridge teachers believed that, in general, the resources provided to them were adequate in all Western Australian science content areas (as shown by the Teacher Questionnaires, Table 7.8). The teachers' proposed follow-up actions suggested that the resources and strategies provided by the PD program met their expectations.

In each school, the category of pedagogical skills represented around a quarter of the teachers' responses to the question "Has this workshop affected your views about teaching science?" Generally, teachers believed that they had been given great ideas and many approaches which had made it easier for them to plan and implement their future science lessons.

Teachers' responses to "What was the main message gained from today's workshops?" revealed the category of pedagogical skills as a common response. At Knightsbridge it was the most frequent response for Workshop 3 and equal most common for Workshop 1. The responses from Winchester showed that it was the most common response for their workshop and at Fenchurch it was found as the most common response in Workshop 3. Teachers believed that keeping activities simple and making the science they teach relevant to children's lives were important messages from the PD program.

Teachers believed they were able to put the pedagogical skills into practice and use the provided resources after the PD experience. Reviewing and revising provided resources were popular follow-up actions after the PD at all three case study schools. At Knightsbridge, the most beneficial aspect of the PD was that it gave teachers direction and showed them activities that assisted them with their planning and implementation of their science lessons. Knowing that the activities worked and that they were adaptable was important for the teachers at Fenchurch. At Winchester discussing ideas with colleagues and trying out some of the provided activities was considered important.

Justine (Knightsbridge) thought that being able to practise the science activities at the PD workshops "before you try them in the classroom" (Field notes, 6<sup>th</sup> June, 2007) was an important way to learn pedagogical skills. Laticia (Winchester) believed that the PD program had provided her with "ideas for activities that were not too hard to prepare and the resources required were easy to obtain" (Field notes, May 21<sup>st</sup> 2006). However,

other teachers at both Winchester PS and Fenchurch said that they would like to have seen more activities and ideas, specifically for younger children.

Jasmine (Knightsbridge) successfully used the pedagogical skills she acquired at the PD workshop directly with her class. At Fenchurch, Katorina and Emily had transferred their newly acquired pedagogical skills from those that they used with the content of Astronomy to Electricity, enabling them to prepare for their students a series of engaging lessons.

In general, teachers were pleased with the resources provided by the PD program. However, even though Emily (Fenchurch) thought that the written resources provided were good, she believed that the assessment documents provided in the Planning and Assessing Workshop “were not the sort of thing [prepared materials] that someone outside the school could provide” (Teacher Interview, 22<sup>nd</sup> February, 2006) and the case study teachers developed their own. All teachers at the case study schools reported increased resources in their schools as a result of the PD program.

The findings of this research show that the PD program increased teachers’ pedagogical skills in ways that were meaningful to them and the Western Australian science curriculum. This outcome is consistent with Kelly and Staver’s (2005) proposal that primary teachers should have sound pedagogical skills in order to be able to engage themselves and their students in meaningful science activities that reflect the curriculum guidelines while addressing the needs of the classroom. The factors affecting teachers’ pedagogical skills were opportunities to try the activities and also being given ideas for use in the classroom. The PD presenters allowed for question and answer time, they valued teachers’ input and they modelled the strategies for the teachers. However, the participants believed that no one PD program could suit each particular year group or school, some synthesis of the program at the school or year level would always be necessary.

***Research Question 2d: What are the factors determining the effectiveness of the KSS PD program in developing teachers’ knowledge and understanding of science to enable them to teach science?***

At Fenchurch, only a small number of responses to the first open-ended question in the WFS, “What would you personally like to achieve as a result of attending this workshop?” related to knowledge. The Working Scientifically Workshop at Knightsbridge and Winchester (Workshop 2) showed the second highest number of

responses. Before the PD program, teachers at Winchester believed that knowledge of the science content area of Energy and Change and an understanding of the curriculum documents were important. The data from Knightsbridge, collected prior to the second PD workshop, also suggested that knowledge is an area in which teachers would like to experience an improvement. Interestingly, when the Fenchurch staff were interviewed they believed the acquisition of knowledge was a goal they sought from the PD workshops.

After the PD workshops, only a small number of responses from any of the seven workshops suggested using the knowledge acquired at the workshops as a common follow-up action. However, knowledge was a frequent response to the post-PD question, “Has this workshop affected your views on teaching science?” at Knightsbridge and Fenchurch. In the Planning and Assessing workshop (Workshop 3) at Fenchurch it was the most common response. Here teachers believed an understanding of the content of Planning and Assessing was an important outcome, and their interviews revealed that they thought they were given the knowledge they required by the PD program.

At Winchester, 43% of teachers believed that the main message of Workshop 2 was about understanding the content of Earth and Beyond and Natural and Processed Materials. Data from the interviews suggested that science content was a valued component of the PD workshops. For example, Emily (Fenchurch) believed that the content from the PD could be used directly in her teaching, and at Knightsbridge teachers thought that they had a better understanding of the Primary Connections curriculum materials. Justine (Knightsbridge) believed that her acquired knowledge was timely as she felt that she had not had the opportunity to look at the content of science for some time. Jasmine, also from Knightsbridge, liked that she was able to ask questions about the content during the PD workshops. Laticia at Winchester believed that her clearer understanding of the outcomes had “overhauled” her teaching and made it more focussed.

Case study teachers at all schools were able to put the knowledge they gained into practice in the classroom. The researcher noted that all teachers at Knightsbridge and Winchester used the content that had been presented at the workshops in their lessons. At Fenchurch the teachers were not using the science content area that was presented in the workshop but they were able to access knowledge about another science content area. Katorina and Emily were able to use some of the material in its original form and they were able to modify other information to suit their year level. Katorina believed that the

most important aspect was “it’s not just about science content; it’s knowing where to go to find out about the content” (Interview, 22<sup>nd</sup> February, 2006), and she believed that the PD program had shown her how to access this knowledge. As a result the teachers were able to plan a term of work in Earth and Beyond (the area of the PD program) and they were able to transfer this knowledge to the area of Energy and Change.

At Winchester Laticia believed the most important part of the PD was that she was given the opportunity to learn about the content of the Curriculum Framework. She believed that she was now “more focussed on an outcome” when she was teaching (Interview, 11<sup>th</sup> December, 2006). Laticia also believed “that the children loved it, learned from it and I found it easy to teach, which was important” (Interview, 11<sup>th</sup> December, 2006).

Jasmine at Knightsbridge thought that the PD program had increased her knowledge about the science outcomes by allowing her to ask questions during the workshops so that she “really started to understand what was meant by the outcomes” (Interview, 13<sup>th</sup> June, 2007). Justine thought that “the PD was what I needed to improve my knowledge of the content and understanding of the Curriculum Framework” (Interview, 24<sup>th</sup> May, 2007).

Taken together, the findings indicate that the KSS PD program increased teachers’ knowledge in the areas of science content and in the area of understanding the Western Australian science curriculum. It was argued in Chapter 2 that that CK and PCK were both important factors to consider when providing a PD experience (Appleton, 2006; Mulholland & Wallace, 2005; Redman, 2005). The factors that assisted teachers’ development of knowledge and understanding of science were the provision of PD content knowledge in the PD program, in the form of explanations and as a booklet of resources, and the development of teachers PCK through having the opportunity to do the hands-on activities and ask questions during the PD.

### **Summary of the Impact of the KSS PD Program on the Case Study Teachers**

The data from the case study schools showed that although each of the areas of confidence, pedagogical skills and knowledge were improved as a result of the PD program, the extent of the improvement was dependent on the nature of the content of the PD workshop and on the participants’ needs. Areas where content was important to the participant, such as the Planning and Assessing document and the content of Earth and



Beyond, resulted in more responses about knowledge as an outcome for teachers. Additionally, individual teachers felt that there were particular areas that required improvement. Each of the case study teachers was affected by the PD program in a different way depending on their prior levels of confidence, pedagogical skills and knowledge in science teaching.

The PD program had increased Jasmine's (Knightsbridge) pedagogical skills and knowledge to the extent that she felt confident to teach science to her regular class rather than trading the class with another teacher.

Laticia (Winchester) had always taught science, but she reported that this usually occurred only twice a term and that it was the first subject to be discarded if there was a special event at the school. However, after the PD program Laticia taught science for an average of one hour a week. Laticia believed that the most important aspect for her was the PD had improved her knowledge base about the Western Australian science curriculum. In company with the pedagogical skills that she had developed as a participant in the PD program, she became more confident to implement science as she had a larger repertoire of strategies and ideas that were consistent with the current curriculum.

The influence of the PD program on Katorina (Fenchurch) was mainly in the area of confidence as she believed she was "more of a social studies/English [subject] sort of person" (Field notes, 11<sup>th</sup> October, 2005). Her increased confidence was attributed to the discussions, activities and strategies used in the PD program. As Katorina explained, "it confirmed that I was on the right track and Edith [the PD presenter] was able to answer some of the questions I had" (Field notes, 14<sup>th</sup> November, 2005). The pedagogical skills developed in the PD workshops and the content described both in Assessment and Planning and Earth and Beyond (knowledge) had positively influenced her confidence in science.

Justine (Knightsbridge) believed she needed the validation of the knowledge and pedagogical skills used in the PD program to ensure that her practice was demonstrative of effective science teaching, thus increasing her confidence. On the other hand, Emily (Fenchurch) had a high level of confidence before the PD program and did not believe that it increased her confidence. What the program did for Emily was to provide her with the content knowledge of Earth and Beyond and Planning and Assessing, assist her in refining her pedagogical skills to use in the classroom and gave her ideas for resources.

**Research Question 3: In what ways do the teachers' levels of confidence, pedagogical skills and science knowledge influence how they teach science to students to encourage the development of scientific literacy?**

The data collected from teachers indicated that they believed that their increased confidence, pedagogical skills and/or knowledge in science, as a result of the PD program, had improved their science teaching. Student interviews and questionnaires provided another perspective to answer this question.

Although for many students, at all three case study schools, science was not their favourite subject, they still reported enjoying their science lessons and looked forward to them each week. Students reported they were doing science on a regular basis (at least once a week), and for two of the case study teachers this was a definite increase compared with what student thought about science the previous year. As a result of students being exposed to a regular science program each week, the teachers had more opportunities to offer strategies enabling students to practice the skills that promote scientific literacy. The students at all three schools liked the way that many hands-on activities were part of their science lessons and they believed they had learnt a great deal of science. The types of activities that students would like to experience were also those that would allow them to participate in incursions or excursions.

The findings from the students' interviews and observations concurred with those of the researcher during the observation period at each school, where the researcher found that the PD program had an indirect impact on the students. As the teachers increased their confidence, pedagogical skills and knowledge, they provided students with more or improved science lessons.

Students at Winchester and in Jasmine's class at Knightsbridge were doing more science than they had in previous years. The increased exposure to science increased the teachers' time to help students practise the skills of science communication, investigating, relating science to life and making informed decisions. For example, Jasmine had integrated her science with language and students spent time talking about the historical aspects of microbiological science in addition to examining the factors that encourage mould development on bread. In the other case study classes, science teaching had improved through a more focussed approach that allowed the teachers to spend time, not just on the content of science but on practising the skills that promote scientific literacy in their students (see Table 2.2 for a list of skills students need to develop scientific literacy).

For example, students were encouraged to talk to each other about their experiments and decide on what variables should be controlled and which variable should be changed in addition to writing their reflections in their journals from time to time. From the researcher's observations it appeared that in all classes, teachers had allowed time for the students to think about their investigations and activities through science communication with the teacher and other students. This encouraged the use of age-appropriate open-ended investigations, speaking of science in a real-life context, and enabling students to ask questions about the science they did.

**Research Question 4: In what ways can schools promote the longevity of the outcomes of the KSS PD program?**

The PD program provided by the KSS can initiate a change in the PL of staff, but as it is a fee-for-service program schools can only sustain the delivery of programs within a defined timeframe. To explore whether the gains achieved by the PD program are maintained, Research Question 4 asked "In what ways can schools promote the longevity of the outcomes of the KSS PD program?"

One of the factors identified in Chapter 2 was that a PD program should aim to encourage and allow opportunities for collaboration and reflection. Kahle (1999) argued that as teachers are adept at social interactions, collaboration should be encouraged. Furthermore, if teachers work in a collaborative learning environment they will feel empowered in their practice (Haefner & Zembal-Saul, 2004). Teachers also need to have time to reflect on their own practice in addition to discussing their practice with others (Loucks-Horsley, 1999). The KSS PD program encouraged a collaborative learning environment during the PD workshops. It also encouraged teachers, after the workshops, to contact the PD presenters if required. During the workshops, the presenter also encouraged teachers to think about their current practice and determine what changes teachers believed they needed to make. However, in the longer term, it is the staff at the school who must take on the responsibility for the collaboration and reflection that can maintain the effectiveness of the PD program.

The case study teachers at Fenchurch believed that the future of their school would include a sound science program. The staff had discussed the need for science to remain a priority and the consensus was that it was not to be a priority but be placed "on maintenance", whereby the teachers would attend to science on a regular basis through cluster meetings and other informal meetings. Fenchurch, prior to the PD program, had a

history of working in collegiate teams called “clusters”. Staff met regularly as clusters to discuss all aspects of the curriculum. The Principal had encouraged this collegiate work and each staff member was part of a leadership team in a learning area which they had selected. Staff were also encouraged to reflect on their practice and to work in a smaller collegiate network of two or three teachers. Emily and Katorina formed such a network and this resulted in a team-teaching partnership where they were empowered to work together to devise the whole Year 6/7 program for these classes. In their final interview, Emily and Katorina told the researcher of the future programs for science, such as Robotics, that were already underway.

Reflection was an important action for Laticia, at Winchester, who believed that the PD was a great starting point but she thought you could not do everything that was necessary just in the PD workshop. She believed that,

You have to have time to go back to your classroom and do one thing [activity] and think about it, decide whether it is worth doing again, if it needs to be modified for your kids and fits with [my choice of] the curriculum. (Teacher Interview, 11<sup>th</sup> December, 2006)

Laticia also thought that her science teaching could be improved by having someone with whom to collaborate. Laticia had been looking forward to being able to collaborate with other staff members in the near future. Unfortunately, this did not progress as she hoped. Laticia found that one of the teachers, Margaret, the science teacher leader who had been seen as an “expert in science” by other staff at the school, continued to dictate thus diminishing and devaluing the staff’s decisions. Laticia explained that

although we were working in small groups in the library we knew one person was in charge. We didn’t really have time to talk to each other. We just listened to Margaret and did what she said. (Field notes, 27<sup>th</sup> July, 2007)

The researcher was invited back to the school by the Principal after the case study period. The Principal wanted to showcase what the teachers had been doing since the researcher had left. In their collaborative work session, Margaret had prepared a

Common Assessment Task for comment by the other teachers. Laticia turned to the researcher and said

I really appreciate what Margaret does. All this work to make up the assessment pieces but if something is not quite right I would be too scared to tell her. (Field notes, 27<sup>th</sup> July 2007)

Unfortunately the collaborative work structure developed at Winchester was not one that promoted teacher empowerment and group reflection. It was argued in Chapter 2 that an effective PD program should aim to assist schools in the development of leadership teams. Roehrig, Kruse and Kern (2007) found that collegiate support was most effective when coordinated by a leader or administrator. However, for the collegiate support to be successful all parties must be empowered, not just the leader. The PD program may encourage leadership teams but it is the responsibility of the school staff to develop effective collaborative structures.

At Fenchurch the collaborative structures worked well, keeping in mind that they were developed prior to the PD program, and showed signs of careful planning. Conversely, at Winchester they were put together quickly in order to achieve an outcome in a short period of time. The researcher noted, during the collaborative session, that two pairs of teachers were discussing modifying the Common Assessment Task later that afternoon, acknowledging that informal collaborative structures were present in the school.

Justine and Jasmine collaborated in the preparation of their science programs at Knightsbridge. Justine explained that this was “a good way to work” (Field notes, March 8<sup>th</sup> 2007). Another factor of effective PD identified in Chapter 2 was that a PD program should aim to promote sustainability and progression. Justine believed that there had been an improvement in science at the school but believed that there was scope for further improvement and more PD workshops. As Justine explained,

We need time to collaborate and reflect with our colleagues. Maybe if we set some time into the timetable for collaboration and reflection in science next year we can keep the ball rolling. (Teacher Interview, 24<sup>th</sup> May, 2007)

Jasmine also believed that collaboration and reflection were necessary to ensure that the science progress she had made in science was not stifled. As Jasmine explained “we need to make sure that we have opportunities to move forward and we need the time to do this” (Teacher Interview, 24<sup>th</sup> May, 2007).

Examination of the literature in Chapter 2 revealed that for a PD program to be sustainable there must be time allowed for understanding and enactment of the changes (Peers, Diezmann, & Watters, 2003), which would best be located in the teachers regular repertoire (Bransford, Brown, & Cocking, 1999). Roehrig et al. (2007) suggested this could only be achieved when there was strong school-based leadership was present. Redman (2005) furthered this comment explaining that this leadership should accommodate teacher empowerment and collaboration. In this study, two schools, Fenchurch and Knightsbridge, had established leadership models that encompassed teachers’ PL in science. There were collaborative structure in place at all three case study school. However, it is important to note that collaboration must not be contrived if it is to be effective. Fenchurch was the school that was most collegiate and had the collaborative structure in place before the onset of the PD program. Both Fenchurch and Knightsbridge had effective collegiate structures because of their effective leadership teams in the respective schools, and hence it was most likely that the impact of the PD program would continue to be sustained in these two schools.

### **Researcher’s Reflections on Method**

The mixed-method approach chosen for this research proved effective. In particular, the PMM was a useful tool to explore understanding of scientific literacy. The larger group of participants, whose results are described in Chapter 4, provided useful baseline information about what is understood by scientific literacy by the general public, high school teachers and primary teachers. This provided a platform to identify patterns from the larger group of participants, especially the primary school teachers, with which to compare the smaller case study sample.

While the PMM interview showed that the researcher placed value on the ideas of individual participants and allowed for in-depth elicitation of details from each respondent, it may also have placed the interviewee under duress because of the one-to-one situation. For example, the personal nature of the PMM interview may have led the respondent to mention aspects they believed the researcher wanted to hear, rather than truthfully answering what they thought. The researcher tried to make the participants feel

at ease by providing an introduction that let them know that what *they* thought about scientific literacy was important, rather than search for some previously learned definition. However, if there were some responses given in the PMM Interviews because the participants believed that was what the researcher wanted, these responses would be difficult to distinguish from the answers that were given as the participants' own thoughts.

Using the research literature to identify the key factors for effective PD enabled a framework to be developed that focussed data collection during evaluation of the various aspects before, during and after the PD program. By communicating with the principals and the PD presenters, the researcher could determine what aspects of the PD program were being modified to suit the particular audience. Observing the PD program was helpful in determining if the strategies that were selected by the PD presenter were suitable for the teachers, and whether or not the teachers followed them up.

The case studies were effective in providing information about the impact of the PD program. The mixed method approach allowed the researcher to gather information from several sources within each case study to triangulate the findings. Additionally, across the case studies the researcher was able to identify patterns that were particular to all schools and some that were specific to each situation. However, the plans of the researcher often had to be modified to accommodate the staff at the schools, as schools are dynamic environments where policy, staffing and the daily operation of the school can change frequently.

The WFS provided valuable data that allowed the researcher to identify teachers' perceptions about confidence, pedagogical skills and knowledge before and directly after the PD workshops. This allowed the researcher to examine the attitudes and beliefs of the teachers by creating a base line of data that reflected the teachers' starting points. Unfortunately, as the data were given to the researcher as summary sheets, she was not able to match an individual's response to the different questions, or to later interviews and questionnaires, thus limiting the value of the data for the case study teachers.

The Teacher Questionnaires provided information about teachers' perceived confidence, knowledge, pedagogical skills and scientific literacy that was used to compare with the WFS and PMM findings. This questionnaire provided additional information to further explain what teachers believed was happening in science in their classroom. Regrettably, at Knightsbridge the questionnaire was made anonymous at the

request of the Principal. Hence this did not allow for the identification of the case study teachers, and the results were analysed differently to those obtained from the other schools, where the case study teachers' responses were examined closely.

The teacher interviews provided a broader understanding of what was happening at the school site outside of the case study classes. This included information about teachers' confidence, pedagogical skills and knowledge in addition to teachers' perceptions of their students' enjoyment of science. These interviews were the major source of data about the longevity of the PD experience. Limited time at the first case study school, Fenchurch, did not allow for the teachers to be interviewed individually. Consequently, the researcher extended the time at the following two schools so that enough time was available to individually interview all teachers.

Student interviews provided the researcher with information about their perceptions of science compared to science they had done in previous years at school. The findings allowed the researcher to elaborate her field notes from classroom observations. Student questionnaires provided information from a wider range of students than those interviewed, including what students thought they did in science and some suggestions of how to improve the science at school from the students' perspective.

Case study teacher interviews not only provided new data, but were an effective way of comparing and contrasting the findings from the other methods. Any uncertainty the researcher had about a particular aspect or situation could be clarified during these interviews. They provided information about teachers' confidence, pedagogical skills and knowledge, and an insight into how the case study teachers' perceived science was progressing in their school as a result of the PD program.

Observations of the case study teachers allowed the researcher to gain first hand knowledge about the activities that occurred in the classroom, and opportunities for clarification of situations through informal interviews with the teachers. The resulting field notes allowed the researcher to understand how scientific literacy was enacted in the classroom, observe the teachers' actions and infer their confidence levels, and observe their use of pedagogical skills, science content and science curriculum knowledge in their natural setting.

The case studies also provided a chronological narrative that revealed unique features of the participants and how they interacted. Anticipated and unanticipated events were recorded, forming an archive of "thick" information. This wealth of information



recognised the complexity and embeddedness of the social classroom situation thus increasing the dependability and credibility of the findings. The transcription data were immediately intelligible and easily understood by the teachers and the researcher. As the researcher acted alone in the case studies, the organisation of dates and times were negotiated easily and consequently the internal validity of information gathered was high.

Throughout the study, a comprehensive audit trail was kept, thus ensuring transferability and trustworthiness of the findings. Cross-referencing the three case studies provided insight into other similar situations (Tellis, 1997). Methodological triangulation with other data from the PMM interviews addressed, at least partially, the potential lack of reliability and poor external validity associated with case studies conducted by a single researcher. Triangulation also enhanced confirmability of the findings.

### **Limitations of the Study**

Throughout this study a number of restrictions were encountered which limit the generalisability of the findings. These included the nature of the sample, modifications requested by the school Principals and the presence of the researcher as an observer-participant and potential change agent.

#### ***Nature of the sample***

The case study school samples were small but appropriate for this qualitative, mixed-method research. The three case study schools that volunteered to participate in this research revealed a variety of ways that the PD program affected the participants and the teaching of science, thus showing considerable diversity. At each of the three case study schools teachers were asked to volunteer to participate in the case study class. At Winchester this resulted in only one class teacher participating, instead of the intended two, as the other volunteer teacher unexpectedly became the Deputy Principal for the research period and relinquished her class. The findings cannot be regarded as typical for other classrooms or schools as only three schools and five classes participated in the study.

#### ***Specifications Imposed by the Principal***

The Principal at each school had his/her own specifications relating to minimising any disruption within their school which resulted in slight modifications of the way the research progressed. For example, at Fenchurch teachers were only interviewed once and they were interviewed together. At Knightsbridge the Teacher Questionnaires were

modified to assist the school by providing some additional information they required. Teacher Questionnaires were also anonymous at Knightsbridge, at the request of the Principal, which prevented identification of which questionnaires were completed by the teachers whose classrooms were observed.

### ***Presence of the Researcher***

The presence of the researcher was likely to have an effect on the teachers who participated in the interviews and the case study teachers and students. This is unavoidable if the researcher wishes to observe what happens in classrooms, and consequently every effort was made to be unobtrusive and not disrupt normal class activities. Nevertheless, the researcher may have affected the participants' responses to some questions. For example, some participants were slightly uncomfortable when answering a question they believed there was a specific answer to and they thought they did not know the correct answer. The researcher endeavoured to reduce the effect of her presence in the interviews and the case study classes by remaining in the school and the class for an extended period of time. She was also open about what she was doing, such as sharing field notes and transcripts, to alleviate possible teacher anxiety.

### ***Transferability***

The findings in this research showed that each school provided some particularistic information that may only be relevant to that school setting, and indeed relevant only to particular teachers with a particular class. However, there were many similarities among the three schools that imply that certain aspects of the effect of the KSS PD program may be common to other primary schools. An example includes the belief that pedagogical skills were the most important aspect of the PD for all three schools.

### ***Researcher's Reflections on the KSS PD Program***

Although it was not an intention of the study, it was evident that the researcher acted as a change agent because the PD presenters and the researcher met on a monthly basis to discuss the PD program. After observing the last of the three PD workshops at the first case study school, the researcher noted that the term scientific literacy was not part of any written material provided by the KSS. Further, Edith, the PD presenter, did not mention the term scientific literacy during any of the three PD workshops, even though the enhancement of scientific literacy was an explicit aim of the KSS. A meeting was organised with Edith and Narelle, two of the KSS PD presenters, and the researcher to

examine this issue. After the meeting, Edith and Narelle decided to use the aspects of scientific literacy from the Rennie et al. (2001) definition and use them in the PD workshops, including the way scientific literacy mapped onto the outcomes of the Working Scientifically strand. This meant that the term scientific literacy subsequently became an integral part of the KSS PD program.

Although Edith made several attempts to show how the definition of scientific literacy aligned with Working Scientifically in the science curriculum, the teachers' focus remained on Working Scientifically to the exclusion of that of the definition of scientific literacy. Furthermore, teachers were more interested in doing some of the activities on offer rather than listen to the explanations about scientific literacy. Edith also continued to use many examples of real-life experiments that could be found in day-to-day living in an effort to explain the science behind the phenomena. However, teachers were more focussed on the pedagogical skills and resources during the workshop.

### **Conclusions and Implications of this Research**

The implications are discussed under themes reflected in the research questions; scientific literacy, teacher knowledge, teacher confidence, teacher pedagogical skills and longevity of the PD program.

#### **Scientific Literacy**

*Implication 1: The concept of scientific literacy must be clearly understood by teachers.*

If one of the aims of science education is to be scientifically literate it is important that teachers know what is meant by scientific literacy. For this to occur teachers need to come into contact with what is meant by scientific literacy in the Western Australian context. The Curriculum Council and Department of Education and Training need to ensure that the meaning is clear by making explicit links to scientific literacy in the document and by using the phrase scientific literacy in conjunction with Working Scientifically directly. All of the aspects of scientific literacy must be understood by teachers. The findings suggest that, presently, Investigating and Communicating Scientifically are two aspects that teachers understand but the other three aspects of Working Scientifically (Science in Daily Life, Science in Society, and Acting Responsibly) are not well understood or enacted in the classroom.

*Implication 2: PD programs need to assist teachers to incorporate the aspects of scientific literacy into their regular teaching program by providing opportunities for teachers to practice being sceptical and questioning and making informed decisions.*

The findings in this research revealed that by doing more science the teachers gave their students more opportunities to practice the skills of scientific literacy. Increased knowledge, confidence and pedagogical skills increased teachers' understanding of the curriculum, science content and how and why they were teaching science. Teachers were able to draw on their experiences from the PD and apply aspects of scientific literacy, especially investigating and science communication, into their science lessons.

The areas of investigating and science communication were particularly well covered by the KSS PD program. Consequently, teachers were able to implement these skills into their teaching. Science in daily life is an area that was covered with some level of competence, but the KSS PD program could provide more opportunities for enhancement of this area. However, two of the aspects of scientific literacy, making informed decisions and being sceptical and questioning, were not as prevalent as the other aspects. Teachers' understanding of these aspects may be limited by the greater time required for the other aspects of scientific literacy and they understand these aspects better. A more equitable allocation of time needs to be given to all aspects of scientific literacy so that teachers are presenting a holistic program to their students.

Furthermore, characteristics such as being sceptical and questioning and making informed decisions involve higher order cognitive and affective skills, as they are not just about providing science information and presenting a way of understanding science. They go beyond the comprehension level, requiring teachers to provide opportunities for their students to question the science they are exposed to and to make decisions based on the science as they understand it. These areas involve value judgements and an understanding of risk in science decision making. In the history of science and traditional science education these value judgements were set aside from the teaching of science concepts, and it is important they be included in current science curricula.

*Implication 3: Further research is required into teachers' understanding of scientific literacy.*

The findings of the PMM revealed that teachers have a limited understanding of scientific literacy in terms of the definition used in the research. Although teachers in

this research showed that what they do in the classroom does encompass more skills than perhaps their responses to the PMM suggest, it is still not inclusive of all aspects of scientific literacy. Additionally, the findings of this research suggest that teachers do not cover all the aspects of scientific literacy when teaching the current Western Australian science curriculum, possibly because it is not easily assessed. PD programs that support science education should be explicitly inclusive of scientific literacy. Research should be directed towards how programs that support the Western Australian science curriculum can achieve this aim. Research could also be extended to explore how links between scientific literacy and the Working Scientifically outcomes of the Western Australian science Curriculum Framework can be made more explicit so that scientific literacy is promoted in schools.

### **Confidence**

*Implication 4: PD programs should endeavour to increase teachers' confidence.*

The KSS PD program resulted in increased teachers' confidence. Data collected during the case studies revealed that the reasons for this increased confidence could be classified into four areas, confirmation, teaching science, teaching more science and the way in which science was taught. First, the PD sessions provided *confirmation* that the way teachers were teaching science was what they should be doing in their classrooms. Secondly, by teachers actually *teaching science* rather than avoiding science lessons in their teaching schedule, their confidence was increased. Teachers had avoided science by either not teaching science at all or exchanging the science part of their schedule with another teacher. Third, this research found that some teachers were *teaching more science* than they had in previous years, and they found this rewarding. Finally, teachers reported that they were *taking a different approach to science* and they believed their new approach was more beneficial for students.

The KSS PD program increased teacher confidence effectively by assisting teachers with science content in a way that was clearly understandable. The PD presenters provided teachers with time to ask questions about any aspect from resources and to practice pedagogical skills. By the teachers asking relevant questions they were able to understand what they were supposed to be teaching and how they were expected to teach science. The open nature of the presenters enabled teachers to feel comfortable and able to ask the questions that mattered to them. This approach should be continued in the PD programs.

## **Knowledge**

*Implication 5: PD programs should expose teachers to science content, especially in the area of the science curriculum work, to develop their content knowledge and pedagogical content knowledge.*

Teachers' knowledge was increased by the KSS PD program in two ways. One was increased knowledge of science content and the other was in understanding the science curriculum guide and the use of the outcomes in the Western Australian school curriculum. At times during a PD workshop there was an overload of science content information, however this information was given to teachers in the form of a written resource for later use.

Science content was important to many teachers, but of more concern to them was "unpacking" the science curriculum, and much of the work of the KSS PD program focussed on the teachers' understanding of the science curriculum. Teachers wanted to know the expectations of the science curriculum. The time given in the PD program to review and ask questions about curriculum documents allowed for a better understanding of what teachers were expected to be teaching in science, especially in reference to the student assessment schedules they were required to address.

It was also important for teachers to be given science content information that they could incorporate into their programs, and was equally important to be given information relating to where they could find other science content information about areas that were not included in the PD program. Their increased knowledge allowed teachers to access information more easily, understand what they needed to teach and how to assess what they were teaching to their students.

## **Pedagogical Skills**

*Implication 6: PD should provide activities that increase teachers' pedagogical skills in science.*

Pedagogical skills were the most important part of the KSS PD program according to the teachers. They valued the opportunities to be informed about ways in which to teach science, and also valued the time they were given in the program to practise these skills. The KSS PD should continue to incorporate time for teachers to practise pedagogical skills in their workshops. Some of the teachers thought they had to modify these activities, especially in the early childhood years. The PD program should endeavour to include some activities that directly relate to teachers of the early years.

The pedagogical skills that teachers were given and trialled during the PD experience allowed them to directly incorporate activities into their classes. This enabled teachers to implement activities they had already tried in the security of the workshop to determine what problems may arise. Giving teachers the opportunity to try these activities was an important aspect of the PD program that encouraged teachers to try something new and by doing so increased their confidence and their knowledge of this activity and its related science.

### **Longevity**

*Implication 7: PD presenters must work with individual schools prior to the PD program to ensure the suitability of the program for the participants.*

There are many effective ways to deliver PD and some approaches may be suitable for some goals or some groups of people but not for others (Banilower, Heck, & Weiss, 2007). It is imperative that PD presenters have knowledge of their audiences' background and learning style (Gardner, 1995), and have spent time determining the most effective and appropriate manner in which to present the material. If this time is spent addressing the needs of the staff, the outcome will be a staff more connected with the PD from the onset of the program. Sound knowledge of the future directions of the school, not just a limited understanding of what they want to obtain from the PD program, are necessary to assist this aim, because after the PD presenters have left, the staff at the school need to find ways to continue their PL.

Previous research into effective PD usually mentions a specific way for the PD presenter to deliver the knowledge but does not take into account the prior experiences, the socio-cultural setting or the self efficacy of the learners. Dall'Alba and Sandberg (2006) highlighted this narrow conception in their critical review of PD stage models. Knowledge of the PD audience is paramount as the program must be contextualised for the learners. The materials used in the PD should be appropriate to the participants so that it promotes understanding *of* practice as well as *in* practice (Dall'Alba & Sandberg, 2006).

Additionally, from the information gleaned in the PMM interviews, it appears that high school science teachers will need a very different approach to the PD learning experience compared to the primary school teachers as they have different interpretations of scientific literacy, levels of confidence, and social contexts which will impact on the way scientific literacy will be developed and promoted.

*Implication 8: As teacher PL does not stop at the conclusion of the PD sessions, further research needs to be done to explore how schools can successfully promote the collaboration of their staff.*

The findings of this research indicate that results that can be attributed to a PD program are not immediate. Many teachers need time to reflect and think about how and why they are going to implement, modify or change their practice. Following the teachers in this research for a period of time after the PD program allowed for a clearer picture of how teachers used the information from the program. Teachers required time to think about what occurred in the PD sessions and process what ideas, strategies and activities would be best suited for the students with whom they were working. When teachers had decided on particular activities they needed to incorporate them into their teaching program, and the time taken to do this was different for each person and each situation.

PD programs have been commonplace in Western Australian schools for the past 20 years. Many of these programs have been limited in their scope due to funding, and competition for PD time between a wide variety of areas, including behaviour management, health issues and the eight Learning Areas. Consequently, science in the primary school had not seen much PD time until recent years, where a small emphasis on science has seen current programs such as the KSS PD programs formed. Many teachers would like to see the work they have done as a result of the PD sustained and ultimately be in a position to see progression with their science teaching in schools.

*Implication 9: Time must be dedicated to teacher collaboration if PD programs are to be effectively and efficiently sustained at the school level. PD presenters should have an understanding of the long term aspirations of the school staff to assist them to continue their PL after the PD program has been completed.*

This research found that teachers needed to have opportunities for collaboration and reflection. The main impediment was time. Teachers believed they needed time to reflect and time to collaborate. It is necessary to provide time for reflection and discussion among and across groups. This will allow ideas to develop that have meaning and any “new” knowledge is accommodated. Teachers thought that this could be achieved if some time was allocated in the school day to engage in collaborative activities with staff members from similar year groups. Fenchurch’s collaborative structure was already in place and as a result teachers were already engaging in collaboration with other



colleagues. If schools put these collaborative structures in place before a PD program, it is more likely that teachers' knowledge, pedagogical skills and confidence gained from the PD will be sustained.

The Principal or science leader in a school should ensure that they provide leadership and collaborative structures that suit the staff in their school. Newman, King and Young (2000) found that PD programs that were sustained had greater gains than those that were short lived. Most schools do not have the funds for an outside agency to provide PD over a sustained time period. However, schools may be able to provide time for teachers to build teams and leadership structures within the school that will aid collaboration. In part, this is the responsibility of the Principal, but some responsibility must be addressed by the State, as the employer of teachers. From 2004 to 2008, primary teachers' Duties Other Than Teaching time has increased by 40 minutes to a total of 220 minutes per week (State School Teachers' Union of Western Australia, 2006), which has allowed teachers a little more time for their own preparation but more time is needed if collaboration is to be effective.

For a PD program to contribute successfully to PL, it must not only be sustainable but accommodate progression (Peers et al., 2003). For this to be achieved, ownership and empowerment of school staff must be ensured, if not the momentum is lost (Redman, 2005). For a program to be ongoing, leadership teams at the schools must include opportunities for teachers to continue their learning journeys. The KSS PD presenters spend considerable time with the leadership personnel at each school to ensure that they design a program that will suit the school. What requires more time is encouraging the school to think of where they want to progress after each PD session and where they want to be six months and a year from the beginning of the process.

*Implication 10: Science education must be respected by the policy makers to ensure that science is taught in primary schools and that PD can be accessed frequently by primary schools and others where it is needed.*

Teaching time for science in primary schools is limited by other Western Australian school curriculum priorities. In Western Australian primary schools the literacy and numeracy curriculum is required to account for 50% of the school day. This leaves 50% of the time to devote to the other six learning areas i.e. less than 10% for science. This equates to 130 minutes maximum time spent on science a week, not including school assemblies and other interruptions to the regular curriculum. Frequently

schools provide less than this, as exemplified when other programs such as camps (Knightsbridge) and graduation preparation (Fenchurch) occur, and science is set aside.

### **Further Research**

*Implication 11: Further longitudinal research is required to study the effects of PD programs.*

Longitudinal research is required to follow teachers over a considerable period of time to find out what are the most successful outcomes of the workshop, why, and how further outcomes can be sustained. Information from the teacher interviews at each school revealed that Department of Education and Training priorities, school priorities and ownership of the continued PL were the fundamental to the longevity of the KSS PD program. From this research it appears that if all three aspects are considered important then longevity will increase, but further research for an extended period of time with several schools is necessary to determine if this is the case.

### **Final Comments**

For a PD program to contribute to the development of a scientifically literate society, educational programs must first determine what scientific literacy means to the participants of a PD program. The data from this research indicated that all four groups involved in exploring the understanding of scientific literacy (primary school teachers, high school science teachers, general public and the case study teachers) demonstrated limited understanding of being “sceptical and questioning”. Because of the low level of responses for the PMM, and the limited enactment shown by teachers of being sceptical and questioning and making informed decisions in the classroom, a focus must be made in this area. It is important for the PD presenters to include activities, strategies and resources that promote being sceptical and questioning, and the ability to make informed decisions and encourage the teacher participants by promoting the awareness of these two aspects of scientific literacy. If they are to understand and apply the aspects of scientific literacy they must see it as something that is familiar and comprehensible.

PD programs that aim to promote understanding of scientific literacy must first address the audience to determine what they know, what they want to know, or what they should know, according to what Clandinin and Connolly (1996) call “the socio-cultural landscape”. What is needed is not just the transfer of knowledge and skills but the development of an understanding of the learners, not only in terms of their prior knowledge, but of the way they are best going to deal with new or conflicting knowledge.

Activities that will promote the development of scientific literacy should be authentic, complex and multidimensional to ensure that links can be made between new information and existing understanding (Hashweh, 2003).

Teachers and students should have an active role in their learning; to learn with understanding a learner must actively construct meaning by creating a model that makes sense to the learner (Rodrigues, 2005b). According to Osborne and Wittrock (1983), the construction of meaning begins with selective attention to an experience, where attention is influenced by a variety of aspects in the long-term memory and cognitive processes. Attention involves both attending to and sustaining interest in aspects of the experience, and it requires voluntarily controlled effort. To construct meaning from this sensory information it is necessary to generate links to what are perceived to be relevant aspects of information in the long-term memory. These generated connections to prior knowledge are critical for meaning to be constructed. PD presenters can provide real-life learning situations that would encourage many teachers to engage in meaningful science learning.

Opportunities should be made available for teachers to engage in the situations where they may need to be encouraged to reflect and question a current issue in science. They can in turn use these pedagogical skills with their students in their own classes. For this to be successfully achieved knowledge of teachers' confidence levels is vital. This could be managed by engaging teachers and students in a real-world debate. Initially, a PD presenter would provide information about a recent or localised situation, the participants would be asked to interpret what was occurring, then encouraging the expression of the teachers' personal thoughts and feelings and proceeding to discuss different viewpoints in a guided and non-confrontational manner. If prior knowledge of the group and their priorities are taken into account, the building blocks of the development of a program, focussing on being sceptical and questioning about current science issues can be formed.

Every learner must integrate their understanding into the various social contexts in which they are situated in ways that are socially acceptable (Barnett & Hodson, 2001). Formal education is not a disconnected entity, it is influenced by society and itself influences society. Consequently, educational change is not autonomous of the social context in which it is formulated or into which it is to be implemented. PD developers and presenters in schools should also be looking for ways they can contextualise and give

opportunities for their audience to not only hear about, but to engage in, real-life activities promoting scientific literacy.

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## **Appendices**

## APPENDIX 1

### Workshop Feedback Sheet Workshop:

School:

Date:

Please find below a summary of the evaluation forms completed by your staff. We appreciate your comments as it assists us to ensure the continuation improvements in workshop quality.

### Pre-workshop responses

#### 1. What would you personally like to achieve as a result of attending this workshop?

Strongly agree      SA      Agree      A      Disagree      D      Strongly Disagree      SD

2. Currently I	SA	A	D	SD	N/A
Have a positive attitude towards teaching Science					
Need adaptable skills and ideas to use in the classroom					
Am confident in Planning effective science program					
Can confidently deliver effective science programs					
Feel confidently able to facilitate student achievement in and science outcomes					

## Post Workshop responses

**1. What actions do you plan to take following today's session?**

**2. Has this workshop met your expectations?**

Yes

No

No Response

**Has this workshop met some of your professional needs?**

Yes

No

No Response

**3. After this workshop I feel**

SA

A

D

SD

Positive towards teaching Science

I have been given adaptable skills and ideas to use in the classroom

I could Confidently plan effective science programs

I could Confidently deliver effective science programs

I could confidently improve student learning in science outcomes

**4. In addition to the questions above, has this workshop affected your views about teaching science?**

**5. What was the main message you gained from today's workshop?**

**6. What future professional development needs in the area of science education?**

**Subject material** (Please tick as many as needed)

Working Scientifically

Assessment

Investigating

Life and Living

Earth and Beyond

Planning

Energy and Change

Other

Natural and processed materials

**7. Additional Comments**

## APPENDIX 2

### Workshop Feedback Sheet Codes

Pre Workshop Evaluation – Goals

Question 1. What would you personally like to achieve as a result of attending this workshop?

100	Personal Goals		
110	Cognitive	111	Better understanding/knowledge of the topic.
		112	Better understanding of working scientifically.
120	Affective	121	Increase confidence.
		122	Increase enthusiasm, Motivation

200	Pedagogical Goals		
210	Ideas-generic	211	Get me started/give direction.
		212	For tasks/ activities/ investigations.
220	Improved skills	221	Planning, programming.
		222	Designing activities, strategies.
		223	Using understanding, investigations.
		224	Assessment.
230	Students	231	Teach in an interesting way.
		232	Teach science to young children, culture.
240	Resources	241	Economical use of materials
		242	Short preparation time.
250	Curriculum Framework	251	Linking working scientifically to conceptual strands
		252	Understanding outcomes.
		253	Leveling students, measuring progression.
260	Integrated science	261	Linking science to ICT
		262	Linking science to numeracy.
		263	Linking science to literacy.

300	Personal Actions		
310	Collaborative	311	Share ideas, materials
		312	Implement ideas collaboratively
320	Affective	321	Be more confident
		322	Have fun with Science
		323	Do more science
330	Cognitive		



# Post Workshop Evaluations - Actions

Question 1. What actions do you plan to take following today's session?

400	Pedagogical Actions		
410	Use ideas-generic	411	Keep referring to provided materials
		412	Use/ do the activities.
420	Improved skills (Teach Better)	421	Use planning ideas, implementing better programming, planning.
		422	Be able to design own activities.
		423	Use investigations
		424	Use assessment activities
		425	Look critically at current practice.
		426	Do more experiments
430	Students	431	Enthuse students
		432	Teach young children
440	Resources	441	Buy/ acquire a new resource.
		442	Visit Scitech/other website.
450	Curriculum framework	451	Linking Ws to concepts
		452	Outcomes
		453	Mapping student progression
460	Integrate Science	461	with ICT
		462	With maths, numeracy
		463	With literacy
		464	With music

Question 4. Has this workshop affected your views about teaching science?

500	No	500	No reason given
		501	Already positive about science
		502	Not really knew I needed to know more
600	Yes	600	No specific reason given
610	Cognitive	611	Better understanding of concepts
620	Affective	621	Increased confidence
		622	Can be fun
		623	Enhanced, reinforced my views
630	Pedagogy	631	Planning, clearer perspective
		632	Alternative approaches, new ideas
		633	Hands-on investigations
		634	Assessment
640	Students	641	Enthusing students
		642	Dealing with young children
650	Resources		
660	Curriculum	661	Working scientifically and concept strands
		662	Integrating science with other areas.

Question 5. What was the main message you gained from today's workshop?

700	Affective	701	Science can be fun.
		702	I can do it, don't be afraid to have a go. Giving me confidence.
		703	Helping others
		704	Reinforcing what I am doing
	Conceptual	720	
800	Pedagogy	801	Be practical, adaptable, plan
		802	Many activities, approaches.
		803	Investigation skills
		804	Assessment, variety of approaches
810	Students	811	Build on where students are.
		812	Can teach to young children.
		813	Value, relevance of science.
820	Resources	821	Science doesn't have to be expensive
		822	Help is available.
830	Curriculum	831	Science is cross-curricular.
		832	Outcomes are understandable.

## APPENDIX 3

### 2003 Teacher Questionnaire used in Previous Research by Rennie (2004)



A partnership between Scitech  
and the Rio Tinto WA Future Fund.

I.D.

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#### QUESTIONNAIRE FOR TEACHERS OF SCIENCE

We request your name/school details for follow-up purposes only. Your responses will contribute to our overall picture for Year 4-5, but will be confidential. Only the researchers will see your name.

Teacher Name \_\_\_\_\_ Sex: ☐ Female ☐ Male

Present school \_\_\_\_\_

#### Teacher Background

##### *Please give details of your teaching experience*

Teaching Qualification(s) \_\_\_\_\_ Teaching Experience \_\_\_\_ years

How many classes do you teach science to? \_\_\_\_\_

What year levels are these classes? \_\_\_\_\_

Have you attended professional development for science this year? ☐ Yes ☐ No

If yes, please describe? \_\_\_\_\_

#### Science Programming

##### *Please give details of your science programming for this year*

How is science taught? ☐ as a separate subject ☐ integrated

On average, how many minutes each week are programmed for science?

Year 4: \_\_\_\_ minutes per week Year 5: \_\_\_\_ minutes per week

What time of day is science usually taught? ☐ am ☐ pm

What science topics were programmed for this year? \_\_\_\_\_


What resources do you usually use in planning your science programmes? (For example, Primary Investigations, Curriculum Council Science Framework, Ministry's Science Outcome Statements, materials from PD attended, the internet etc.) \_\_\_\_\_

## Teaching the Science Strands

*Please respond to these questions about teaching each science strand to Year 4-5 level.*

	Earth & Beyond	Energy & Change	Natural & Processed Materials	Life & Living
1. My own interest in teaching science is best described as				
highly interested	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
interested	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
not interested	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. My own background knowledge for teaching science is best described as				
extensive	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
adequate	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
extra preparation needed	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. My skill in teaching science is best described as				
competent	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
reasonable	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I'm not too sure of my ability	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. My confidence in teaching science				
very confident	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
confident	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
not very confident	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. The resources available to me for teaching science are				
extensive	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
adequate	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
limited	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. I use outside resources (such as the internet) and people (such as a park ranger)				
very often	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
often	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
sometimes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. When teaching science, I usually				
design my own activities	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
adapt ideas from resources	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
follow a given course	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## Why Teach Science?

**Listed below are some possible reasons for teaching science.**

**How much importance does your science teaching and programming give to each of these considerations in teaching science to children at Year 4-5 level?**

*For each statement, please tick the box that most closely indicates the level of importance you consider appropriate for Year 4-5 science.*

Possible reasons for teaching science to Year 4 and 5	Very low importance			Very high importance	
1. to interest children in science	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. to provide scientific knowledge	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. to practice manipulative skills	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. to practice communication skills - verbal	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. to practice communication skills - written	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. to demonstrate the importance of making decisions based on information	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. to show that decisions made in science have social consequences	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8. to practice problem-solving skills	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9. to prepare students for science later on	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10. to show how science is related to everyday life	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
11. to integrate science with other school subjects	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
12. to develop social skills (such as cooperation)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
13. to develop self-discipline and independence	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
14. any other reason – please state _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Has the class visited Scitech Discovery Centre this year? ☐ Yes ☐ No

Has the Scitech Roadshow visited your school this year? ☐ Yes ☐ No

How many science-related excursions and/or incursions will your class have during 2003? \_\_\_\_\_ excursions \_\_\_\_\_ incursions/visitors

Please list: Excursions \_\_\_\_\_  
Incursions/visitors \_\_\_\_\_

## What Happens in your Science Lessons?

**Think back over your lessons in science during this year. Probably you use a variety of different techniques or activities in your teaching, possibly some more than others.**

Please estimate how frequently each of the following kinds of activities occurs in your science lesson.

Please tick the box that most closely indicates the number of science lessons in which the activity occurs.

Activities in Science Lessons	Frequency of lessons on average in which the activity occurs				
	Very few lessons		About half of lessons		Nearly every lesson
1. teacher tells or explains <b>science content</b>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. question and answer, <b>teacher-led</b> class discussion	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. teacher demonstration	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. children do the same <b>teacher-directed</b> experiment or activity	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. show/play film/CD/tape/TV presentations	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. children use computers for science work	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. children use internet at school for science	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8. children plan and do their <b>own</b> experiment or activity	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9. children work in small groups	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10. children work alone on directed written work	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
11. children research <b>own choice</b> of assignment or project	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
12. children do activities outdoors	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
13. Other activity – please describe _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Please make any other comments you wish about science teaching and learning for

boys and girls and the different strands of science.

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## APPENDIX 4

### Teacher Questionnaire used at Fenchurch and Knightsbridge

A partnership between Scitech  
and the Rio Tinto WA Future Fund.

I.D.

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#### QUESTIONNAIRE FOR TEACHING SCIENCE in primary school

The purpose of this questionnaire is to explore your understanding of why science is included in the curriculum and how you teach science to your class.

We request your name/school details for follow-up purposes only. Your responses will contribute to our overall picture of science in primary schools, but will be confidential. Only the researchers will see your name.

Teacher Name \_\_\_\_\_ Gender: ☐ Female ☐ Male

Present school \_\_\_\_\_

Teacher Background \_\_\_\_\_

Please give details of your teaching experience

Teaching Qualification(s) \_\_\_\_\_ Teaching Experience \_\_\_\_\_  
years

How many classes do you teach science to? \_\_\_\_\_ What year level(s) are these  
classes? \_\_\_\_\_

Have you attended professional development for science this year? ☐ Yes ☐ No

If yes, please describe? \_\_\_\_\_

#### Science Programming

Please give details of your science programming for this year

How is science taught? ☐ as a separate subject ☐ integrated ☐ incidental

On average, how many minutes each week are programmed for science? \_\_\_\_\_ minutes per  
week

Do you meet this programmed target ☐ usually ☐ mostly ☐  
sometimes

What time of day is science usually taught? ☐ am ☐ pm

What science topics were programmed for this year?

What resources do you usually use in planning your science programs? (For example,  
children's interest, current events, Primary Investigations, materials from PDs attended,  
Curriculum Council Science Framework Guide, the internet etc.)

Please check the box that best describes your own attitudes and perceptions about teaching science.

1. My own interest in teaching science is best described as	Not interested					Very interested
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Compared with other subjects I find it difficult to teach science	Rarely					Always
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. I am effective in monitoring children doing science activities or experiments	Rarely					Always
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. My own background knowledge for teaching science is best described as	Limited					Extensive
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. I find it difficult to explain to students the science behind the activities they do	Rarely					Always
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. Students' science questions are easy for me to answer	Rarely					Always
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. My skills in teaching science are best described as	Limited					Extensive
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8. My confidence in teaching science is	Not very confident					Confident
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9. The resources available to me for teaching science are	Limited					Extensive
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10. I use outside resources (such as the internet) and/or people (such as a local expert) in my classroom	Rarely					Often
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
11. When teaching science, I welcome students' questions	Rarely					Always
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
12. I am continually searching for better ways to teach science	Rarely					Always
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
13. I am enthusiastic about teaching science	Rarely					Always
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>



### Why Teach Science?

Listed below are some possible reasons for teaching science.

How much importance does your science teaching and programming give to each of these considerations in teaching science to children?

For each statement, please tick the box that most closely indicates the level of importance you consider appropriate for science.

Possible reasons for teaching science to children	Very low importance					Very high importance
1. to interest children in science	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
2. to provide scientific knowledge	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
3. to practice manipulative skills	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
4. to develop communication skills - verbal	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
5. to develop communication skills - written	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
6. to demonstrate the importance of making decisions based on information	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
7. to show that decisions made in science have social consequences	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
8. to practice problem-solving skills	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
9. to prepare students for science later on	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
10. to show how science is related to everyday life	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
11. to integrate science with other school subjects	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
12. to develop social skills (such as cooperation)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
13. to develop self-discipline and independence	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
14. any other reason – please state	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

Has your class visited Scitech Discovery Centre this year?

☐ Yes ☐ No

Has the Scitech Roadshow visited your school this year?

☐ Yes ☐ No

How many science-related excursions and/or incursions will your class have during 2005?

\_\_\_\_\_ excursions

\_\_\_\_\_ incursions/visitors

Please list:

Excursions \_\_\_\_\_

Incursions/visitors \_\_\_\_\_

### What Happens in your Science Lessons?

Think back over your lessons in science during this year. Probably you use a variety of different techniques or activities in your teaching, possibly some more than others.

Please estimate how frequently each of the following kinds of activities occurs in your science lesson.

Please tick the box that most closely indicates the number of science lessons in which the activity occurs.

Activities in Science Lessons	Frequency of lessons on average in which the activity occurs				
	Very few lessons		About half of lessons		Nearly every lesson
1. teacher tells or explains <b>science content</b>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. question and answer, <b>teacher-led</b> class discussion	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. teacher demonstration	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. children do the <b>same teacher-directed</b> experiment or activity	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. show/play film/CD/tape/TV presentations	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. children use computers for science work	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. children use internet at school for science	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8. children plan and do their <b>own</b> experiment or activity	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9. children work in small groups	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10. children work alone on directed written work	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
11. children research <b>own choice</b> of assignment or project	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
12. children do activities outdoors	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
13. Other activity – please describe	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

When **you** teach science what do **you** usually do?

☐ Design your own activities      ☐ Adapt ideas from resources      ☐ Follow a given course

Please make any other comments you wish about science teaching and learning for boys and girls and the different strands of science.

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**Thank You for Your Responses**

## APPENDIX 5

### 2006 QUESTIONNAIRE FOR TEACHING SCIENCE IN KNIGHTSBRIDGE PRIMARY SCHOOL

Please check the box that best describes your own attitudes and perceptions about teaching science.

1. My own interest in teaching science is best described as	Not interested				Very interested
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Compared with other subjects I find it difficult to teach science	Rarely				Always
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. I am effective in monitoring children doing science activities or experiments	Rarely				Always
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. My own background knowledge for teaching science is best described as	Limited				Extensive
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. I find it difficult to explain to students the science behind the activities they do	Rarely				Always
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. Students' science questions are easy for me to answer	Rarely				Always
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. My skills in teaching science are best described as	Limited				Extensive
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8. My confidence in teaching science is	Not very confident				Confident
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9. The resources available to me for teaching science are	Limited				Extensive
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10. I use outside resources (such as the internet) and/or people (such as a local expert) in my classroom	Rarely				Often
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
11. When teaching science, I welcome students' questions	Rarely				Always
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
12. I am continually searching for better ways to teach science	Rarely				Always
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
13. I am enthusiastic about teaching science	Rarely				Always
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## Teaching the Science Content Strands

*Please respond to these questions about teaching each science strand*

	Earth & Beyond	Energy & Change	Natural & Processed Materials	Life & Living
1. My own interest in teaching science is best described as				
highly interested	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
interested	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
not interested	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. My own background knowledge for teaching science is best described as				
extensive	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
adequate	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
extra preparation needed	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. My skill in teaching science is best described as				
competent	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
reasonable	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I'm not too sure of my ability	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. My confidence in teaching science				
very confident	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
confident	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
not very confident	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. The resources available to me for teaching science are				
extensive	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
adequate	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
limited	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. I use outside resources (such as the internet) and people (such as a park ranger)				
very often	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
often	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
sometimes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. When teaching science, I usually				
design my own activities	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
adapt ideas from resources	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
follow a given course	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## Scitech “Investigating” Professional Learning (PL)

I found the Scitech Investigating PL

☐ Very helpful and I am now confident in this aspect of science

☐ Very helpful but I require more assistance

☐ Not very helpful, I already knew the information

☐ I'm not sure because I still don't know where to start

☐ Other, please explain

On a scale of one to ten how confident are you at *planning* a science unit? (ten being the most confident) \_\_\_\_\_

On a scale of one to ten how confident are you at *assessing* a science unit? (ten being the most confident) \_\_\_\_\_

Do you believe you need assistance in planning with (tick as many as applicable)

☐ Investigating

☐ Earth and Beyond

☐ Life and Living

☐ Natural and Processed Materials

☐ Energy and Change

Do you believe you need assistance in assessing with (tick as many as applicable)

☐ Investigating

☐ Earth and Beyond

☐ Life and Living

☐ Natural and Processed Materials

☐ Energy and Change

Have you heard of Primary Connections? Yes ☐ No ☐

Would you like to know (more) about Primary Connections? Yes ☐ No ☐ Unsure ☐

## APPENDIX 6

### Student Questionnaire



A partnership between Scitech  
and the Rio Tinto WA Future Fund.

I.D.

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Office Use Only

### SCHOOL SCIENCE SURVEY 2007

Please tell us about yourself

My School .....

My Teacher's Name .....

I am in year

(Circle which year)

4    5    6    7

I am a

(Circle one number)

boy                      1  
girl                     2

**On the next pages are some questions about your science lessons at school.**

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	Nearly every lesson
<b>In my science lessons</b>				
We do experiments.	1	2	3	4

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

**Please answer each question on the next pages.**

**Remember:**

**Put a circle around the number for the answer which is right for you.**

**If you make a mistake, cross it out then put a circle around the right number like this,**

1    ~~2~~    3    4

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

		<b>Never</b>	<b>Some science lessons</b>	<b>Most science lessons</b>	<b>Nearly every lesson</b>
<b>In my science lessons</b>					
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
<b>In my science lessons</b>					
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
<b>For science</b>					
		<b>Never</b>	<b>Some science lessons</b>	<b>Most science lessons</b>	<b>Nearly every lesson</b>
10.	we do activities outside in the playground, at the beach or in the bush.	1	2	3	4
11.	we have excursions to the zoo, museum, Scitech, 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 for science.	1	2	3	4
<b>My teacher</b>					
15.	listens to my ideas.	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
		<b>Never</b>	<b>Some science lessons</b>	<b>Most science lessons</b>	<b>Nearly every lesson</b>

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

	Almost never	Some- times	Often	Nearly always
<b>The science we do at school</b>				
19. is easy to understand.	1	2	3	4
20. is enjoyable.	1	2	3	4
21. makes me think.	1	2	3	4
<b>In science we need to be able to</b>				
22. think and ask questions.	1	2	3	4
23. remember lots of facts.	1	2	3	4
24. understand science ideas.	1	2	3	4
25. explain things to each other.	1	2	3	4
26. recognise the science in the world around us.	1	2	3	4
<b>During science lessons</b>				
27. I am excited.	1	2	3	4
28. I am curious.	1	2	3	4
29. I am bored.	1	2	3	4
30. I am confused.	1	2	3	4
31. I learn a lot.	1	2	3	4
	Almost never	Some- times	Often	Nearly always

**Please answer the next question in the space below.**

**Write down what you like most about science lessons.**

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THANK YOU FOR YOUR HELP



## APPENDIX 7

### CODING CATEGORIES FOR STUDENT QUESTIONNAIRES

	<b>General</b>
000	<i>Uncodeable/irrelevant</i>
001	<i>Sarcastic</i>
002	<i>Alienated negative</i>
003	<i>General negative</i>
004	<i>General Positive</i>
005	<i>Don't know</i>
	<b>Teaching and Learning Activities</b>
110	<i>Hands on experiments/ activities/ investigations/ making things</i>
115	<i>Like design/choose own experiments</i>
116	<i>Likes when the Teacher demonstrates</i>
117	<i>Like writing up lab reports/recording results</i>
119	<i>Like working independently</i>
120	<i>Like drawing in science</i>
130	<i>Like taking notes/writing/copying/dictation</i>
132	<i>Like bookwork/work from textbook/reading</i>
134	<i>Like reading aloud, speaking to class/asking questions in front of the class/presenting to class</i>
135	<i>Like class discussions/share ideas/contribute/participate</i>
137	<i>Like group work/working with friends</i>

140	<i>Like outdoor activities and excursions</i>
148	<i>Library research/projects</i>
152	<i>Like homework/research at home</i>
160	<i>Like Lots of variety</i>
164	<i>Like lecture/teacher talking</i>
180	<i>Like seeing other people learn</i>
190	<i>Like following teacher instructions</i>
	<b>Management of Learning</b>
214	<i>Teacher makes sure we understand</i>
244	<i>Like that we don't do much work</i>
245	<i>Like that we do lots of work/work hard</i>
	<b>Teacher and Teaching</b>
310	<i>Teacher gives rewards</i>
320	<i>Like teacher</i>
342	<i>Good communicator/explains things well</i>
346	<i>Teacher chooses good topics</i>

	<b>Student Attitude/Behaviour/Feeling</b>
401	<i>Fun, interesting, enjoy</i>
402	<i>Boring</i>
	<b>Resources</b>
510	<i>Equipment is good, ample, safe/like to use equipment</i>
532	<b>Guests/guest speakers</b>
544	<i>Internet use</i>
546	<i>Computer use</i>
	<b>Grading and Assessment</b>
601	<i>Likes Tests</i>
	<b>Content</b>
701	<i>Specific like /topic, lab activity</i>
705	<i>Like learning new things/doing new things/we learn a lot/educational/make new things/discover new things</i>
706	<i>Like the topics covered</i>
707	<i>Like the pursuit of knowledge</i>
710	<i>Like challenge –makes us think/experiments</i>
711	<i>Like relevance/learning about nature/world around us/how things work</i>
712	<i>Like learning about my future/what's in store for me</i>
713	<i>Unpredictable/weird/unusual</i>

## APPENDIX 8

### Teacher Case Study Information and Consent

Date:

Dear

#### Participation in the Kid's Science State Initiative

As you know, your school is participating in some professional development evaluation regarding science teaching and learning in schools.

XX has agreed that I may approach you to ask for your support in this project to ensure the continued improvement of science teaching and learning in schools.

#### What would involvement mean for you and your class?

I ask for your cooperation to collect some data about the effectiveness of the professional development activities in which you have participated. This will involve a questionnaire and a formal interview lasting about 35 minutes (teacher relief will be provided if required). In addition, I would like to visit your classroom for observation of science lessons. In conclusion I will ask you about the follow up teaching activities that you may have undertaken. At all times I will work closely with you and your school to minimise any disruption, and always provide a copy of the data I collect. Of course the names of your school, teachers and children will remain confidential when I report my research, and you may choose to discontinue your involvement at any time.

I will be meeting with you on Monday 12<sup>th</sup> September at 9.45am. In the meantime, please feel free to contact me using the information below. You can read more about the KSS at <http://kids-science-state.scitech.org.au>, or contact Mr Paul Fleay, Manager, Kids' Science State Initiative, Scitech Discovery Centre  
Phone: 9481 6295

Yours sincerely

Rosemary Evans

**Researcher:** Rosemary Evans

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**Supervisor:** Prof. Léonie Rennie

**Phone:** 9266 3155

**Email:** [L.Rennie@curtin.edu.au](mailto:L.Rennie@curtin.edu.au)

**Curtin University Human Ethics Committee:** Secretariat

**Phone:** 9266 2784

**Email:** [S.Darley@curtin.edu.au](mailto:S.Darley@curtin.edu.au)

## APPENDIX 9

### PMM Teacher Information Sheet

#### Teacher Participant Information Sheet for Person Meaning Mapping (PMM)

You are being invited to take part in a research study which is being completed as the requirement for a PhD thesis. Before you make your decision it is important for you to understand why the research is being done and what it would involve. Please take your time to read the information thoroughly. Please do not hesitate to email or call me if you have any questions or like more information.

The purpose of the research is to evaluate a professional development program produced by the Kids Science State. One of the Kids Science State's initiatives is the development of scientific literacy in the Western Australian population. The Kids Science State has professional development officers that work to address the promotion of scientific literacy in the professional development they provide to Western Australian school teachers. The effectiveness of the Kids Science State professional development program needs to be measured both for the science education community and the Kids Science State to determine its success in promoting scientific literacy within the science teaching area in primary schools.

You have been invited to participate in this study as science is a priority for your school this year and as such you have taken part in three Kids Science State science professional development sessions in semester one. It is your decision whether or not to take part. If you decide to take part, you can still withdraw at any time, without giving a reason. You have been given this information sheet to keep and should you agree to participate you will receive a copy of your signed consent form. You will have opportunities to see drafts, make amendments, and comment on the final version of any related reports or papers.

The study involves you being interviewed to obtain your understanding of what science is about. The interview will take approximately 30 minutes of your time at a time that is mutually convenient. All information gathered from you will be kept confidential and private, retained in a locked storage unit at the Curtin University of Technology and when any information is presented in journals or the PhD thesis pseudonyms will be used and some of the information altered to ensure your anonymity.

If you have any questions now or at any time about the study please contact me or my supervisor on the numbers or emails below. If you want to discuss the study with someone who is not directly involved with the study (for example, about the information you have received, the conduct of the study or your rights as a participant, or a complaint you have), you can contact Curtin University Human Research Ethics Committee Secretariat on 9266 2784.

Yours faithfully  
Rosemary Evans

**Researcher:** Rosemary Evans

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**Supervisor:** Prof. Léonie Rennie

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**Curtin University Human Ethics Committee:** Secretariat

**Phone:** 9266 2784

**Email:** [S.Darley@curtin.edu.au](mailto:S.Darley@curtin.edu.au)

## **APPENDIX 10**

### **District Office Letter**

Date:

District Office

Dear

#### **Research relating to the Kids' Science State Initiative**

The Kids' Science State Initiative is a partnership between Scitech Discovery Centre, the Rio Tinto WA Future fund and the Department of education and Training that aims to contribute towards the development of a scientifically literate community through a holistic approach to science education in primary schools across Western Australia. Scitech aims to achieve this through providing professional development for teachers, an expanded Science Roadshow, new exhibitions and online resources for students, parents and teachers.

As part of this project, Scitech is cooperating with Professor Léonie Rennie at the Science and Mathematics Education Centre (SMEC) Curtin University of Technology, to review the outcomes and outputs of the Kids' Science State Initiative over the next 3 years, focussing in particular on the benefits of incursion programs, professional development for teachers and resources for children.

One of the schools in your district, Fenchurch Primary School, has offered their support and involvement in this valuable longitudinal science research project to ensure the continued improvement of science teaching and learning in our schools. The school has already taken advantage of the professional development at a reduced price as they participated in the baseline data collection.

We have previously discussed this study with Mr Greg Robson (Executive Director, teaching and learning, Curriculum policy and Support), who advises that the study addresses an area of interest to the Department of Education and Training (DET), and therefore he is pleased to approve our request to approach schools to invite their participation. We will ensure that the DET Policy for Research in government Schools will be adhered to in conducting the research.

This research is part of my PhD studies whilst I am on leave without pay from the Department of Education. I will be working closely with two teachers this year and would be happy to provide you with findings in due course if you are interested. If you have any queries in the meantime, please feel free to contact Professor Léonie Rennie on 9266 3155 or myself, Mrs Rosemary Evans on 9266 3792 at Curtin University of Technology.

Should you wish to discuss the Kids' Science State Initiative, please contact: Mr Paul Fleay, Manager, Kids' Science State Initiative, Scitech Discovery Centre, Ph: 9481 6295

Yours sincerely,

Rosemary Evans

## APPENDIX 11

### Letter to the Principal

Date:

**Subject: School Science Study PhD Research**

Dear,

Thank you for taking the time to receive further information after our initial conversation last term. Ideally, the study will involve all of your staff involved in the Scitech professional development, in which your school participated during first semester. The staff will be asked if they would volunteer to respond to a 15-minute survey about their perceptions of science in the curriculum and aspects of the professional development program. Additionally, the staff will be asked if they would volunteer to two, 30-minute interviews, one at the beginning, and one at the end, of the study. These would be held at a time convenient to them - before, during or after school. If the interview is to take place during school time I am able to provide relief funds if all internal interviews are kept to a maximum of two days. From the staff members interviewed I will ask for three volunteers to participate in the case studies. The case studies will involve these teachers and the students in their classes. All participants will be given information sheets and informed consent forms, participation will be on a strictly voluntary basis. The case studies would involve student surveys, classroom observation of science lessons, and informal conversations on an ad hoc basis.

I believe it would be mutually beneficial to conduct research in this area. Whilst the research will contribute to my own thesis, the independent observation and feedback I will provide for the school and to the individual teachers will be of benefit to your science program. Naturally I wish to minimise interruption to the school's program, assist teachers where I can, and try to be as unobtrusive as possible. The case studies will not interrupt the routine of the classroom or interfere with the students' learning. The teacher interviews would take a total of one hour of the participating teacher time, and will be negotiated with the teacher and yourself. The student surveys will take the students approximately 15 minutes, and will be conducted at a time that is convenient to the teacher and her/his students.

I will provide a full report to the school at the end of the study and talk with staff or yourself at any time about the study. Please do not hesitate to contact me, my supervisor or the ethics secretariat if you have queries. Should you accept the invitation to participate in the study I understand that you have a procedure with regard to research in your school and I seek to follow these processes to concur with the necessary guidelines by completing the necessary paperwork.

Yours faithfully

Rosemary Evans

**Researcher:** Rosemary Evans  
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