The Implementation of the new Australian Curriculum: Science
A study of the experiences of a range of Queensland schools and teachers

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ABSTRACT

In 2011 the national Australian Curriculum was launched. This included a complete reformation of the entire set of curriculum documents and processes from Foundation (Kindergarten) to Year (Grade) 10. This study investigated school and teacher responses to the implementation of the new Science Curriculum and subsequently, influences on teachers’ classroom planning and practice.

Teachers from three primary schools participated in the study, one State (government) School, one Independent School, and one Catholic School. The male and female participants had a range of teaching experience, from one year to 36 years. Teachers’ Science backgrounds varied from no previous coursework, to four university-level courses and a range of previous Science professional development.

Study methods included surveys, interviews, observations and field notes. All 52 teachers from the three case study schools were surveyed, while nine teachers, three from each school, provided the nested case study design. They participated in semi-structured individual interviews of approximately 30 minutes, before and after the initial 10-week teaching period with the new curriculum. They were also observed teaching two Science lessons that were recorded using field notes.

Results revealed varied implementation processes and practices in schools and in classrooms. However, highly effective practices included leadership involvement in change, appropriate and sustained professional development, and a school culture with capacity building routines.

This study was the first one known to investigate the Science Curriculum implementation in regional schools in Queensland, Australia. It demonstrated the positive and negative effects of new government policy, school leadership, and professional development support for teachers during curriculum implementation.
STATEMENT OF ORIGINALITY

I confirm that the work involved in researching and writing this thesis was my own. My supervisors provided feedback and guidance as appropriate and in accordance with supervisory regulations.

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# TABLE OF CONTENTS

1 INTRODUCTION ........................................................................................................................................... 14

1.1 New Curriculum Implementation ............................................................................................................. 14

1.1.1 School Administration ......................................................................................................................... 19

1.1.2 Teachers .............................................................................................................................................. 19

1.1.3 Framework .......................................................................................................................................... 21

1.2 Rationale ................................................................................................................................................. 22

1.3 Purpose ................................................................................................................................................... 23

1.4 Overarching Research Question ............................................................................................................. 24

1.5 Scope of the Study .................................................................................................................................. 24

1.6 Significance .............................................................................................................................................. 24

1.7 Overview of the Thesis ............................................................................................................................. 25

2 LITERATURE REVIEW .............................................................................................................................. 26

2.1 Science Curriculum Reform: A Brief International History ................................................................. 26

2.1.1 United States .................................................................................................................................... 27

2.1.2 United Kingdom ................................................................................................................................. 29

2.1.3 Australia ........................................................................................................................................... 31

2.1.4 Creation of the New National Curriculum ......................................................................................... 37

2.2 Conceptual Framework ........................................................................................................................... 40

2.3 The Macrosystem: Cultural Beliefs and Ideologies ............................................................................... 46

2.4 The Exosystem: Education Policies and Science Curriculum .............................................................. 50

2.4.1 Government Decisions ....................................................................................................................... 50

2.4.2 Common Styles of System Implementation ....................................................................................... 52

2.4.3 Science Curriculum ........................................................................................................................... 56

2.4.4 Curriculum into the Classroom ......................................................................................................... 58
2.4.5 Primary Connections .................................................................59
2.4.6 Summary .................................................................................61
2.5 Mesosystem: School Collaboration with Curriculum ..................62
  2.5.1 Principals .............................................................................63
  2.5.2 Professional Development / Professional Learning ............69
  2.5.3 Science Teaching and Professional Development ............77
  2.5.4 School Environment ..............................................................78
  2.5.5 Building Capacity / Organisational Capacity .....................80
  2.5.6 Summary .............................................................................80
2.6 Microsystem: Primary Teachers ............................................82
  2.6.1 Knowledge ...........................................................................83
  2.6.2 Confidence ..........................................................................86
  2.6.3 Pedagogy .............................................................................91
  2.6.4 Summary .............................................................................94
3 THE RESEARCH PARADIGM AND CONSIDERATION OF METHODS .....97
  3.1 Research Orientation/ Justification of Paradigm .......................97
  3.2 The Researcher .........................................................................98
  3.3 Case Study Research/ Criteria for Case Study .........................99
    3.3.1 Case Study Procedures .......................................................101
    3.3.2 Case Study Protocol ..........................................................102
    3.3.3 Limitations of Case Study Research .................................103
  3.4 Trustworthiness and Ethical Considerations ............................104
    3.4.1 Trustworthiness Criteria ....................................................104
  3.5 Trustworthiness and Methodological Triangulation ..................106
  3.6 Perspective of the Role of Researcher .....................................107
  3.7 Context ....................................................................................108
3.7.1 School Cases/First Level Cases ........................................... 109
3.7.2 State Government School .................................................. 109
3.7.3 Independent School .......................................................... 110
3.7.4 Catholic School ............................................................... 111
3.7.5 Participant Cases/Second Level Cases .................................. 111
3.7.6 Procedures ........................................................................ 113

3.8 Data Sources ........................................................................ 115
3.8.1 School Policy and Planning Documents ................................. 115
3.8.2 Survey ................................................................................ 116
3.8.3 Interviews .......................................................................... 117
3.8.4 Observations ...................................................................... 117
3.8.5 Field notes .......................................................................... 117

3.9 Data Analysis and Interpretation ............................................ 118
3.9.1 Survey ................................................................................ 118
3.9.2 Interviews .......................................................................... 120
3.9.3 Observations ...................................................................... 121

4 FINDINGS ................................................................................ 123
4.1 Overview ............................................................................... 123
4.2 Bronfenbrenner’s Macro and Exosystems ................................. 123
4.2.1 The Australian Curriculum .................................................. 124

5 STATE SCHOOL ...................................................................... 129
5.1 Bronfenbrenner’s Mesosystem ............................................... 129
5.1.1 The State Primary School: Pre Implementation ..................... 129
5.2 Bronfenbrenner’s Microsystem: State School Pre Implementation 141
5.2.1 Case Teacher Characteristics and Classroom Contexts ........ 141
5.2.2 Preparing to Teach the New Science Curriculum ............... 145
5.2.3  Confidence to Use and Teach the New Science Curriculum ... 148

5.3  After One Year of Implementation ........................................... 150

5.3.1  Beliefs about Science Teaching and Learning ....................... 151

5.3.2  Case Study Teaching Approaches ......................................... 153

5.3.3  Teacher Implementation Processes in the State School .......... 155

5.3.4  Support for Primary Teachers ............................................. 160

6  INDEPENDENT SCHOOL ................................................................. 165

6.1  Bronfenbrenner’s Mesosystem ................................................. 165

6.1.1  The Primary Independent School: Pre Implementation .......... 165

6.2  Bronfenbrenner’s Microsystem: Independent School Pre Implementation ........................................... 172

6.2.1  Case Teacher Characteristics and Classroom Context ............. 172

6.2.2  Preparing to Teach the New Science Curriculum .................. 176

6.2.3  Confidence to Use and Teach the New Science Curriculum ... 181

6.3  After One Year of Implementation ............................................. 182

6.3.1  Beliefs about Science Teaching and Learning ....................... 183

6.3.2  Case Study Teaching Approaches in the Independent School 184

6.3.3  Teacher Implementation Processes in the Independent School 188

6.3.4  Support for Primary Teachers ............................................. 191

7  CATHOLIC SCHOOL ................................................................. 196

7.1  Bronfenbrenner’s Mesosystem ................................................. 196

7.1.1  The Primary Catholic School: Pre Implementation ............... 196

7.2  Bronfenbrenner’s Microsystem: Catholic School Pre Implementation 201

7.2.1  Teacher Characteristics and Classroom Context ................. 201
LIST OF FIGURES

Figure 1 - Bronfenbrenner’s Bioecological Systems Model (2006) ...............21
Figure 2 - Bronfenbrenner’s Ecological Systems Model (1979) .................41
LIST OF TABLES

Table 1  Abbreviated Research Timeline (2012-2013) ................................. 115
Table 2  Alignment of Survey and Research Questions ............................... 119
Table 3  State School Teachers’ Ratings of the Preparation for
   Implementation of the Australian Curriculum: Science .................... 138
Table 4  State School Teachers’ Ratings of Personal Experiences in Science
   Pre and Post the Implementation of the Australian Curriculum: Science
   ............................................................................................................. 149
Table 5  State School Teachers’ Ratings of Beliefs about Teaching Science
   Pre and Post the Implementation of the Australian Curriculum: Science
   ............................................................................................................. 152
Table 6  Independent School Teachers’ ratings of Preparation for
   Implementation of the Australian Curriculum: Science .................... 170
Table 7  Independent School Teachers’ Ratings of Personal Experiences in
   Science Pre and Post the Implementation of the Australian Curriculum:
   Science ..................................................................................................... 178
Table 8  Independent School Teachers’ beliefs about teaching Science pre and
   post implementation of the Australian Curriculum: Science ............. 187
Table 9  Catholic School Teachers' ratings of Preparation for Implementation
   of the Australian Curriculum: Science .............................................. 200
Table 10 Catholic School Teachers' Ratings of Personal Experiences in
   Science Pre and Post the Implementation of the Australian Curriculum:
   Science ..................................................................................................... 208
Table 11 Catholic School Teachers' Ratings of Beliefs about Teaching
   Science Pre and Post the Implementation of the Australian Curriculum:
   Science ..................................................................................................... 212
Table 12 Teachers’ Ratings of preparation for Science implementation Pre
   and Post the Implementation of the Australian Curriculum: Science.... 221
Table 13  Teachers’ Ratings of Beliefs about Teaching Science Pre and Post the implementation of the *Australian Curriculum: Science* ..................223

Table 14  Teachers’ ratings of personal experiences in Science Pre and Post the implementation of the *Australian Curriculum: Science* ..................224
1 INTRODUCTION

The new national Australian Curriculum was created in 2011 to improve the quality of teaching and learning and to deliver a more equitable education for all Australian students. However, as a result of low Science scores on national testing such as the 2008 National Assessment Program: Science Literacy (NAPSL)\(^1\) and the 2007 Trends in International Mathematics and Science Study (TIMSS), quality Science teaching became a national priority for Australian schools. This study investigated the implementation of the new Australian Curriculum: Science (ACARA, 2011) in the state of Queensland. One particular region was selected which included a primary\(^2\) school from each of the State, Catholic, and Independent school sectors, and focused on the implementation support provided by the education system, and the school, and the teachers’ experiences during implementation of the new Science curriculum.

This section discusses major influences that impact on the implementation of a new curriculum and curriculum reform in Science education. An understanding of curricular reform is provided as it sets the stage for this study. A brief introduction to the new curriculum implementation in Queensland, school administration influence on implementation, teachers and implementation and the theoretical framework that guides this study follows.

1.1 New Curriculum Implementation

In 2011, a new set of (Foundation-Year 10)\(^3\) curricula in all subject areas was rolled out across all Australian states. Each state had responsibility for implementation; and, in Queensland, the government decided that four subjects, including Science, were to be implemented in the first year. In Queensland, there are three different school systems and their

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\(^1\) NAPLAN is the Australian National Assessment Program Literacy and Numeracy exam for students in years 3, 5, 7, and 9.

\(^2\) Elementary school is called primary school in Australia. Depending on the state, it covers Years 1 to 6 or 7.

\(^3\) Foundation is the new term for Kindergarten and the term ‘Years’ is equivalent to the term ‘Grade’ in Australia.
administration: the state, public school system, the Catholic School system (administered through the Catholic Church), and the Independent School system (a loose association of schools from other religions or non-aligned organisations). Each system has its own support and regulatory procedures. In Queensland, the government delegated responsibility for curriculum implementation to schools, but provided some support for state schools. A natural question then was: “How would the schools and teachers cope with the demands of implementation, particularly in Science?” Research provides some guidance about what schools and teachers need in order to implement a new Science curriculum.

Several studies have investigated curriculum implementation (Cowie et al., 2009; Cronin-Jones, 1991; Datnow & Stringfield, 2000; DeMonte, 2013; Fullan & Pomfret, 1977; Hamilton et al., 2003; Hipkins, Cowie, Boyd, Keown, & McGee, 2011; Hord & Huling-Austin, 1986; Roehrig, Kruse, & Kern, 2007). Common concerns include: improving student engagement and community engagement, understanding the key competencies within the curriculum, embedding aspects of implementation or processes into school routines, learning together to build capacity and improve practice, strengthening achievement through evidence-based practice, assessing curriculum resources, leadership, and critical and constructive use of data. More specifically, Science curriculum implementation reflects the above concerns but also has concerns specific to Science teaching. Roehrig and Kruse (2005) analysed teachers’ practices prior to and during implementation of a Science curriculum and found that the degree of change was related to the teacher’s beliefs about the teaching and learning of Science, their personal Science knowledge and their years of teaching experience. Further studies (Akerson, Cullen, & Hanson, 2009; Anderson, Feldman, & Minstrell, 2014; Dass & Yager, 2009; DeMonte, 2013; Desimone, Porter, Garet, Yoon, & Birman, 2002; Garet, Porter, Desimone, Birman, & Yoon, 2001; Haefner & Zembal-Saul, 2004; Newmann, King, & Youngs, 2000; Parise & Spillane, 2010; Spillane, 2014; Supovitz, Sirinides, & May, 2009) indicate that teachers need to have effective and sustained professional development in order to successfully meet the demands of a
new curriculum. DeMonte (2013) has identified some structures she believes need to be in place so that professional learning can become embedded in schools. These include:

- Establishing a strong evaluation system that identifies strengths and weaknesses in teaching practice.
- Encouraging administrators in schools and districts to take steps to become experts in changing standards and student assessments and making sure teachers are aware of these.
- Supporting administrators in schools and districts in the creation and collection of resources about new standards and assessments to help teachers maintain and improve classroom instruction.
- Adapting staffing, the organisation of the school day, and the other basic structures of schools to support better teaching (p. 20-21).

The findings of previous studies indicate the complexities of making large-scale curriculum changes that have substantial impact on those closely connected to the curriculum. In particular, the teachers and the leaders in the schools need extensive support (Cowie et al., 2009; DeMonte, 2013; Hipkins et al., 2011).

There have also been a number of studies (Anderson et al., 2014; Desimone et al., 2002; Lee, Hart, Cuevas, & Enders, 2004; Watters & Ginns, 2000) that suggest the outcomes of a new Science curriculum implementation may not always be highly successful. In this context, Watters and Ginns (2000) identified that many primary teachers have beliefs and attitudes based upon prior Science experiences that affect their Science teaching. These may be positive, but are more often negative and lead to teachers feeling uncomfortable and unqualified to teach Science.

Professional development then becomes an important focus to improve teachers’ attitudes, beliefs and Science teaching practices. Hamilton et al. (2003) observed that when there was a lack of support and professional development for teachers, there was much variability in practices between schools and even between teachers within the same schools. In addition, sometimes teacher beliefs and lack of practice with new teaching strategies
hindered changes in practices (Lee, Hart, Cuevas & Enders, 2004). In order for a new curriculum to be implemented well, Guskey (2002) posited that professional development must be continuous and on-going. Doing so greatly increases the likelihood of positive changes in attitudes, beliefs and teaching practices. Further, professional development with a focus on specific instructional practices increased the likelihood of teachers continuing to use those practices (Desimone, Porter, Garet, Yoon & Birman, 2002). Another factor that seems to contribute to productivity and change is that of relationship trust between teachers and between teachers and administrators during instructional coaching and professional learning (Anderson, 2014). Trust in relationships during on-going professional learning impacts on the depth of learning.

During large-scale reform, the leadership, the teachers and the students need to be considered carefully. Fullan (2011) identified several main ‘drivers’ of educational reform that he believed many school districts tended to focus on, that are counterproductive to long-term positive results. For example: accountability, individual teacher and leadership quality, technology and fragmented strategies. He also recommended a focus on four drivers he considered to be at the ‘heart’ of educational reform. These are:

1) the learning -instruction-assessment nexus. This is about keeping the main focus of reform around teaching and learning;
2) social capital to build the profession: ‘building collaborative cultures within and across schools’;
3) pedagogy matches technology: bringing innovation into how we use technology and pedagogy for effective teaching. And lastly
4) systemic energy: when the correct drivers for reform underpin the direction of the reform and are ‘conceived and pursued as a coherent whole’ they become ‘mutually supportive and interactively corrective’ (p. 18).

Research has identified that the decisions and actions made by the state system leadership (Fullan, 2009), the school leadership (Cosner, 2014), and
the teachers (Peers, Diezmann, & Watters, 2003) have a substantial impact on the implementation of a new curriculum (Cowie et al., 2009; DeMonte, 2013; Fullan, 2007).

Previous research has concluded that implementation of new curriculum is often placed in the hands of the teachers with little preparation and support (Peers et al., 2003). This leads to varied results in meeting the new curriculum objectives with little to no change in some schools, to substantial change in others (Crowther, Andrews, Morgan, & O’Neill, 2012; Little, 1993; Roehrig & Kruse, 2005). The implementation of Science curriculum in the past has seen little change in practice, with Australian students continuing to score below students in many other countries in international testing such as Trends in International Mathematics and Science Study (TIMSS)\(^4\) and the Programme for International Student Assessment (PISA)\(^5\). This is often attributed to the failure of teachers to implement the new programs as intended. Reasons for this have emanated from earlier studies such as Wallace and Louden (1992) who felt the curriculum developers did not consider the teachers, students or the school communities. Clark and Peterson (1986) and Tobin and McRobbie (1996) identified that teacher beliefs and views impacted on change and educational reform. In addition, Verloop (1992) reported that practical knowledge (beliefs and knowledge about teaching) will influence how teachers respond to curriculum change.

A misaligned implementation would likely be due to inadequate professional development during the curriculum change initiative. Without appropriate support to assist teachers in changing their teaching practice, the old behaviours can remain steadfast (Van Driel, Beijaard, & Verloop, 2001). The issues relate to two key areas: school administration, and teachers.

\(^4\) TIMSS is a large-scale assessment designed to inform educational policy and practice by providing an international perspective on teaching and learning in mathematics and Science.

\(^5\) PISA provides data from internationally standardised tests that enables Australia to compare and monitor its performance with that of other countries.
1.1.1 School Administration

Success is highly dependent on the school administration. Studies indicate that the role of the principal influences curriculum delivery (Lewthwaite, 2004), classroom instruction (Parise & Spillane, 2010; Printy, 2010; Sebastian & Allensworth, 2012), student learning (Gurr, Drysdale, & Mulford, 2006; Leithwood, Seashore, Anderson, & Wahlstrom, 2004; Sebastian & Allensworth, 2012) and building school capacity (Hilton, Hilton, Dole, & Goos, 2015; King & Bouchard, 2011). School capacity refers to the current level of knowledge, skills and working relationships by all members of the school community and their ability to create and accomplish goals for improvement as well as maintain the ability to analyse progress and make adjustments as needed. It incorporates both school leaders and teachers.

It is clear that schools are different and may require different kinds of support and development. It is important that schools are flexible to meet the demands of change by supporting teachers with professional development to improve teaching practice that impacts positively on student learning. The leadership within schools have the greatest authority to impact either positively or negatively on the processes of support and development of teachers and their teaching (King & Bouchard, 2011).

1.1.2 Teachers

Success is also highly dependent on the teachers (Peers et al., 2003). The role of the teacher in curriculum implementation is critical. Teachers’ individual attitudes towards change and towards the new curriculum are important contributing factors to the direction of the change process. Teachers’ individual competencies may even affect the quality of the change (Altrichter, 2005a). Since teachers are seen as the main implementers of a curriculum, they themselves are in control of the direction taken in teaching and learning activities or instruction (Cuban, 1998; Fullan, 2011; Kirk & MacDonald, 2001; Sahlberg, 2012; Van Driel et al., 2001; Van Driel, Verloop, Van Werven, & Dekkers, 1997). It is important then, that teachers’ ideas, attitudes and values align with the central philosophies of the
curriculum. It is also important that teachers’ knowledge and skills align with the requirements of the new curriculum. When this is not the case, processes need to be in place to assist teachers with additional supports, such as appropriate and effective professional development and collaborative approaches. These will increase the likelihood of success with teaching quality and student performance outcomes (Berry, Johnson, & Montgomery, 2005; Bolam et al., 2005; DeMonte, 2013; Erickson, Minnes Brandes, Mitchell, & Mitchell, 2005; Fishman, Marx, Best, & Tal, 2003; Jenlink & Kinnucan-Welsch, 2001; Yoon, Duncan, Lee, Scarloss, & Shapley, 2007).

In addition, Kennedy (2005) posited that reform agendas often do not align with teacher agendas. For example, teachers in his study: 1) held multiple and conflicting intentions, 2) had versions of reform ideals that were slightly different from reformers’ versions, 3) often interpreted institutional guidelines to suit their own beliefs and values, 4) and some held unproductive or dysfunctional beliefs about how students learn (p. 231-232). When teachers are left to decipher curriculum changes themselves without effective professional learning with their colleagues and appropriate leadership, the implementation is likely to be fragmented and disjointed (Kennedy, 2005; Lewthwaite, 2004).

In summary, primary school teachers struggle with implementing Science in the classroom. Educational reform is a recurring worldwide phenomenon. The United States, New Zealand, United Kingdom and Australia are quite familiar with curricular changes. Curricular change is normally initiated at some level above the teacher, such as at federal, state or the school leadership levels. Schools and teachers are required to adapt to changes in curriculum, pedagogy, and resources as they attempt to implement the new mandated innovations in their classrooms. A report on the implementation of new curricular reform in New Zealand (Cowie et al., 2009) highlighted some challenges. These include: acquiring a shared understanding of the curriculum intentions among staff and confusion around specific teaching strategies required. Sometimes a school may gain an understanding of the ‘big’ picture, but not fully understand how it could work in their classroom.
1.1.3 Framework

Finally, schools and teachers work within a wider cultural and regulatory context, so a lens for viewing these together is helpful. The research points to several influences before, during and after initial curriculum implementation in schools. These include state level decisions, school level decisions and teacher decisions. Implementation can even be influenced by factors such as the school community, students, resources and time. Fullan also recognised these factors as influential in building school capacity, referring to these as: government, organisation characteristics, local, and teacher and student characteristics (Fullan, 1983, 1994). These factors fit well with Bronfenbrenner’s framework for Bioecological Systems (2006). Bronfenbrenner’s framework included several layers of influence from the political and cultural level (Macrosystem) through the local society, local politics, the family and the school (Exosystem and Mesosystem), to the teacher and child in the classroom (Microsystem). (See Figure 1)

![Figure 1 - Bronfenbrenner’s Bioecological Systems Model (2006)](https://www.google.com.au/search?q=image+Bronfenbrenner+model&tbm=isch&tbo=u&source=univ&sa=X&ved=0ahUKEwizqge37s3LAhWDK6YKHdteBXwQsAQIQGw&biw=1774&bih=843#imgrc=1uVUvi5Qcw7eBM%3A)

A clearer understanding of these systems would, according to (Altrichter, 2005a), reduce the problems of curriculum implementation.
More recently, Fullan (2011) stressed that “vertical accountability (transparency at the classroom, school, district, and state levels) is essential for sustainable progress” (p. 9). He went on to explain that attitudes around capacity building, engagement and trust building produce accountability and are critical for whole system reform. This would include implementation of a new curriculum, especially a new national curriculum.

With this in mind, while considering the implementation of a new national curriculum in Australia, the present study adopted Bronfenbrenner’s ecological systems as a guiding framework. His inclusion of time and processes involved at each level aligned well with the types of influences that were being discussed during the development of the national curriculum. Details of the guiding framework will be discussed further in Chapter 2.

Given that previous research has shown implementation of a new curriculum, including Science curriculum, can be problematic, and primary school teachers in Queensland were required to implement three other subjects at the same time (within three different school systems with differing support structures), the key research focus for this study became evident.

1.2 Rationale
The recent introduction of a national curriculum that would enact changes to all subject areas for P-12 educators has been unprecedented in Australia. The possibility, therefore, of challenges during implementation were likely. The fact that Science had recently been identified by the major State system authority (Education Queensland) as requiring support and professional development in Queensland and was one of the key areas targeted for improvement, made science an important subject area to focus on for this study. In addition, the nature of the difficulties experienced by primary school teachers in teaching Science are well documented within systems’ authorities and in other research; so this research project only sought information from participants as contextual and benchmark data, for gauging the value of the support provided and any subsequent influences on their classroom planning and practice. Further, research about Queensland
school responses to Science curriculum initiatives is almost non-existent (Education Queensland, 2011a; Queensland Government, 2011). Similarly, the extent to which teachers were able to improve their Science teaching on the basis of the new national curriculum in Queensland and the support (if any) provided by their school and education system has not been well documented. Given that the different education school sectors in Queensland have provided different types and levels of support, there was the opportunity to compare what occurred in schools from each sector.

This study will contribute information about the ways that school leaders have chosen to prepare and support their teachers to implement a new science curriculum and the ways that primary teachers have chosen to prepare themselves including identifying the type of support they require to implement a new science curriculum. In addition, this study will contribute to the understanding of educational reform in schools and classrooms and the impact of the policy decisions that are made at the top of an organisational structure and passed down to the constituents below who are charged with following those policy decisions.

1.3 Purpose
The purpose of this study was to investigate how schools and teachers prepared themselves prior to and during the implementation of the new national Australian Science Curriculum in the State of Queensland. In particular, it investigated a school from each of the State, Catholic, and Independent school sectors, focusing on the implementation support provided by systems and schools and how teachers experienced their implementation of the new curriculum. It was understood that state and federal decisions were expected to be followed. Therefore, curriculum changes, once established, were meant to be implemented in the schools. This top down approach is a well-established process, thus the study had a focus on the implementation of the curriculum within schools and classrooms.
1.4 Overarching Research Question
In what ways does the new national Australian Curriculum: Science provide impetus, at school and teacher levels, for Science curriculum change and for improving Science teaching; and to what extent can such impetus influence changes in practice?

1.5 Scope of the Study
It was the intent of this study to focus on the new Science curriculum orientation, planning preparations for teaching and support provided for teachers and schools.

Australia has reported concerns about Science teaching and the future of Science in society (Goodrum, Hackling & Rennie, 2001; Peers, Diezmann & Watters, 2003). There is no doubt that the number of students going into scientific fields of study following high school has dropped significantly (Kennedy, Lyons & Quinn, 2014). Therefore, there has been a strong push to improve Science teaching in primary schools and to also improve the image of Science in schools. Research tells us that often primary teachers lack the Science education and professional confidence required to successfully teach Science with the current pedagogical approaches (see Chapter 2). Therefore, this study may provide insight into the factors that influence the implementation of a new national Science curriculum in primary schools, and may be of benefit to other systems and countries.

1.6 Significance
This research has broad implications for educational theory, government policy and particularly for system authorities and school and classroom practice. It may inform policy at the state and federal levels concerning curriculum implementation. This research is the only one known to have studied the implementation of the Australian Curriculum: Science in Queensland schools and thus has the ability to contribute to previous research. It will contribute to the understanding of the impact of school leaders and school cultures or practices towards promoting change and improvement within their schools. In particular, the research will contribute to understanding the implementation processes of schools and teachers.
when expected to understand and teach a new curriculum. Finally, this research will add to the understanding of the impact of beliefs and attitudes about teaching and the effectiveness of science professional learning in developing science knowledge and effective pedagogy.

1.7 Overview of the Thesis
The thesis involves an examination of the implementation of the new Australian Science Curriculum in three selected Queensland schools. The background, significance, problem and purpose of the study have been presented in this first chapter. Chapter two is the review of literature and provides a brief history of Science reform in three countries who have been through similar curriculum reform and also focuses on the literature in relation to the new national Australian Curriculum with an emphasis on Queensland’s systemic responses, school and teacher challenges during curriculum reform, and concludes with a discussion of professional development in the context of curriculum reform. The qualitative methods are described and justified in Chapter Three with an emphasis on the different contexts as an important component of teacher and school actions. Chapters Four to Eight describe the findings from each school and the teacher implementation processes involved. More specifically, Chapter Four provides an overview of the findings and their connection to the Bronfenbrenner framework. Chapter Five provides an analysis of the data of the State School; Chapter Six provides the results of the analysis of the Independent School; and Chapter Seven provides the result of the analysis of the Catholic School. Finally, Chapter Eight provides a discussion of the main findings during curriculum implementation of the three schools combined. The main findings are discussed in Chapter Nine with links to the literature on curriculum change and reform, Science teaching and professional development. Chapter Ten presents the conclusions to the study, limitations and suggestions for future research.
This chapter provides a comprehensive overview of research conducted in the field of Science curriculum implementation. The purpose of the review is to situate this study within the broader context of Science curriculum implementation research and critically analyse curriculum implementation approaches as they impact on Science teaching and learning. This review will provide a context for understanding and interpreting the circumstances surrounding this study, particularly in relation to teacher involvement and support and the administrative practices in the three different school system contexts involved in the study.

The chapter begins with a brief historical review of curricular reform in the United States, the United Kingdom and Australia (section 2.1). This is followed by an overview of the theoretical framework selected to guide this study (section 2.2). This framework stems from the belief that surrounding environmental factors have a direct impact on the development of human behaviours, responses and relationships. Connections between this framework and education systems, policies, schools, principals, teachers and teaching and learning will be made. The three key components of the theoretical framework will be discussed in their own sections; Macrosystem (2.3), Exosystem (2.4), Mesosystem (2.5), and the Microsystem (2.6).

2.1 Science Curriculum Reform: A Brief International History
Designing the purpose, content and structure of school curriculum has caused heated debate, not only in Australia, but also in other countries. There are many who care deeply about what is taught in schools as it reflects who we are as a people and our cultural values. The United States, United Kingdom and Australia have each faced similar challenges of designing curriculum that encompassed the beliefs and cultural expectations required to successfully educate their nation’s young. Following is a brief synopsis of events that have occurred around curriculum reform in the United States, United Kingdom and Australia.
2.1.1 United States

A series of historical events in Science education that have taken place in the United States of America is similar to the one being experienced in Australia. As early as 1954 but especially with the Russian launch of Sputnik in 1957, the USA had begun to realise the importance of knowledge in Science and technology for the future growth of society. The National Science Foundation (NSF) began to support improvement projects in teacher education and curriculum development (Welch, 1979). At this time the NSF noted decreased enrolment in Science, lack of interest in Science, poor teacher knowledge and little time spent teaching Science as concerns that needed to be addressed. The scientific community (e.g. American Institute of Physics and the National Science Teachers Association) became involved in supporting teacher training and curriculum development at the college level, high school level and later the primary school level. However, only slight improvement was observed. By the 1970s after regular examination of the preparation of Science teachers, it was concluded that teachers did not have adequate preparation in Science (Kahle, 2007), particularly for the first nine years of schooling (Welch, 1979). It was believed there were several barriers contributing to the situation. Some of these barriers included: time and money to continue to support ‘unprepared teachers’, ‘inherent difficulty of change’ and ‘conservatism’ in schools, ‘lack of federal policy’, ‘inflation’ and ‘competing demands’ such as integration, back to basics and mainstreaming of special education students (Welch, 1979, p. 292).

Concerns about the lack of improvement led the National Science Foundation to look into Science curriculum and change. They identified that, “the successful implementation of innovations is generally considered to require a degree of change, capability, and motivation not typically found in schools” (Hughes, as cited in Welch, 1979, p. 293). This was earlier supported by Fullan (2007) who noted that federal or state governments (depending on the country and system employed) “can push accountability, provide incentives (pressures and supports), and/or foster capacity building”
Further, Fullan believed that when governments applied only accountability and incentives (usually in the form of pressures), they often only achieved short-term, superficial results. When all three were applied, chances of positive, long lasting achievements were improved. However, this seems to be a rare outcome. Predominately, Fullan (2007) has found that governments tend to follow the accountability route that includes extra workload with little assistance to schools and teachers. Incentives appear to follow the pressure strategy, without including the needed support incentives such as professional development to assist with the required changes, such as capacity building, which refers to a whole school developmental approach that increasingly lifts teacher knowledge and skills in a gradual and collaborative way (Fullan, 2007).

Fortunately, success stories about school improvement can be found. There were two states in the United States that invested in capacity building along with accountability and incentives in the 1980s; North Carolina and Connecticut. After nearly two decades of school capacity building, these two states moved to the top of the nation in 4th Grade Reading and Mathematics scores (Hammond & Ball, as cited in Fullan, 2007). Thus, it seems there can be success and sustainability when capacity building is included in the change process (Corcoran, McVay & Riordan, 2003; King & Newmann, 2001; Spillane 2014).

Teacher expertise is a key component of student learning outcomes. Recently the focus on school improvement, teaching practice and student outcomes has been the leading driver for many countries (Kahle, 2007). Darling-Hammond and Loewenberg (1997) prepared a report for the National Commission on Teaching and America’s Future that identified teacher qualifications as the major influence on student achievement. Teacher qualifications refers to teacher knowledge about content and students in so much as this knowledge shapes what is taught and how it is taught. They went further to identify that this knowledge of the content and of their students would also influence their ability to assess students’ progress and interpret students’ work. Darling-Hammond and Loewenberg (1997) also
identified that when a student is in a classroom with an ineffective teacher for three years in a row, the student scores on national tests lowered by 50 percentile points. Therefore, curriculum reform and curriculum change need to help teachers increase effectiveness, need to be accepted by staff, and supported with materials, time and opportunities to learn.

The urgency became a reality with the publication of *No Child Left Behind* reform in the US (2001) and *Every Child Matters* reform in England (2005). The United States and the United Kingdom were facing a similar reality.

### 2.1.2 United Kingdom

The United Kingdom has also had its share of curriculum reform over the last few decades. During the 1990s and the onset of a national curriculum, the government aimed to regulate schools with targets and tests to ensure that standards were achieved (Hancock & Eyres, 2004). Due to concerns about literacy and mathematics levels in primary schools compared to other countries, the National Literacy Strategy and the National Numeracy Strategy were introduced. Reports from the Office for Standards in Education (OFSTED) mentioned criticism of teachers and their teaching approaches. The writers of the new curriculum perceived the need for UK teachers to adopt similar teaching practices as the countries who achieved higher results on international tests. The reform:

- set out in detail what should be taught with an emphasis on traditional subject content and memorisation activities,
- expected ‘whole class’ instruction as the style of pedagogy, and
- specified targets to be met.

The reform documents included a description of how the literacy and numeracy periods should be run with the teaching strategies consisting of step-by-step learning of skills. The writers had chosen a pedagogical approach based upon a teaching process rather than the way children learn. However, this pedagogical approach did not allow teachers to collaborate and make decisions about teaching and learning within their context. Teachers’ voice had been essentially removed. Additionally, teaching
assistants were created as an afterthought to solve growing problems with students who could not learn with this ‘lecture’ approach. The assistants’ role predominantly became one of remediation work with the lowest achieving students. Those who could not keep up with the direct teaching approach and the increased speed of curriculum coverage were sometimes removed to work with the assistant. Eventually, up to 25% of the students were placed with assistants. The Ontario evaluators’ first report of this program indicated that there was early success, then later found that there were concerns with teachers’ ability to teach and indicated that the teachers needed to do more (Earl, Fullan, Leithwood, & Watson, 2000). As a result, the increased pressure to raise test scores had an impact on the teachers’ acceptance of this reform. Teachers were essentially backed into a corner and had no choice but to conform to the reform expectations. In doing so, their attitudes and beliefs may not have aligned with and may have impacted on teaching and learning outcomes. Certainly the pedagogical approaches, the removal of many students for remediation, and the lack of school collaboration and decision making, have caused regression in educational approaches.

When investigating the impact of Science reform (Banner, Ryder, & Donnelly, 2009), a vast discrepancy between interpretations of student needs within and among schools was identified, as well as discrepancy between actual Science teaching and expectations that seemed to arise from differences in school priorities and teachers’ professional judgements. Banner et al. (2009) reported in the Enactment and Impact of Science Education Reform (EISER) study, the teacher responses to Science reform. Banner et al., (2009) suggested that, while the teacher is important in reform and is often held accountable when it is not implemented as intended, the disparity is commonly due to teachers’ lack of understanding of the reform and/or the motivations behind the reform. Issues raised by teachers included personal concerns, internal school concerns, or external concerns. Banner et al., (2009) concluded there was a range of factors that influenced teachers when implementing reform, and that teachers needed time to exercise their professional judgement so they may enact external
reform policies in ways that reflected the needs of their students and the priorities of their schools.

More recently, the UK has turned its attention towards improvement in Science teaching and student outcomes. Ryder, Banner and Homer (2014) argued for flexibility with reforms and Science curriculum change to allow teachers to adapt the new requirements to their local contexts. In addition, they posited that the professional development that is often included with reform should support teachers towards “developing an informed and critically reflective perspective on curriculum policy directives” (p. 1). These suggestions require teachers and schools to work more collaboratively rather than independently to create shared understanding and purpose (Ryder et al., 2014).

Around this same time, the Queensland Government in Australia was investigating where the state ranked nationally and internationally in numeracy, literacy, and Science.

2.1.3 Australia

The concept of a national curriculum has been discussed in Australia for several decades. Before the 1960s the federated states held to largely separate identities and created their own curriculum with little direction from national government authorities. By 1963 the Commonwealth began to fund school education that also linked to collaboration on projects that were part of the national interest. In 1969, the Australian Science Education Project began, which may be viewed as the beginning of the direction towards a national curriculum. This was a partnership that also involved teachers in the process of curriculum development (Piper, 1997). This soon led to the creation of the Curriculum Development Centre in 1975 that opened the doors to the Commonwealth Government to intervene in curriculum issues. Around this time, Varley’s report (Varley, 1975) on science teaching and learning in Queensland, caused concern. The Queensland Science curriculum, in the early 1980s, was the Sourcebook created by the State Department of Education through the Primary Science
Project. It incorporated a hands-on approach with the use of basic scientific processes. Between 1986 and 1990 there were several important occurrences that led to a change in curriculum. One of these was the agreement by the Australian Education Council to map curriculum across the States. The mapping exercise was followed by an attempt to write a common curriculum framework (March 1994) which led to the abolishment of the Curriculum Development Centre. Another occurrence was a new policy statement by Education Minister, Dawkins, *Strengthening Australia’s Schools: A consideration of the focus and content of schooling* (Dawkins & Department of Employment Education and training, 1988). This policy encouraged a national curriculum and also began to draw industry demands and expectations into the broader ideas of school curriculum. In addition, *The Hobart Declaration on Common and Agreed National Goals for Schools* (Australian Education Council, 1989) was intended to set a direction for a common curriculum framework and curriculum reform in Australian schools (Dekkers & De Laeter, 2001; Piper, 1997).

By 1991 the official basic framework for curriculum development in all Australian states and territories were the eight Key Learning Areas. A few years later, the Australian Education Council met and failed to endorse the curriculum statements meaning the States and Territories were left to proceed as they wished. In 1999 the *Adelaide Declaration on National Goals for Schooling in the Twenty-First Century* was signed by all states and territories, which reinforced the eight Key Learning Areas (KLAs) established in 1991. The resultant new outcomes-based Queensland P-10 Science Curriculum was released in 1999, with a professional development package provided to each teacher on DVD. Many seminars on the new idea of outcomes-based education were also run as the various new subject syllabuses were rolled out. To this point training and professional development around the new curriculum or specifically, the Science curriculum, was at the discretion of each school and teacher, though a number of districts obtained funds to run short courses for representatives from district schools. The curriculum materials contained some form of written information about the curriculum expectations, teaching strategies
and standards but provided minimal support and no specific active training about how to plan, teach and assess according to the new Science teaching strategies.

The First Science Curriculum Released

Between 1999 and 2000, the Commonwealth Government performed a review of Science, mathematics and technology teaching in Australian schools (Goodrum, Hackling & Rennie, 2001). The report noted that primary school teachers often did not teach Science, or did not teach it systematically. They also reported an uncertainty among primary teachers about how to teach Science. Also noted was low interest in Science and low levels of Science knowledge. This finding was consistent with other research into teaching primary Science over the preceding 40 years (Appleton, 2006; Bandura, 1986; Harlen & Holroyd, 1997). The Commonwealth recommended increased Science teaching time and a need to improve teacher knowledge.

Regardless of the decades of new initiatives and new curriculum documents, primary teachers were still not receiving the support needed to make substantial changes in Science teaching practice (Tytler, 2007). In order to address these concerns, a national primary Science curriculum development program funded by government and private enterprise, *Primary Connections*, (managed by the Australian Academy of Science) was developed based on current research, and built on an earlier funded curriculum, *Primary Investigations*. *Primary Connections* are a series of innovative Science and literacy support materials that were trialled and revised to help build teacher confidence and competence to teach Science in primary schools. These materials were developed through a project team under the auspices of the Australian Academy of Science and the (Commonwealth) Department of Education, Employment and Workplace Relations (DEEWR) staff. The developers understood the importance of assisting teachers in developing their knowledge as well as their students’ knowledge and developing passion about discovering how our world works. The underlying principles of these materials are the use of a 5E pedagogical model (Bybee, Taylor, Gardner, Van Scotter, Powell & Landes, 2006) that incorporates Science and literacy,
planned student investigations, embedded assessment, and cooperative learning strategies (Australian Academy of Science, 2009). There was also a comprehensive professional development program to support teachers in implementation. Unlike previous curriculum reform, these curriculum documents were not mandated for use instead leaving the decision to individual schools. If schools decided to adopt it, they would purchase it and pay for support through their own funds. Teachers in many Australian schools adopted *Primary Connections*, which came with professional development modules to assist the understanding of its purpose, and develop Science teaching and learning pedagogy. A school collaborative approach was encouraged so that on-going learning and support could be facilitated.

National Agreement

By 2008, all states and territories agreed to align their curriculum with the concepts of “Essential Learnings”. This bureaucratic resolution to the problem of state differences in curriculum led educators to adopt the Key Learning Areas that divided knowledge into eight separate subject areas. Only a few years into this alignment process, the Federal Minister for Education, suggested moving to a national curriculum because he viewed the Key Learning Areas (KLA’s) as a “defacto common or national curriculum” where the states still have control but there was too much variation between states and territories (Reid, 2005). The Education Minister also introduced the *Schools Assistance Bill* that aimed to provide federal funding for schools from 2005-2008, to a significantly new level. State schools were required to commit to a variety of objectives in order to receive funding. In the years leading to 2008, the government tried to gain consensus on the vision and plan for the national curriculum. Finally, in 2008 *the Melbourne Declaration on Educational Goals for Young Australians* acknowledged the changes for the 21st century that were placing demands on Australian education.

In addition, Masters, The Chief Executive Officer of the Australian Council for Educational Research (ACER) was given the task in 2008 to review and
provide advice and recommendations on the state of the primary education system in Queensland, specifically in the areas of literacy, numeracy, Science, assessment and teacher quality. Masters was to review the 2008 National Assessment Program Literacy and Numeracy (NAPLAN)\textsuperscript{6}, the 2006 National Assessment Program Science Literacy (NAPSL), the 2007 Trends in International Mathematics and Science Study (TIMSS) results, the Year Two Diagnostic Net\textsuperscript{7} 2007 and other research material for all primary schools and all school sectors of education, state and non-state. His final report, \textit{A Shared Challenge: Improving Literacy, Numeracy and Science Learning in Queensland Primary Schools}, was released on May 1, 2009. Masters noted significant issues that needed addressing; one of those being the lack of Science competency among Australian school students. He made several recommendations aimed at improving literacy, numeracy and Science. The Queensland Government’s response to the report was supportive. The (State) Department of Education, Training and Employment (2009) conceded that teachers needed to have adequate subject knowledge to teach students in the areas of literacy, numeracy and Science. The Department further stated they would “make Science a priority for state schools” (p.4).

Meanwhile, nationally, stakeholders from various societal positions were able to contribute their views about the development and discussions around the national Australian Curriculum. These views were considered in the collation and analysis of the data released in the \textit{Framing Paper Consultation Report Science, Nov 2008-Feb 2009} (National Curriculum Board, 2009). Section 5.3 of this report considered primary Science teaching and noted that, “the problem identified for primary schools was more to do with the absence of Science being taught rather than with the relevance of what is being taught” (p. 11). This indicated that the stakeholders felt that many primary teachers do not teach Science, or at best teach it irregularly, a fact documented only a few years earlier by

\begin{itemize}
\item \textsuperscript{6} NAPLAN is the Australian National Assessment Program Literacy and Numeracy exam for students in years 3, 5, 7, and 9.
\item \textsuperscript{7} The Year Two Diagnostic Net was developed to support learning and development in literacy and numeracy in the early years.
\end{itemize}
Goodrum et al., (2001). Other considerations identified were that primary school teachers would need professional development in both Science concepts and pedagogy. Additional issues included resources available to teachers, using digital technologies, mandated teaching time for Science, and time and support for implementation (Darling-Hammond & McLaughlin, 1995; Fullan, 2011). These considerations suggested the need for specific and effective professional development.

A Focus to Improve Science Teaching

Since Science was viewed by many as a matter of concern in primary schools, a plan was conceived to place 100 additional teachers into state primary schools to allow experienced Science teachers to visit schools and provide a professional development service for Science teaching improvement to teachers in Years 4-7. The State Education Department decided to develop “primary teachers’ skills and knowledge to teach and assess Science more effectively (2009, p.4)” before releasing standardised testing of Science. This was the first time the education department had chosen to provide high school teachers to deliver professional development in Science to primary school teachers. Other school sectors, the Independent and Catholic Schools, were to provide their own professional development in the areas of literacy, mathematics and Science.

In 2009, the Australian Commonwealth Government, with support from the state and territory governments, established the Australian Curriculum, Assessment and reporting Authority (ACARA) to oversee the development and implementation of a national curriculum in key subject areas. By 2012, most states and territories had begun the first phase of implementation of the new Australian Curriculum.

This was the culmination of political manoeuvres over several decades to establish a uniform curriculum nationally, and eradicate the inter-state curriculum variability that disadvantaged students who moved interstate and contributed to uneven outcomes for students in different states. Another contributing factor was the poor performance of Australian students nationally and internationally from Year Three to Year Ten as
documented by the National Assessment Program – Literacy and Numeracy (NAPLAN) tests and the Third International Mathematics and Science Study (TIMSS); and on-going reports about the poor state of Science teaching (such as Goodrum et al., 2001).

Therefore, in order to create a more unified education system whereby each state and territory would be expected to follow the same expectations and standards, a national curriculum was created. This new curriculum aimed to improve student achievement levels and performance levels by placing higher demands and expectations on student learning. As the various subject area curriculum were made available, teachers were expected to implement the new Australian Curriculum for all subject areas and at all year levels. However, ‘Lessons from the past’ would seem not to have been heeded. Schools and teachers were again handed an entire curriculum and expected to implement it. Teachers were expected to understand the intent, philosophy and changes to content and teaching pedagogy with little to no support. History and prior research indicates this would not lead to the intended outcomes in Science (Corcoran, McVay, & Riordan, 2003; DeMonte, 2013).

Predominant political agendas and discontent with students’ test score results had seemed to drive changes in curriculum throughout history (Kahle, 2007). Unfortunately, it would again seem that discontent with student progress only inspired curriculum change rather than setting the focus on developing the capacity of our teachers and our schools.

2.1.4 Creation of the New National Curriculum

The Australian Curriculum, Assessment and Reporting Authority (ACARA) was established to administer the national curriculum reform movement across Australia. This is a statutory body, established in 2008 under the Australian Curriculum, Assessment and Reporting Authority Act of 2008. It was funded under a National Partnership Agreement between the Commonwealth and the states and territories.
Some of the functions of ACARA, (found in the Charter for ACARA) are as follows:

a) develop and administer a national school curriculum, including content of the curriculum and achievement standards, for school subjects specified in the Charter;

b) provide school curriculum resource services, educational research services and other related services; and

c) provide information, resources, support and guidance to the teaching profession. (2010a, p. 1)

ACARA acts as the national educational body and is often the source of educational policy and directives.

The scope of this national project was so broad that it was necessary for the development of the curriculum to follow a precise process. Advisory groups, writers, panels, working groups and an ACARA Board were chosen to develop the curriculum. Many of those positions were voluntary and required an expression of interest to be completed. According to ACARA, development of the Australian Curriculum represented a commitment by all Australian states and territories to work together to develop a world-class curriculum for all young Australians. The scope of the new curriculum was so broad that every component of the previous curriculum had changed, or no longer existed. Even the terminology used to describe the various curriculum components had changed.

The new curriculum was developed in three phases:

**Phase One:** English, Mathematics, Science and History

**Phase Two:** Geography, Languages and the Arts

**Phase Three:** Health and Physical Education, Technologies (Information and Communication Technology and Design and Technology), Economics and Business, and Civics and Citizenship.

The Australian Curriculum was structured to include a number of new approaches. It followed the use of ‘learning areas’ to organise content but also included new expressions and terminologies such as ‘general capabilities’ and ‘cross-curriculum priorities’ that were to be applied across the Australian Curriculum.
Teachers needed to learn and understand the purpose and value of several main elements contained in the new Australian Curriculum. These main elements are described below:

A **rationale** that explained the place and purpose of the learning area in the school curriculum.

The **Aims** that identified the major learning students will be able to demonstrate as a result of learning from the curriculum.

An **organisation** section that provided an overview of how the curriculum in the learning area would be organised from Foundation year to Year 10 plus separate documents for Years 11 and 12.

**Content descriptions** that specify what teachers were expected to teach. These were accompanied by **elaborations** that illustrated the content descriptions.

**Achievement standards** that described what students were typically able to understand and able to do, and which were accompanied by work samples that illustrated the achievement standards through annotated student work.

**General capabilities** that described a set of skills, behaviours and dispositions that applied across subject-based content.

**Cross-curriculum priorities** that ensure the Australian Curriculum was relevant to the lives of students and addressed the contemporary issues they faced.

It was thought that the general capabilities and cross curriculum priorities would add richness and depth to the learning areas and help students see the interconnectedness and relevance of their learning (ACARA). This was viewed as a unique feature of the Australian Curriculum. The complete restructuring of the curriculum meant that the curriculum presented to teachers and school leaders was unfamiliar and involved new objectives and procedures. The changes made for each subject area would require time and professional development for schools and teachers to become familiar with the new terminologies, structure and expected procedures and practices. Further, after an examination of the framework for the new
Australian Curriculum: Science, Haeusler (2013, p. 15) reported to lack cohesion and that “these flaws have consequences for school curriculum leaders and teachers of science, in particular those teachers who are less experienced”.

2.2 Conceptual Framework

To understand and apply systemic change or curriculum reform within organisations requires an understanding of historical, social, professional, organisational and administrative influences on people. Therefore, Bronfenbrenner’s Bioecological Systems Theory (2006) was chosen as an appropriate framework to describe how those influences impact on people and their actions.

This study used Bronfenbrenner’s Bioecological Systems Theory (Bronfenbrenner & Morris, 2006) that was developed out of his original Ecological Systems Theory (Bronfenbrenner, 1979, 2009) as a guiding conceptual framework (see Figure 2). The Bioecological Systems Theory informed this study and guided aspects of data collection and interpretation. This particular framework was chosen because it includes several aspects of the environment that influence a person both directly and indirectly. In the context of a school situation, many factors influence the teaching that occurs in classrooms and may be external to the school or internal to the school. A consideration of each of these factors mean a more holistic approach to studying the school is possible. Bronfenbrenner’s Ecological Systems Theory framework was used by (Lewishwaite, 2006a) in previous studies to help interpret teacher development and change in particular areas.
The Bioecological Systems Theory (Bronfenbrenner & Morris, 2006) has additional components of person, time, contexts and proximal processes added to the original Ecological Systems Theory (see Figure 2). There are many expectations and beliefs attached to curriculum that need to be understood and supported by schools and teachers. Bronfenbrenner’s bioecological systems framework, with a focus on the teacher, would seem to support understanding of teacher/school interactions and their impacts on actions in implementing a new Science curriculum. A brief description of this model follows.

Bronfenbrenner’s model contains a set of five concentric circles. The innermost circle is the focal point where all interchanges impact on the individual or group being considered: where the teacher, students and the classroom are situated.
According to Bronfenbrenner, the influential environment is not limited to a single setting but extends and “incorporates connections between settings, as well as to external influences emanating from the larger surroundings” (Bronfenbrenner, 1979, p.22). In other words, the environment can be configured as a set of concentric circles, each dwelling within the next. Bronfenbrenner has labelled the circles, moving from innermost to outermost as: Microsystem, Mesosystem, Exosystem and Macrosystem.

The focus of this study was to examine the teachers’ actions and their interactions within a school when attempting to understand and plan to implement a new Science curriculum. The structure of the micro and meso systems guided the study and subsequent data analysis. The other two systems (Exo and Macro) are more external to the school but also have an impact on the schools’ and teachers’ actions. These are discussed briefly.

Macrosystem

The outermost circle encompassing all is the macrosystem, and contains the consistency of belief systems and ideology underlying the cultures and subcultures that exist within the other systems (micro-, meso-, and exosystems). This is what makes our societies function; an understanding of the macrosystem lies within each person’s subconscious and becomes a part of our responses to each other and activities in our lives. Our belief systems are slow to change and ensure that regardless of circumstances, the beliefs and ideology of our culture will remain relatively steadfast and reliable.

Exosystem

The next circle within the macrosystem is the exosystem. This contains one or more settings that do not involve the individual as an active participant but rather, the events of the macrosystem affect the individual or what happens in that setting. For example, the activities or decisions of a governing body and policies may affect a person who is in the classroom setting. Environmental influences outside the immediate microsystem setting can be linked to the exosystem.
The next two systems were the main focus of this study. They are the microsystem (centre) and the mesosystem (surrounds the microsystem).

Microsystem

The microsystem represents the most personal and intimate environment with face-to-face interaction regularly experienced. The microsystem is the innermost ring and, in this study, contains the teacher and the students. It has the most immediate and the most powerful influence on the classroom participants and their actions. This level of interaction contains a variety of possibilities. For example, the activities and responses to outside political influences can be observed. In addition, interactions between people can be observed. These interactions form a type of relationship that are reciprocal and can be either negative or positive.

Another component of the microsystem is that of ‘roles’. That is, each person has a social position which sets out the activities, relationships and performances expected of them. At the microsystem level, all of these components occur within one setting or context.

Mesosystem

The circle surrounding the microsystem is the mesosystem which contains many microsystems and interrelations among settings and contexts - for example, family, work place and social life. The mesosystem contains the same basic components found in the microsystem, but the nature of the interconnections may be different. More people will be involved and participation in multiple settings is evident. The influences from multiple settings such as communication and knowledge can be observed. Also co-workers and staff interaction would be considered part of the mesosystem. According to Bronfenbrenner’s (2009) research: “the world of work emerged as a key setting of the mesosystem in adulthood. Job conditions were perceived as potent forces affecting the respondent’s ability to function…..” (p. 236).
Bronfenbrenner later adapted this original model to include the impact of processes and context on a person or groups over time. This he called the Bioecological model (Bronfenbrenner & Morris, 2006) (see figure 1).

Proximal Processes

Here the proximal processes refer to the particular forms of interaction between organisms and environments over time. These are viewed as highly significant and central to the immediate and future development of persons and groups. Those experiences and the way the environment is perceived are related to cognitive development through life stages (from childhood to old age or for the purposes of this study: preservice teacher, novice teacher, experienced teacher, accomplished teacher, lead teacher). Whether the experiences are positive or negative, they contribute in a powerful way to the development of the person and their responses. Some of these interactions or proximal processes between people include independent or group activities, learning new skills, problem solving, making plans, performing complex tasks and acquiring new knowledge. Proximal process is a critical component and therefore has specific distinctive properties. These are:

- For development to occur, the person must engage in an activity. To be effective, the activity must take place “on a fairly regular basis, over an extended period of time” (p. 796). For example, this means that doing things over a couple of days does not assist development, nor do activities that are often interrupted. One reason for this is that, to be developmentally effective, activities must continue long enough to become “increasingly more complex.” Mere repetition does not work.
- Developmentally effective proximal processes are not unidirectional; there must be influence in both directions. For interpersonal interaction, this means that initiatives do not come from one side only; there must be some degree of reciprocity in the exchange.
- Proximal processes are not limited to interactions with people; they also can involve interaction with objects and symbols. In the latter circumstance, for reciprocal interaction to occur, the objects and symbols in the immediate environment must be of a kind that invite attention, exploration, manipulation, elaboration, and imagination (Bronfenbrenner & Morris, 2006, p. 789).

These proximal processes are found at all layers of Bronfenbrenner’s model, constituting a valuable part of the microsystems and mesosystems, which were the main components of this study. The specific proximal processes
that contributed to the manner in which teachers and schools chose to function in regards to the new Science curriculum were investigated in this study.

These *proximal processes* also influence the learning of scientific inquiry processes, inquiry skills or pedagogies which are the expected methods (ACARA) to teach and practice Science. There are also similarities to several educational learning theories such as: Vygotsky’s Social Development Theory (1962), Bandura’s Social Learning Theory (1977), Bruner’s Discovery Learning (1960), Kolb’s Experiential Learning Cycle (1984) and Bloom’s Taxonomy (1956). These are discussed more fully later in this chapter.

**Summary**

These theories about learning and developing are fundamental to most teacher education programs and also help to guide the understanding of the actions of the participants in this study.

Bronfenbrenner’s Bioecological system therefore constituted the main conceptual framework for this research. His ideas about the environment influencing a person’s actions, decisions and learning fit well with the objectives of this study. It is useful to look at each case (school and teacher) as part of the interrelated and interconnected systems. The interactions and the influences from the different systems can be observed and as discussed particular themes become evident. The ecological model provided guidance in relation to data sources in each of the microsystem, mesosystem, exosystem and macrosystem settings. The data collected from the first two sources helped identify potential factors of influence around the understanding of the new curriculum, and how it was implemented at the school level and the individual teacher level. Issues such as planning, resources, professional development, content knowledge and teaching strategies were identified and linked to particular systems, as well as the effect those systems had on teacher learning and personal development.
The concept of considering a whole school context in this study is important. An ecosystem containing policies and regulations placed upon the school affect each person within the school environment. In addition, there are many factors influencing a teacher’s development and capacity to teach effectively. Bronfenbrenner’s bioecological framework gave insight into the web of activities and interrelationships that make a school function and in turn influenced how teachers implemented the curriculum. In particular, it helped reveal the intricacies of implementing a new Science curriculum imposed upon them.

The literature will be reviewed and discussed within the frameworks designed by Bronfenbrenner to help establish the context of the study. The discussion will begin with the outer layer (macrosystem) and move through each subsequent layer to finish in the centre with the microsystem.

2.3 The Macrosystem: Cultural Beliefs and Ideologies

The macrosystem (outer-most layer) provided a contextual overview of the beliefs and ideologies that may shape our view of Science education whether it be in our world, our country or in our schools. Each has observable cultural and belief systems in place.

For example, the United Nations Educational Scientific and Cultural Organisation (UNESCO) created a world vision for education: *Education for All* (Ainscow, 1995). As educated people, we understand and value the ideology of education having the power to transform lives.

Similarly, in Australia, we believe in education for all (Fensham, 2014). However, this has been a developing belief over the last hundred years as Australian peoples were struggling with identity and coping with change. The country has grown to encompass and include the original indigenous people, and many other cultures of the people who migrated here. This
process has demanded reformation of national beliefs around education but has ultimately led to a belief in education for all (Barr et al., 2008).

Learning Theories Impact our Belief Systems

An important aspect of our belief system in schools is the way we believe people learn. Several theories about learning have influenced primary Science education since it became a separate subject in schooling (previously called “Nature Study” in Queensland in 1966). Gagne, Piaget, Vygotsky and Bruner are a few of the key educational theorists of influence. Gagne applied the behaviourist ideas of Skinner to primary Science, arguing that the cognitive skills (process skills) of Science should be the focus of teaching using a structured sequence of small learning tasks with immediate feedback (Gagne, 1967). The curriculum project, *Science – A Process Approach* (Padilla, 1990) exemplified his views. The 1979 Queensland Syllabus was strongly influenced by his theory. Piaget contributed many ideas around learning and development, which informed curriculum and teaching practices. From the 1920s, Piaget conducted many studies with children and proposed the stages of cognitive development that he believed children pass through at different times in their lives. He also formulated the view that existing knowledge within the learner is important when constructing new knowledge (Piaget, 1977). In other words, a student will interpret and begin to make sense of new experiences in relation to his or her past experiences no matter what depth of understanding that experience holds. This idea has helped to shape the philosophy of constructivism, a major focus of the 1999 Queensland Syllabus. According to Koch (2006):

> a common theme in constructivist theories is that the learner approaches new experiences with a set of pre-established beliefs and naive theories and that learners change those beliefs and theories only when they cannot reconcile new data with presently held conceptions (p.93-94).

Another theory, social constructivism, proposed by Vygotsky (1962), described learning as influenced or mediated by communication and
language within a group (inter-psychological processes) rather than something that is done individually (intra-psychological processes). Vygotsky believed there was more depth to learning when students were able to discuss within a community of learners and reformulate their ideas, receive expert feedback and then reflect on the information and its application. Such ideas have contributed to social constructivism and sociocultural theory. According to Rogoff (1990), the sociocultural process is shaped by ‘tools for thinking’ and is situated in the use of language. The aim is to develop fully a person’s social practice, personality and comprehensive ability through specific conditions and activities that develop personal meaning. These theories including those of Bandura (below), have gained more prominence in the most recent national Science Curriculum.

Other theorists, such as Bruner and Ausubel, were influenced by Piaget’s work. Bruner (1960) went further to propose that we often limit children’s learning by our own expectations, when children are capable of learning more at a younger age than we expect. Bruner was also an advocate of what has become called “discovery learning”, which was a basis for the 1966 Queensland Science syllabus. Unfortunately, what is understood by the term “discovery learning” has become muddied over the years, with many education administrators and teachers holding views akin to a laisse faire approach. Ausubel was more formative (Ausubel, Novak, & Hanesian, 1968) and believed that when we discover what a child knows, we could then begin to teach him or her appropriately. Ausubel also stressed the value of prior knowledge as part of the learning process, and suggested strategies such as advanced organisers.

More recently, others have built upon the foundational theories of Gagne, Piaget, Vygotsky and Bruner. Bandura’s Social Learning Theory (Bandura, 1977) posited that people learn from one another through observation, imitation, and modelling. The theory may be considered a bridge between behaviourist and cognitive learning theories because it encompasses attention, memory, and motivation. Kolb (1984), an American educational theorist, built upon earlier work by Dewey and Small (1897) and Lewin
(1947) to create the principles behind Experiential Learning. Kolb believes “learning is the process whereby knowledge is created through the transformation of experience” (1984, p. 38). The theory presents a cyclical model of learning, consisting of four stages; concrete experience, reflective observation, abstract conceptualisation and active experimentation.

Today, teachers are informed through teacher education programs to understand these learning theories and to use them in their own teaching practices, influencing what we perceive as good practice in teaching and learning. Learning theories weave throughout the entire Bronfenbrenner framework, beginning as a belief system that reaches across all levels including policy levels, through personal learning, interactions and teachers’ personal belief systems. That is, beliefs about learning and teaching, derived in varying degrees from these theories and others, are implicit (sometimes explicit) in curriculum, policy documents, school practices and policies, and teachers’ classroom practices. While these implicit beliefs may align, more often than not there are mismatches through which teachers have to navigate.

Summary

Each of the educational learning theories above reinforces components of Bronfenbrenner’s model of human development. Bronfenbrenner unites the person with their environment, their interrelationships, their employment, the governing policies, the society, culture and world in which they live, as a means of identifying how learning and development can be shaped both negatively and positively. Similarly, those learning theories have informed Science curriculum development in Queensland over the decades, the emphasis shifting according to the theories most widely accepted at the time; but still retaining some emphasis on what went before. For instance, the 1966 Syllabus emphasis was discovery through activity; the 1979 syllabus emphasis was process skills through activity; and the 1999 Syllabus emphasis was cognitive constructivism informing activity-embedded pedagogy employing process skills.
As a society, we believe students need to be able to think scientifically in a world in which Science and technology increasingly impact their lives. Given the growing centrality of Science and technology in modern societies, this is considered a key outcome of education for all students by the end of schooling. It is considered important for them to be able to think scientifically about evidence, or the absence of evidence, for claims that are made in the media and elsewhere, as part of daily life (Ainley, Kos, & Nicholas, 2008). These values we hold about Science understanding imply that our teachers and educators will hold the same values and have the skills to be able to teach effectively and to prepare their students. These values impact on the outcomes that occur within schools and classrooms.

2.4 The Exosystem: Education Policies and Science Curriculum

Education policy and Science curriculum at a system level provide expectations for Science proficiency (Kahle, 2007) and lie within the exosystem of Bronfenbrenner’s Ecological system’s model. The exosystem helps to frame and inform the decisions and practices that occur in schools. This section discusses some of the relevant government decisions, common styles of system implementation and the Science curriculum.

2.4.1 Government Decisions

The creation of a national curriculum is an attempt to unify the cultural beliefs and values about desired ways of teaching and learning.

As previously mentioned, in 2009, the Australian Commonwealth Government, with support from the state and territory governments, established the Australian Curriculum, Assessment and Reporting Authority (ACARA) to oversee the development and implementation of a national curriculum in key subject areas. This was the culmination of political manoeuvres over several decades to establish a uniform curriculum nationally. Poor performance by Australian students nationally and internationally from Year Three to Year 12 on Literacy and Numeracy (NAPLAN) tests and the Third International Mathematics and Science Study
(TIMSS) contributed to this decision. Reports about the poor state of Science teaching (such as Goodrum et al., 2001) were also available.

For the first time in Australia, a national curriculum was created in core subject areas including Science and each state and territory would be expected to follow the same content and standards. This new curriculum aims to improve student achievement and performance by placing high demands on student learning. As the various subject area curriculum have been made available, Queensland teachers were expected to follow the new Australian Curriculum for all subject areas and all school year levels.

As explained previously, the Australian State of Queensland had lower scores than most other states in the above tests, and commissioned a review of school performance in 2008 (focusing on literacy, mathematics, and Science). The outcome, the Masters Review, “A Shared Challenge: Improving Literacy, Numeracy and Science learning in Queensland Primary Schools” (Masters, 2009), recommended that a number of support structures be provided for teachers in order to improve student test scores. The Queensland Government subsequently proposed a number of strategies in response to the report (Department of Education and Training, 2009). These formed part of the context for the rollout of the national Science Curriculum in 2013 which is known as the Australian Curriculum: Science. Further, the Queensland Government acknowledged that the majority of primary school teachers were not strong in their Science knowledge and teaching delivery, so developed a series of online “teacher guides” called Curriculum into the Classroom (C2C), as the main form of system support for teachers. The current Queensland Department of Education and Training (DET) view would seem to be that implementing C2C is in fact, implementing the national curriculum (QCAA).

Although DET set the general timeframe for implementation, state schools have been given some flexibility in their implementation schedule, but have also been given responsibility for professional development. However, this has been without any increase in financial or other resources. Meanwhile, Independent and Catholic schools set their own priorities and schedules.
Such a curriculum implementation model has typically been referred to in the literature as a top-down approach (e.g., Van Driel et al., 2001), however, Sandholtz and Scribner (2006) found that top down regulation often led to inequitable teaching outcomes and low quality instruction. Nevertheless, local school responsibility for professional development provides the possibility that a more collaborative implementation and support model could occur. In this context it was therefore pertinent to examine how schools and teachers undertook the task of implementing the national Science curriculum. This study consequently focused on the implementation of the national Australian Curriculum: Science in Queensland primary schools, including the use of C2C.

2.4.2 Common Styles of System Implementation

A number of previous studies have investigated curriculum implementation and curriculum reform. The approaches used are discussed below.

2.4.2.1 Top Down Approach

According to Van Driel et al.,(2001) the top-down approach to curriculum implementation, such as the one that occurred in Queensland, often results in failed reform. Kennedy (2005), revealed that there is often a repetition of failure to implement the intended change in schools during large-scale reform. These changes include creating curriculum expectations that require: more rigorous and elaborated content, greater intellectual engagement and universal access to knowledge. While these change points are seen as important to most stakeholders, the difficulty is achieving these outcomes. When robust changes are made in the curriculum and robust changes are expected in the implementation of that curriculum, extensive supports need to be in place to assist teachers and schools to understand the changes expected in their knowledge, beliefs and values, regarding teaching practices. In addition, school community circumstances need to be assessed and plans made for capacity building routines. When any of these components suffer, reform or change may be unattainable (Kennedy, 2005). Since the Australian Curriculum: Science was developed at a national level,
it was up to the states and schools to ensure these components were in place.

Several studies (e.g., Carless, 1998; Fullan, 2001; Fullan & Miles, 1992; Powell & Anderson, 2002) have indicated that systemic curriculum change is most successful with high quality teaching support and development materials to assist teachers in addressing and shaping their attitudes, knowledge, and practices. The implementation of reform-based Science curriculum requires teachers to make adjustments in both their understanding of subject matter and the learning and teaching of Science. Without support, teachers are inclined to become frustrated and return to previous methods of teaching. A thorough understanding of the “theoretical underpinnings and the classroom applications” is essential across school staff and the entire school district for implementation to be consistent and achieve the expected goals (Carless, 1998, p. 355). In the implementation model used in Queensland, it was left to schools to provide the necessary support in both the theoretical underpinnings of the new curriculum, and high quality teaching support for specific implementation.

2.4.2.2 Programmed Approach

According to Altrichter (2005a) and earlier Fullan (1983), curriculum implementation could be undertaken using a programmed approach or an adoptive-evolutionary approach. This approach to implementation concentrates on the areas that are viewed as inadequate, failed or otherwise not meeting the intended expectations. All shaping of the innovation occurs in the beginning during the creation process and may not meet the needs of persons in varying areas. Berman (1980) adds that the programmed approach is suitable when the participants are in agreement, the environment is stable, the organisation already has high integration and the amount of change needed is small and step-by-step.

2.4.2.3 Adaptive-Evolutionary Approach

This approach to implementation is based on the idea that the innovation itself will require modification during roll out and is viewed as a realistic and
necessary process. Further, the shaping of the innovation occurs during all phases of the implementation process and allows input from the practitioners at ground level. Berman (1980) viewed an *Adaptive-Evolutionary Approach* as being more suited to large changes made in diverse and unstable environments, and with persons who are in conflict with each other and, possibly, with the innovation. Some examples of this type of roll out would include professional development or professional learning, which is described later.

The implementation of the new Australian Curriculum is similar to an *Adaptive-Evolutionary Approach*. That is, modification during roll out was expected, however, there was only limited input at the teacher level. As mentioned above, the role of the teacher in curriculum implementation is critical. Since teachers are seen as the main implementers of a curriculum (Kimble, Yager, & Yager, 2006; Roehrig & Kruse, 2005), they themselves are in control over the direction taken in teaching and learning activities or instruction. It is consequently important for successful implementation, that teachers’ ideas, attitudes and values align with the central philosophies of the curriculum (Akerson et al., 2009; Kimble et al., 2006; Ryder, Banner, & Homer, 2014). It is also important that teachers have the knowledge and the skills that are embedded in the new curriculum (Akerson et al., 2009; Desimone et al., 2002; Kimble et al., 2006). When this is not the case, processes need to be in place to assist teachers with additional support, such as appropriate and effective professional development. These will likely increase teaching quality and, hopefully, improve student performance outcomes (e.g., Bolam, McMahon, Stoll, Thomas and Wallace 2005; DeMonte 2013; Yoon, Duncan, Lee, Scarloss and Shapley 2007).

Also, it is more likely when considering a nation-wide rollout that there would be diverse and even unstable environments where staff may be in conflict with the new curriculum changes, as suggested by Berman (1980). With a roll out such as this, provision for professional development and professional learning is imperative so that they can contribute formatively to the implementation process.
Another potential impact upon the implementation of the new *Australian Curriculum: Science* is the socio-political context. As outlined earlier, Queensland students’ performance in Science has compared poorly to other Australian states in recent years, resulting in political dissatisfaction with school performance. Such socio-political pressures have influenced schools in the United States for some years. In the context of pressures arising from the “*No Child Left Behind Act*” in the United States, a study by Rinke and Valli (2010) investigated school and teacher responses to implementing change designed to achieve Adequate Yearly Progress (AYP) in particular curriculum areas based upon national test scores. In order to maintain funding, resources, and other supports, teachers and schools had to demonstrate they could maintain AYP in areas found to be deficient on national tests, so this was a “high stakes” reform for the schools concerned. Rinke and Valli (2010) found that while school contexts varied and the type of staff support required varied, when schools are under high-stress situations and support was limited, little to no change occurred. To the contrary, schools that had less pressure and more support to change tended to have longer lasting and effective change in teaching and learning and other curricular outcomes.

Since Queensland publishes yearly student achievement outcomes in Mathematics and English for specific Year levels but not for primary Science, then Science may not be considered “high stakes.” It could therefore fit within Rinke and Valli’s low-stress schools - providing potential for effective change within schools that have planned for professional development.

Research on Science education reform in the USA by McLaughlin (1990) indicated that reform takes time and requires both a top-down and a bottom-up approach to implementation. Carpenter et al., (2004) identified factors for reform success and its sustainability. They include: (a) developing teacher learning communities to examine the new ideas, student learning and instructional practice, (b) professional development to support
teachers and (c) partnerships outside the school community that provide materials and human resources.

Education systems often have reform imposed upon them, as in this current study. It would seem appropriate and beneficial for the future of our students and society if curriculum reform included teacher involvement, was sustainable and supported by school districts. In other words, a combination of top-down and bottom-up methods that involve greater interaction with the teachers and the classroom processes may create a more comprehensive approach to reform (Datnow, 2005; Hamilton et al., 2003).

The research into professional development will be discussed further in the mesosystem section, as it relates more closely to the school, principals and teachers.

2.4.3 Science Curriculum

A brief summary of the features of the new Australian Curriculum: Science is provided followed by a description of curriculum guides available to teachers.

2.4.3.1 Purpose

The study of Science from Foundation to Year 10 was designed to develop students’ interests in Science and appreciation of how Science provides a means of exploring and understanding the changing world in which they live. It was designed to provide an understanding of scientific inquiry methods, a foundation of knowledge across disciplines of Science; and develop an ability to communicate scientific understanding and use of evidence to solve problems and make evidence-based decision (DeMonte, 2013). This explicit approach to inquiry-based learning is a new approach to teaching Science for many teachers.

2.4.3.2 Structure

The new Australian Curriculum: Science is structured into interrelated strands. These strands are Science Understanding, Science as a Human
Endeavour and Science Inquiry Skills. Science understanding includes content in the areas of biological Science, chemical Science, earth and space Science and physical Science. Science as a human endeavour refers to the nature and development of Science, and in society the use and influence of Science. The inquiry skills component focuses on expanding skills that show children how scientists work, by allowing them to question and predict, plan and conduct investigations, process and analyse data and information, and evaluate and communicate information from investigations. The curriculum writers state that the teaching pedagogy is expected to move away from a transmission model to a more inquiry-based model (The National Curriculum Board, 2009). For example, the following model describes developmental levels of inquiry teaching and learning (Rezba, Auldridge & Rhea, 1999). There are four levels of inquiry with level one being the lowest level. At level one (Confirmation), students are provided with a question, the methods and the solution. This is highly structured and confirms their current knowledge and understanding. Level two (Structured) does not provide the solution. Level three (Guided) does not provide the methods and solution. Level four, or Open inquiry, is completely student designed and formulated. It is expected that students are carefully moved through these steps gradually increasing skills from highly structured inquiry to more open levels of inquiry.

The inquiry model of teaching is multifaceted, requiring substantial knowledge of content and Science process skills. It is predictable that this required emphasis will indicate the need for professional development. This is reflected in the findings of Goodrum et al., (2001), who reported that inquiry pedagogies are considerably different from transmission pedagogies and are also more resource intensive. This aspect alone would require substantial professional development (The National Curriculum Board, 2009, p. 13).

The State schools were provided with further curriculum documents in the form of unit plans, lesson plans, digital resources and assessment called Curriculum into the Classroom to assist implementation.
2.4.4 Curriculum into the Classroom

Since the ACARA curriculum content information was written in broad terms, the Queensland Government decided to assist teachers in identifying specific content understandings and to help them make appropriate pedagogical choices. They therefore funded the creation of another set of documents through Education Queensland and the Queensland Studies Authority (QSA) called *Curriculum into the Classroom* (C2C), to be available online to state schools. The aim of this project originally, as stated by DET, was to: “support its [DET] schools with the implementation of the Australian Curriculum and to assist them to meet its goal for state schooling of one vision, one curriculum, one platform, different ways” of meeting student needs (Education Queensland, 2013).

The C2C was a comprehensive set of online examples and resources that had been designed by teachers for teachers. To develop them, teachers were seconded as writers to the project for specific periods and/or topics. DET claimed that the materials were continually being reviewed with feedback from schools. C2C was intended to be a starting point for curriculum planning, with its Internet format making it easy to access and adapt to meet the needs of the school community.

The C2C documentation is effectively a set of teachers’ guides that outline the specific content, assessment, teaching strategies, resources, lesson plans, and policy requirements for teachers to adopt or adapt. These resources are meant to help teachers enact the core of the *Australian Curriculum*. In addition, Education Queensland indicated that the Curriculum into the Classroom (C2C) materials have been created to reduce workload by modelling expectations and providing the clarity and consistency within the materials so schools and teachers will then address all the requirements of the new *Australian Curriculum* (Education Queensland, 2011b).

While no formal documentation about feedback from teachers and schools is publically available, anecdotal evidence from teachers and Science education researchers suggests that many of the documents are not
particularly helpful; and in particular, there was no provision for the sort of professional development primary teachers felt that they needed. Further, the materials were not available for public scrutiny and evaluation. Only recently did the Minister for Education request that the C2C materials be made available to all Queensland schools (Minister for Education, 2014); that is, also to the non-government sectors. Given the dearth of such information, this study is a first step in providing research into the extent that state school teachers find C2C useful as an aid to implementing the Australian Curriculum: Science.

An alternative set of Science curriculum resources mentioned previously, Primary Connections, written by the Australian Academy of Science, remained an option for all schools to use. A brief outline of those resources follows.

2.4.5 Primary Connections

Primary Connections are a series of innovative Science and literacy support materials that were trialled and revised to help build teacher confidence and competence to teach Science in primary schools. These units and concrete materials were developed through a project team under the auspices of the Australian Academy of Science and The (Commonwealth) Department of Education, Employment and Workplace Relations (DEEWR) staff. The project team understood the importance of assisting teachers in developing knowledge and a passion about discovering how the world works. The underlying principles of these resources involve the use of a 5E pedagogical model (Bybee et al., 2006) that incorporates Science and literacy, planned student investigations, embedded assessment and cooperative learning strategies (Hackling, Peers & Prain, 2007). The 5E model is also considered a science inquiry model that developmentally improves students’ skills and understanding (Bybee et al., 2006, 2009).

Teachers in many Australian schools adopted Primary Connections, which came with professional development modules to assist the understanding of its purpose, and develop Science teaching and learning pedagogy. A school
collaborative approach was encouraged so that on-going learning and support could be facilitated. With the Australian Curriculum implementation beginning in 2012 for Queensland state schools, many schools who were using *Primary Connections* resources tended to abandon them as they no longer aligned with the curriculum. However, the developers moved quickly to revise them to align with the new curriculum. Some private and Independent Schools have continued to use them, or adopted them after they were rewritten to align with the new *Australian Curriculum: Science*.

Compared to C2C, *Primary Connections* could be considered as educative curriculum materials as described below.

2.4.5.1 *Educative Curriculum Materials*

Teacher guides are different from educative curriculum materials in that educative materials include background to extend teachers’ knowledge and development, such as those found in the *Primary Connections* resources. Recent research by Davis and Krajcik (2005) into the use of educative curriculum materials revealed that the provision of these materials may provide mixed and varied results. For example, when the materials include too many choices for teachers, the learning outcomes for students may not meet the curriculum and reform intentions. Likewise, when the materials are too prescriptive (as in teacher guides) and do not allow for teacher intervention or discretion, it may cause the materials to be even less effective. Therefore, the materials themselves may require professional development in order to be effective during Science teaching and learning. Further, a study by Collopy (2003) identified that teacher beliefs about how to teach a particular subject may not align with the new materials and teaching strategies. When this happened, Collopy observed teachers teaching differently from the expectations of a new curriculum and the new teaching strategies. She noted the need for effective professional development to allow opportunities for teachers to learn the new requirements and thus to begin to change their beliefs about teaching and learning in that subject area. Therefore, the *Primary Connections* resources,
could be considered instructional guides, but would be most effective if associated with professional development to ensure understanding of the embedded philosophy and new pedagogies.

2.4.5.2 Primary Connections Provide Support in Science

Queensland government agencies have acknowledged the importance of professional development for teachers to gain understanding of the new national curriculum. Education Queensland (EQ) and the Queensland College of Teachers (QCT) have acknowledged on their websites that “the work of teachers implementing the Australian Curriculum involves significant continuing professional development” (Department of Education and Training, 2014). Education Queensland and Department of Education, Training (DET), have stated that it was the responsibility of each state school to arrange professional development around the implementation of the new Australian Curriculum. However, with tight budgets, short time frames, and several new curricula to implement within a few years, providing sufficient professional development for all teachers would be a major challenge. However, if Primary Connections were continued in schools rather than abandoned, quality professional development could be accessed and initiated as required.

2.4.6 Summary

A new national curriculum called the Australian Curriculum was created to ameliorate the international standing of Australian students on PISA and TIMSS evaluations and on national testings such as NAPLAN and NAPSL. This Australian Curriculum would be the first to expect Australian students to be taught the same content in each State and Territory. Although this change sets high expectations and seeks the best for our nation’s children, change also triggers anxiety for those on the front lines. This top down approach to the creation of the Australian Curriculum was made open to public scrutiny and input at the completion of the first draft. Stakeholders at all levels voiced their opinions. However, the final
curriculum that would be released to the schools and teachers, was considered as a required curriculum that should be implemented.

Science has been identified as a subject area for which teachers often lack requisite content knowledge, appropriate pedagogy and confidence to teach (Appleton, 1995, 2006; Harlen, 1997, 2009). Yet there has been very little support provided to teachers to improve their teaching in this area. Now, with further changes in science curriculum expectations for teaching and learning, it would seem necessary that support be provided to schools and teachers to implement the new Australian Curriculum: Science. These challenges faced all schools, including independent schools and Catholic schools, and they were even more challenging as most schools had to rely on their own resources for professional development activities. These outer layers where the government decisions and actions about the new national curriculum have been made, have set the context for this study. These decisions impact on schools and teachers and the ways they decide to implement the new Australian Curriculum: Science. This impact is at the heart of this study.

A closer examination of professional development during new curriculum reform and implementation can be conducted in the mesosystem.

### 2.5 Mesosystem: School Collaboration with Curriculum

It is within this mesosystem that the principal, teachers, their colleagues and the community can potentially meet to discuss, debate and assist each other to find clarity and understanding within the curriculum. The principal and other school leaders have important roles as decision makers, goal setters, encouragers and partners during implementation. This is the focus of the next section followed by some of the professional development and professional learning options available for schools to use during curricular reform.
2.5.1 Principals

The Queensland Association of State School Principals (QASSP) shared the concerns reported by Masters (2009) and supported his recommendations. However, the QASSP believed there should be a direct monetary/grant entitlement to every school to support the need for resources and training in Science. There were three factors that Principals believed impacted on the quality and quantity of Science teaching in primary classrooms:

...firstly, a lack of clarity about what represents Science learning at each year level in a school; secondly, the often ‘messy’ and labour intensive preparation required for effective Science teaching in a traditional classroom space; and lastly the fact that significant scientific concepts are not always well understood by teachers (Queensland Association of State School Principals, 2009, p. 4).

Principals have seen discrepancies between the desired Science outcomes of the curriculum and the actual practices of classroom teachers. As leaders in the school, principals are expected to have the ability and capacity to lead their staff in the directions required to develop outstanding teaching practices and student achievement. To what extent do they have this ability? According to Dinham (2012), “the most effective school leaders are making the leadership of teaching and learning their prime focus and are empowering others, through distributed leadership, to revitalise teaching and learning in their schools” (p. 6). DuFour and Marzano (2009) conclude that principals should no longer be expected to be instructional leaders, but should be learning leaders who help teachers use student evidence and data to drive their practice and professional learning. DuFour and Marzano (2009) further suggested that principals no longer have the ability to know all the content that is to be delivered, nor do they have the ability to know the best teaching strategies for all of the curriculum content. Therefore more time spent in building teacher capacity through collaborative activities would lead to building capacity throughout the school. This notion was supported by Supovitz, Sirinides and May (2009), who maintained that the work of principals is important because it has a direct influence on student outcomes, notably when teachers’ practices are shaped through “collaboration and communication around instruction” (p. 1).
In Queensland, through a centralised transfer process, teachers are regularly moved between schools and also moved into leadership positions such as Principals, Deputy Principals and Heads of Curriculum/Departments. The staff may be promoted based upon superior teaching skills, management skills, or other skills. However, if we consider that most teachers have little to no Science background, training, or confidence to teach Science according to the current research standards (Goodrum et al., 2001; Appleton, 2003), then it could be assumed that most of the principals and other school leaders who are leading primary schools have similar educational backgrounds and may not have the personal Science skills necessary to support teachers with the new Australian Curriculum: Science practices. Murphy (1994) stated that: “even when principals are supportive of reform, their ability to provide effective leadership may be hampered by their own experience, training, or beliefs” (Murphy, as cited in Datnow & Castellano, 2001, p. 222).

Another challenge for many principals in primary schools is ensuring that teachers implement reforms as intended. This is difficult when many primary teachers are isolated in their classrooms and work autonomously throughout the day. Further to this, Datnow and Castellano (2001) noted that principals must also learn to manage and guide teachers through new reform instructional models and develop collaborative teams to address the reform expectations. There are high expectations for the principals and other school leaders to meet in order for successful change and improved student outcomes to occur. This is a high demand for principals who have an ever-growing list of responsibilities to fulfil.

Principals are considered the leaders in the school who manage government expectations, parent and community demands, and teacher concerns. They are expected to keep the school operating smoothly. The last few decades have seen principals dealing with increased workloads that have often led to a decrease in their effectiveness (Fullan, 2008). Yet, several studies have investigated effective principals and principal leadership (DuFour & Marzano, 2009; Elmore, 2000; Gurr et al., 2006; Leithwood, Harris, &
Hopkins, 2008; Leithwood & Riehl, 2003; McLaughlin & Talbert, 2006; Newmann et al., 2000) and note their contribution in school success as valuable.

There is substantial evidence identifying principals as a critical component to the success of staff attitudes, school and staff development and even student achievement outcomes (Gurr et al., 2006; Leithwood et al., 2008; Leithwood & Riehl, 2003; Leithwood et al., 2004; Printy, 2010; Sebastian & Allensworth, 2012). Therefore, their participation in school improvement should not be overlooked.

Leadership research was reviewed by Leithwood and Riehl (2003), predominantly from the United States and the United Kingdom, and identified effective leadership as valuable to school improvement. Leithwood and Riehl (2003) defined leadership as “those persons, occupying various roles in the school, who work with others to provide direction and who exert influence on persons and things in order to achieve the school’s goals” (p. 9). Additionally, a number of studies have centred on school leadership and its impact upon teacher professional development (Leithwood et al., 2008; Printy, 2010), teacher instruction (Gurr et al., 2006; Sebastian & Allensworth, 2012) and student learning outcomes (Leithwood et al., 2004; Sebastian & Allensworth, 2012). School leadership is thus seen as a key component of the overall success of schools. In fact, Leithwood et al., (2004) posited that “the total (direct and indirect) effects of leadership on student learning account for about a quarter of total school effects” (p. 5). In addition, Hattie (1999) identified teacher instructional quality and reinforcement about learning as having the highest effect size on student learning. It can therefore be shown that improving leadership is a key to successful schools and successful teaching and learning (Hattie, 1999). In order to build school capacity, the leadership need to be collaboratively involved alongside the teachers as ‘active co-participants’ rather than part of the backdrop as an observer (Hilton et al., 2015; Lewthwaite, 2004; Newmann et al., 2000). Further, Lewthwaite (2006a) noted that developing
teachers as leaders can also positively influence change and development within a school.

Leithwood and Riel (2003) described five claims that could be defended by their research evidence. These are described briefly below.

1. Successful school leadership makes important contributions to the improvement of student learning.

2. The primary sources of successful leadership in schools are principal and teachers. In addition to principals and teachers, leadership is, and ought to be, distributed to others in the school and school community.

3. A core set of ‘basic’ leadership practices is valuable in almost all contexts: setting directions; developing people; redesigning the organization.

4. In addition to engaging in a core set of leadership practices, successful leaders must act in ways that acknowledge the accountability-oriented policy context in which almost all work, including the market, decentralization and professional and management accountability.

5. Many successful leaders in schools serving highly diverse student populations enact practices to promote school quality, equity and social justice through: building powerful forms of teaching and learning; creating strong communities in school; nurturing the development of educational cultures in families; expanding the amount of students’ social capital valued by the schools. (p. 2-7)

Additionally, Hattie (1999) reported that many educational authorities at the time in Australia often took pride in classrooms that were quiet, and offered learning that mimics, listens and regurgitates information, when they would be better to:

- Establish high and rigorous standards for what accomplished teachers and principals should know and be able to do,
- Operate a national voluntary system to assess and certify teachers and principals who meet these standards, and
- To advance related education reforms for the purpose of improving student learning in Australasian schools. (p. 24)
The leaders in a school are key for successful outcomes in all areas. Gurr, Drysdale and Mulford (2006) studied five schools in Tasmania and nine schools in Victoria who had principals who were identified as successful leaders by their peers. They also found improved student outcomes according to national exam data. A range of government schools was involved in each study, with four Catholic and one independent school included in Victoria. Gurr and colleagues identified leadership models for each of the States. The components of the models involved teaching and learning outcomes, school capacity, personal and professional capacity, school vision/mission, leadership, principal values, support, community context/support, and commitment.

The two models, which are very similar, thus created a common and important model for Australia. The main theme and most important components of a successful school leader, according to Gurr and colleagues were the values and beliefs the school leaders hold and their contribution to whole school capacity building and teaching and learning.

In addition, principals and school leaders not only influence teaching, they also have an impact on student learning outcomes. Leithwood et al., (2004) conducted a comprehensive review and analysis of research studies to determine how leadership influences student outcomes. They identified three sets of core practices:

- Setting directions, vision, group goals and high performance expectations
- Developing people through support, stimulation and modelling
- Redesigning the organization through collaborative cultures and building productive relations with parents and the community. (p. 8-9)

Their conclusion was that the principal and school leadership are vital to school-wide success and accounts for about 25% of the variation in student achievement scores. Similarly, Marzano, Waters, and McNulty (2005) who examined 69 schools, also found that there was about a 25% association between the principal’s actions and students’ success. Further, Anderson
(2002) showed that during curriculum implementation, teacher progress: “was enhanced by principals who became personally involved in supporting the changes, and who proactively engaged their staff and external resources in a collective sustained implementation effort” (p. 360). Principal engagement during professional development for teachers was also supported by Hilton, Hilton, Dole and Goos (2015), with a positive influence being noted. Hattie (1999) also concluded that leadership and the decisions by the school leadership can impact on school and student success. For example, teacher style (0.42), mastery learning (0.50), direct instruction (0.82), instructional quality (1.00), reinforcement (1.13) and remediation (0.65) had the largest effects on student learning (0.00 = no effect and 1.0 = one standard deviation or advancing a child’s achievement by one year). In contrast, leaders who focused on policy (0.24), finances (0.12) or physical attributes of the school (-0.05) showed less impact on student learning (Hattie, 1999).

It therefore appears that the manner in which schools decide to organise the implementation of a new curriculum greatly influences the teaching and learning outcomes in the school. As noted by Rinke and Valli (2010) principal support and leadership help shape the culture and school development, and is a valuable component to professional development and reform change.

The move for principals to become more involved in managing change and in developing collaborative learning teams of teachers to address their specific school concerns has been evolving slowly for the last 25 years (Fullan, 2008). There is an abundance of research to indicate that this type of model is successful when moving schools through change and developing school improvement (DuFour & Marzano, 2009; Fullan, 2008; Hilton et al., 2015; McLaughlin & Talbert, 2006; Supovitz et al., 2009). Whatever the chosen strategy for implementation, the factors affecting implementation remain the same (see Figure 1). Organisations will see greater, long-term success when these factors are addressed effectively. The research is overwhelmingly consistent in that the practitioners (both educational leaders and teachers)
working at ‘ground’ level are the ones who need to be carefully considered (Keys, 2005), listened to, developed, and allowed to make their own decisions within their own contexts in order for the implementation to proceed in ways that will meet the needs of the teachers in diverse areas and the students with diverse needs (Altrichter, 2005a; Fullan, 2011; Sahlberg, 2012).

Professional development and professional learning are ideally planned and initiated within the mesosystem context. Some options for professional learning are discussed below.

### 2.5.2 Professional Development / Professional Learning

As key players in the mesosystem, principals as leaders in the school have an impact on professional development, school capacity (Lewthwaite, 2006b; Printy, 2010; Sebastian & Allensworth, 2012) and student outcomes (Leithwood et al., 2004; Marzano et al., 2005). The previously noted concerns are the central part of the mesosystem in this study. It can be mistakenly assumed that all schools are the same and therefore will all be successful with the same implementation plans and processes. However, there is substantial research that indicates that schools are very different from one another and also have different levels of capacity (Corcoran et al., 2003; Fullan, 2008; Pilkington & Lock, 2013).

Decades of research suggest that the task of professional development during curricular reform is considerable (Fullan, 2009; Johnson, 2007; Lieberman & Pointer Mace, 2008). *The McKinsey Report* (Barbour & Mours shed, 2007) identified that the top performing school systems in the world successfully addressed the following four factors: (a) attracting high quality people, (b) strategies for developing instructional practices in an ongoing manner, (c) cultivating, selecting and developing instructional leaders and (d) data-based attention and decisions to address any problems (Barber & Mours shed, 2007) through professional development.

After synthesising years of research on professional development and teacher learning, Hawley and Valli (1999 as cited in Sandholtz and Scribner,
identified eight characteristics of effective professional development. They found professional development:

1) is driven by analyses of student work
2) involves teachers identifying their personal learning needs
3) is school and context based
4) utilises collaborative problem solving
5) is continuous, sustainable and supported
6) is information rich
7) allows opportunity to develop theoretical understandings
8) is part of a comprehensive change process

Moving schools from a more transmissive approach through professional development towards more effective practices proved to be difficult (Sandholtz & Scribner, 2006). A study by Sandoltz (2006) revealed that administrators wanted to remain in control of decisions and found it difficult to allow collaborative efforts by teachers to lead the way.

As noted by Peers, Diezmann and Watters (2003), in regard to implementing new curriculum: “the time required to understand an innovation and to reflect on and make changes to teaching practice was the most significant concern. Without the provision of adequate time for professional growth, it is unlikely that teachers will effectively implement new teaching practices” (p. 104). With this in mind during a national curricular reform, it would seem essential to prepare for effective professional development and professional learning from the higher levels in an education system.

However, there are barriers to addressing curriculum change in schools. As alluded to previously, teachers’ beliefs are an important aspect for consideration in professional development. In a relevant study that examined reform-based Science curriculum in high school, Roehrig and Kruse (2005) identified that even teachers with positive beliefs towards reform-based teaching had shortcomings in content knowledge and the teaching of Science lessons. They concluded that teachers would implement reform-based curriculum according to their beliefs, attitudes, and knowledge
unless there was professional development and learning to provide guidance and clarity towards the new expectations and new curriculum demands.

Further to this, a study by King and Newmann (2001), reported that teachers needed to be included in a school wide professional community that consists of:

- clear shared goals for student learning,
- collaboration and collective responsibility among staff members,
- reflective professional inquiry by staff members, and
- opportunities for staff members to influence the school's activities and policies. (p. 89)

These factors lead to effective and sustainable change in schools and are reflected in other school development programs that are considered important for developing effective teachers. Furthermore, the literature provides some guidance as to the types of professional development that may be appropriate for sustained development and changes of practice.

Some forms of professional development are considered less effective, such as, the common ‘one-off’ workshop style of professional development (Loucks-Horsley, Hewson, Love & Stiles, as cited in Garet et al., 2001, p. 920), while others are described as more effective for long-term change in teacher practice and in enhancing student achievement (DeMonte, 2013; Garet et al., 2001; Parise & Spillane, 2010; Spillane, 2014; Wenger, 2009; Wenger, McDermott, & Snyder, 2002). The latter tend to involve some form of continuous professional development over a longer period of time. Examples include Organisational Learning (Mulford & Silins, 2003), Continuous Professional Development (Peers et al., 2003), Professional Learning Communities (Dufour et al., 2006) and Building Capacity (Fullan, 2009, 2010) and are described below.

2.5.2.1 Organisational Learning

Organisational Learning, developed in the 1980s, was originally more business-focussed considering management organisation, but its popularity caused it to become more general to encompass all changes in regard to
systems thinking and continuous improvement. Business practice is the focus, so improvement may mean individual change or organisational change with the intention to improve performance of the organisational system. This approach required a strong alignment of values and beliefs between the personnel and the organisation. Organisational Learning (OL) involves “establishing trust and collaboration, having a shared and monitored mission, taking initiatives and risks within the context of supportive, on-going and relevant professional development” (Mulford & Silins, 2003, p.178). The process of OL values the active contribution of all participating staff. It is interesting to note that research by Mulford and Silins (2003), observed that teachers from large schools, with many years of teaching experience, were the least likely to make changes to their teaching.

2.5.2.2 Continuous Professional Development

Continuous Professional Development (CPD) provides formal and systematic activities planned to enhance teachers’ professional growth (Lessing & De Witt, 2007). CPD is valuable, particularly in primary Science education, given the difficulties teachers have with limited subject matter knowledge, limited Science pedagogical content knowledge, and low levels of confidence to teach Science. The on-going nature of this development model would seem suited to addressing the varied needs of the teachers within a school.

Continuous Professional Development (CPD) that occurs over longer periods of time often includes subject knowledge and specific pedagogical knowledge that can lead to an increase in students’ understanding (Guskey & Sparks, 2002; Peers et al., 2003; Summers, 1994). Many studies have confirmed that teacher professional development that extends over years, proves to be the most beneficial for the whole school and for long term sustainable outcomes (DeMonte, 2013; Parise & Spillane, 2010; Shields, Marsh, & Adelman, 1998; Weiss, Montgomery, Ridgway, & Bond, 1998). In support of this view, Peers, Diezmann & Watters (2003) noted:

The time required to understand an innovation and to reflect on and make changes to teaching practice was the most significant concern ... Without the provision of adequate time for professional growth, it is
unlikely that teachers will effectively implement new teaching practices (p. 104).

2.5.2.3 Communities of Practice

Wenger (1998) developed the concept of Communities of Practice (CoP) for professional development. These are groups of people who interact regularly and have a shared concern for something they do and a desire to improve. In a school setting it could be a group of teachers who decided to get together out of a concern or passion for something and the desire to improve through group interaction. The group is run and organised by its members - for example, primary teachers who want to improve Science-teaching skills. This model is a teacher-led model that allows the teachers to decide which concerns are addressed and how they will address them. CoP may include self and group educating, peer observation, peer support and experimentation.

2.5.2.4 Professional Learning Communities

Professional Learning Communities (PLCs) is a more recent model of professional development that requires a change in the traditional schooling structures around professional development (Vescio, Ross & Adams, 2008). The aim is to improve student learning by improving teaching. PLCs require collaboration between all staff and school leadership, the school community and a few other relevant community organisations. Strong PLCs lead teachers to collaborate more effectively and efficiently, to become more student-centred and as a result of continuous practice, student outcomes may improve (Vescio et al., 2008). Research on Professional Learning Communities (PLCs) indicates that, when teachers are involved in school cultures with leaders that promote teachers’ capacity to make decisions about the curriculum and teaching that lead to improved student learning, the changes can be dramatic and long lasting (Berry et al., 2005; Bolam et al., 2005; Hollins1*, McIntyre, DeBose, Hollins, & Towner, 2004; Rinke & Valli, 2010; Supovitz & Christman, 2003).
In order to sustain Professional Learning Communities, Hargreaves (2007) outlined seven principles. These are:

1. Depth – concentrate on what matters
2. Relationships (the heart and soul of PLCs)
3. Endurance
4. Data driven
5. Diversity – promote diversity
6. Resourcefulness
7. Conservation (p. 184-192)

Whole school collaboration and communication with strategic community involvement and innovation can lead to sustained changes in teaching and learning. Professional Learning Communities (PLCs) can be found in schools across the globe. The basic design and purpose of PLCs include reflective dialogue, removing isolation of practice (Lortie, 1975), developing a collective focus on student learning, collaboration and shared values. Teachers and school communities need to set aside time for communication, sharing and developing trust, respect and openness for school improvement to occur. Professional Learning Communities can address both the structure and the culture of the school. However, the culture of schooling is the most difficult aspect to change (Fullan, 2007). Fullan (2007) believes that large-scale development is difficult and often fails because we are “talking about changing a culture, one that has endured for at least a century” (p. 149). Since professional development and professional learning are valuable components to new curriculum implementation, the case study schools in the present study were observed and professional development identified and its impact discussed.

2.5.2.5 Teacher-Leaders and Instructional Coaching

Another important aspect of the school community mesosystem is the role of teacher-leaders (if they exist in a school) in professional development. Teacher-leaders within a school context refers to teachers who are in a position to promote teaching and learning improvement and who also
possess the leadership skills and subject knowledge required to provide support for other teachers. That is, while not having the role and authority of the Principal, they can play a key leadership role in curriculum and its implementation. Lewthwaite (2006a) suggested that the teacher-leader model can be successful; however, success in developing the teacher-leader depended upon such factors as the disposition of the teacher and the environmental conditions.

The role of a teacher-leader could be considered as “instructional coaching”. Coaching is a form of learning that can help teachers “transfer their learning from professional trainings to classroom practice” (Anderson, Feldman & Minstrell, 2014, p. 1). Research examining “instructional coaching” investigated the relationship between coaches and teachers (Anderson, Feldman & Minstrell, 2014). Anderson and colleagues described the first three years of the working relationship as increasingly more productive and focused when the teachers and coaches were working together on a weekly basis. Their study also investigated the transfer of learning to classroom practice and revealed success that was predominately based upon building trust between the coach (often a peer teacher) and the classroom teacher. They posited that developing a trustworthy environment promotes greater productivity through shared information, knowledge and experiences. Trust was such a strong component that even after four years of working with the same school of teachers, the instructional coach could still sense the need to cultivate the relationship. Further, Anderson and colleagues surmised that effective coaching may lead to positive organisational health. Instructional coaching requires sufficient time, trust and role synchrony in order to promote effective collaboration and reflection among teachers. Anderson and colleagues suggested that coaching may be a mechanism by which schools or even districts can maintain ‘organisational health’ because when it is working effectively, it builds and maintains trusting relationships. Their research identified trust as a key component of successful change in practice.
Developing teacher-leaders is a way to encourage change in schools. In the midst of Science curriculum reform in New Zealand primary schools, Lewthwaite (2006a) used Bronfenbrenner’s ecological model to help examine and interpret personal attributes and environmental factors’ influence on developing Science teacher-leaders in the midst of Science curriculum reform in New Zealand primary schools. Bronfenbrenner’s model focused on both the person and the context for development. This assisted Lewthwaite (2006a) in identifying that individual personal attributes such as Science content knowledge and Science pedagogy are important when determining the influences on developing Science teacher-leaders. Equally as important were the environmental factors that contributed to or impeded the development of teacher-leaders. Lewthwaite (2006a) believed there were factors at each level of Bronfenbrenner’s ecological model and factors between levels that influenced the individual outcomes. Some of those factors were: content knowledge, interest, parent and community aspirations, professional support, school leader expectations, government policy and priorities. Bronfenbrenner’s ecological model was successful in helping Lewthwaite (2006a) to understand the dynamics of developing teacher-leaders, which contributed to the decision to use the model in this study.

Lewthwaite’s study informs the present study by providing relevant background information about curriculum reform in the past for Queensland schools. While this study is not looking at developing Science teacher leaders, the information about teachers’ Science abilities, preferences, teaching strategies, professional development, policies and processes provide contextual information about Science education in the state of Queensland prior to this study.

As noted earlier, a teacher support initiative by the Queensland Government was to appoint selected secondary Science teachers as *Science Sparks* to assist primary school teachers. To what extent the Science Sparks functioned as instructional coaches was one facet investigated in this study.
2.5.3 Science Teaching and Professional Development

When considering Science teaching, research has demonstrated that primary teachers typically lack confidence to teach Science (Appleton, 2002, 2003; Harlen & Holroyd, 1997; Murphy, Neil, & Beggs, 2007), and have limited knowledge of Science content and inquiry-based pedagogy (Abell, 2007; Mulholland & Wallace, 2005; Van Driel, Verloop, & de Vos, 1998). This results in a tendency for some primary teachers to avoid teaching Science, or to teach it using strategies more appropriate to other subjects (Harlen 1997). That is, professional development needs to focus on more than just the new curriculum; it also needs to address teachers’ confidence to teach Science (Murphy et al., 2007), their content knowledge and associated pedagogical knowledge (Anderson, Feldman & Minstrell, 2014), beliefs about Science teaching and learning (Roehrig & Luft, 2004; Savasci-Acikalin, 2009), and knowledge of inquiry pedagogies (Kawalkar & Vijapurkar, 2013; Skamp & Peers, 2012). Professional development associated with the new Australian Curriculum: Science could therefore be expected to be multi-dimensional and require careful planning to be effective.

Desimone, Porter, Garet, Yoon & Birman (2002) found that, during their three-year longitudinal study on the effects of professional development on teachers’ instruction, one main component to increasing teachers’ capacity to teach to high standards was the inclination of teachers to want to improve student achievement. Most teachers will attempt change when they know it will benefit the students.

However, it seems that teachers are not able to participate in many such high quality professional development opportunities, usually due to time constraints and limited funding (Birman, Desimone, Porter, & Garet, 2000). If teachers were exposed to regular high quality professional development, as shown by Desimone et al., (2002), changes in teaching could be anticipated. According to Guskey (1991) and Garet et al., (2001), good professional development requires substantial resources, funding, and a coherent professional development plan. Funding an entire school for high
quality continuous professional development is very costly and often outside school budgets.

Desimone et al., (2002) found that schools generally did not have a coherent professional development plan that was effective and consistent for all teachers. Often professional development is left up to individual teachers to decide on the areas in which they want to improve, and then seek out a workshop, course or other means to improve their skills and knowledge. This can leave schools and teachers with *ad hoc* training in a range of areas. The research shows that a strategic and cohesive approach to meet identified goals for teacher and student improvement needs to be created for sustained change in practice to occur in our schools (Corcoran et al., 2003).

After the implementation of the new curriculum began, the Queensland Government published a new Professional Development Plan (Education Queensland, 2012) with suggested effective strategies for school and teacher improvement; but left it in the hands of schools to deliver. No direction, additional funding or support was provided.

An alternative to whole school professional development is to focus on a smaller number of teachers in each school who can begin the process of change and later support other staff through the change.

### 2.5.4 School Environment

The final aspect relating to professional development is the school environment, which provides an overall context for implementation of the new Science curriculum and includes school climate (social and cultural features), administration, and organisational structures. These also influence the implementation of a new curriculum (Cheng, 1994) as school organisations consider how they can maximise the curricular change.

According to Cheng (1994), there are three kinds of approaches to curricular change used in school organisations. The first is *Simplistic Curriculum Change*: “This approach assumes teachers are passive, their competence is static and curriculum change can be planned and implemented effectively by administrators or external experts” (p. 27).
The second is *Teacher Competence Development*. This approach assumes curriculum change is imposed and teacher competence can be developed easily to satisfy all needs of the changed curriculum. The third approach, called *Dynamic Curriculum Change*, identifies that both the curriculum and the teachers need to change to maximise the effectiveness of the curriculum and to facilitate teaching and learning.

Cheng’s studies have revealed that the first two approaches result in short term and mechanical changes. However, the third approach incorporates teacher voice and ideas around the curriculum change. In regard to teaching skills and the learning outcomes, the third approach is reportedly more effective in the long term. Therefore, to achieve effective implementation of the Australian Curriculum: Science, Queensland schools would preferably use a dynamic curriculum change model. Cheng’s work aligns with findings from Desimone et al., (2002), Kimble, et al., (2006), and Akerson, Cullen and Hanson (2009), who found that when the teachers were given the opportunity to consider their personal strengths and weaknesses, their student and community needs, along with the curriculum, they could then make informed decisions about the changes needed in each area and how to go about making those changes. When teachers’ opinions and expertise are valued and they become part of the process of the decision making for the changes within their school culture, then there is a high level of ownership of the process by the teachers (Kimble et al., 2006). These findings further inform Queensland schools about the nature of desirable professional development. The emphasis on the teacher involvement is critical, because student achievement is impacted more by the teacher a student has, than by the type of school a student attends (Goldhaber & Brewer, 1997).

If we consider the influence of the principal and school leaders of a given school, the professional development and professional learning that occurs in that school, the effectiveness of the interrelationships and the school environment and context we are considering, and the capacity of that
school, then, the stronger the school capacity, the more effective the school is overall. This is discussed below.

2.5.5 Building Capacity / Organisational Capacity

The terms Building Capacity and Organisational Capacity refer to a school’s capacity to influence the quality of teaching and learning. The components of school capacity include the teachers’ knowledge, skills and dispositions, the principal’s leadership plus the distributed leadership, school processes, program coherence, the technical resources and the professional community (King & Bouchard, 2011). It has the potential to build stronger commitments and improve skills within the group (Fullan, 2007). Since the whole group generates these new skills and processes, the whole group then shares them. This makes school capacity powerful for creating change (Corcoran et al., 2003; Cowie et al., 2009; Spillane, 2014). The manner in which a school works towards improving its internal processes can determine the effectiveness of the school’s capacity to influence teaching and learning. When school capacity is effective and collaborative, it becomes a long lasting and sustained process that is capable of working through all concerns (Fullan, 2007). This approach to school development is a long-term investment that becomes part of the school culture and embraces the people, their abilities, attitudes, feelings and ideas. Together, these factors allow for learning and growth as a whole system and move schools and teachers towards effective practices. One facet of the current study was to investigate the capacity of the case study schools through their reported school processes during implementation of the new Australian Curriculum: Science.

2.5.6 Summary

A top down influence that expects change and improved student outcomes is often necessary to effect change in schools. However, schools need the ability and the knowledge to create a school culture that effectively builds school capacity and one which can improve teaching and learning. Since each school community is unique, it is important for each school to develop
their own processes that lead to change in teaching practices and increased school capacity.

Consequently all aspects of understanding a new curriculum, including theoretical frameworks, subject matter knowledge, planning, teaching, and assessing need to be carefully and thoughtfully addressed through effective professional development and professional learning opportunities with the teachers who are charged with implementing the new *Australian Curriculum: Science*. 

While improvement and change in education are often desirable, they can be difficult to implement. While curriculum reform is a regularly occurring phenomenon, it is not easily accepted by teachers (Mulford, Silins, & Leithwood, 2004). Superficial change or change in materials and program documents are made easily. But these types of changes do not lead to improved student achievement and long term improvement in teaching and learning. So it is common for change in schools to take a longer period of time. Mulford et al., (2007) confirmed through years of case study research in several Australian schools that meaningful change in teacher knowledge, pedagogy and student outcomes, is established slowly through changing the tightly held belief systems and values held by staff and the school community.

Meaningful and long-lasting change is centred around the teacher and requires intensive development with year level peers or as a school community effort (Hargreaves, 2007; Parise & Spillane, 2010; Fullan, 2001; Lewthwaite, 2006a). Parise and Spillane (2010) suggested that, “on the job” learning is more effective than formal types of learning. Since teachers have regular contact with students and control over the teaching and learning environment, “improving teachers' knowledge, skills, and dispositions is critical to enhancing student achievement” (King & Newmann, 2000, p. 576).

So far, this review has shown that the Bronfenbrenner mesosystem is the place where change is to be instigated, and its influence is seen in the microsystem.
2.6 Microsystem: Primary Teachers

A key component of Bronfenbrenner’s framework at the microsystem level is the classroom, in which a key figure is the teacher. The teacher has therefore been placed at the centre of the adapted model of his work (see Figure 2) and is a focal point in this study. The historical context of primary Science teaching is therefore a relevant component to be considered (Kahle, 2007). There have been many studies conducted with primary teachers and students to understand Science education classroom practices (Appleton, 2007). These classroom practices sit in both of Bronfenbrenner’s microsystem and mesosystem; but it is in the former where the strongest influence of face-to-face interactions occurs.

Teachers as a second layer of leadership within a school community, have an impact on the teaching and learning, student outcomes and community relationships (Moir, 2013; Thornton, 2010). However, primary teachers are often referred to as ‘generalist’ teachers because they are expected to know and be able to teach eight or more different subject areas. In other words, primary teachers could be described as needing a breadth of knowledge rather than depth of knowledge in most subject areas. Since this is often the case, teachers sometimes lack confidence to teach certain subjects and science concepts therefore leading them to teach with a didactic and rote approach (Hashweh, 1987; Office for Standards in Education (OFSTED), 1994).

Curriculum related to literacy and numeracy have had a high profile on State agendas and in schools, resulting in these being a priority for professional development. As Science is considered to be a lower priority (Masters, 2009; Goodrum et al., 2001; Appleton, 2002), teachers therefore often give it less time and focus. Science is one of the main subject areas where primary teachers may feel less capable and confident to teach. Since this has been the case for some time, there are often teaching and learning concerns that influence the overall effectiveness of the teaching and learning of Science in primary Science classrooms (Tytler, 2007).
Research has identified the teachers (particularly those who teach in certain ways) and the classroom experiences to be responsible for the majority of the student learning (Hattie, 1999). Therefore, teacher support and professional development and professional learning are important components of new curriculum implementation.

The most common factors effecting Science teaching performance are the teacher’s personal knowledge of Science, confidence to teach Science, beliefs about Science and Science pedagogy (Danielsson & Warwick, 2014; Wallace & Louden, 1992). Other factors have been noted, but play a lesser role. These are: time, resources, facilities and preparation (Cowie et al., 2009; DeMonte, 2013). While these play a smaller role in a teacher’s disposition towards teaching, they do cause problems when not supported by the school. This section examines the following four factors: teacher knowledge, confidence, attitudes and beliefs and pedagogy relating to Science.

2.6.1 Knowledge

Studies reveal primary teachers’ knowledge of Science content remains a concern after fifty years (Skamp, 1989; Appleton, 1995, 2006; Goodrum et al., 2001; Wallace & Louden 1992). Prior to 1986, the description of a good teacher was centred on the teacher’s knowledge of a discipline including the facts, theories and principles. Shulman (1986) suggested another component of teaching as essential to effective teaching: pedagogical knowledge. It includes the effective use and knowledge of instructional principles, classroom management, learners and learning and educational aims. The term, *Pedagogical Content Knowledge* (PCK), was also introduced by Shulman (1986), and refers to a combination of content and pedagogy specific to particular subject areas and year levels that enhance and stimulate the best teaching and learning conditions.

Shulman highlighted the role of effective teaching strategies to develop greater engagement in student learning and to demonstrate higher levels of achievement. Shulman (1986) identified subject content linked with pedagogical knowledge as, “the ways of representing and formulating the
subject that make it comprehensible to others” (p 13). Making a subject comprehensible refers to the illustrations, analogies and explanations that a teacher uses in lessons. Shulman equated curricular knowledge to the ways teachers use current materials, digital or otherwise, to demonstrate knowledge of concepts. He suggested that content and pedagogy need to be engaged together to provide the best teaching and achieve the best learning outcomes. However, “Pedagogical Content Knowledge (PCK) is tacit, or hidden, knowledge. There is wide agreement that PCK is a useful construct, though finding out exactly what it comprises and using this knowledge to support good practice in teacher education is not easy” (Kind, 2009, p. 170).

Teachers’ knowledge of the subject specific matter may refer to their personal content knowledge (Schwab, 1978) such as, understanding physics and chemistry or even the ability to translate the content when teaching students. It is also said to refer to syntactic structures of Science (the ways in which truth and validity are established), substantive structures of Science and nature of Science and technology. It is this kind of knowledge where primary teachers commonly fall short (Abell & Roth, 1992; Appleton, 2006; Harlen & Holroyd, 1997). Research revealed that primary teachers tend to have limited Science content knowledge (Appleton, 2003; Davis, 2004; Schwartz & Lederman, 2002).

Further to this, primary teachers tend to have similar misconceptions about Science concepts or science content, as do the students they teach (Allen, 2014; Hope & Townsend, 1983). This area of research has led to concerns about the quality of Science teaching that Australian students are receiving (Goodrum et al., 2001).

As mentioned, a key factor in student achievement is the teacher. Consequently, primary school teachers’ knowledge of Science has an effect on the learning outcomes of students. It affects students’ perception of Science and their interest to do further Science. It also affects their understanding of how the world works and their personal impact on the environment.
In response to the identified issues of teacher knowledge and PCK, teacher preparation programs have more recently begun to increase the Science coursework component of education programs at the university level. In addition, there has been a slight increase in the amount of Science professional development provided by schools for their teachers to improve in their knowledge of Science. Overall however, there has only been marginal change and improvement in the teaching and learning of Science (Masters, 2009). Over the years, the blame of inadequate Science outcomes has been placed on teacher preparation, lack of materials and poor programs (James & Hord, 1988). There has been a quest to clarify the problem and provide solutions for several decades. The following discussion outlines some aspects of this research.

Knowledge about teaching develops gradually (Wallace & Louden, 1992; Mulholland & Wallace, 2005). It involves testing and trialling of strategies (Haefner & Zembal-Saul, 2004; Huberman, 1989; Vail Lowery, 2002), trying out new ideas and problem solving. Teaching knowledge typically develops from demands within the classroom (Doyle & Ponder, 1977; Fitzgerald & Schneider, 2013; Vail Lowery, 2002).

Teachers may not be aware of their own inadequacies in teaching. They may believe their teaching is not problematic, when in fact there is “considerable discrepancy between teachers’ views of their own practice in elementary Science and the views of Science educators who observed their teaching” (King, Shumow & Lietz, as cited in Roberts, Abell, & Lederman, 2007, p. 497). Teachers also feel it is best to maintain the status quo when it has been ‘successful’ for them in the past (Fullan, 2008), especially when changing may involve risk and large time investment. Sometimes it is lack of confidence that will keep teachers holding onto traditional and out-dated methods of teaching Science. These teacher perceptions add to the slow changing dynamics of school curricular reform.
2.6.2 Confidence

Primary teachers’ confidence to teach Science topics with appropriate pedagogy has been a topic of research for many years. Harlen and Holroyd (1997) investigated the link between teachers’ understanding of Science concepts and their confidence to teach those concepts. They noted that while there is often a link between the two, where, if they reported high understanding they also reported high confidence and with low understanding there was low confidence. However, at times teachers reported the opposite. That is, occasionally there were teachers who reported high understanding of Science but low confidence in teaching the subject, or high confidence but low understanding. They believed the results were based upon varied influences previously encountered that may increase or decrease confidence such as:

- Teachers’ own schooling and personal experience
- The nature of their in-service experiences
- The experience of pressure and curriculum overload in schools
- The support available from colleagues and materials resources
- Teachers’ general views of their professional capability

Confidence is one area that impacts on teachers’ behaviours towards teaching Science (Palmer, 2001). It is also believed that there is a connection between a teacher’s interest in Science and their confidence to teach Science (Skamp & Peers, 2012).

Since many primary teachers have received little to no prior Science coursework, this may affect their confidence to teach Science (Appleton, 1997; Jarrett, 1999; Skamp, 1989). Harlen and Holroyd (1997) identified that some teachers are more confident than others to teach Science regardless of their Science background. However, Appleton (2003) noted that many teachers taught Science in a manner that was comfortable for them even though their preferred strategies were not necessarily considered best Science teaching strategies.
Confidence can affect teaching performance, negatively or positively. Prior experiences, content area knowledge, teaching strategies and professional learning have an impact on Science teaching confidence (Appleton & Kindt, 2002; Danielsson & Warwick, 2014). Teachers who have taken Science courses and have been successful in Science have more confidence to teach Science than those who have had poor Science experiences (Appleton, 2006). However, teachers who were previously taught Science with out-dated pedagogies may have those influences creep into their current teaching styles (Danielsson & Warwick, 2014) thus making it difficult to move easily into the preferred inquiry-based pedagogy for Science teaching. In fact, Danielsson and Warwick’s research has reported that new teachers have difficulty developing an identity as a teacher of Science due to previous experiences, knowledge about Science and their confidence to teach Science.

Confidence also affects the time and strategies teachers apply to Science lessons. Research has consistently shown that many primary teachers teach little to no Science over the span of a week (e.g., Angus, Olney & Ainley, 2007; Masters, 2009; Smith & Neale, 1991). Further, what is taught, is often performed through lecture style teaching, workbooks (Martin & Hand, 2009; Weiss, 1994) and activities that are ‘guaranteed to work’ (Appleton, 2006). Primary teachers find it easier to follow an activity or worksheet script, because there is a greater sense of control. However, the depth of student learning is often restricted because teachers tend not to discuss the Science concepts behind the activity. For example, Appleton, Hawe, Biddulph, and Osborne (1984) researched the use of two types of teacher guides. One was very scripted and full of detail for an inexperienced teacher; and the other had less detail for the more confident and experienced teacher. It was found there were discrepancies between teacher actions and the intentions of the teacher guides. The guides were not enough. Teachers still needed professional development to go along with the guides. Unfortunately, low confidence also means there is little inquiry-based teaching occurring in primary schools. Inquiry teaching is highly engaging and interactive but teachers with low confidence find this strategy
threatening (Appleton, 2006), believing they will have less control and may not know the answers to students’ questions.

Further, the provision of highly structured Science materials made little difference to participating teachers’ confidence and teaching practice in the study conducted by Goodrum, Cousins, and Kinnear (1992). Confidence levels of teachers were investigated before, during and after the use of a new structured Science program. In the beginning, the main concern by the teachers was management of groups, time and keeping students on task. As they developed understanding of the program, their concerns switched to Science content. By the end of the year, teachers were at different levels of concern and confidence. Many of the teachers felt their confidence had improved due to the structure of the program and positive feedback from students; for many however, their lack of Science knowledge remained a vital concern. This study demonstrated (as do others: Birman et. al., 2000; Garet et. al., 2001; Lewthwaite, 2006a; Hargreaves, 2007; King & Bouchard, 2011) that teacher professional development in the form of on-going support helps to improve teacher confidence to teach Science because primary teachers’ Science content knowledge is closely connected to their confidence to teach Science (Murphy et al., 2007).

Past Science experiences, content knowledge and confidence are further shaped by particular attitudes and beliefs about Science teaching.

2.6.2.1 Attitudes and Beliefs

Several studies have investigated teacher beliefs in regard to Science and Science teaching (Cronin-Jones, 1991; Fitzgerald, Dawson, & Hackling, 2013; Hancock & Eyres, 2004; Haney, Lumpe, Czerniak, & Egan, 2002; Jones & Carter, 2007; Keys, 2007; Lederman, 1999; Levitt, 2002; Prawat, 1992b). There are conflicting results with some reporting little connection between beliefs and teaching practice (Hancock & Eyres, 2004; Lederman, 1999; Lederman & Zeidler, 1987) and many others that support some connection between teacher beliefs and instructional practice (Haney et al., 2002; Haney & McArthur, 2002; Jones & Carter, 2007; Keys, 2007; Levitt, 2002). However, authors agree that beliefs should be considered within the
teacher and school contexts. According to Keys (2007) and Jones and Carter (2007) teachers' beliefs strongly influence the way they teach, and in turn, the way their students will learn. While teachers do not often have a strong knowledge of the Science content, they often do have strong beliefs about what Science is and how it ought to be taught and learned (Smith & Anderson, 1984). Their beliefs may or may not align with current research about best Science teaching practices. Therefore teacher beliefs should also be considered when teachers are expected to implement a new curriculum (Roehrig & Kruse, 2005).

Teachers’ attitudes about Science also impact on the quality of Science teaching (Fitzgerald et al., 2013; Jones & Carter, 2007; Palmer, 2001), even to the degree that “attitudes and beliefs play a significant role in shaping teachers’ instructional practices” (Jones & Carter, 2010, p. 1067). Nearly every aspect of teaching is affected including, but not limited to, “lesson planning; teaching; assessment; interactions with peers, parents, and students; as well as her professional development and the ways she will implement reform” (Jones & Carter, 2007, p. 1067). Haney, Lumpe, Czerniak and Egan (2002) reported similar findings, including teachers attending to equity issues, encouraging a collaborative approach, and teaching content that was developmentally appropriate and tied to the real world. Further, Fitzgerald et al., (2013) identified teaching strategies to be related to teachers’ beliefs.

So it appears that everything that occurs in a classroom is decided and shaped by the teacher. Bybee (1993) maintained that teachers are the change agents of educational reform and that teachers’ beliefs must not be ignored. In addition, Prawat (1992b) identified that teachers’ views of teaching and learning influence their decisions and opinions about teaching. These views are part of their belief system, and are very difficult for them to change; especially since their beliefs are embedded in their practice.

According to Keys (2006), teachers need to be motivated to change in order to bring about sustained change. In his study of the new Queensland Science curriculum in 1999, Keys (2006) identified teacher beliefs and
studied how those beliefs, “influenced and shaped the implementation of a Science curriculum” (p. 500). He compared the beliefs of seven teachers from one Queensland high school and one Queensland primary school with their classroom practices. Keys identified that typically, what a teacher believes is what they practice. However, he also identified some gaps between beliefs and practice. One reason teachers did not always act on their beliefs was the lack of on-going professional support.

Attitudes and beliefs are often developed through past experiences (Priestley, Edwards, Priestley, & Miller, 2012; Roehrig & Kruse, 2005). This would include Science experiences in the classroom. Therefore, teachers’ attitudes may also influence the attitudes of their students (Fitzgerald, Dawson & Hackling, 2013). In this context, a study with preservice elementary Science teachers revealed many more negative descriptors towards Science than positive descriptors when recalling their past experiences in school (Palmer, 2001). According to Hawkins (1990), their previous primary school Science experiences have a strong effect on a student’s interest and confidence to learn about and teach Science in the future. He supported the view that teachers who were taught “little and poorly” as children become teachers who teach “little and poorly” (p. 97) in the classroom.

Low content knowledge and confidence can cause not only avoidance behaviours, but also affect teachers’ attitudes and beliefs about becoming effective Science teachers. Recently Fitzgerald and Schneider (2013), after the introduction of the new Australian Curriculum: Science, discovered that while there has been a small increase in confidence among primary teachers to teach Science, there are still many teachers who lack confidence to teach the Science concepts and teach using inquiry pedagogy. It is vital then that teachers are prepared and educated appropriately so they grow in knowledge, pedagogical practice and confidence to teach Science effectively. This could avoid a perpetuating cycle of poor Science experiences and lack of Science teaching that lead to teachers and a society without full understanding of Science content knowledge and the nature of Science.
Another area that is affected by teachers’ ability to develop student understanding of Science concepts or content is the way teachers teach; or pedagogy.

2.6.3 Pedagogy

The most recent reforms and movement in primary school Science expect the pedagogy around inquiry skills (also known as process skills in previous Science curriculum) to be developed and practised (Fittell, 2010; Tytler, 2007). According to the document, *Shape of the Australian Curriculum: Science*, inquiry skills include the following abilities:

- posing questions, planning, conducting and critiquing investigations, collecting, analysing and interpreting evidence and communicating findings. This strand is concerned with evaluating claims, investigating and making valid conclusions. It also recognises that scientific explanations change as new or different evidence becomes available (p. 6).

These skills are explicit descriptions of the kinds of hands-on activities or a processes approach (Sanderson & Kratochvil, 1971) that teachers are expected to prepare, demonstrate and lead their students through. The combination of content knowledge and process or inquiry skills is hoped to bring students to a better understanding of the impact and influence of Science on society and our decisions for the future. Inquiry skills may also enhance student engagement and thinking, and increase student interest in Science (Goodrum, Druhan, & Abbs, 2012; Tytler, 2007); and may lead more students to pursue careers in scientific or technological vocations (Goodrum, Hackling & Rennie, 2001).

The method chosen as most appropriate for children and one that leads children to acquire a more accurate understanding of scientific processes and nature of Science is an inquiry approach (Skamp & Peers, 2012; Tytler, 2007). An inquiry approach to teaching follows a constructivist view of learning through social development. The difficulty with primary teachers following an investigative or inquiry approach can be their lack of content
knowledge that leads them to have shallow or even limited capacity to develop students’ conceptual understanding (Harlen & Holroyd, 1997). In addition, the lack of understanding of an inquiry approach to teaching Science may cause teachers to teach Science with less effective strategies (Smith et al., 2007). One aspect of the current study is to identify teachers’ style of pedagogy in Science, along with the professional development provided, in regard to teaching Science.

According to Anderson and Smith (1984), teachers need strategies that are successful for facilitating students’ conceptual change in Science. However, as described earlier, teachers will often teach according to their particular knowledge of Science, confidence to teach, beliefs about teaching, and prior experiences. For example, the following study compared two approaches to Science teaching. Hapgood, Magnusson, and Sullivan Palincsar (2004) conducted a study that looked at Science inquiry teaching in a Year 2 classroom. They noted that while there is movement from the traditional textbook-based activities in which students copied or labelled various diagrams, this approach still occurs in many classrooms. Some teachers used hands-on activities that turned out to be little more than students just handling materials, rather than problem solving, or reflecting on observed events. There are similar findings about students’ textbook use by Stake and Easley (1978); and Weiss (1987).

The opposite was found when the Year 2 teachers were involved in community of practice learning. They were seen as being able to teach with some depth in an inquiry mode and meet the district elementary Science program goals. The teachers used an inquiry-based approach with activities aimed to engage students to construct meaning. The findings support the inquiry-oriented approach, which improved students’ attitudes towards Science and scientists. These students indicated they found Science interesting, while the ‘traditional’ classroom students found Science to be boring and made them feel uncomfortable. The process or inquiry approach more closely resembles the Science of real scientists and demonstrates the purpose of Science in the real world.
Further, complications with Science teaching have been reported. Furtak and Alonzo (2010) suggested that some primary teachers emphasise, “doing and feeling during inquiry-based lessons” (p.425) and having fun, over the teaching of content. Appleton (2002) supported this observation; and went further to say that sometimes teachers believed if the activities were easy to manage and fit within the routines of the classroom, the Science lesson worked well. This approach to teaching Science may indicate particular beliefs about learning and teaching Science, lack of confidence to teach the content, or even the lack of understanding about how to teach Science effectively. When teachers lack content knowledge and confidence to teach Science, student performance will be low (Furtak & Alonzo, 2010; Rennie, Goodrum, & Hackling, 2001), and interest in Science will be low (Appleton, 1995; Ginns & Watters, 1999). Therefore, teacher pedagogy and subject expertise are important factors in determining student achievement (Darling-Hammond, 1997).

Another reason to teach with an inquiry approach is the ability to address misconceptions or alternative conceptions. It is important to note that misconceptions hinder correct Science concept understanding. Constructivist views of learning identify pedagogy as important in the development of concepts (Skamp & Peers, 2012; Tytler, 2007). Misconceptions or alternative conceptions in Science are known to exist with both students and teachers (Allen, 2014). These are understandings of Science concepts that do not align with scientific research. Therefore, the choice of pedagogy has been found to influence the ability to correct pre-existing alternative conceptions so that Science concepts can continue to develop and build accurately.

Other approaches to teaching science include teaching by topic, teaching by theme and teaching content directly. An example of teaching by topic would be: teaching specifically about “erosion”. Teaching by topic while it can provide depth it can be very narrow. However, the development of topic knowledge can help to improve content knowledge (Ahtee & Johnston, 2006). An example of teaching by theme would be: “Dinosaurs”. Teachers
who choose a theme approach include many subject area concepts, but often provide little depth of learning (Walmsley, 1994). Teaching by content refers to teaching subject matter such as facts and may or may not be done in isolation or with processes that assist in conceptual understanding (Mohan, 1979; Bay, Staver, Bryan & Hale, 1992). This latter study surveyed teachers’ preferred approach to teaching science as from among: a process approach, a topic approach, a theme approach, or a content approach.

### 2.6.4 Summary

These factors that influence teacher performance and student learning need careful consideration when mandating curricular change. The creation of a national curriculum seemingly requires extensive and effective professional development across all schools for the curriculum to maintain the unified and enhanced standards it has aimed to achieve.

Science teaching and learning became a concern in Queensland after Varley’s report (Varley, 1975), “Science in the Primary School”, was published in 1975 and is still a concern at beginning of the 21st century (Osborne & Dillon, 2010; Tytler, 2007). As research consistently demonstrates, the teacher is at the core of curriculum implementation (Altrichter, 2005a; Cuban, 1998; Fullan, 2011; Kirk & MacDonald, 2001; Sahlberg, 2012; Van Driel et al., 2001). Teachers are also the significant factor determining the quality of student learning outcomes (Darling-Hammond, 2000). When PISA and TIMMS results indicated that Australia was not producing the outcomes expected in comparison to other countries, it could be assumed that teachers and schools would be targeted to make changes. This was certainly the case with the movement towards a national curriculum.

When schools are unprepared to achieve the standards of a large-scale curricular reform, little can be achieved. As Garri (2006) pointed out: “Over and over again, these reforms fail, and these failures are laid at the feet of the teachers who were asked to do the challenging task of implementing the reforms” (p. 83). Indeed, teachers and schools need effective long-term
support to achieve the types of changes required in a large national curriculum reform.

Bronfenbrenner’s Bioecological Systems model contains many systems and each has a specific contribution to the overall understanding of the complicated set of influences in education and specifically, in Science education. This model illustrates the nature of top-down decisions and helps to explain the actions of those at lower levels who are influenced by those decisions, such as school leaders and teachers. The top-down aspects reflected in the Macrosystem and Exosystem levels are largely set by legislation, policy and associated decision-making through national and state systems authorities. Hence, the focus of this thesis is on the decisions made at school and teacher levels in the implementation of the new Australian Curriculum: Science.

This thesis identified school contextual factors and processes introduced, or lack thereof, to support the implementation of the new Australian Curriculum: Science, and any perceived changes to teachers’ Science teaching practice associated with their attempts to implement the Curriculum. It informs this national imperative and engages with research examining the capacity of teachers to teach Science.

The review of the Literature has led to an understanding of the multiple factors associated with Science curriculum implementation. With the new Australian Curriculum: Science implementation mandated, the following sub-questions were created.

Sub-questions:

1. Which school contextual factors do the school leaders and teachers see as being most relevant to making changes in the implementation of the new Australian Curriculum: Science and in Science teaching?

2. To what extent do the teachers feel confident to teach Science and feel prepared to implement the new Australian Curriculum:
Science (including initial training and subsequent professional development)?

3. Which beliefs about teaching Science do the teachers hold, how frequently do they teach Science, and what teaching strategies do they commonly use when teaching the new Australian Curriculum: Science?

4. After one year from the release of the Australian Curriculum: Science,
   a) What have schools and teachers done to implement the curriculum?
   b) How has the implementation of the new Science curriculum impacted on the school and teacher actions about how to teach Science?
   c) What actions do teachers believe should occur to progress implementation?
3 THE RESEARCH PARADIGM AND CONSIDERATION OF METHODS

3.1 Research Orientation/ Justification of Paradigm

This study essentially followed a pragmatic qualitative research approach (Morgan, 2007). It involved an interpretive, naturalistic approach to the topic, using selected case studies. As such it adhered to several philosophical paradigms that strengthen the purposes of research. For example, qualitative research allows for a more in-depth study of contexts and participants. It is about the people’s personal experiences and may be adapted to the needs of the people and situations studied also allowing an inductive explanation about a phenomenon. Research based on data sources such as observations and interviews require a mutual understanding and cooperation between participants and researcher. A text such as interviews or observations will involve multiple meanings therefore interpretation is used to analyse the text. There are contextual components and value components within the observations and interviews that require some degree of interpretation and trust when analysing (Lincoln & Guba, 1985; Schwandt, Lincoln, & Guba, 2007; Shenton, 2004).

The personal involvement of the Researcher is considered as a valuable aspect. Her experience and expertise helped to guide interpretation of the data. Reality can be interpreted multiple ways; therefore, the Researcher’s understanding of the contexts may lead to a somewhat subjective interpretation. However, understandings of the contextual interpretations are based on the Researcher’s experience and background within the topic of the study (Graneheim & Lundman, 2004). The Researcher discussed preconceptions based upon previous experiences with a relevant colleague. Strategies were suggested and employed such as audiotaping and transcribing so that another person could audit the texts and provide feedback.

Qualitative research design typically includes several theoretical paradigms, which define the assumptions, propositions and concepts that orient the design and ultimately guide the actions of the research. This qualitative study fits well with an interpretive paradigm (Denzin & Lincoln, 2011) that
implies particular features about people and their experiences (Willis, Jost, & Nilakanta, 2007). This paradigm assumes that reality is socially constructed. Methodologically an interpretative paradigm typically includes surveys, observations and interviews as data gathering approaches. That is, the people, their knowledge and associated events are inseparable. In particular, people and their experiences are a central part of how we understand each other and the world. As Willis et al., (2007) stated: “It is a view from a group that shares certain beliefs and expectations” (p. 98). The thoughts, stories and actions of participants in a study are valuable sources of information that contribute to understanding a context and multiple views from multiple participants aid in developing a more complete and robust understanding of phenomena under study (Denscombe, 2014; Foon, 1987). For example, the response of teachers in a state, government school who are faced with a new national Australian Curriculum: Science to implement is a particular context. To obtain school case study data, with a pragmatic choice of data sources, their perspectives may be gauged through the use of interviews, observation and surveys (see Appendices A, B and F).

The Researcher participates as an observer, who may also participate to a limited degree, and has experience in the context of the study, thus bringing some depth of understanding to the context. Trust between the Researcher and participant is essential. The Researcher interacted with the participants across a period of time and in different situations. There were observations, discussions and interviews that occurred throughout the study in a manner that flowed in concert with the situation and the events at the time. It was important that the Researcher did not intrude on, but rather blended in with the regular routines and expectations of the school and classroom. The Researcher’s past experience also contributed to the understanding of the situations and context and is described below.

3.2 The Researcher

The Researcher participated in primary schools for 26 years as either a teacher, or Deputy Principal and had the privilege of participating in the many facets of school life as is expected of one who is employed in
education. These included teaching and learning, assessment, professional
development, program writing, classroom management, parent meetings,
leadership roles and much more. Curriculum changes have occurred
several times in the last 26 years. The Researcher attempted to implement
new curriculum and trained other teachers in the use of a new curriculum.
Additionally, there were experiences with the classroom side of education as
well as the administration side of education. These experiences placed the
Researcher in a good position to be able to interpret the happenings within
and around school life.

Each of the case schools was considered by their system authority to be
typical schools in the region and were known to the Researcher prior to the
study through university connections. The State and Independent Schools
were schools the Researcher had previously visited to observe students
practicing and then to discuss progress with their mentors. The Catholic
School partnered with the Researcher during a university courses so that
pre service students could work with their children in a Science activity.
Personal relationships with these schools and the teachers had developed,
so trust was already being built. The Researcher observations and
discussions in the case schools were valuable, as it enabled interpretation
the situations to develop a clearer understanding of the processes the
schools and teachers decided to follow.

Thus, the method or approach chosen was the case study approach.

3.3 Case Study Research/ Criteria for Case Study
A case study approach was chosen for the ability to discover particular
detailed information, which enabled a thorough description of people and
experiences within a specific location (Denzin & Lincoln, 2011). Initially, the
case or cases must be identified and boundaries set around what is to be
studied so a comprehensive understanding of the case(s) can be determined.
Olson (Merriam, 1998, pp. 30-31) identified three main aspects of case
studies: particularistic, descriptive and heuristic.
Particularistic includes suggestions as to what to do or what not to do in a similar situation. Descriptive is the ability to illustrate the complexities of a situation and the fact that many factors contributed to it. This would include information from a variety of sources. Heuristic explains reasons for a problem including the background and why the innovation failed or worked. It may also evaluate, summarize and conclude, increasing its ability to be applicable.

Case studies, therefore, have the potential to draw in valuable information from particular situations that are transferable to other situations. According to Merriam (1998), the knowledge gained from case studies is more concrete than abstract. It is more contextual and derived from lived experiences. Case studies are further developed by reader interpretation, as the reader brings their own knowledge and experience. Case studies also are more based on a particular population that the knowledge is referenced to (p. 31-32).

Case study research may be conducted individually or as multiple case studies. This research study has investigated three case study schools and three case study teachers from each school. This represents a nested-case studies design (Yin, 2015) and was considered a suitable methodological strategy. Yin (2014) described holistic or embedded case studies as representing a form of case study design, which can exist with either single- or multiple-case studies. In the present study there were three schools as the major cases and the teachers were the embedded components. The rationale for case selections is described below. Employing a case study approach allowed the Researcher to spend time at the sites and personally interact with the school, its procedures and its staff. This was particularly useful when examining the programs, policy and procedures operating within each school context. Observations and artefacts constitute a large part of the case studies (Denzin & Lincoln, 2011). It is important to select the cases to be studied carefully and there must be a set of criteria that helps to establish the credibility and reliability of the information gathered.
3.3.1 Case Study Procedures

The purposive sample of cases was carefully considered against the research questions that shaped the direction of the project. The schools needed to be within the study region for repeated access throughout the semester and the following year. It was also important that the schools be the schools that I had a working relationship with, to assist depth of understandings of school procedures and policy. Another advantage was the established trust I already had with many of the staff. It allowed observations and discussions to be more open with the classroom teachers.

There are three main types of schools in Queensland. They are State or Government Schools, Independent Schools and Catholic Education Commission Schools. It was decided that one of each that was considered typical for the chosen region, would be a case school so there could be a diversity of data sources and potential for some comparison among these three types of schools.

While there was still diversity among state schools due to student numbers, school environment, parents and communities, the chosen state school had essential commonalities with other state schools in the region. These included: teachers with a range of science backgrounds but many with very little current science professional development, some experience with the Primary Connections Units, implementation of the new science curriculum in the form of Curriculum into the Classroom (C2C) and involvement with a Science Spark Teacher.

The Independent School and Catholic School also had teachers with a range of science backgrounds but due to internal professional development and the ability to create their own units of work and to purchase programs as needed meant there could be great diversity between Independent schools and between Catholic schools depending upon the direction of the leadership. Therefore, the teachers’ backgrounds, the diversity and the range of choice for these schools make them typical.
Each of these types of schools was impacted in some way with the move to the new *Australian Curriculum*. In order to obtain information about the procedures operating in the schools, it was necessary to look closely at the classrooms. Since most of the State schools were receiving science professional development funded by the state in the form of *Science Spark Teachers* for Years 4-7 (if they opted for it), it was decided to obtain volunteers from those year levels first. All teachers in the case schools voluntarily chose to participate. However, sustained encouragement was given to all teachers in the schools to participate. It was understood that teachers who are reluctant to teach Science would be unlikely to volunteer. This means the sample of teachers may have an inbuilt bias. The range of ages and experiences of the volunteer teachers was similar across the three schools. Schools in the region have a number of teachers with several years’ experience and many are nearing retirement. According to DET, National Teaching Workforce Dataset (Australian Government, 2014) for Australia reported that 75% of teachers are female, the median age is 44 with the majority of teachers between 25 and 60 years of age. The majority (75%) have completed one degree for teacher registration. The volunteer teachers for this study were similar to the general description of teachers in Australia and therefore can be viewed as a typical representation of teachers in the region. Teachers in their first year of teaching were not chosen for individual cases due to their lack of experience with the previous Science curriculum and school procedures.

### 3.3.2 Case Study Protocol

Each school was contacted and approached in a personal manner. Principals were met to discuss the project and to extend a personal invitation to participate. A timeline was established with all the necessary meeting dates arranged for the school level information. This included staff meetings and staff survey time and associated procedures. Surveys were explained and handed out in hard copy form during a staff meeting. A specific request for volunteer full-time teachers in Years 4-7 was sought at that time since the professional development provided by the state school
system targeted Years 4-7 teachers. They were asked to add their email address to the bottom of the form, and if interested to be contacted at a later date to begin the individual case studies. There were three volunteers for the State and Independent Schools and two for the Catholic School. One of the Catholic school volunteers had a part-time teaching position and suggested her partner teacher as the third volunteer. The partner was new to teaching Year 5 and declined participation. These eight volunteers became the individual case studies. It is common in primary schools to have teachers with strengths in differing subject areas. It is also understood that the volunteers may have had a propensity towards science and therefore may have more confidence to teach science than others in their schools. The lack of other volunteers may have been due to the required classroom observations and having strengths in subjects other than science.

When each volunteers’ background in science, number of years teaching, amount of professional development in science and responses to the surveys were compared with other teachers in their school, they appeared to be a typical sample of volunteers for their school (see Appendix J and Tables 12,13,14).

3.3.3 Limitations of Case Study Research

While the case study approach offers a rich and holistic account of a phenomenon, there are limitations. Some of the limitations of using case study approach include time at the case sites, the inability to predict future behaviour of the case, a possible insurmountable amount of data that requires time and cost to sift through and the number of school cases and teacher cases involved in the study.

The amount of time at the sites was established in advance through a working calendar. Case study approach is highly descriptive and is meant to describe and explain the processes and the phenomena; so it was made clear from the outset what the objectives were, rather than to attempt to predict the future through a, ‘If this happens, then this would occur’ philosophy. Case studies have the potential to collect large amounts of
data in the form of documents, interviews, observations, conversations, emails, and so forth. That would require a tremendous amount of time to transcribe and make meaning of the data. The researcher’s lack of experience could have been an issue with understanding the contexts, except that the Researcher spent 30 years in primary schools and university education; and thus had developed understanding of how schools operate and the history of curriculum and teaching. The Researcher felt able to understand what school personnel said, what they meant and what they were doing.

Keeping the school cases to three meant being able to manage it more effectively and to achieve the depth of analysis since there was only one Researcher. Therefore meeting with each person involved in the study multiple times occurred, as well as completing classroom observations, spending time in the staff room with teachers, keeping field notes and collecting documents from each school, all over two school terms (half a school year).

3.4 Trustworthiness and Ethical Considerations

It is important that research is valid and the ethics of a project carefully managed. The project followed the requirements for ethics at the university and was approved with the ethics code: S/12/438. The manner in which volunteers were chosen, data collected and analysed, the storage of data and the cross checking for validity and accuracy of information was adhered to as required with ethics protocol. In qualitative research, Merriam (2002, p. 15) suggested: “it is the rich, thick descriptions, the words (not numbers) that persuade the reader of the trustworthiness of the findings”. There are four criteria that Guba (1981) believed should be considered when seeking trustworthiness in a research study. These were elaborated by Shenton (2004) below.

3.4.1 Trustworthiness Criteria

Qualitative inquiry from the naturalist point of view is well described by Shenton (2004). He followed Guba’s (1981) criteria and added examples of
processes to follow to obtain trustworthiness of data. The criteria are: *credibility, transferability, dependability and confirmability.*

*Credibility* is the ability to demonstrate internal validity, in other words, “to ensure that their study measures or tests what is actually intended” (p. 64). This study demonstrates credibility through the following techniques suggested by Shenton (2004): following well established research methods (interviews, surveys, observations), being familiar with the culture of the participating organisations, triangulation of data, iterative questioning to uncover inconsistencies in statements, debriefing sessions with colleagues and supervisors, involving other researchers with qualifications and experience, and involving the participants in checking that the discourse being analysed is true and accurate.

*Transferability* is the notion that the findings of a study can be applied to other situations. Often qualitative research is specific to small numbers of organisations and small numbers of people; so it can be difficult to see the ability to transfer to other situations. However, while a case may be unique, it may also be an example of a larger or broader group. This study uses a structured sample of schools and teachers within a geographic region. It is possible that these schools and teachers are a representation of the larger group of schools and teachers within that same region. Details about the schools, participants, the types and methods of data collection are provided so that duplication of the study may be possible with other schools and participants.

*Dependability* refers to a clear understanding of the processes for data gathering including what was planned and how it was executed. The processes followed were duplicated with each school and documented on a calendar. It was important to follow the same steps for each location and with each participant. A document was created to ensure consistency of procedure through the order of events, repeated at each site.

*Confirmability* is concerned with the objectivity of the study and the Researcher. It is important for the Researcher to understand her own predispositions and follow steps such as triangulation to ensure the findings
reflect the experiences and ideas of the participants rather than the Researcher's preferences. This study drew information and quotes from the participants’ interviews and the observations and the surveys. These data sources were checked against each other to obtain a comprehensive representation of each school.

3.5 Trustworthiness and Methodological Triangulation

Denzin (1970) distinguished among four forms of triangulation:

1) Data triangulation, which entails gathering data through several sampling strategies, so that slices of data at different times and social situations, as well as on a variety of people, are gathered.
2) Investigator triangulation, which refers to the use of more than one researcher in the field to gather and interpret data.
3) Theoretical triangulation, which refers to the use of more than one theoretical position in interpreting data.
4) Methodological triangulation, which refers to the use of more than one method for gathering data. (p. 2)

In the present study methodological triangulation was applied.

Methodological triangulation includes using multiple sources of data (Yin, 2015). These sources of data identify different ways to consider information and can be used to clarify meaning of the phenomena. Information from various data sources such as interviews, written records or reports, policy and curriculum documents and observations of behaviour can be used to converge information to build a more holistic view. Case study findings are, “likely to be more convincing and accurate if based on several different sources of information” (Yin, 2014, p 116). The problem of validity can be overcome more effectively with evidence from multiple sources.

In an interpretive study, it is common to seek understanding of the world in which we live. To do this three aspects of a person’s life are considered. These are: personal, cultural and historical. Data gathered around these aspects will aid in interpreting and making sense of the meanings others have made of their world (Creswell, 2009; Yin, 2014).
This study has analysed data from teachers, principals and school Heads of Curriculum. The data sources include audiotaped pre-interviews, surveys, observations, and audiotaped post interviews. Written artefacts supplied by the school were also used. These items included planning documents, curriculum statements and guides and school policy documents and they contributed to the methodological triangulation. For example, after themes and coding were completed with all data collected, the case teacher interviews and principal interviews from a school were compared with the classroom observations from that school to identify and confirm key themes and anomalies. These were then compared with the school survey data. This was repeated for each school. Finally, schools were compared with each other (Appendices H and I).

3.6 Perspective of the Role of Researcher
An interpretivist view encourages the Researcher’s knowledge and perspective to influence the research process since the Researcher will have insights into the phenomena under study. This close association will influence the research questions through to the interpretations drawn from the data. The researcher’s role in case studies involving classroom observations was important: my presence in the room might have changed the nature of the transactions to some degree, even if the assumed role is non-participating observer. The Researcher’s role for this study, that was considered most appropriate, was as a participant observer (Creswell, 2012), which allowed the Researcher to readily interact with teachers and students prior to, during, and after, the lessons. That is, the Researcher met with all teachers the semester prior to have a conversation about their next science unit to discover their topics, their approach to teaching it, their background knowledge with the topics, previous teaching experience with the topics and support provided in the school to assist in science. The Researcher visited each school a minimum of 16 times to observe planning, listen to conversations, get to know the school staff, ask questions, conduct the surveys, observe teaching and interview the volunteers. This time spent in the schools also minimised the notion of a visiting expert from a university
making judgements about the teaching, and maximised opportunities for the Researcher to be a resource for the teacher, if desired. One of the boundaries set by the researcher was that the Researcher would not initiate any advice regarding science teaching. However, the Researcher let them know she would be happy to assist in any way they would like to request. Any such requests for assistance from the teacher could provide windows into understanding professional development needs in implementing the curriculum.

The Researcher attempted to view the cases through their experiential lens, shaped by the interpretivist paradigm, and yet resist potential sources of bias. Any biases demonstrated need to be identified and made known to readers of the research. For this study, the Researcher chose the case study schools in the manner described, initiated all meetings, presented the surveys and conducted all interviews and observations. This could raise credibility issues. As mentioned previously, the Researcher utilised the expert opinion of her supervisors when evaluating the data. A reputable transcribing service transcribed interviews and observations. The transcriptions were given to all staff who participated in the interviews and observations, for their endorsement of accuracy. In addition, two outside people were sought to assist with the interpretation of data. One was an experienced NVivo user and trainer who was active in research projects and research grants. She worked in the university research office and was an NVivo consultant for research students. The other was a university researcher who was a statistician. He assisted in the data analysis through SPSS. As an outsider to the study, he provided his view of the analysis. Both people contributed to the analysis and brought another point of view to the results. All this added to the depth and validity of the analysis.

3.7 Context

This study involved three schools and nine teachers who were introduced to the new Australian Curriculum, as it was released for use in 2012 school year (Refer to the Literature Review section for details of the curriculum rollout.). In January of 2013, the schools and teachers were expected to be
teaching with the new *Australian Curriculum*. This included curriculum in Reading, Writing, Mathematics, History and Science. These schools and teachers had no connection with the creation or trialling of the curriculum documents. Each school and teacher encountered the new curriculum in 2012 and needed to plan how to gain understanding of the curriculum documents and their expectations. This study was planned and conducted over a semester in the second half of the first year of implementation. The Catholic School, due to staffing issues and the inability for me to access the teachers at the end of 2012, moved their participation time to the first school term of the second year of implementation. At this point most teaching and been completed and the school was preparing to close.

Two levels of nested or embedded case studies, referred to as levels, are part of the design of this study (Yin, 2014). The three school case studies are considered the first level of cases. The teacher volunteers, who are the second level of cases, make up the embedded cases within each school case. These cases are described below.

### 3.7.1 School Cases/First Level Cases

This study included one State Government School, one Independent School and one Catholic School. These are the first level cases. Each of these schools was expected to embrace the new *Australian Curriculum: Science*; but each has their own system regulations and processes to follow which could have made the manner in which the schools decided to implement the new curriculum vary. Each school was considered typical for the region based upon data about teachers in Australia from DET National Teaching Workforce Dataset (2014) and demographic data from the *My School* website. Further details are provided below.

### 3.7.2 State Government School

The chosen State School for this study was located in a regional city of Queensland. The State School had 14 teachers, a principal, and a Head of

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8 My School is a website that provides information about schools in Australia.
Curriculum. There were approximately 250 students from Foundation to Year Seven\(^9\). There was a large transient population and several families (about 7%) from other countries who spoke English as a second language. There were as many as fourteen countries of origin represented at this school. A small number of students were Indigenous Australians. Many of the families lived in nearby houses and apartments, with the principal identifying these families (85%) as between low and middle-income families. There were ten full time teachers, most of whom were very experienced with between 10 to 35 years of teaching; only one teacher was a first year teacher. This primary school’s principal was in his second year at the school and the Head of Curriculum had been at the school for 4 years. It is common in this education region for principals and curriculum leaders to move between schools. The transient nature and cultural mix of students and their families are also common in the region’s state schools. This school was not included on the list of Top Primary Schools in Queensland for English and Mathematics (Better Education, 2008).

### 3.7.3 Independent School

The chosen Independent School was larger, with about 800 students over two campuses. The Primary section of the school (Foundation to Year 6) had approximately 400 students. There were fourteen full time staff with ten of them having between 10 and 30 years teaching experience; the remaining four had 4 to 5 years teaching experience. There was a principal and a deputy principal who also acted as the curriculum head. Both the Principal and the Deputy had worked in the school for a number of years. This Independent School is included on the list of Top Primary Schools in Queensland for its Year 5 academic performance in English and Mathematics (Better Education, 2008). The Independent School students were primarily from local suburban areas with families (90%) in the middle to upper income bracket. However, many students were bussed to the

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\(^9\) At the time of the study, Queensland primary (elementary) schools typically had a Preparatory Year for 4 year-olds, followed by Years 1 to 7. Year 7 will be transitioned to high school over the next few years, though some schools have already completed the transition.
school from locations up to an hour away. Approximately 1% spoke a language other than English and approximately 50 were born in another country; only one student was indigenous. Similar descriptions can be found for many other Independent schools in this education region.

3.7.4 Catholic School

The chosen Catholic School had a student population of about 680 students in Foundation to Year 7, with 3 classes of each year level. There were 28 full time teachers, a majority of them were experienced teachers. This primary school had a principal and a Curriculum Head. The Catholic high school is located on the same campus. This Catholic School is included on the list of Top Primary Schools in Queensland for its Year 5 academic performance in English and Mathematics (Better Education, 2008). The families live within the surrounding suburbs and are considered to be primarily (90%) middle to upper income earners. About 7% of the students are from various ethnic backgrounds and approximately 1.5% had an indigenous background. The SES and academic performance were considered to be typical of this region’s Catholic Schools.

3.7.5 Participant Cases/Second Level Cases

In order to examine change processes from a previous curriculum to a new national curriculum, this study sought teacher participants from Years 4-7, who had experience teaching the previous (State) curriculum and had participated in school planning for teaching and learning. The new Australian Curriculum: Science, with its associated changes in content, teaching strategies and pedagogy, required professional development. The Queensland government made professional development available in the form of Science Spark teachers for state school teachers in Years 4-7, just prior to implementation of the new Australian Curriculum: Science. For this reason, teachers in Years 4-7 were the preferred teachers. The volunteers were teachers who may have felt more comfortable with the subject of science, however as self-expressed they had plenty to learn. Volunteers who
felt more confident and knowledgeable due to the required classroom observations were to be expected. These teachers are the second level cases.

3.7.5.1 State School Teachers

Mrs L

Mrs L was an experienced classroom teacher in her 25th year of teaching. She was the teacher for a Year 5 class and had previously taught in Years 1 through 6. Mrs L studied Biology in high school and had received Science Sparks professional development.

Mrs S

Mrs S was an experienced classroom teacher in her tenth year of teaching. She was teaching a Year 4 class and had experience teaching Years 2 to 5. Mrs S studied Biology in high school and studied Biology, Chemistry, Physics, Earth and Space Science at university through teacher education courses. She also participated in the recent Science Spark professional development.

Mr B

Mr B was a classroom teacher with 34 years’ experience. He had previously taught in Years 3 and 4. Mr B studied Biology and Chemistry in high school and participated in the Science Sparks professional development. At the time of the study he was the Year 6/7 combination class teacher.

3.7.5.2 Independent School Teachers

Mr D

Mr D was a classroom teacher with eleven years’ experience teaching students in years 3, 4, 6, 8, 9, 10, 11 and 12. Mr D studied high school physics and one General Science course during university studies. He was the Year 4 teacher during this study.

Mrs N

Mrs N had eleven years’ experience with Years foundation, one and two. She studied Chemistry and Physics in high school. Mrs N also studied Biology
and General Science offered in education during university studies. She was the year one teacher during this study. While the focus was on Years 4-7 teachers, she volunteered when others did not volunteer to participate. The Researcher believed her view and experiences would still be valuable.

Mrs T

Mrs T was an experienced teacher of 30 years. She was teaching the Year 6 class but has also taught Years 1-8, 10, 11 and 12. Her high school teaching was in the area of sociology and religion. Mrs T studied Biology in High School and General Science during university studies.

3.7.5.3 Catholic School Teachers

Mr C

Mr C had 31 years’ experience teaching in Years 3-7. He studied Chemistry and Physics during high school. He also studied four university science courses: Biology, Chemistry, Physics and Earth and Space. He was the Year 7 teacher during this study.

Mrs M

Mrs M had six years’ experience teaching Year 5. She studied one General Science and one Environmental Science course while at university. Mrs M was the technology leader in the school and the part time Year 5 teacher in this study.

Mrs A

Mrs A was a Year 5 teacher with 26 years’ experience. She previously taught Years 1, 2 and 3. Mrs A was placed in Year 5 for the first time in 26 years. She was not confident to teach Science with someone watching her so she withdrew from the project.

3.7.6 Procedures

3.7.6.1 Phase 1

This phase consisted of meeting with the principal during Term 3 to explain and plan the project. Each meeting held with the staff to introduce the
project and complete surveys was placed on the school calendar. The Researcher obtained the school calendar for reference to special events, such as sports days, for planning purposes. The Researcher was invited to socialise in the staff room and have lunch with staff upon each visit.

3.7.6.2 Phase 2

This was the school engagement phase. During this phase meetings were held 2-3 weeks before the end of term 3 with the teachers to provide project information, conduct surveys and elicit teacher volunteers. Teachers were provided with an information letter (Appendix D and consent forms (Appendix E). Those interested in participating provided their contact information. When queried, the Principal, Deputy Principal or the Head of Curriculum thought that the volunteers were representative of the staff in general; and, in respect to Science teaching, and that they had no greater Science background than other teachers in their school\(^\text{10}\). The Science planning meetings were organised as informal meetings and mostly observational in nature. The Researcher observed the teachers while planning the Science units for the following term and asked questions when needed for clarification. At this time, the Researcher organised to observe two Science lessons. Case study teachers were reminded that the Researcher was willing to participate in the Science lesson in any capacity required by the teacher. Within two weeks of the final observation, the Researcher conducted an interview (Appendix B).

3.7.6.3 Phase 3

This phase occurred in Term 3 of the following school year. The purpose was to re-administer the survey to all teachers to see how the implementation of the new *Australian Curriculum: Science* was perceived by teachers to be proceeding in each school and in their classroom. At this time, the Researcher took the opportunity to meet with the teachers to

\(^{10}\) The leadership in these schools assumed that the volunteer teachers were representative of their school’s teaching staff. It is common for primary school teachers to be diverse in knowledge, skills and backgrounds.
confirm the transcriptions from the earlier observations and interviews. A meeting with the Principal or Head of Curriculum was also conducted to present an overview of the findings about their school at that point in time.

Table 1 Abbreviated Research Timeline (2012-2013)

<table>
<thead>
<tr>
<th>Date</th>
<th>What</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.7.6.4</td>
<td>Phase 1</td>
</tr>
<tr>
<td>July 10-30</td>
<td>Contact schools about participation in project</td>
</tr>
<tr>
<td></td>
<td>Meet with Principals</td>
</tr>
<tr>
<td></td>
<td>Set initial meeting and survey dates</td>
</tr>
<tr>
<td>3.7.6.5</td>
<td>Phase 2</td>
</tr>
<tr>
<td>Sept 5-15</td>
<td>Attend staff meetings at schools</td>
</tr>
<tr>
<td></td>
<td>Visit with teachers in staff room during lunches</td>
</tr>
<tr>
<td></td>
<td>Pre survey</td>
</tr>
<tr>
<td>Sept 10-20</td>
<td>Contact the volunteers to set up first meeting</td>
</tr>
<tr>
<td></td>
<td>Organise future meetings and observations</td>
</tr>
<tr>
<td>October</td>
<td>Meetings and observations at schools</td>
</tr>
<tr>
<td>November</td>
<td>Conduct final interviews</td>
</tr>
<tr>
<td>3.7.6.6</td>
<td>Phase 3</td>
</tr>
<tr>
<td>February</td>
<td>Conduct final surveys</td>
</tr>
<tr>
<td></td>
<td>Confirm accuracy of interview and observation transcripts</td>
</tr>
<tr>
<td></td>
<td>Meeting with Principal or Deputy</td>
</tr>
<tr>
<td>February</td>
<td>Conduct final interview with Catholic school</td>
</tr>
</tbody>
</table>

3.8 Data Sources
A number of data sources contributed to shaping the descriptions of actions and processes in the schools and classrooms of the three Queensland schools. The data sources included curriculum policy and procedural documents, surveys, interviews, observations and field notes (samples can be found in the Appendix). These are described below.

3.8.1 School Policy and Planning Documents
A number of national and state policy documents, mandatory curriculum, curriculum implementation guides and student outcome evaluation procedures were in force in the field of Science education in primary schools (e.g., TIMMS and the National Assessment Program – Science Literacy\(^\text{11}\)). As described in Chapter 2, these included policy and curriculum documents from the Australian Curriculum Assessment and Reporting Authority

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\(^{11}\) National Assessment Program – Science Literacy (NAP-SL) is a sample assessment that began in 2003, administered every three years and focusses on Year 6 students. It tests their ability to apply a broad range of conceptual understandings of science to make sense of the world and their understanding of natural phenomena.
(ACARA) and Education Queensland. These are the two main bodies who regulate the teaching and learning expectations within Queensland. These documents were reviewed and the expectations, actions, and priorities, of schools and teachers in the implementation and teaching of the new Australian Curriculum: Science in primary schools identified.

3.8.2 Survey

The survey (Appendix A) questions originated from Tisher and Power (1975) in a study of educational values, perceptions and lessons while using a new curriculum. The survey was later adapted by Appleton (1982) for a project that evaluated science curriculum. It was further adapted for the research purposes of this study based on the current literature review. Appleton used the semantic differential scale to identify (student) teachers’ feelings about their own teaching of science. It was identified by rotated factor analysis, and was the first major factor identified in the analysis. It had a Cronbach alpha value of 0.90, which is considered high, suggesting appropriate internal validity. As the validity of the survey had been largely established in earlier studies, pilot testing was not undertaken.

The survey was adapted around the key concepts for curriculum reform and teaching Science identified in the Literature Review and the objectives of the Australian Curriculum: Science. It was administered before, and one year after, the implementation of the new Curriculum and gathered data directly from the school principal, the curriculum head, and all the teachers in the three schools. The survey was distributed during a staff meeting and collected during the meeting; all staff who were in attendance at school completed the survey. The schools commonly make staffing changes each year. Due to some re-allocation of teaching responsibilities and staff the numbers for the Pre and Post surveys varied. For example, some teachers who taught in Prep and Year One believed the Science curriculum changes did not affect them and therefore, chose not to complete the survey. In addition, some questions were left unanswered resulting in a small proportion of missing data for specific questions. However, the survey
results only include those teachers who have worked at the school during
the entire study. Further details are provided in the Findings Chapters.

The survey elicited information about teachers’ professional experience (age,
number of years teaching and the Year levels taught), their initial teacher
preparation processes, any subsequent in-service development, Science
knowledge, Science teaching beliefs and the Science teaching procedures
they used in their classrooms and may have been taught to use. These data
at the school level were to be used to form a broader context for the
interpretation of the interview and observational data, and to assist in the
development of the case studies.

3.8.3 Interviews

An understanding of school processes used to implement the new *Australian
Curriculum* was obtained through semi-structured audiotaped interviews
with the principal and curriculum head. Semi-structured audiotaped
interviews (Yin, 2014, 2015; Denzin & Lincoln, 2011) were also used as
conversation initiators with the volunteer teachers to help expand on their
views and to clarify classroom observations. This allowed the Researcher to
expand on comments when needed. These interviews aligned with the
research and survey questions and contributed to part of the triangulation
of data. Interviews (Appendix B) lasted approximately 30-45 minutes and
were fully transcribed for analysis.

3.8.4 Observations

The participating teachers were observed while they planned and taught two
Science lessons based on the *Australian Curriculum: Science* and their
chosen support materials. The observations helped understanding the
transition from curriculum to school planning processes and finally, to
classroom practices. Each lesson was about an hour long.

3.8.5 Field notes

Field notes were taken of the two lessons observed with each teacher; and a
number of artefacts (e.g., photographs, class notes, worksheets) were
collected to provide examples of materials or processes used in the school and by teachers. The field notes recorded the observation details, thus documenting the teaching strategies, resources and curriculum used by the school and teachers. The amount of time spent on Science, the methods of preparing for Science and how teachers sought assistance were also noted. Upon conclusion of each lesson, the teacher and the Researcher discussed the lesson objectives and outcomes and ideas for the next lesson. These notes (Appendix F) were handwritten and then typed later in the day. The field notes sought to record information that would inform the Research Questions (see page 94).

### 3.9 Data Analysis and Interpretation

#### 3.9.1 Survey

The surveys were predominantly Likert-scaled with one to five ranks, with five being a high positive response. However, the confidence scale was a semantic differential, which uses opposite terms at either end of the scale, with a seven-point scale. The opposites are mixed to avoid the automatic response of ticking everything on one side. The survey would provide insight into the schools’ and teachers’ planning implementation processes for the new *Australian Curriculum: Science*. The surveys were aligned with two main Research Questions.
Table 2  Alignment of Survey and Research Questions

<table>
<thead>
<tr>
<th>Survey Section</th>
<th>Research Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section A: Demographics, Science background and Science PD</td>
<td>RQ 2 To what extent do the teachers feel confident to teach Science and feel prepared to implement the new <em>Australian Curriculum: Science</em> (including initial training and subsequent professional development)?</td>
</tr>
<tr>
<td>Section B: Science Curriculum (five-point Likert scale)</td>
<td>RQ 2 To what extent do the teachers feel confident to teach Science and feel prepared to implement the new <em>Australian Curriculum: Science</em> (including initial training and subsequent professional development)?</td>
</tr>
<tr>
<td>Section C: Confidence (Seven-point Semantic differential used)</td>
<td>RQ 2 To what extent do the teachers feel confident to teach Science and feel prepared to implement the new <em>Australian Curriculum: Science</em> (including initial training and subsequent professional development)?</td>
</tr>
<tr>
<td>Section D: Beliefs about Teaching (five-point Likert scale)</td>
<td>RQ 3 Which beliefs about teaching Science do the teachers hold, how frequently do they teach Science, and what teaching strategies do they commonly use when teaching the new Science curriculum?</td>
</tr>
<tr>
<td>Section E: Science Teaching Practice (five-point Likert scale)</td>
<td>RQ 3 Which beliefs about teaching Science do the teachers hold, how frequently do they teach Science, and what teaching strategies do they commonly use when teaching the new Science curriculum?</td>
</tr>
</tbody>
</table>
It also revealed information about teachers’ Science background and beliefs, and their Science teaching procedures. The survey data were coded and placed into SPSS for analysis of the distribution of item response patterns and any pre-post variations. This began with frequency tests to provide general information and mean ranks. The data were also analysed by an outside person who repeated the initial tests and continued with further tests. Tests for difference between schools were made with the Kruskal-Wallis Test (Appendix C). All tests were repeated with a final post survey to determine if there were any significant changes or trends over the year. The same survey was used for the pre and post surveys.

3.9.2 Interviews

The interviews revealed the case study teacher reflections on the curriculum and planning processes. They gave insight into teachers’ thoughts about the new curriculum and how they were handling the implementation processes. These interviews held with the school principals and/or Curriculum leaders and the participating teachers, lasted approximately 30-45 minutes. The interviews were then fully transcribed by a professional transcribing company and were provided to each participant to view for correctness. They were able to respond with changes if needed through email. These transcripts were then read multiple times to gain a total impression. Then an examination to identify meaningful chunks or units of information about the planning and implementation practises of the school and the teachers occurred. These units, given descriptive codes (Miles, Huberman, & Saldaña, 2013) with the use of NVivo were abstracted to combine by school, the practices employed (see Appendix H, I). These same units were later used to compare similarities and differences among schools through matrices. Two other people outside the study who were familiar with the use of NVivo assisted in checking coding of units and checking meaning with random samples from each school. The analysis was mostly interpretive and concerned with identifying meaning behind the data. All data for the first level and second level cases were themed and triangulated through the use of NVivo, in order to obtain a clear and consistent view of
the manner in which the schools and participating teachers prepared to implement, and then actually implemented, the new *Australian Curriculum: Science* (Appendices H and I). Several themes emerged for each school. Specific events, procedures and quotes were identified, which provided evidence for the themes.

### 3.9.3 Observations

Observations consisted of initial planning observations and two Science lesson observations with each case study teacher. The planning observations occurred in the term prior to the lesson observations. These were audio-recorded as teachers explained how they planned for Science, what they used to plan with and what they might need to consider when planning for Science. The classroom observations were organised to occur in the following term. One each week for two weeks was conducted. If needed, observations were rescheduled to suit changes in the class schedule. Observations were for the entire Science lesson and were recorded in detail by topics, site and teacher. Subsequently, these observations were transcribed and provided to the teachers for acceptance of accuracy. These transcribed observations became what are referred to as field notes. The experiential descriptions of events within the natural setting helped to heighten the awareness and understanding of others’ actual experiences. As knowledge is socially constructed, the descriptions of case study experiences and case study contexts assist researchers to construct knowledge (Stake, 2013).

Validity was checked through triangulation of the data; checking multiple perceptions and data points to clarify meaning (Appendices H, I). A simple discourse analysis was applied to the written and spoken data as it enabled the Researcher to understand the conditions behind a specific issue and gain a view from a different perspective, in order to develop a more comprehensive view of an issue. Spoken and written discourses are common ways of communicating and producing and transmitting meaning in our society (Schiffrin, Tannen, & Hamilton, 2008). When persons are communicating, it is understood that there is some shared meaning of the
context. Without the shared understanding, misinterpretation may ensue. It is important that the Researcher has substantial understanding of the contexts and systems in which the case studies reside. While there is always room for misinterpretation while communicating, the Researcher’s understanding of the teaching, curriculum and school contexts enabled understanding of issues. It is understood that each school and classroom is unique; and time observing to develop a clear understanding of the uniqueness of each is essential.

All data collected were coded, so links could be made to changes over time. Data reduction occurred by inductively identifying common themes, topics, situations, contexts, statements, and the like, and categorising these commonalities (Miles et al., 2013). All names and schools remained anonymous in published materials. Pseudonyms were used when needed.
4 FINDINGS

4.1 Overview
This chapter presents the results from the surveys, interviews, and classroom observations at the three case study schools. The data are organised under the respective research questions, in conjunction with Bronfenbrenner’s bioecological systems (Bronfenbrenner, 1979, 1999), as a theoretical guide; though some degree of overlap among systems is inevitable. The details surrounding the levels of the Bronfenbrenner systems analysis have been described in previous chapters.

This chapter examines the data relevant to the overall research question:

In what ways does a new national *Australian Curriculum: Science* provide impetus, at school and teacher levels, for Science curriculum change and for improving Science teaching, and to what extent does such impetus influence changes in practice?

The purpose of this chapter is to explore at each level-national government, state government, and among schools and teachers, the expected and perceived processes followed for implementation of the new national *Australian Curriculum: Science*. Details surrounding the creation of the national curriculum were established in Chapter 2. The following section details processes in the State of Queensland, which respond to national government expectations. These sections detail the schools’ processes and views, and teachers’ processes and views of implementation of the new national *Australian Curriculum: Science*. Information is presented from the three selected case study primary schools - a State government school, an Independent School and finally, a Catholic School.

4.2 Bronfenbrenners’s Macro and Exosystems
Large and diverse contextual systems such as cultural beliefs and ideologies, and education systems and policies frame the Science curriculum expectations and implementation. These are the broader systems that establish overarching policies and the traditions and expectations that determine schools’ priorities and direction. These beliefs,
policies and priorities have been established systemically and externally and framed the context for this study. They are further described below.

4.2.1 The Australian Curriculum

4.2.1.1 District Level Beliefs, Ideologies and Policies

Events at state and federal levels influence the decisions at the school level. These events have shaped the context of the implementation processes and decisions within the case study schools and their classrooms. For example, The Melbourne Declaration on Educational Goals for Young Australians (Barr et al., 2008) inspired the Australian Curriculum. It sought to see all students obtain high quality schooling experiences. Therefore the new Australian Curriculum included essential skills perceived as valuable for twenty-first century learners. According to the Curriculum Design Paper, there is a “focus on deep knowledge, understanding, skills and values that will enable advanced learning and an ability to create new ideas and translate them into practical applications” (Australian Curriculum Assessment and Reporting Authority, 2013, p. 8). The curriculum aimed to be as rigorous.

In addition, the creation of the Australian Curriculum, Assessment and Reporting Authority (ACARA) and their decision to work with state and territory education authorities to support the implementation of the Australian Curriculum (Australian Curriculum Assessment and Reporting Authority, 2013) meant changes in the nature of curriculum leadership and decision making procedures in the state of Queensland. The Queensland Studies Authority (QSA), now known as the Queensland Curriculum and Assessment Authority (QCAA), established an implementation timeline. In Queensland, 2011, the Foundation/Prep to Year 10 teachers of English (Reading and Writing), Mathematics and Science were to begin engagement with the new Australian Curriculum.

However, an additional aspect in the curriculum implementation process in Queensland was the creation of the Curriculum into the Classroom (C2C) documents that were delivered online to all state schools in Queensland.
State schools were advised these were pre-aligned units of work that were written ‘by teachers, for teachers’ and included very detailed lesson plans, assessment tasks and web links, YouTube videos, Scootle\textsuperscript{12} activities (a website with digital resources for teachers of Years F-10) and much more. This caused some confusion and frustration as communication about the purpose of the C2C caused some teachers to believe they were expected to use only the C2C documents in the implementation process. School interpretation of expectations from the state level indicated that the new curriculum documents (C2C) were aligned with the new Australian Curriculum and therefore needed to be carefully followed. Mrs L explained: “There was a curriculum coming out that we all had to follow. I think there was a breakdown [in communication] as some of the people thought that you had to follow everything and you had to do everything [in the curriculum] and I think people stressed about it.” This seems to be misinterpretation of system and curricular intentions, and is an example of communication loss between the top (exosystem) and the classroom (microsystem).

In 2012, after an initial viewing of the new Australian Curriculum (ACARA) materials, all schools in Queensland were to be completely transitioned to using the new Australian Curriculum for English, Mathematics and Science. All schools could access the ACARA website but only the state schools could access and choose to use the C2C materials for English, Mathematics and Science for the first several months. This included planning, teaching, assessing and reporting following the new curriculum standards. In addition, the national History curriculum was introduced for trialling. In 2013, schools were meant to be using the ACARA website or C2C materials for English, Mathematics, Science and History. In 2014, Geography, Health, Physical Education, Technology, The Arts and Languages were added to the list of new curriculum to begin teaching. This large-scale, top-down approach is a common way for government and district authorities to...

\textsuperscript{12} Scootle is a national digital learning repository with teacher access to more than 20,000 digital learning items.
instigate change they believe is needed; and in this case, regulated. However, in previous large scale curriculum reforms, variation in implementation practices were often found from site to site (Hamilton, McCaffrey, Stecher, Klein, Robyn & Bugliari, 2003). Thus, a top down approach combined with a swift implementation timeframe, was highly demanding and problematic for schools and teachers. It would require substantial support and professional development/learning opportunities in order to build school capacity (Fullan, 2007).

Curriculum changes

Initially, the curriculum changes seemed to be major ones for teachers, often because the terminology used had changed. For example, the science areas which were previously called: Science and Society, Earth and Beyond, Energy and Change, Life and Living, and Natural and Processed Materials no longer existed. In their place were more traditional names; Biological Sciences, Chemical Sciences, Earth and Space Sciences and Physical Sciences. The topics or content to teach remained relatively similar, however, they were structured differently. For example, Science and Society was mostly about the nature of science and still exists in the new curriculum, but under the topic: Human Endeavour. Human Endeavour is not a strand that is studied during a school term as previously, but is now embedded into each strand as a component of each of the main strands.

In addition, the previous curriculum did not use terms such as: investigations or inquiry. Rather, the outcome statements referred to students spending a majority of time in science processes such as: discussing, identifying, describing, collecting, comparing, examining, modelling, analysing and presenting information as separate entities. However, the combination of these in an appropriate sequence is considered to be the natural scientific processes, inquiry learning or investigations and should be familiar to teachers. The new curriculum has a component called: Inquiry Skills that describe the investigation process and is embedded into each science strand. Teachers are therefore, expected to teach the content of the strands through the Inquiry Skills while also
incorporating Human Endeavour components. Therefore, new language and terminology needed to be explained to teachers and professional development provided for them to understand how to reshape their teaching of science.

Another curriculum change was the placement of the science content. The previous curriculum did not have explicit content for each year level. Instead it had science concepts that could flow among three Year levels, and thus could be viewed and taught as conceptual development to meet the needs of students. In the new Science curriculum, specific science content is assigned to Year levels and some content that was once taught at lower, middle or upper primary school, was moved to other levels thus requiring teachers to teach content they had not taught before.

Teacher Support provided at District Level

The Queensland Studies Authority (QSA), as it was called at the time, understood that such a swift implementation plan would require some support for teachers, especially since their school time consisted of mostly face to face contact with students and very little time to become familiar with the new curriculum. The QSA developed a series of short online resources and professional development videos that focussed on developing teachers’ knowledge and understanding of the new curriculum structure and documents (Queensland Studies Authority, 2010).

However, the details of the implementation processes were to be “determined by state and territory and school authorities, taking into account the needs of their systems, schools and teachers”, so as to “present the curriculum to teachers in ways appropriate to their [own] contexts and are responsible for providing teaching and learning and assessment advice” (ACARA, 2014, p. 7). This decision to hand the implementation processes over to the schools themselves, indicated the developers “assume[d] that schools are best able to decide how to deliver the curriculum…” (ACARA, 2010, p. 11). Giving schools this autonomy meant they were expected to cater to the needs of their specific school community.
The details of the individual school implementation processes are outlined for each of the study schools in the following chapter.
5 STATE SCHOOL

5.1 Bronfenbrenner’s Mesosystem
The mesosystem is concerned with staff, peer, colleague and leadership profiles, interactions and expectations within a school setting, particularly around curricular issues. To provide an understanding of school context, a brief overview of the school is necessary. The main features of the school are described, followed by a condensed version of the school events leading towards implementation of the new curriculum.

This provided information in relation to the first research sub-question:

What school contextual factors do the school leaders see as being most relevant to making changes in the implementation of the Australian Curriculum: Science and in Science teaching?

5.1.1 The State Primary School: Pre Implementation
This regional state school of approximately 250 students was located near a city centre. It was central to main shops and transportation. In recent years, this school has become increasingly transient and multicultural in its enrolment, with declining numbers over the last several years. The surrounding region is growing and expanding with more schools being built in newer suburbs.

This state school still has many of the same staff who were teaching in the school ten years earlier. At the time of this study, there were nine full time teachers and four part-time teachers in a single-streamed school with two multi-age classrooms. It had a new Principal in 2010 and a part-time Head of Curriculum soon after the arrival of the Principal. According to the new Principal, the experienced staff of the school had not been challenged to make changes to their practice or to school procedures until he became their Principal. The teachers mostly taught the same year level for many years and often spent time in their own classrooms, planning and teaching in a manner that was very isolated from other teachers.
5.1.1.1 Concerns Identified and Addressed by the Principal

With state government pressure to lift NAPLAN test scores for schools across Queensland, the Principal instigated some professional development for the teaching staff. The school invested in the *First Steps* resource materials (Government of Western Australia, 2013) for enhancing literacy and mathematics teaching. These materials, according to the website for the Department of Education of Western Australia, helped teachers meet the needs of all students “with practical, accessible, classroom-tested teaching procedures and activities. The series will help teachers to diagnose, plan, implement and judge the effectiveness of the learning experiences they provide for students” (2013). During its gradual implementation, the Principal spent time observing teachers using processes from *First Steps*.

The Principal reported that he valued Science. After classroom walkthroughs and general observations, he noticed irregular Science teaching practice. Some teachers preferred a worksheet approach and others taught Science with reading comprehension worksheets and books that included a varied pedagogical approach. Some teachers taught Science when they could fit the subject in among other curriculum imperatives. With this inconsistency noted, he purchased the *Primary Connections* Science materials to help get Science teaching moving in a more appropriate direction. Although professional development is a key component of introducing *Primary Connections* into a classroom, at this early stage, none was provided. The Principal did not have the time and the Head of Curriculum did not have the Science knowledge to provide the necessary professional development. This was the first time this school and Head of Curriculum (HoC) had addressed the teaching of Science. According to the Head of Curriculum: “No one’s been working with anyone around Science [until now]. P.S. Science is irrelevant.”

Traditionally, the state school relied on most of its professional development coming through the regional education office. These opportunities usually involved a focus on literacy and numeracy. More recently, in 2010 when the Science Spark initiative began, the regional office allocated a Science Spark
teacher to visit their school to assist with Science professional development. This was a high school teacher who was tasked with supporting the Year 4-7 primary school teachers in the teaching of Science. However, the school had already purchased and started using the *Primary Connections* Science materials at this time. So the Principal and Head of Curriculum decided to have the Science Spark teacher provide professional development to the teachers with these existing Science materials.

The Science Spark teacher worked with the Year 4-7 teachers to help them gain an understanding of the *Primary Connections* units. This was the first professional development these teachers had received in the teaching of Science. The school and teachers began to explore the Science units by using *Primary Connections* as their basis and starting point. They began to learn about the 5 E inquiry method (Bybee, 1997) and investigations in Science through these materials. However, there was no professional development about Science content. The materials contained some background content information and this was considered sufficient. As the HoC notes: “So that was really successful and from there we started to develop real Science units. The 5 E model we talked a lot about and how to do that”. The HoC also explained that the teachers personalised the *Primary Connections* units, creating ‘real Science units.’ That is, they were real and meaningful to the teachers; but there was also the suggestion that the *Primary Connections* materials were impractical or inadequate for teachers to use ‘as is’, due to the changes made to curriculum content in Science. The Science Spark teacher, with a teacher and the HoC (who had little to no Science background) started rewriting the Primary Connections units to align with the new *Australian Curriculum: Science*. In this way, the school leadership modified the professional development provided by the regional office to suit the needs of the school.

While the teachers cooperated with the Science Spark teacher, the professional development thrust was perceived as being orchestrated by the school leadership, and was not highly valued by a number of teachers (Sandholtz & Scribner, 2006; Collopy, 2003). This was evidenced by poor
attendance to the voluntary workshops and professional development sessions. The HoC explained: “Initially, [the Science spark Teacher] had to really work with teachers to get them up and get them moving.”

The following year (2011), the teachers were told to put all the previous work aside, and begin using the Australian Curriculum and the state-wide *Curriculum into the Classroom* (C2C) documents so they could implement the new curriculum in 2012. C2C were Queensland’s version of an aligned set of curriculum documents that contained premade year overviews, units of work and lesson plans that teachers could pick up and use immediately. Unfortunately, the *Primary Connections* resources (*Australian Government, DEEWR*) at this time did not align with the new curriculum; this took a few years to occur and was gradually rolled out year by year. Consequently, after just one year of use, *Primary Connections* was discontinued, to the frustration of the HoC:

“So our agreed investigation model has probably gone now, which is a shame” (HoC).

5.1.1.2 Adopting the Australian Curriculum: Science

After just a year of becoming familiar with using *Primary Connections*, the Principal informed the teachers to transition into using the new Australian Curriculum and using the *Curriculum into Classrooms* (C2C) resources. This is when the stress began to mount among teachers in the school, because of short timeframes, limited resources, the number of subject areas being changed, and the personal time investment required by all concerned. As the Principal observed: “There was no real nice way to do it.” The school ran a couple of professional development activities on the new initial documents of C2C. Later, the HoC led them through the new Australian Curriculum website to guide teachers through the format, contents and location of information. The teachers were then left to discover more about the curriculum in their own way in their own time. The teachers had already planned the 2011 school year with the old curriculum, but teachers had to try to fit in some trial runs of the new curriculum. Most of the teachers at this school waited until school term four to trial some of the subject areas;
all but one decided to trial the literacy or numeracy lessons first. This one teacher did not want to trial anything, indicating a discontent with the disruption. According to the Principal: “…another one has just sort of folded her arms, it’s not for her yet, and that’s all right”. Overall, the new curriculum and document changes were overwhelming for them while they were finding their way.

The school administration tried to relieve the pressure on teachers; according to the Principal, “We’ve taken a real softly, softly approach with it to let them find their feet” (Principal). The HoC commented: “The teachers were happy to be left alone to have a go at it and just to see how it went for them”. The Principal also thought that the teachers might like the C2C because of its structure and “definite plan” of prepared lesson plans and assessment items, or even because of the digital resources provided in the documents. The units the teachers collated and used were viewed by the Researcher; and seemed to be a collection of activities and objectives without any clear inquiry sequence or structure, using mainly electronic resources and worksheets.

5.1.1.3 Pre Implementation: Trial Period

During the early stages of school planning with the new Australian Curriculum, when teachers were still using the ‘old’ curriculum, the Principal designated a team of teachers to lead discussion in literacy and numeracy, identifying where they were as a school, where they needed to go and how to get there. This committee was formed so there would be a more positive and inclusive response from staff when decisions were made. The team mapped the literacy and numeracy curriculum strategy, by comparing the old and new curriculum then shared this mapping with the staff. The teachers were asked to begin trialling the curriculum units and lessons made available in C2C. It was up to them how much they actually used of the C2C materials and they were free to trial Mathematics, English (Reading and Writing) or Science subject areas. Since the teachers were already feeling overwhelmed and overworked, the Principal felt overloading them with extra work would add complications, frustrations and concerns.
Hence, it was his choice to ‘ease them in’ by voluntarily participating and trialling as they desired. It should be noted that, while time was spent helping teachers to understand the changes made to literacy and numeracy, this did not occur for the Science or History curriculum. Only those who participated in sessions with the Science Spark received any assistance in regard to the Science curriculum. This too, is a common occurrence within primary schools. As Spillane (2005) pointed out, teachers and school leaders spend more time discussing literacy over mathematics and mathematics over Science, identifying that the subject itself will determine the amount of time that will be spent in discussions, planning and professional development.

With the school’s emphasis for Science changed from Primary Connections to C2C, and the Science Spark teacher on maternity leave, a new Science Spark teacher came in to complete the support program. This new teacher was asked to familiarise the Years 4-7 teachers with the new Australian Curriculum: Science. The Principal expected the teachers to go to the Science Spark teacher’s sessions on a voluntary basis. These sessions were held once a week after school. Only a handful opted to attend, however, and attendance was irregular.

5.1.1.4 Professional Development with the Australian Curriculum: Science

The Science Spark teacher and the Principal decided their new goal would be to get the teachers planning and teaching with assistance from the Science Spark teacher. Some teachers wanted him to help with planning, and others wanted him to come in and teach Science for them. At this point, only one teacher took advantage of the assistance. Others did not want him to even enter their rooms - admitting weakness is often a difficult thing for teachers to do (Hinchey, 2010). These were common responses for teachers who lacked confidence and Science content knowledge (Murphy et al., 2007).

For interested teachers, most of the Science Spark’s professional development occurred in the Science room. This was a recently built room that had a long rectangular shape. It contained bench tables and chairs.
similar to those found in a high school lab. They were a bit too tall for the primary school students, but suitable for the teachers. In this room he would introduce the interested teachers to some of the activities found in C2C. He also showed YouTube videos then provided materials to repeat what was seen in the short clip. Several weeks later, after he had time to develop a relationship with the school staff, the Science Spark teacher observed some teachers teaching Science and provided feedback to them. In the end, for the reluctant teachers, the Science Spark teacher would teach a lesson in the classroom with the teacher observing, then the HoC would take the class while the Science Spark teacher and the classroom teacher discussed the lesson. In this way, the school leadership tried to get everyone involved by finding approaches to suit the varied staff reactions to professional development.

5.1.1.5 Teacher Responses to Professional Development

The survey results from 10 of the state school teachers pre the 2013 new curriculum implementation (see Tables 3, 4 and Appendix A) revealed a range of opinions about the adequacy of professional development for helping teachers feel confident when implementing the new Australian Curriculum: Science and C2C. Some (4/12) of the teachers at the State School felt the professional development was ‘not useful’, other teachers (8/12) felt it was useful to some extent. This is also elaborated in the interview transcripts.

Interested teachers had positive responses: “It was good to hear what strategies I’m actually using. Sometimes you just wonder whether you are covering what you are meant to be” (Mrs S).

Some were more critical: “[The Science Spark teacher] would sometimes have a bit of difficulty adapting to a primary school environment and toning it down to a primary school environment. He would have a tendency to want to go into the secondary mind rather than the primary school mind. In the end, he adjusted quite well because he was making kids ask questions” (Mr B).
It became clear to some teachers that perhaps the sessions with him were not just about the new curriculum. The teachers were beginning to see that he would also address their lack of understanding of the Science content. “I suppose [he] was probably teaching things that we’re supposed to be aiming at on C2C. We weren’t there yet. Maybe in regard to what the teacher should have understood and also what the kids should be understanding as well” (Mr B).

The Science Spark also used YouTube videos (part of the C2C materials) to teach the teachers and show what was available for them to use. He provided further YouTube links and Smart Board links for them but this received a mixed response. Very few had a smart board and some of the more experienced teachers did not see YouTube videos as a very appropriate way to teach children. The majority of the teachers surveyed (6/10) disagreed with ‘online sources’ as the predominant place to find information about Science at the beginning of the study. A year later, only 33% (4/12) teachers disagreed with using ‘online sources’. It appeared the placement of the new curriculum documents and resources in an online format contributed to some changes in opinion.

A younger teacher, who had some Science background, indicated that she did not benefit from the professional development sessions: “All this stuff I had done ages ago [while at another school] so it was like a refresher course for me” (Mrs S).

Some teachers also perceived a problem with a secondary teacher advising primary teachers: “Sometimes primary teachers are very sceptical of Science advisors who are secondary based” and found them hard to understand; “I’m not understanding what you [were] saying” (Mr B). Secondary teachers were viewed as having different approaches to teaching and learning and to have greater content knowledge in specific content areas. This put primary teachers in a position of avoidance so they did not embarrass themselves. This was evident when many teachers chose not to participate in the professional development until required to do so by the Principal.
The intermittent nature of the professional development support was also problematic for some: “I probably get more from other teachers than from the advisors because advisors are usually here one day and gone the next. Basically [my support] comes from more experienced teachers” (Mr B). Interestingly, no one could identify a staff member who was considered knowledgeable in Science. A number of teacher responses indicated they were not interested in working with the Science Spark or felt he could not relate to them and their teaching context.

In addition to trying to gain understanding and skills in Science, teachers were also trying to develop a better understanding of the literacy and numeracy components of the new *Australian Curriculum*. For decades, pressure had been applied to schools and teachers to address and improve teaching and student outcomes in literacy and numeracy. This pressure still exists; so consequently, teachers continue to spend more time on literacy and numeracy. Therefore, many did not see Science as a priority.

Table 3 presents Pre and Post data about teachers’ perceptions of the planning, preparation, professional development and resources for the Australian Curriculum: Science. The Table also represents survey responses from 10 teachers at the beginning, just prior to implementation and from 14 teachers after one year of implementation. The change in number is due to the Early Years (P-3) staff deciding it was important for them to respond after they used it for a year. Initially the Early Years teachers felt they did not teach much science and so did not want to complete the survey. The 14 post responses were from teachers who taught the *Australian Curriculum: Science* during the first year of implementation. The numbers represent the sum of the positive responses (4 agree or 5 strongly agree on a five-point scale). These were then computed to percentages.
Table 3  State School Teachers’ Ratings of the Preparation for Implementation of the Australian Curriculum: Science

<table>
<thead>
<tr>
<th>Section B</th>
<th>State School PRE</th>
<th>State School POST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation for Implementation</td>
<td>%, n=10</td>
<td>%, n=14</td>
</tr>
<tr>
<td>Looking Forward to new curriculum</td>
<td>30 (3/10)</td>
<td>25 (3/12)</td>
</tr>
<tr>
<td>Extent of School planning and preparation</td>
<td>22 (2/10)</td>
<td>8 (1/12)</td>
</tr>
<tr>
<td>Extent of Personal planning</td>
<td>78 (7/9)</td>
<td>42 (5/12)</td>
</tr>
<tr>
<td>Felt prepared to teach Science</td>
<td>56 (5/9)</td>
<td>58 (7/12)</td>
</tr>
<tr>
<td>Have the Science resources to teach</td>
<td>11 (1/9)</td>
<td>50 (6/12)</td>
</tr>
<tr>
<td>Workshop PD in school beneficial</td>
<td>22 (2/9)</td>
<td>27 (3/11)</td>
</tr>
<tr>
<td>Ed system PD beneficial to help Science teaching</td>
<td>13 (1/8)</td>
<td>8 (1/12)</td>
</tr>
<tr>
<td>School PD beneficial to help Science teaching</td>
<td>20 (2/10)</td>
<td>0 (0/12)</td>
</tr>
<tr>
<td>PD sufficient to feel confident to implement Science</td>
<td>33 (3/9)</td>
<td>9 (1/11)</td>
</tr>
</tbody>
</table>

5.1.1.6 The Usual State School Planning Process

Each year, the school began the year by planning and preparing for the semester. This state school provided two staff planning days a semester: one day was provided at the beginning of each term.

In 2012, the teachers were expected to fully implement the new national English, Mathematics and Science curriculum. School policy allowed teachers to spend the first year of implementation teaching the subjects, units, lessons and their assessment as they saw fit for their own students.
and teaching preferences. There was almost universal compliance by the teachers: “[Except for one teacher,] I would say everyone else was using it and adapting it to suit their own needs” (HoC). In other words, there was variation in the manner of implementation from classroom to classroom. There was no systematic or school-designed approach expected or provided.

The C2C materials were the preferred documents to refer to when planning with the new curriculum, most likely because they were new. The Head of Curriculum explained that she would sit down with each teacher and check their planning documents to make sure they were teaching the main components of the curriculum. The expectation of the school administrators was that the teachers could simply pick up the new curriculum, plan their teaching program and teach it. If desired, they could approach the Head of Curriculum for advice and support. The HoC stated she made herself available to assist staff, but no one sought her assistance with Science. While the administrators knew teachers lacked Science background knowledge and related professional development, there were no additional support structures in place to assist them. After the Science Spark teacher left the school, the teachers also recognised that the HoC did not specialise in Science. For example, Mr B stated: “If I went to the HoC in regard to things on Science, I’m not too sure she would have the answers to those questions. She would probably direct me to another individual who was more Science-minded.”

5.1.1.7 The Head of Curriculum Viewpoint

The Head of Curriculum believed that the “C2C is an excellent way to just monitor how you are rolling out the Australian Curriculum. It’s been written to address in a reciprocal cycle the needs of the Australian Curriculum”. In other words, she believed that everything had been mapped out for the teachers like never before. They could follow the intent of the curriculum in the way they desired. As she put it: “It’s your own journey”.

While this statement reflected the State Education Department promotional information about C2C, it implied that teachers could adapt the material in any way they wished, and it would still align with the intent of the
Australian Curriculum. That is, there were embedded assumptions in this claim that as yet had not been substantiated. Further, following a curriculum outline in any way one chooses, allows for multiple interpretations and implementation outcomes.

When comparing the previous school Science curriculum to the new Australian Curriculum, the HoC made a number of observations. She noticed that teachers only focused on the content of the Essential Learnings and largely ignored the Ways of Working. These are comparable to content Understandings and Inquiry Skills in the new curriculum. She thought that the teachers could more readily deal with the content and assess it, rather than aspects that were less familiar, such as the scientific inquiry process in the curriculum. She attributed this partly to time constraints: “There’s just not enough time to really get down and deep into what is in there [in the curriculum].” In other words, she believed teachers would teach the content but ignore the Inquiry Skills (process skills).

The HoC also noted that using the C2C meant that teachers did not have the time nor the opportunity for deep consideration of the content expectations outlined in the curriculum. She concluded: “That’s always a downfall of having someone else plan for you because if you don’t really pull it apart yourself and understand what it means and then plan your assessment and track it back and do all of that, you miss sometimes the actual purpose of it.” She also compared this with Primary Connections that importantly contained the essential background knowledge for teachers. Her experience with using it had helped her to discover that she had been teaching a unit for years without completely understanding some of the science concepts or content. She therefore felt this was a vital component of the Science curriculum for teachers, as it helped to resolve common student misconceptions. She thought that this needed to be more apparent in the C2C documents.

However, while the HoC understood teachers’ lack of Science knowledge and the importance of teachers being prepared for the new curriculum in order to gain a more complete understanding, she and the Principal decided the
The best way for teachers to learn about the new curriculum would be to become submersed in it, on their own time and in their own way.

The teacher participants’ implementation procedures will follow.

5.2 Bronfenbrenner’s Microsystem: State School Pre Implementation

The Microsystem focus here is on the teachers and students. The microsystem represents the most personal and intimate environment with much face-to-face interaction experienced. It has the most immediate and the most powerful influence on those involved and the level of interaction contains a variety of possibilities. Relationships are reciprocal and may be negative or positive. Additionally, the influence of political agendas can also be observed. This section examines the second research question:

To what extent do the teachers feel confident to teach Science and feel prepared to implement the new Australian Curriculum: Science (including initial training and subsequent professional development)?

To understand better teachers’ comments and actions during implementation, it is necessary to provide a brief description of the school scene by describing the volunteer teachers’ characteristics and their classroom environments. This is followed by their preparation efforts with the new Australian Curriculum: Science including concerns; and finally, their Science teaching confidence.

5.2.1 Case Teacher Characteristics and Classroom Contexts

The following descriptions of the volunteers were derived from the survey sections A, C and D results, the interviews and classroom observations. The section aims to provide an overview and description of the case study teachers in relation to their teaching background, education, description of their classroom and their perceptions of science and science teaching.

5.2.1.1 Yr 4: Mrs S

Mrs S was an experienced classroom teacher in her tenth year of teaching. She was teaching a Year 4 class and had experience teaching Years 2 to 5 students. Mrs S completed biology during high school and one course each
of biology, chemistry, physics, earth and space and general environmental studies during university. She indicated that the university coursework plus her natural interest in Science have contributed to her Science teaching ability. Mrs S has received three hours of Science professional development in the last five years. Her classroom consisted of between 29 and 34 children during the observation year. She described her class as “chaotic” and containing children who were at various levels of ability including those with special needs requiring extra support.

Mrs S said she felt comfortable teaching Science. Her survey results (Appendix J) show she rated herself ‘4’ (agree) out of ‘5’ (strongly agree) as being greatly ‘prepared to teach and able to follow the new Science curriculum’. She felt her school and district did very little to prepare her with professional development. Mrs S rated her personal experiences with Science very high. She rated highly, Science as ‘worthwhile’, ‘enjoyable’, ‘rewarding’, and ‘important’, and her ‘confidence’ in teaching Science at ‘6’ on a seven-point scale. Mrs S thought Science should be taught with ‘Science processes’ and ‘Science content’. She also believed in teaching with ‘observations and experiments’, ‘demonstrations by the teacher’ and having ‘open discussions among students’.

5.2.1.2 Mrs S’ Classroom

At the time of observation, this classroom had 29 students in a room that looked cramped for space and cluttered but showed signs of student learning and examples of work. The desks were placed in four rows side by side with all desks facing the front of the room. There was no extra floor space for sitting on the floor for learning activities. The teacher’s desk was at the back of the room and also faced the front. Mrs S’ desk contained random piles of books, papers and miscellaneous items. There were piles of paper, books and various materials on shelves and filing cabinets all around the room. The walls displayed examples of student work and the whiteboard had the daily schedule visible with remnants of the last writings on the board still visible. There was one desktop computer in the room and it was connected to the ‘smart board’ for instructional use.
5.2.1.3 Year 5: Mrs L

Mrs L was an experienced classroom teacher in her 25th year of teaching. She was the teacher of a Year 5 class but had previously taught in Years 1 through 6. Mrs L’s high school course work consisted of biology. She had completed no Science courses at university. Mrs L described her background as void of anything Science-related that might have helped her with the teaching of Science. She had received five hours of Science professional development in the last five years. Mrs L’s Year 5 classroom contained 27 students. Two were intellectually impaired, one was intellectually advanced and one had extreme absentee concerns. She described the class as mostly “middle of the road”.

Mrs L indicated there was professional development provided by the district and the school but felt it only ‘somewhat’ (3) prepared her for teaching Science (Appendix J). She rated the ease of ‘following the curriculum’ at a very low ‘2’ (strongly disagree) out of ‘5’ (strongly agree). Mrs L felt she spent a ‘great amount’ of time (4) preparing for Science. When she rated her ‘personal experiences with Science’, she gave a low rating to Science as being ‘worthwhile’ and also to her level of Science ‘confidence’. However, Science as ‘rewarding’ and ‘important’ were rated highest at ‘6’ on a seven-point scale. Mrs L viewed Science teaching as being ‘student-centered’, using ‘observation and experiments’ in ‘small groups’ with an emphasis on ‘content’ matter. She did not believe in teaching ‘Science processes’, using ‘teacher demonstrations’, having ‘Science rules’ and using ‘online resources’.

5.2.1.4 Mrs L’s Classroom

There were 27 students in Mrs L’s class with 23 present. This classroom was on the upper level of the building and presented as busy, cluttered and child centered. The teacher’s desk was just at the entrance to the room with paper, books, laptop and other items strewn over it. Students’ desks were arranged in groups of 4-6 students. The room had stacks of various items lying around the room. There were displays of past topics on the walls and on tables. One long table at the back of the room was full of papers and miscellaneous items randomly placed. There was a small room off to the
side where there were collections of resources and books. This was a small classroom with little room to walk around.

5.2.1.5 Year 6/7: Mr B

Mr B was a classroom teacher with 34 years’ experience. He had previously taught in Years 3 and 4. At the time of the study he was teaching Year 6/7 composite class. Mr B reported that he had completed biology and chemistry in high school, but no university Science courses. Mr B believed he had about 12 hours of Science professional development in the last 5 years. There were 28 students in the Year 6/7 composite class with 16 in Year six and 12 in Year seven. Three students used English as second language (ESL) and had difficulty reading and writing English, also two students had a learning difficulty.

Mr B was happy with the ‘planning and preparation’ for the new curriculum, the level of ‘district and school professional development’ as well as his ‘self-preparation’, and rated them at ‘4’ (agree) out of ‘5’ (strongly agree) (Appendix J). Mr B also rated highly his personal experiences with Science. That is, he found Science to be ‘rewarding’, ‘important’ and ‘enjoyable’. He rated his ‘confidence’ as ‘6’ on a seven-point scale. Mr B rated negatively (‘1’ unable to answer or ‘2’ strongly disagree) the following: ‘practical Science experience’, use of ‘observation and experiment’, ‘students working at their own rate’ and the use of ‘online materials or resources’. He rated highly (‘4’ agree or ‘5’ strongly agree) the use of ‘process skills’, ‘discussions’ and following the ‘same activities for all groups’ of students.

5.2.1.6 Mr B’s Classroom

Mr B’s classroom was spacious, but relatively barren. It was an old room that used to be an open classroom for two classes. He had rows of desks set up at one end with a long empty table. At the other end of the room stood four computers on desks for student use and a display table. This space allowed him to separate the composite class to teach separately as needed. There was a large floor space in the middle that could be utilised for many purposes. No student work was displayed on the walls. Only a small table
in the corner with the remnants of a ‘failed’ steel wool activity was still on display. Mr B’s desk was in the far corner of the room facing the students’ desks. He had filing cabinets and shelves of books and resources beside him. This classroom had a dated appearance.

5.2.2 Preparing to Teach the New Science Curriculum

These State School teachers were looking forward to the new Australian Curriculum: Science. The teachers were expected by the school leadership to discover, understand and implement the curriculum on their own. The survey results show that 89% (8/9) of the State School teachers at the beginning of the year reported they had to personally plan and prepare for implementation. However, the teacher surveys indicated that at this time only 56% (5/9) felt very prepared to teach the Science curriculum. If they desired, these State School teachers were provided with some professional development through a Science Spark teacher to help gain an understanding of the Science components. Only a few took advantage of this initially, as they felt that their priorities for preparation were with literacy and numeracy (English and Mathematics) curriculum. However, after spending time with the Science curriculum, some concerns related to preparation emerged.

5.2.2.1 The Science Curriculum Concerns

One concern was time (see Appendix G), usually the lack of it. ‘Time’ identified in this research study referred to:

- time to understand the overall view of the new curriculum as well as each subject area,
- time to identify the changes at each year level,
- time to identify concepts and topics that are new to the curriculum or to the teachers,
- time to identify how to provide content professional development for teachers,
- time to identify new strategies expected to be used, (eg., science inquiry processes)
• time to learn how to teach with those strategies,
• time to work out effective questions, problems and challenges with school staff, and importantly,
• time to repeat these processes with each new curriculum area.

The teachers tried to access various components of the Australian curriculum and C2C, with their main focus being on C2C. The main difficulty reported was that they were so busy and that there was little time to spend exploring either set of documents. Even conversations with other teachers were limited: “We talk as much as possible but it’s difficult” (Mrs L). The teachers explained that there was a large amount of information to examine, let alone understand; “I thought I’d do what I can and I took what I thought would work on board” (Mrs L). Then there was the issue of fitting the planned lessons into their teaching schedule: “I knew there was no way in the world I’d be able to teach all of that. Not with the interruptions you have in a school” (Mrs S).

The final time-related issue was trying to understand the content and pedagogical purpose for some of the C2C material and make it meaningful for their students, as Mrs L stated: “Some of it I think, why are you bothering with that? I think it has also stressed people [because] it has been harder for the kids...the way they moved the content around”. The science concepts and content were not in the same year-to-year order as in the previous curriculum. This raised concerns about sequence and developmental learning.

Teachers also had difficulty choosing teaching and learning activities from the many activities listed in the C2C documents. This related to their ability to understand the Science content, how to teach the content and ways to get students to understand the content. Mr B explained: “[The other same year-level teacher] and I have been fairly selective. [The criteria we used were] ‘this is within or not within our range of capabilities.’ So we’ll pick

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13 This is essentially an issue of Science pedagogical content knowledge, not necessarily a problem with C2C itself. Using C2C led to teachers being confronted with their limited PCK in a number of Science areas.
this one, this part, and this component here and do this. This part here, we can use as an assessment tool”. Sometimes the topics had activities that were so difficult for the teachers to understand that some had no idea what to do – so they were glossed over or ignored.

Contrastingly, a case study teacher felt that the activities in C2C were inappropriate because they were similar to the content from an earlier Year-level in the previous curriculum. She had to spend time doing research to find other suitable activities, particularly in her preferred form of teaching - hands-on activities: “It wasn’t just me going blah, blah, blah, kids looking at me bored and scribbling in their books. They could actually do something” (Mrs S). She also felt C2C provided too many worksheets.

Another issue raised was that the C2C materials were very cluttered and not user-friendly – navigating through the numerous suggestions was tedious, and following suggested links made it more tedious. This caused some of the experienced teachers to give up and go back through the old *Primary Science Sourcebooks*\(^{14}\) to look for activities. One teacher thought that the C2C was, “actually going back to what we did in the past” (Mr B). He thought the *Primary Science Sourcebook* was quite user friendly; and, since it was familiar, it cut down on time to plan and prepare. Consequently, when some teachers were seeking activities that matched a topic from C2C, they began using the old *Sourcebook* activities to teach from.

Other teachers were concerned about pedagogical processes, such as ways to help students link prior knowledge to the current topics. They felt that such pedagogical help was missing from C2C (in comparison to the inclusion of such help in the earlier *Primary Connections*). This led to concerns about curriculum continuity and conceptual development, as Mrs S stated: “My worry with C2C is how effective that that flow on effect will actually have and how big the gaps are in between each content”. In other words, teachers needed to know when the concepts are going to be taught. They wanted to know if there was a gradual development of concepts over

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\(^{14}\) The Sourcebooks were Teacher Guides of activities for the 1979-1999 syllabus. They had been extensively trialled and were popular with teachers.
time, or if the concept was only taught once in the primary school years. This information helped them to understand how to prepare to teach and then teach the concepts.

The final concern expressed by one teacher was the erroneous idea that C2C was linked to the national testing regime, and she was therefore teaching to the test: “I have to do it this way, the way C2C wanted it. I couldn’t put my own stuff in” (Mrs S). In the early days of implementation, it was common for teachers to believe they were given a set of teaching documents with assessment included that needed to be followed precisely in order to achieve successful outcomes.

A common concern to all teachers was the lack of materials and equipment in the school for many of the hands on activities, found in the C2C. If they wished to use these C2C activities, they felt they needed to purchase the required resources themselves, generally using their own funds. As Mrs L stated: “There’s stuff you need to go and buy. I think you need to have a budget where we can say I need the cash to go and buy flour or soft drink.” However, half of the teachers said there were some resources available at the school to teach the new Science curriculum and half said there were many resources available. The types of materials they required determined their responses. For example, content areas with new activities and those requiring consumables led to teachers feeling they were lacking resources.

5.2.3 Confidence to Use and Teach the New Science Curriculum

Confidence affects a person’s actions, and so it is with Science teaching. If a teacher has developed high levels of confidence in Science, that teacher is more likely to spend time teaching Science (Wenner, 2001). Confidence levels are raised when the person has been involved in positive experiences with Science. Below are the confidence ratings of the state school teachers prior to their teaching with the new Australian Curriculum: Science and again one year later. This time the early years teachers who opted out of the pre survey, chose to participate in the second survey making the number 14. However, some questions were left unanswered. Section C represented in
Table 4 used a seven point semantic differential to determine personal experiences with science. The numbers are the sum of the positive (5, 6 and 7) responses. These were change to percentages.

Table 4  State School Teachers’ Ratings of Personal Experiences in Science Pre and Post the Implementation of the *Australian Curriculum: Science*

<table>
<thead>
<tr>
<th>Survey Section C Personal Experiences in Science – State School</th>
<th>PRE Implementation (10 teachers)</th>
<th>1 year POST Implementation (14 teachers)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% n/10</td>
<td>% n/14</td>
</tr>
<tr>
<td>Try to <strong>teach more often</strong></td>
<td>60 (6/10)</td>
<td>58 (7/12)</td>
</tr>
<tr>
<td>Science is <strong>Worthwhile</strong></td>
<td>60 (6/10)</td>
<td>83 (10/12)</td>
</tr>
<tr>
<td>Science makes me <strong>Happy</strong></td>
<td>70 (7/10)</td>
<td>83 (10/12)</td>
</tr>
<tr>
<td>I feel <strong>Confident</strong></td>
<td>70 (7/10)</td>
<td>83 (10/12)</td>
</tr>
<tr>
<td>Science is <strong>Enjoyable</strong></td>
<td>70 (7/10)</td>
<td>67 (8/12)</td>
</tr>
<tr>
<td>Science is <strong>Rewarding</strong></td>
<td>70 (7/10)</td>
<td>92 (11/12)</td>
</tr>
<tr>
<td>Science is <strong>Important</strong></td>
<td>70 (7/10)</td>
<td>83 (10/12)</td>
</tr>
</tbody>
</table>

The majority of the teachers in the state school demonstrated a solid level of confidence and positive attitudes in relation to Science teaching. When considering the limited professional development available in the history of this school, we can assume the teachers were teaching in a manner they found suitable and were therefore satisfied with outcomes prior to the implementation of the new *Australian Curriculum: Science*. It seems the Science Spark teacher modeling Science teaching influenced some teachers. Those who volunteered for individual sessions with him found the personalized approach helpful because it linked directly to their Year level curriculum and instruction. It especially influenced finding Science as ‘rewarding’, ‘important’ and ‘worthwhile’. However, there was very little change to attitudes overall with a slight move towards a more positive response. This is likely due to the general acceptance of the new *Australian Curriculum: Science* and C2C, since teachers were still able to continue teaching in their usual ways, whether it was inquiry-based or not.
Teacher confidence has been found to increase when they achieve success with new teaching strategies (Hoy & Spero, 2005; Fitzgerald & Schneider, 2013) and see improved student outcomes (Skamp & Peers, 2012). These teachers had received limited professional development and some were able to begin applying new teaching strategies with the assistance of a Science Spark teacher. It would appear that those few sessions had begun to change teachers’ perceptions of Science to more positive ones (Table 4). Descriptively, the percentage of teachers who felt ‘happy’ and ‘confident’ with their Science teaching increased from 70% (7/10) at the beginning of the year to 83% (10/12) after a year. For those finding it ‘rewarding’, there was an increase from 70% (7/10) to 92% (11/12). The Science Spark support initially helped to boost teachers’ perceptions of their Science teaching in this school. Overall, the teachers seemed more confident with the use of the curriculum materials and to attempt the activities, but seemed less likely to follow an inquiry approach. However, after he left and with no one to support them, the classroom experiments and inquiry focus began to fade away.

5.3 After One Year of Implementation

This section used classroom observations to identify teachers’ actions when planning and teaching the new Australian Curriculum: Science. Teacher efficacy beliefs are known to account for differences between teachers’ actions (Ertmer, 2005; Fitzgerald, Dawson & Hackling, 2013) and teaching effectiveness (Riggs & Enoch, 1990; Fitzgerald et al., 2013); and teachers’ actions can reveal beliefs about Science teaching (Smith and Southerland, 2007). This section examines the third and fourth sub-questions:
The third sub question:

Which beliefs about teaching Science do the teachers hold, how frequently do they teach Science, and what teaching strategies do they commonly use when teaching Science?

5.3.1 Beliefs about Science Teaching and Learning

Teachers learn successful strategies for teaching and typically continue to maintain those strategies, until they find another way that demonstrates greater success (Jones & Carter, 2007; Keys, 2007; Priestley et al., 2012). It is common for teachers to have a desire to improve their teaching when they know the changes they make will improve student outcomes. Until then, teachers are often reluctant to change their teaching strategies (Guskey, 2002, 2004).

The following table represents teachers’ beliefs in the State School about teaching Science. The numbers used are the sum of the positive responses (4 agree or 5 strongly agree on a five-point scale). These were changed to percentages.
Table 5  State School Teachers’ Ratings of Beliefs about Teaching Science
Pre and Post the implementation of the Australian Curriculum: Science

<table>
<thead>
<tr>
<th>Survey Section D</th>
<th>PRE Agree (4) or strongly agree (5) (10 teachers)</th>
<th>1 year POST Agree (4) or strongly agree (5) (14 teachers)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers’ beliefs about teaching Science – State School</td>
<td>% n/10</td>
<td>% n/14</td>
</tr>
<tr>
<td>The structure of the Science course should be based on process not content.</td>
<td>50 (5/10)</td>
<td>50 (6/12)</td>
</tr>
<tr>
<td>There should be an emphasis on teaching Science through Science topics rather than concepts.</td>
<td>40 (4/10)</td>
<td>25 (3/12)</td>
</tr>
<tr>
<td>The teacher should emphasise the content matter of the lesson.</td>
<td>100 (10/10)</td>
<td>58 (7/12)</td>
</tr>
<tr>
<td>Science should be based on student observation and experiment.</td>
<td>40 (4/10)</td>
<td>58 (7/12)</td>
</tr>
<tr>
<td>Science lessons should be demonstrated by the teacher to the class.</td>
<td>50 (5/10)</td>
<td>73 (8/11)</td>
</tr>
<tr>
<td>There should be activities carried out by different groups in class.</td>
<td>40 (4/10)</td>
<td>64 (7/11)</td>
</tr>
<tr>
<td>There should be open discussions among students to communicate their work.</td>
<td>100 (10/10)</td>
<td>92 (11/12)</td>
</tr>
</tbody>
</table>

Descriptively, substantial changes in beliefs over the year may be noted in the table. The Pre surveys were given soon after the Science Spark Initiative completed; with the Post survey being conducted after teachers had been planning and teaching the Science curriculum for a year on their own. There appears to be a substantial change towards believing that content should not be taught and smaller changes towards greater belief in observation, experiment, demonstrations and group activities. This demonstrates that there are teachers who still do not believe in following the main aspects of inquiry teaching. Based on the interviews, the reduction in content focussed teaching meant that they now knew they are supposed to teach through experiments and activities rather than their previous methods of reading recall and rote learning activities. This may demonstrate the beginning of a shift towards a more inquiry-focussed belief about how Science should be taught. However, this does not mean they knew how to
go about teaching in this manner. It would appear the conversations with the Science Spark teacher had opened up Science teaching ideas and thoughts for some teachers. Experienced teachers realised they were expected to change their teaching approaches. The HoC explained: “By the end, [the Science Spark Teacher] did a lesson and then I took the class so he could go and reflect with the teacher about what they’d seen; and then the teacher did a lesson and then they went and reflected about what they’d seen together.”

5.3.2 Case Study Teaching Approaches

Science teaching with the new *Australian Curriculum: Science* is meant to follow an inquiry approach (ACARA, *Shape of the Australian Curriculum*, 2009). That means students are observing, exploring, asking questions, planning investigations, describing, collecting and analysing data, then recording and presenting data. Conclusions should be drawn by the learners and based upon the data gathered. Science teaching has been moving towards science process and investigations for decades (see Chapter 2). The previous curriculum and also the *Primary Connections* initiative introduced teachers to this approach to Science teaching. Therefore, inquiry focused Science teaching could be expected to be observed in teachers’ planning and teaching. Below are examples of teachers’ approaches to teaching Science that were observed at this school (See Appendix F) and provide understanding of science teaching in the classroom.

5.3.2.1 Hands-on Approach

Mrs S preferred a hands-on approach where students interact with materials and each other, but usually began with specific vocabulary or a review of lesson activities. Students were asked to copy and define the vocabulary in the unit of study (e.g., push, pull, force and friction). Mrs S regularly used the outdoor environment, the Science lab and the classroom to complete activities. These were usually modeled or instructed verbally. After the activities she expected students to write about or draw what they saw happen.
5.3.2.2 Mixed Approach

Mrs L mostly used a mixed approach. She began her lessons with a review of the previous lesson; then introduced the new activities. She used a variety of approaches; modeling, rotations, and small group work. After the activity, they were requested to write up what happened. She had them write their predictions (after the activity), the objectives, the materials, the steps and what happened in each activity.

5.3.2.3 Traditional Approach

Mr B primarily followed a traditional approach that included Science worksheets, reading worksheets, computer activities and small group and whole class activities. He had a strong preference for developing core vocabulary and did so with worksheets, writing and computers. Mr B also showed a strong use of information recall activities. This was evident through his worksheets and his exam questions.

5.3.2.4 Inquiry Approach

None of these teachers followed an inquiry approach, or an approach to teaching Science that involved thinking and working scientifically. If so, they would have included some of the following: developing a question, designing activities, interpreting, explaining and hypothesizing, sharing results and solving problems (Anderson, 2002). However, the activities were predominately procedural and step-by-step, isolated events. It should be noted that, ‘inquiry’ is not an approach that is normally completed in one lesson; rather it is a series of sequential lessons that build up a scientific process of inquiry. None of these teachers demonstrated a series of activities that built upon the other. None of them were able to describe to me previous lessons or units of work that followed scientific inquiry. However, some of the individual lessons observed could be included as one lesson in a series of scientific inquiry lessons such as those found in the 5 Es in Primary Connections.
5.3.3 Teacher Implementation Processes in the State School

Teachers’ beliefs about teaching Science and their understanding of Science teaching strategies influenced their implementation of the new *Australian Curriculum: Science*. This is described below.

The fourth set of sub-questions:

After one year from the release of the *Australian Curriculum: Science*,

a) What have schools and teachers done to implement the curriculum?

b) How has the implementation of the new Science curriculum impacted on the school and teacher actions about how to teach Science and

c) What actions do teachers believe should occur to progress implementation?

Some teachers believed the *Australian Curriculum: Science* had increased in difficulty. Some of the C2C material was difficult for teachers to understand and some of the concepts were difficult to implement pedagogically. The HoC noted: “We have to teach physics in all year-levels, even in Foundation”, while Mr B gave this assessment: “For a lot of primary teachers, they have no trouble getting their head around the [previous] version than the upmarket C2C version”.

Mrs S. stated that due to Science professional development in her previous school, she felt comfortable teaching Science with a hands-on approach and did not mind the “noise and messiness” often associated with Science. Mrs S took time to research her topics and find activities she thought were most suitable. For example, the following activity was taken from *Primary Connections*. Mrs S and the students went to play a tug-of-war activity on the oval to help demonstrate friction. The activity was carefully planned with some interesting additions to help students think about friction. They played one game with bare hands. During a second attempt, the losers were given plastic gloves to grip the rope. For the third attempt, gloves were given
to the winners with liquid soap applied to their hands for lubrication. A brief discussion ensued about needing friction to pull. Mrs S’ lesson was an illustrative one that tried to make concepts concrete for students’ understanding, however, it does not allow for self-directed activity (Martin, 2009).

The Year 5 case study teacher, Mrs L, also spent some time researching the content and approach, but her research was mostly related to looking through the C2C activities to find what she wanted to do. Just prior to one of my observations she had completed a demonstration lesson evaporating ice with a hair dryer. The following week, she gave her student teacher a lesson to prepare - “an experiment with solids, liquids and gases”. The activity included mixing a ‘Red Bull’ drink with milk to observe a curdling process. There was evidence of students misunderstanding the Science concepts involved, as the process had demonstrated a chemical change, not a change from a liquid to a solid as inferred. Mrs L felt that teachers needed a clear understanding of Science concepts in order to provide appropriate experiences for students.

In contrast to both Mrs S and Mrs L, Mr B did not enjoy researching on the internet or searching through the long list of C2C activities for ideas, but preferred to use activities and materials he had used in the past. For example, Mr B often sought direction from the old Primary Science Sourcebooks and his personal collection of worksheets and Science reading sheets. When he had to teach a topic he was less familiar with, he did not research the topic, nor did he trial the activities before teaching them. His success with the activities was limited at best, and is demonstrated when Mr B said he tried to do the temperature activity with steel wool to show oxidation, but it did not work. According to Mr B, there was no heat produced so students could not graph the outcome. There was some misunderstanding of the intention and the concept focus of the activity. Mr B focussed on students making a graph rather than the formation of rust and ideas associated with that concept. He also had a vinegar and bicarbonate activity for students to try, but did not attempt it. Instead, he
had them grow crystals from a kit. The unit focus, according to the ACARA and C2C should have been: Chemical Science - Changes to materials can be reversible, such as melting, freezing, evaporating; or irreversible, such as burning and rusting. The above examples demonstrated some of the consequences of a teacher’s lack of understanding of the core concepts.

Lack of understanding of the curriculum content and how to teach it can lead to ineffective teaching and learning activities. Use of inadequate materials or resources can also lead to ineffective and low quality teaching, as in the examples above. However, a year later there was relatively no change (58%) at this school with State School teachers feeling ‘very’ prepared to teach the new Science curriculum and most reported they had spent time themselves preparing for the C2C Science curriculum. This feeling of preparedness may reflect their level of understanding of how science should be taught or even the priority they placed on it. The personal preparation time is possibly related to their reports that the school did little to help them prepare. As described earlier, the school administration decided it would be best to allow the teachers to get to know the new curriculum in their own way and in their own time.

The surveys, interviews and observations from this school indicated that the teachers were beginning to change their beliefs, but had not yet moved to changing their teaching behaviours. In other words, the Science pedagogy portrayed in the new curriculum continued to need support and guidance to develop the teacher skills required for successful Science teaching and learning.

It is well known that teachers make the final decisions as to what is taught and how it is taught in their classrooms (Johnson, 2007). In this case, school leaders failed to lead the teachers through a process of collaboration to identify the staff and student needs and align these with the Australian Curriculum: Science. Teachers were unable to find support from each other, as they could not identify any of their colleagues as being a leader in Science. The Science Spark teacher provided support, but only for those who did not feel threatened by his expertise. There is long established
literature describing how many teachers when forced into implementing other peoples’ ideas begin to lose the capacity to theorise about their work leading to atrophy or ‘deskilling’ (Smyth, Dow, Hattam, Reid & Shacklock, 2005).

Science was no longer a focus after the Science Spark left the school. The teachers had a year to gain familiarity with the new curriculum documents; and this familiarity with the documents in itself may have reduced stress, as teachers then could feel they knew what needed to be taught and would be seeking relevant activities and resources. Observations and surveys across the time of the study indicated that the teachers improved in understanding that Science should be taught in a practical way with hands-on activities and investigations, even though this is still not a preferred way to teach for some. The school did not seem to provide a compelling case for Science teaching with the new curriculum.

The survey results in Table 5 above may also shed light on how the teachers believed Science should be taught. The data indicate that the teachers did not have a firm understanding of the Australian Curriculum: Science teaching expectations. After a year, the staff were split on many of the ideas/beliefs about how to teach Science. For example, 50% (6/12) believed Science should be based on processes and 58% (7/12) believed Science should be based on content, these beliefs reflect different teaching approaches. However, 58% of staff agreed that observation and experiment should be used to teach science. This is slightly higher than the belief that science should be based on process, which includes a similar pedagogical style. Perhaps the term ‘process approach’ was not clearly understood even though it was a term used in the previous curriculum documents and connected with investigations. In addition, the belief that the teacher should demonstrate Science lessons was expressed by 73% of the teachers, while 27% disagreed with this strategy. This also could lead to very different pedagogical approaches (Dobey & Schafer, 1984) and could be resolved with effective professional development (Roehrig & Kruse, 2005).
On the other hand, there was one statement that demonstrated strong agreement among these staff. That was: ‘students should have open discussions to communicate their work’. This is interesting, as one of the three case teachers demonstrated some use of this strategy and shared with me other lessons (not observed) when meaningful discussion took place. Another case teacher, Mrs L, liked setting up ‘experiments’ but was unable to explain concepts and phenomenon. The discussions were around what was observed rather than why. The third case teacher, Mr B, sought a regurgitation of facts during discussions because he had a strong focus on teaching science through literature. The case teachers often taught Science content through didactic instruction regarding vocabulary and frequently led discussions, in a question-and-answer format.

5.3.3.1 Science Activities That Work

Research has demonstrated that primary teachers prefer to use ‘activities that work’ to demonstrate success in Science. This was noted with these teachers too.

Appleton (2002) identified that many primary teachers prefer ‘activities that work’ for several reasons. They are more manageable, more predictable, use readily available materials and can be integrated with other subjects.

Teachers in the current study also stated they preferred to use activities that work, and they searched the Internet, books and other resources looking for activities that appeared easy to manage, used few materials, were easy to access and easy to understand. This type of planning does not necessarily lead to inquiry and investigative teaching practices in Science.

Mrs L prepared three rotation activities (described later) that she said were chosen because she had ‘no trouble understanding’ the expectations of the three C2C activities, and the materials were easy to locate.

Mr B decided to go back to his earlier worksheets and a prepared activity of making crystals, when the hands-on activity earlier from the C2C unit materials “did not work”.

159
Mrs S was unhappy with many of the C2C units so decided to use her favourite resources and activities from multiple sources that she used in the past.

5.3.4 Support for Primary Teachers

Teachers regularly reported they required more content knowledge in Science. “I think what we don’t have enough of, is the knowledge of Science.” Primary teachers felt that they “can teach anything” because “we know our kids”. However, “we know their styles and their needs, but if we don’t get the content sometimes we struggle in making sure. So we might just do a surface job through no fault of our own” (Mrs L).

Some teachers suggested support that included a buddy teacher to discuss Science and share ideas with. Mrs S said: “There’s none of that goes on”. This was a common suggestion that continued to resurface. A ‘buddy’ also refers to someone who is known and trusted. This is important when teachers feel vulnerable in terms of their capacity. This accords with research that focuses on teacher participation in learning in ways that make it more applicable and personal, such as in the Community of Practice approach (Wenger, 2002, 2009) and the Professional Learning Communities approach (Bolam et al., 2005; Vescio et al., 2008).

Other teachers looked at “surviving the moment” and teaching what they were capable of teaching at that time. “I’ve worked in schools where we just swapped lessons plans with fellow teachers if we didn’t know how to teach something...like Science. That kind of support worked really well” (Mrs S). This is seen as an immediate fix rather than a long-term solution. Teachers’ skills and knowledge would not seem to be improving with this avoidance approach to teaching Science.

Schools are under pressure to provide professional development for teachers each year. Since the introduction of the Australian Curriculum and C2C program, the Primary school in the study has had support in various areas; for example, in comparing and mapping out the old and new curriculum for Literacy and Mathematics and assistance from a Science Spark teacher for
Years 4-7. After spending a year using the new Science curriculum in the form of C2C, the school administration felt the Science curriculum was being taught and they were moving forward with it. However, the teachers expressed a need for further Science support primarily in the areas of resources and knowledgeable science people. Interestingly, they felt they were doing well in regards to their understanding of the teaching strategies to be used, the Science knowledge required, how to use Science materials and the expected ways of assessing student learning in science. It appears as though they felt they were teaching science well. Mrs S commented: “I must admit, this would be one of the savviest staffs that I’ve, especially the upper, worked with in regards to science. Previous schools, I’ve known teachers to point blank refuse to teach science because they just didn’t get it.”

Observations and interviews reveal case study teachers’ choices of teaching activities and ultimately the development of their Science teaching philosophy at this school varied and thus they have achieved different degrees of alignment with the new *Australian Curriculum: Science*. None of them expressed a complete understanding of the new curriculum requirements, associated content knowledge and knowledge of inquiry processes. Addressing teachers’ beliefs and content understanding are important when seeking to make curriculum change (Harlen, 2009). This is evident from the observations described below.

Mr B reported that his students did not know much about Science investigations when they first started with him in Year 6, however, he believed he provided plenty of experiences with investigations to prepare them for high school Science. While Mr B portrayed himself as the ‘Science person’ in the school due to his interest in Science, his traditional approach did not incorporate inquiry methods. He said he used investigations in the classroom, but it seemed his idea of investigations meant that students merely wrote up a scientific report of the process and the data collected. However, students were still told what to do. They were not taught to question and seek answers to their questions then revise their questions
and continue to seek answers based on acquired data. Observations
revealed there was little to no data collected. This traditional approach is
known to affect students’ Science achievement negatively (Smith, Desimone,
Zeider, Dunn, Bhatt & Rumyantseva, 2007). Similarly to other teachers, he
also provided activities that ‘worked’ in the past (Appleton, 2002). He then
had students copy required information onto a sheet of paper. Students
would subsequently read Science stories, answer questions, define
vocabulary, and memorise information. Based upon class observations and
the information he provided, his described Science “investigations” only
occurred twice in that semester. This type of Science instruction fails to
meet the expectations for scientific inquiry (Goodrum et al., 2001) in the new
curriculum.

Experienced teachers have been through many iterations of curriculum
reform or change in the past (Fullan, 2001). To them, this is an expected
experience that one must ‘weather’. As indicated by Mrs L: “curriculum
come and curriculum go...” They believed they would do the best they could
and by the time they began to get used to this one, a new one would come
along to replace it. With this knowledge and recurring experience, teachers
kept their favourite activities, experiments, readings, and worksheets in a
safe place in their rooms to reuse in the future. Mr B stated: “I still have
stacks of notebooks with all the old sheets that I can pull out and use”. So
regardless of the curriculum changes, they still had the familiar activities to
rely on. Unfortunately, this also reflects an attitude lacking serious focus on
change of teaching practice.

These three volunteer teachers from the school reflected the kind of Science
teaching that occurred in other classrooms in the school and continues to
occur. These teachers have a limited amount of Science education and a
limited amount of Science professional development. It was clear they did
not understand teaching with process skills or investigations that have been
part of the curriculum since they began teaching. According to Smith et al.,
(2007), teachers without degrees in Science or with less than 35 hours of
sustained Science professional development, were unlikely to improve their
Science teaching and their students’ Science outcomes. The Science Spark teacher may have been a good way to begin the focus on Science professional development and improvement across Queensland, but it was not inclusive of all teachers and was not sustained. Science professional development in this school was not seen as important by all staff. That is, they had other curriculum priorities and imperatives.

By the end of the year, the school leadership decided to move on to another agenda. They felt it was important to focus more on general pedagogy across curriculum fields and develop greater differentiation to student needs across all year-levels. As the HoC explained: “How are we teaching, what are you doing that’s working well, what am I doing, let’s share, that’s more the level we’re at”. The Art and Science of Teaching by Marzano (2007) was their next focus for professional development. This move reflects a similar focus at the time for many Queensland state schools. Professional development with the Australian Curriculum: Science has been largely replaced with a professional development program to improve general teaching skills. This is not a subject specific initiative and so will not necessarily address pedagogy that is pertinent to a subject such as Science.

This school responded to the demands of the new Australian Curriculum: Science implementation as best they could and probably in a similar manner as had been attempted in implementing past curriculum reform. Curriculum changes are common and an expected event by teachers in schools; and, unfortunately often a poorly received and poorly executed one (Fullan, 2007). The objectives of the new Australian Curriculum: Science and its associated assumptions about teacher knowledge and pedagogy were not observed in implementation or operation in this school. Many of the teachers at this school are still teaching in much the same way as they have previously taught, albeit with new materials added to the mix.

It is long established that teachers are the key to curriculum implementation (Duffee & Aikenhead, 1992). During curriculum change it is important to assist teachers in learning new content and teaching strategies (Guskey, 2002; van Driel, Beijaard & Verloop, 2001). The Australian
Curriculum: Science requires rigorous teaching with the expectation of improved student learning outcomes. This school had some initial Science professional development, but teachers were subsequently left to continue the curriculum implementation on their own, with few other forms of support available.

5.3.4.1 Assessment

Assessment was another area that concerned the teachers. While assessment was not a specific focus of this research project, it is interesting to note how the teachers dealt with the assessment strategies provided in the C2C materials.

Mr B always prepared his own Science examination for his students. He believed this would help prepare them for high school. This examination included identification of images as being chemical change or physical change, knowledge of definitions and recollection of facts and experiment outcomes.

Mrs L and Mrs S stated they tried the C2C assessments but found them to be very long and difficult for students to understand. They also believed the rubrics provided were vague and held low expectations. Both decided to write their own assessment tasks and rubrics.

A Summary reflecting the situation of this school, along with the other schools in this study, is presented in Chapter 8: Looking at Three Schools. Chapter 8 was created to provide a summary that would assist the reader to view each school as a whole and to make comparisons among the schools.
6 INDEPENDENT SCHOOL

6.1 Bronfenbrenner’s Mesosystem

The mesosystem is concerned with school level interactions. This Independent School had different expectations and processes from those reported and observed at the State School in the study. However, there are some similarities in school administration processes and justifications for those processes. A brief description of the school context will lead into the school curriculum processes just prior to and during the 2012 curriculum implementation year. This information informed the first research question:

What school contextual factors do the school leaders see as being most relevant to making changes in the implementation of the Australian Curriculum: Science and in Science teaching?

6.1.1 The Primary Independent School: Pre Implementation

This Independent School contained a primary school and a high school on the same campus - some distance separated the two sectors. There was a teaching and learning staff group for both school sectors who were in charge of the curriculum issues, therefore, each sector was expected to handle the details of the curriculum development and implementation in the manner thought suitable for their sector. The Deputy Principal of the primary school was also the curriculum leader at this school.

The primary school had approximately 400 students from the local suburban area. The Deputy Principal identified the students as primarily Australian and middle to upper income bracket. Teacher experience ranged from beginning to highly experienced with teachers working together in year-levels to plan and solve problems.
Prior to 2011, the primary school Science curriculum at this Independent School consisted of a document that was written by one of the high school Science teachers and approved by the Deputy Principal. During past curriculum reform, the Deputy Principal organised curriculum reference groups of teachers who volunteered to change and rewrite their curriculum documents so they would align with the Essential Learnings in the previous curriculum. This occurred in the following manner: Teachers chose a subject area and worked with a group of teachers. The Deputy/HoC presented them with questions and planning considerations so they could develop a new scope and sequence for the main subject areas. He then used their collaborative information to create a curriculum document for each year-level. For Science he engaged teachers from the high school to assist when needed. Since many primary school teachers had limited Science content knowledge, they invited a high school Science teacher to help with the writing and the creating of Science lessons and activities. This caused some angst between the high school Science teacher and some of the primary teachers when they could not agree on the philosophy, knowledge or pedagogy behind the Science curriculum. Nevertheless, primary school teachers had a curriculum document containing a weekly lesson focus, activities and assessment ideas. Boxes of concrete materials were created to support that Science curriculum implementation.

6.1.1.1 School Professional Development and Planning

A contrasting series of events evolved with the planning and preparation for the new Australian Curriculum: Science. The initial planning for this Curriculum, began with the Deputy Principal organising ‘collective planning’ by asking teachers to look into elaborations for each subject area to see how well it aligned with the curriculum they were using at the time. They were to see if some of the old curriculum could mesh with the new curriculum expectations. A number of teachers thought this was busy work, as Mrs T stated: “useless and just a waste of time”. The study survey responses agreed with this perception, particularly in the area of Science, as 100% of the teachers felt there was only a small amount of ‘Science planning
organised by the school’ and was not viewed as ‘beneficial for the new curriculum’.

The option of purchasing the *Primary Connections* Science resources to use as prepared units of work for the primary school was brought to the Deputy’s attention. At this point, the C2C was only available for the government schools. The Deputy was informed that a nearby school had been using *Primary Connections* for the last several years and decided to spend two days in that school observing and discussing the use of the *Primary Connections* curriculum with their Head of Curriculum. The Deputy Principal was happy with the inquiry approach and the pedagogy it encouraged. As he noted: “It gave teachers a good baseline set of ideas, skills and resources that they could draw upon. I felt it was not too little in support or too much in support”.

The *Primary Connections* units and lessons were being rewritten to align with the new *Australian Curriculum: Science*, so there was no need to further align and rewrite the Science curriculum for teacher use especially when Science was viewed as a weaker subject area for teachers at the school. With the onset of the new Australian Curriculum and the purchase of the *Primary Connections* Science units, teachers were told to “scrap the old curriculum” (Mrs N and Mrs T).

One valuable aspect of the *Primary Connections* units is the ability to purchase the teacher guidebooks with accompanying boxes of resources and professional development packages. The school chose to purchase the guidebooks without the associated materials and professional development. The Deputy felt they had enough resources already collected within the school. The teachers had been working with the high school teacher to develop the previous Science curriculum, so the Deputy Principal believed the primary teachers did not need further professional development. Since *Primary Connections* was developed for teachers and includes background knowledge, sequential lessons with sample worksheets and assessment, the Deputy felt: “it’s a fairly reasonable support tool” and the concepts that were
taught by the high school teacher with the Science curriculum for the *Essential Learnings* “can still apply”. It’s a matter of “looking at all things on balance. We have had some professional development [in Science] in the past”. He added: “We have to look at priorities from an administration point of view”. This was a response similar to the state school. Both schools chose to provide more time to investigate and respond to the new literacy and numeracy curriculum documents, than was made available for the new *Australian Curriculum: Science*.

In addition, by the end of the year, the Independent School Deputy Principal/HoC decided to provide professional development based on Marzano’s *Art and Science of Teaching* (2007). He believed the teachers could follow the curriculum, but what they needed was to improve their generic pedagogy. The *Art and Science of Teaching* program would work towards that end. Thus, there would be no further professional development on the implementation of the new curriculum.

All the teachers (100%) felt prepared to teach the new science curriculum regardless of having ‘little to no professional development provided by the school’ (100%) for science and the *Primary Connections* resources. This was a noticeable change from the beginning of the year when 2 out of 14 teachers reported they felt they ‘were not prepared to teach the new curriculum’, 10 out of 14 felt ‘somewhat prepared’ and another 2 teachers felt ‘very much prepared’ (see Table 6). However, as a result of no professional development, teachers only had their previous experiences and knowledge to guide them. The fact that the *Primary Connections* are science units that are designed to be teacher friendly in relation to science content, pedagogy and include an entire unit of work, may have influenced their feelings of being prepared. This high perception of preparedness may be also due to being experienced teachers with multiple strategies for handling new situations and repeated curricular imperatives. In addition, the new Science resources with detailed information and lesson plans may have put them at ease as well.
According to the Deputy/Head of Curriculum, primary teachers are “jacks of all trades”. However, the Deputy/Head of Curriculum commented that primary school teachers generally do not feel comfortable with Science teaching. He believed this is particularly strong in early childhood. He felt most early childhood teachers tend to focus more on literacy and numeracy development. Further, he found it common for primary teachers in general to not have an interest in Science, since very little time is actually spent on Science. In fact, the Deputy/Head of Curriculum believed teachers’ experiences in Science would affect the way they taught. He explained: “I think if a teacher has had experiences either as a learner that have been very positive in Science or as a teacher early in their development that has been positive for them, then their propensity to teach Science will [be high] and to engage with that is high. If, to the contrary, that’s been the case, well, then you can see that [Science] kind of slips by the wayside.”

Another consideration is the type and amount of Science studied in university and high school preparation. The Deputy/Head of Curriculum discovered that, with the low amount of Science hours required in High School and the limited amount that seems to be included in university preparation courses, the new teachers were beginning teaching with a “very narrow understanding or skillset in relation to teaching Science”.

The Independent School Deputy Principal/Head of Curriculum had a genuine understanding of primary teachers’ struggles with teaching Science, but unfortunately did not have the knowledge or skills to provide them with real assistance himself. He believed that the multiple pressures of introducing several curricula simultaneously, high-stakes testing, limited funding, and school/parental expectations made it difficult to provide the necessary support in Science to teachers. He therefore, chose the expedient option of using Primary Connections.

Table 6 presents Pre and Post survey data about teachers’ perceptions of the planning, preparation, professional development and resources for the Australian Curriculum: Science. The Table also represents survey responses from 14 teachers at the beginning, just prior to implementation.
and from 8 teachers after one year of implementation. The change in number is due to the staff decision to share the planning and teaching load by dividing up the subjects to be taught. The 8 post responses were from teachers who taught the *Australian Curriculum: Science* during the first year of implementation. The numbers represent the sum of the positive responses (4 agree or 5 strongly agree on the five-point scale). These were then changed to percentages.

Table 6  Independent School Teachers' ratings of Preparation for Implementation of the Australian Curriculum: Science

<table>
<thead>
<tr>
<th>Section B</th>
<th>Independent School PRE</th>
<th>Independent School POST</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%, n=14</td>
<td>%, n=8</td>
</tr>
<tr>
<td>Looking Forward to new curriculum</td>
<td>43 (6/14)</td>
<td>0 (0/8)</td>
</tr>
<tr>
<td>Extent of School planning and</td>
<td>0 (0/14)</td>
<td>13 (1/8)</td>
</tr>
<tr>
<td>preparation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extent of Personal planning</td>
<td>14 (2/14)</td>
<td>25 (2/8)</td>
</tr>
<tr>
<td>Felt prepared to teach Science</td>
<td>14 (2/14)</td>
<td>13 (1/8)</td>
</tr>
<tr>
<td>Have the Science resources to teach</td>
<td>0 (0/14)</td>
<td>13 (1/8)</td>
</tr>
<tr>
<td>Workshop PD in school beneficial</td>
<td>0 (0/14)</td>
<td>17 (1/8)</td>
</tr>
<tr>
<td>Ed system PD beneficial to help</td>
<td>0 (0/14)</td>
<td>0 (0/8)</td>
</tr>
<tr>
<td>Science teaching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>School PD beneficial to help Science teaching</td>
<td>0 (0/14)</td>
<td>0 (0/8)</td>
</tr>
<tr>
<td>PD sufficient to feel confident to</td>
<td>0 (0/14)</td>
<td>0 (0/7)</td>
</tr>
<tr>
<td>implement Science</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6.1.1.2 Deputy Principal’s Suggestions for Implementation

While the Deputy Principal took the stance to not provide professional development in Science in order to accomplish the school goals and the teaching agenda, he did believe the curriculum roll out was too swift: “I think that there needed to be more time in trial period for this and the other Australian Curriculum [subjects] rather than...by this date we start”. He also stated that a more sensible approach to implementation of the New Curriculum “would have been to start with a Foundation Year and Year One rather than all years, maybe one subject and roll it out little by little....I’m hearing...from colleagues that teachers are feeling really overburdened by this”.

The Deputy Principal understood that the main purpose for changing to the national curriculum was to keep “moving and advancing learning opportunities for students”. However, time in his role had shown him that, “spending some really good quality money on teacher development and pedagogical understanding as to how kids learn and how teachers best teach” is better than spending the money on rewriting the curriculum.

In addition, there are other pressures on schools. As the DP/HoC explained: “Other pressures on us, have made this curriculum a real challenge...NAPLAN tests and the upcoming NAPSAL tests... parent expectations and school accreditations. Schools do not have the time and money to spend on quality professional learning.”
6.2 Bronfenbrenner's Microsystem: Independent School Pre Implementation

The Microsystem represents the teacher and student interactions as well as teacher-to-teacher interactions. The impact of political, systemic and school decisions can be seen through the classroom teaching and interactions among staff. The classroom teachers’ concerns, and implementation actions are discussed after developing a clearer context of the participant teachers’ characteristics and their classroom environments. This section examines the second research question:

To what extent do the teachers feel confident to teach Science and feel prepared to implement the new Australian Curriculum: Science (including initial training and subsequent professional development)?

Several pertinent issues raised by the Independent School teachers are discussed, followed by descriptions of selected classroom observations of Science teaching. To understand better teachers’ comments and actions during implementation, it is necessary to provide a brief description of the school scene by describing the volunteer teachers’ characteristics and their classroom environments.

6.2.1 Case Teacher Characteristics and Classroom Context

The following descriptions of the volunteers were derived from the survey sections A, C and D results, the interviews and classroom observations. The section aims to provide an overview and description of the case study teachers in relation to their teaching background, education, description of their classroom and their perceptions of science and science teaching.

6.2.1.1 Yr 1: Mrs N

Mrs N had 11 years’ experience with Years Foundation, one and two. She was the Year one teacher during this study. Her Science background consisted of chemistry and physics courses in high school, a university level earth and space course and a general environmental science course. Mrs N opted to be the Science teacher for the Year one students.
Mrs N reported on the survey that she was not at all looking forward to the new *Australian Curriculum: Science* (Appendix J). She also indicated she had no ‘professional development from the education system’ or ‘the school’. She therefore had no support to help her teach the new curriculum. However, after seeing the new curriculum, she rated herself as ‘4’ (agree) out of ‘5’ (strongly agree) to be ‘able to follow the new curriculum’, reporting that it appeared “sequential and full of information”. Additionally, Mrs N identified Science as ‘worthwhile’ and ‘enjoyable’. She also placed her ‘confidence’ to teach Science at ‘5’ on a seven-point scale. Mrs N had strong positive (5) beliefs around student ‘experience’, ‘observation’ and ‘group discussions’. She also showed inconsistency in the approach to teaching Science when she rated ‘4’ (agree) for the importance to teach each of the following: ‘content’, ‘theme’, ‘process’ and ‘topics’. The four approaches have different teaching philosophies and teaching strategies that did not necessarily align with the current expected practices. These responses indicated Mrs N felt fairly confident teaching Science and employed a range of teaching strategies.

### 6.2.1.2 Mrs N’s Classroom

Mrs N had a large well-organised classroom. The main entry was on one side of the rectangular room and another door across the room led to the patio area. This classroom shared a kitchen with another Year one classroom and had an adjoining door into that classroom. Students’ desks were arranged in groups of six. There were displays of student work on the walls, hanging from the ceiling and on top of a couple of round tables and short bookshelves. The remnants of the Science sound unit were still atop the tables. There was a small floor area set up at one end of the room with a projector and speaker system for Mrs N to use to save her voice. Mrs N’s desk was in the far back corner of the room near the storage nook. The room, while full of student work was organised and tidy. Mrs N described her class as “really active” and “full on”. Her class consisted of 24 students; 8 girls and 16 boys. She had one student identified with Autism Spectrum
Disorder (ASD) and two with Attention Deficit Hyperactivity Disorder (ADHD).

6.2.1.3 Yr 4: Mr D

Mr D was a classroom teacher with 11 years of experience teaching students in Years 3, 4, 6, 8, 9, 10, 11 and 12. He had completed high school physics and a general environmental science at university. Mr D believed his life experiences and past coursework benefitted him when teaching Science. He had extensive work in electronics and has always loved Science. He had two hours of Science professional development in the last five years, and had taught the Science for two of the Year four classes.

His survey results indicated he felt there was no professional development by the education system and the school (Appendix J). Instead, he personally planned for Science and felt he was able to follow the new curriculum. Mr D rated himself ‘6’ on a seven point scale for personal experience, with Science as ‘important’, ‘enjoyable’ and believed he could ‘teach it more often’. He also rated himself highly in ‘confidence’ to teach Science with a ‘6’. Mr D rated his belief in ‘group work’ and ‘discussions’ very highly. He was unsure if the ‘teacher should demonstrate the Science activities’ and if there ‘should be an emphasis on particular topics’. However, he had strong beliefs about the value of ‘child-centred learning activities’, and ‘group work’ along with a focus on ‘Science processes’.

6.2.1.4 Mr D’s Classroom

This large square classroom was modern and organised with built in floor cupboards and bench tops on two sides of the room. The white boards were at the other two ends of the room. Student desks were arranged in groups of 4-6. There were jars with soil samples for each class atop one of the benches. A few posters decorated the walls. The shelves were orderly with books, students’ composition books and other school supplies. Mr D’s desk was in the corner near the door. Here he had stacks of student work, lunch and other items on his desk and the bench beside him. He taught a Science
class of 30 students and one of 28 students. His class contained a mix of low to high achievers. None required special learning assistance.

6.2.1.5 Yr 6: Mrs T

Mrs T is an experienced teacher of 30 years. She was teaching the Year 6 class but has also taught Years 1-8, 10, 11 and 12. Her high school teaching was in the area of Sociology and Religion. Mrs T had completed high school biology and general environmental science at university. She did not participate in any Science professional development.

Mrs T was very interested in the new curriculum; but identified on her survey that the school provided ‘some’ information about the new curriculum, but that professional development was insufficient (Appendix J). She rated her time planning highly at ‘4’ (agree) out of ‘5’ (strongly agree) and felt she was able to follow the new curriculum. While Science is not part of her teaching background, she felt Science was ‘important’ and ‘worthwhile’ and that she should ‘teach it more often’. She rated her ‘confidence’ to teach Science at ‘5’ on a seven-point scale. Mrs T believed students would ‘remember more from activities’, than merely ‘factual presentations’. She also believed in ‘discussions’, ‘establishing rules’ during Science and ‘catering to differences’. She obtained her Science information from ‘books’ and ‘online sources’. Mrs T gave negative responses to ‘teaching Science concepts’, ‘topics’, ‘themes’ and ‘processes’ as well as the use of ‘teacher demonstration’ and ‘group work’. She was unsure whether or not all ‘students should be doing the same Science activities’. Many of these responses demonstrate lack of Science teaching understanding by Mrs T.

6.2.1.6 Mrs T’s Classroom

In order to reach the large airy classroom, it was necessary to walk through a small courtyard that was shared by two classes. There was another patio space at the opposite side of the room where a second door was located. These two outdoor spaces were occasionally used for teaching. The classroom was large and rectangular, with a white board at one end and
with the teacher’s desk in the front corner. Shelves were placed around the room and contained books and other school items in an organised fashion. Student desks were arranged in rows for the first observation and in groups of 4-5, with a couple of students seated individually for the next observation. It is believed this was changed due to our conversations about Science teaching after the first observation. No student work was on display; the walls were bare. The back of the room had a small table covered with a white cloth containing religious artefacts. There was a large floor space and one chair for the teacher near this table. Mrs T's Year 6 class consisted of 27 students. There was a range of student ability levels with one student on a special learning plan; another student had extreme behaviour difficulties. She described her class as energetic and friendly.

6.2.2 Preparing to Teach the New Science Curriculum

Only two teachers at this Independent school were very interested in the new Australian Curriculum: Science. Just over half of them (8) had ‘little to no interest’ in the new curriculum. At this early stage, a majority of the teachers were disinterested in the Science curriculum change. They had experienced some frustrations with their last set of curriculum documents, so were not eager to begin new curriculum documents again. When it came to Science planning with the Australian Curriculum: Science and the Primary Connections units, the teachers were on their own. Many of the teachers (85%) spent substantial time planning and becoming familiar with the new Science curriculum in their own time.

The first rewritten and Australian Curriculum aligned units from Primary Connections arrived in early 2012. The Deputy led a brief meeting where teachers were given their first books and asked to compare them with the ACARA website. Teachers had to spend their own time getting to know the materials, the new content and structure. The teachers worked together in year-level meetings to correlate the Australian Curriculum with the Primary Connections curriculum. They were also able to decide if they would divide up the teaching areas for more focussed teaching and planning. Many teachers were already doing this. Most year-levels decided to divide up the
subjects so each teacher was working with two to three classes and teaching an equal amount, based upon the time allocations and their personal subject preferences. This meant only eight teachers were actually teaching Science. There was no other Science professional development available for the teachers.

6.2.2.1 Professional Development

The volunteer case study teachers in this school indicated they would like more time to understand the “bigger picture”. That is, the layout of the curriculum from foundation to Year seven. One teacher felt very strongly that the preparation for the new curriculum was practically non-existent. “The professional development that we did have on the new curriculum was next to useless and just a waste of time basically. So it’s more or less been up to us, just as individual professionals to get it together” (Mrs T). The teachers felt some professional development would have been very useful. These statements reflected the survey findings, as the majority of the teachers felt there was ‘little to no professional development’ to help implement the new Australian Curriculum: Science. “I can’t think of the last time that I would have even seen Science Professional Development available” (Mr D). Teachers have suggested the need for “some good solid professional development” (Mrs T). The teachers sounded very keen to take on Science professional development around “new ideas, new approaches, new resources, that sort of stuff” (Mrs T). There was also a sense of understanding that they may be “behind the times” in their teaching of Science. As Mr D stated: “I’d love to just go off and do some Science professional development, just to lift my game. Just to be sure that I’m on the right track, that I haven’t gotten stuck in a rut”. The general feeling by the staff was that there was a need for professional development and the person in charge of teaching and learning should plan for it. Mr D further asserted: “They’re tasked to at least give us some sense of a framework and then the opportunity to play with it a bit. Feedback, talk with other teachers...and have some good collegial conversations across year-levels”.


6.2.2.2 Working with Primary Connections Units

Teachers’ confidence in teaching Science (or lack thereof) affects the manner in which Science is considered and taught by the teachers. The confidence levels appeared to be related to prior experiences with Science, the amount of Science background and the Science professional development a teacher had received. The teachers’ backgrounds are described above. Survey questions sought ratings of how they felt about teaching Science. It should be noted that this school was substantially higher in confidence than the other two schools at the beginning of the implementation year. The staff generally had a very positive attitude towards Science and felt it was a very important subject.

Table 7 below indicates the positive responses from the 14 (Pre-survey) and 8 (Post-survey) primary Independent School teachers on a seven-point scale with the highest choices of five, six and seven combined. The number of Post-survey participants differs to an extent because some teachers chose to swap classes for other subjects to reduce their load with the new curriculum. As a consequence, this further reduced the number of teachers teaching science.

Table 7  Independent School Teachers’ Ratings of Personal Experiences in Science Pre and Post the implementation of the Australian Curriculum: Science

<table>
<thead>
<tr>
<th>Survey Section C</th>
<th>PRE Implementation</th>
<th>1 year POST Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal Experiences in Science – Independent School</td>
<td>(14 teachers)</td>
<td>(8 teachers)</td>
</tr>
<tr>
<td>%</td>
<td>n/14</td>
<td>%</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Try to teach more often</td>
<td>62 (8/13)</td>
<td>88 (7/8)</td>
</tr>
<tr>
<td>Science is Worthwhile</td>
<td>93 (12/13)</td>
<td>88 (7/8)</td>
</tr>
<tr>
<td>Science makes me Happy</td>
<td>77 (10/13)</td>
<td>88 (7/8)</td>
</tr>
<tr>
<td>I feel Confident</td>
<td>85 (11/13)</td>
<td>75 (6/8)</td>
</tr>
<tr>
<td>Science is Enjoyable</td>
<td>85 (11/13)</td>
<td>88 (7/8)</td>
</tr>
<tr>
<td>Science is Rewarding</td>
<td>85 (11/13)</td>
<td>75 (6/8)</td>
</tr>
<tr>
<td>Science is Important</td>
<td>92 (12/13)</td>
<td>63 (5/8)</td>
</tr>
</tbody>
</table>
Lack of professional development with the new *Australian Curriculum: Science* led teachers to adapt the *Primary Connections* for their own use. They felt it met the needs of their students with some units, but others did not suit them at all. For example, the Year One chemical Science unit was difficult. “[The children] love doing it but the actual concepts of some things change and can’t be changed back and other things can change but can [also] change back…some of that kind of stuff was beyond them” (Mrs N).

However, they agreed the units were a starting point that needed building upon. When planning and comparing the *Primary Connections* with the ACARA documents, some teachers were inclined to add in activities or adjust activities to complete the alignment and suit their teaching preferences. As Mr D explained: “There are still bits that don’t work and bits that are missing and some of it didn’t line up much at all. I think there’s enough there to get people well and truly going. I actually quite like the *Primary Connection’s* stuff”.

The *Primary Connections* were seen as suitable for beginning teachers or teachers who were not confident in Science or even avoided Science. “For someone who has never taught Science it’s really great in terms of that, monkey see, monkey do” (Mr D).

One teacher felt there was not enough time to cover the units properly. One particular Science unit about the Natural and Man-Made world was not completed. “It was just enough just to try and unpack some of the natural causes for kids” that the man-made part was left out completely. (Mr D).

In contrast, Mrs T in the upper primary found that students were saying, “We’ve done this in [Year] 3 or 4 or 5. So we’re looking at how we…extend them”. For example: The students had completed a unit on electricity previously so Mrs T and another teacher were looking at “getting them to design an eco-house and set up a whole lighting system for this house in a box”.


In the past the success of Science activities determined whether or not it would be maintained or abandoned. “Sometimes we’ll try something one year and it either worked – well good. We’ll refine for the next year. If it flopped, well then let’s ditch that and try something else” (Mrs T). This attitude continued with the Primary Connections. For example, Mrs T discovered her students loved the book, The Cockroach War. So she decided to add ‘solar-powered insects’ and the book to the unit on electricity for the following year.

They had no extra support with these Primary Connections resources. This set of materials, designed and tested to follow an inquiry approach and teach concepts developmentally, was misunderstood due to lack of professional development. They were left to seek information from the Australian Curriculum website for guidance on topic information and depth of topics. “Look, we’d love just some more information. We really have been told – go into the website. Go and have a look” (Mrs N).

Time was an issue for Mrs N as the young children “take ten times as long as anticipated”. So finishing units can be challenging. On the other hand another teacher saw time as a concern because “collecting the resources and setting things up is probably one of the hardest things…” (Mrs T). Teachers were feeling “very overloaded with the massive changes all throughout” (Mrs N). They tried to “co-ordinate timetables and resources with the secondary school” (Mrs T) but this was viewed as a time issue since both campuses ran on different schedules.

The Primary Connections documents appeared “wordy” and “unwieldy” to the teachers as they felt the writers seemed to be trying to tick all the boxes for the new Australian Curriculum. When preparing for the lesson activities they just wanted to “get to it”. Regardless, the teachers were happy with the Primary Connections units. Mrs T stated: “I’m really excited about the Primary Connections and it gives us so much more structure than what we’ve had in previous years. Even though it doesn’t cover everything in the curriculum, we’re going beyond that and sourcing from elsewhere. At least it’s a good core resource. So I feel we’re on the right track there at least”.
6.2.2.3 Resources

The primary teachers were expected to use the Science materials left from the previous curriculum. The survey indicated that 100% of the teachers felt the school had very little to some suitable resources for Science teaching. Many felt they were lacking the types of resources needed for the lessons in the Primary Connections, which led teachers to adapt activities where needed. Lessons were even skipped when they felt the resources were not available; or they did not know how to make substitutions. “There are times when there’s not stuff … that we need. Then it’s just pull stuff together...” (Mr D).

Mr D thought the senior school Science labs were very well resourced and available for teachers to use, and to seek equipment support. It is known that the senior school has aides to help prepare materials. Mrs T thought it would be very helpful if the primary could have aides too. “If we want to get things organised [for Science] we have to do it in our lunch breaks or our non-contact time”.

Preparing purchase orders was thought to be time consuming and difficult “so in the end you end up paying for stuff yourself anyway and that just builds resentment towards [Science] and things in general too” (Mrs T).

Science support for the upper primary was available from the head Science teacher in the senior school. Mrs T welcomed this support as she enjoyed the collaboration. “I really value particularly in Science, the communication with [the Head of Science]. It’s nice to have that support and people you can talk to”.

6.2.3 Confidence to Use and Teach the New Science Curriculum

By the end of the first year of implementation, teachers’ confidence levels were maintained along with viewing Science as ‘worthwhile’ and ‘rewarding’. This is likely due to the use of the Primary Connections units. In addition, teachers appeared happier with the new curriculum probably due to its structure and the embedded background information for teachers. They were able to teach themselves the basics about the structure and purpose of
the \textit{Primary Connections} due to the comprehensive information provided in the materials. They found the resource lists, activities and worksheets helpful when planning. The assessment section was viewed as being valuable, with checklists available and linking with the Australian curriculum expectations. However, the sequence of inquiry activities were not always followed and sometimes activities were substituted with other activities they knew about from previous curriculum materials. The only aspect not observed and also not commented on were the group management suggestions and resources. According to Mr D: “I actually quite like the \textit{Primary Connection} stuff. At least it was a launching pad. I think the 5Es approach is good. If you’re really not confident teaching science, I felt that at least it provided really good step by step [instructions].” This may have led to some teachers spending more time teaching Science.

In contrast, to teachers’ levels of confidence, science was no longer viewed as being ‘important’ (Table 7). Identifying Science as important or not important may be influenced by the school’s priorities. Often the district and school will apply more time and money to areas deemed important or of value. It is well known that schools and districts across the world have placed greater value in Literacy and Numeracy.

\subsection*{6.3 After One Year of Implementation}
This section used classroom observations to identify teachers’ actions when planning and teaching the new \textit{Australian Curriculum: Science}. Their actions also reveal their beliefs about Science and Science teaching. This section examines the third and fourth research questions.

The third sub-question:

Which beliefs about teaching Science do the teachers hold, how frequently do they teach Science, and what teaching strategies do they commonly use when teaching Science?
6.3.1 Beliefs about Science Teaching and Learning

By the end of the year, the survey results indicated that these teachers had moved to a more content-focussed belief about Science teaching than either process or topic approach. There was also a substantial decline in the belief that teaching in small groups was suitable. This demonstrated movement away from an inquiry approach. The school chose to prioritise support in English and Maths thus limiting the extra time to become familiar with the new *Australian Curriculum: Science*. Interviews revealed that teachers decided to focus on the content, which was clearly specified in the *Primary Connections* units, due to time constraints to prepare for science activities. Additionally, teachers wanted professional development to support their understanding of Science, especially with new year-level concepts. Teachers believed in the use of student observation and experimentation (88%, 7/8) and discussions (100%) in Science, which demonstrated there may be some alignment with an inquiry approach (Harlen, 2009). A smaller proportion of teachers believed science should be taught by topics (38%, 3/8) and in groups (25%, 2/8). The lack of professional development for these teachers unfortunately left them divided in regards to the appropriate pedagogy for Science teaching (examples below). These teachers spent time trying to self-educate but lacked some of the necessary content knowledge and on-going support necessary for sustained improvement in Science teaching and learning. This ultimately affected their reported level of confidence (Murphy et al., 2007).

With school focus on Literacy and Numeracy, 79% of the teachers felt there ‘should not be more time allotted to Science teaching’ than is already expected.

Science support and Science materials were at a minimum. As with the State School, these teachers would have used the previous state curriculum and should have been familiar with science processes, process skills and investigations. However, it seems many did not have a clear understanding of this approach to teaching science. Teachers were searching, reading and self-teaching with the new *Australian Curriculum: Science*. They were finding
alternative and innovative ways to plan and prepare to teach Science. This
did not mean they were necessarily teaching in the manner expected;
through an inquiry approach. This was evident in the examples of teaching
observed.

6.3.2 Case Study Teaching Approaches in the Independent School

The classroom observations and interviews (see Appendix B) captured that
these three Independent School teachers had a style of teaching that
matched their personal experiences with Science. The more Science
background and interest in Science a teacher had, the more their Science
teaching and discussions reflected an inquiry approach and an ability to
develop deeper student understanding of the concepts. A number of
approaches to teaching Science were observed and are described below.

6.3.2.1 Inquiry Approach

One teacher’s Science knowledge and experience with inquiry learning
enabled him to create effective inquiry learning sequences. For example,
when Mr D was working on an earth and soil unit, his students first
predicted what they thought they might find in soil. He focussed them on
discovering the components soil. The students collected soil samples in
jars, added water and mixed. They observed this settled over time until the
jar contained layers of soil. He demonstrated how to observe the contents
then sketch the observations. These results were later compared with a real
section of land that had been cut away to see two metres depth of soil and
patterns. Mr D was not afraid of messy activities. He assisted students in
learning how to observe and record their findings. He followed a simple
inquiry approach with interactive and real life components.

6.3.2.2 Trial and Error

Similarly, when a teacher had little or no Science background but was
interested to learn and improve classroom teaching skills, their actions
reflected this attitude. Mrs T was quick to say she knew very little about
Science and felt out of her depth. She spent hours researching information to support her knowledge and she was keen to try out the inquiry approach for my observations. Mrs T located a *YouTube* video on the Scientific Method to support student learning. She tried a yeast investigation found in the *Primary Connections* books. This was the first time she tried to lead an investigation so she eagerly sought my advice with this chemical Science unit. Mrs T knew she would make mistakes but was not afraid to do so. She didn’t feel threatened learning with the students; however, she preferred they did not know that she lacked knowledge and skills (See Appendix F). Mrs T wanted to learn how to teach with an inquiry approach and therefore sought my support after the observations. We spent some time after school discussing and planning so she could continue on her own.

### 6.3.2.3 Assimilating Prior Strategies

On the other hand, a teacher who was skilled at working with young children and had many teaching strategies to keep children engaged, used those particular strategies to teach Science. Mrs N was an experienced early childhood teacher. She had a range of effective teaching strategies such as the use of music to teach concepts and vocabulary, the use of concrete charts and hoops for Venn diagrams to sort items into ‘natural’, ‘man-made’ or ‘not sure’, and the use of literature to help represent topics and concepts. It is common for teachers to use familiar strategies learned through other subject areas, which they know work, to teach Science. However, an inquiry approach in Science was still expected and was not observed in this classroom.

### 6.3.2.4 Modelling / Demonstration

Modelling or demonstrating is a common and effective technique used to teach many subject areas. These teachers used modelling to teach Science. However, the teachers with a Science background tended to use modelling more often than those who did not have a strong Science background. They also modelled more Science appropriate behaviours than those with less Science background. For example, Mr D held up his jar of soil, talked
about general observations, pointed to a few interesting items in his jar. Then, using the whiteboard drew his jar and what he saw in his jar with careful consideration of details. He spoke about what he was seeing and drew simultaneously. He labelled the items and layers. On the other hand, Mrs T who was less confident in Science only gave students a list of steps to follow. There was no modelling or demonstration provided.

6.3.2.5 Observation

Knowledgeable Science teachers also see observation skills as a key component of Science. As described above, Mr D felt observation in Science was a key component to successful learning. He found this to be a difficult strategy for students to learn.

In contrast, teachers lacking Science knowledge often overlook observation skills as a key component of the Science activities. Mrs T tried to use observation when working on a yeast investigation that included different combinations of yeast, sugar, salt, warm water and balloons attached to the bottles. Students were asked to describe the observed outcomes of the four yeast jars and any balloon inflation. Students focused on the balloon inflation component (as did Mrs T) and not any other aspect such as what was happening inside the jars. Here, further understanding of the particular science concept was needed.

6.3.2.6 Utilising Prior Knowledge

Further, identification of student prior knowledge was a common component of teaching and learning at this school. For example, in a biology unit in Year One, when the teacher had the students draw their sketch of a snail before looking at a real snail, she discovered they had minimal knowledge, even misconceptions about snails. This information helped her prepare for teaching.

The Independent School teachers understood the value of open communication with their students, however, were not so comfortable with
some effective teaching strategies for Science like – group lessons, teacher demonstrations, and the process approach (see Table 6).

In Table 8 the numbers represent the sum of positive responses (4 agree or 5 strongly agree on a five-point scale). These were then converted to percentages. The Post survey included only those teachers who taught science after the re-distribution of key subject areas to reduce the preparation load. Thus, there is a reduction in numbers for the post survey. At times some questions were left unanswered.

Table 8 Independent School teachers’ beliefs about teaching Science pre and post implementation of the Australian Curriculum: Science

<table>
<thead>
<tr>
<th>Survey Section D</th>
<th>PRE</th>
<th>POST</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Beliefs about teaching Science – Independent School</strong></td>
<td><strong>Agree (4) or Strongly Agree (5)</strong></td>
<td><strong>Agree (4) or Strongly Agree (5)</strong></td>
</tr>
<tr>
<td><strong>%</strong></td>
<td><strong>n/14</strong></td>
<td><strong>%</strong></td>
</tr>
<tr>
<td>The structure of the Science course should be based on process not content.</td>
<td>86</td>
<td>50</td>
</tr>
<tr>
<td>(12/13)</td>
<td>(4/8)</td>
<td></td>
</tr>
<tr>
<td>There should be an emphasis on teaching Science through Science topics rather than concepts.</td>
<td>46</td>
<td>38</td>
</tr>
<tr>
<td>(6/13)</td>
<td>(3/8)</td>
<td></td>
</tr>
<tr>
<td>The teacher should emphasise the content matter of the lesson.</td>
<td>62</td>
<td>63</td>
</tr>
<tr>
<td>(8/13)</td>
<td>(5/8)</td>
<td></td>
</tr>
<tr>
<td>Science should be based on student observation and experiment.</td>
<td>62</td>
<td>88</td>
</tr>
<tr>
<td>(8/13)</td>
<td>(7/8)</td>
<td></td>
</tr>
<tr>
<td>Science lessons should be demonstrated by the teacher to the class.</td>
<td>36</td>
<td>38</td>
</tr>
<tr>
<td>(5/14)</td>
<td>(3/8)</td>
<td></td>
</tr>
<tr>
<td>There should be activities carried out by different groups in class.</td>
<td>42</td>
<td>25</td>
</tr>
<tr>
<td>(6/14)</td>
<td>(2/8)</td>
<td></td>
</tr>
<tr>
<td>There should be open discussions among students to communicate their work.</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>(14/14)</td>
<td>(8/8)</td>
<td></td>
</tr>
</tbody>
</table>
6.3.3 Teacher Implementation Processes in the Independent School

The beliefs teachers hold about Science and Science teaching often determine how they will implement a new Science curriculum (Haney et al., 2002; Roehrig & Kruse, 2005; Savasci-Acikalin, 2009; Tobin & McRobbie, 1997).

The fourth set of sub-questions:

After one year from the release of the *Australian Curriculum: Science*,

a) What have schools and teachers done to implement the curriculum?

b) How has the implementation of the new *Australian Curriculum: Science* impacted on the school and teacher actions about how to teach Science and

c) What actions do teachers believe should occur to progress implementation?

A year later, the teachers (100%) felt there was ‘little to no professional development provided by the school’. Thus, the teachers reported that they had experienced no professional development with *Primary Connections*. However, they also reported they felt (100%) ‘some to greatly prepared to teach the new curriculum’. They described the new curriculum, *Primary Connections*, as a guide that was informative and easy to use. Consequently, teachers only had their previous experiences and knowledge to guide them. This perception of preparedness may be due to being experienced teachers with multiple strategies for handling new situations and repeated curricular reform imperatives.

This school had a well-established process of allowing teachers to act as professionals by working together in teams to plan, teach, and solve problems. The Deputy Principal took advantage of this when he provided what he felt was a complete Science curriculum for teachers to follow. He asked the teachers to work in their teams to develop an understanding of the new curriculum. However, their personal capacity with Science knowledge limited the depth they could reach and the support they could
provide for each other. This was all that was available to them within this primary school. If a year-level team decided to teach all the subjects themselves, then teams planned the Science units together. If one person was going to teach for the entire year-level, then that teacher was left to plan alone.

6.3.3.1 Self-Educating

In the beginning, the teachers read, studied and researched information in the Primary Connections units and the Australian Curriculum: Science. As the teachers began to teach the Primary Connections Science units, they were able to identify concerns. The new curriculum revealed knowledge gaps with themselves and the students, as they moved from the previous curriculum to the new curriculum. This made Science teaching challenging when the teachers found themselves teaching a concept for the first time, one which was also new to the students. In addition, teachers were unfamiliar with what was learned previously and how to connect prior knowledge with the science concepts. For example, the sound concepts in Year One and the soil concepts in Year Four had several abstract ideas (such as wave lengths and soil composition a kilometre under the ground) that the teachers found difficult to explain and to find ways to assist student understanding. The lower primary teachers seemed to realise that they had to engage with more science concepts and more difficult concepts than previously. “I was surprised myself at how abstract some of the concepts were and how easy it is as an adult to assume that some of these constructs that I've built are almost common sense. But of course they certainly aren’t. How do you build those constructs? Certainly my experience this year has been that these guys weren’t ready to build some of that conceptual understanding” (Mr D).

6.3.3.2 Curriculum Details across Year Levels Sought

The case teachers desired more specific work with the framework of the new curriculum. As previously explained, the teachers at this Independent School commonly worked in year level teams to plan and solve problems
pertaining to their students’ learning and year level subjects. They became very familiar with their own year level information but felt it was important to know and understand the spectrum of learning from Foundation to Year 7. Teachers wanted to “have some sense of where everything is moving from and to [in the curriculum]…and how each [year] level is building [for] the next” (Mr D). A missing link was a clear understanding of the intentions year level by year level and strand by strand (for example, biology).

6.3.3.3 More Science professional development

Another suggestion was more Science professional development. The original professional development they had with the Essential Learnings and the high school Science teacher were in the past, and did not include an investigations approach for primary students. “I would love to have time with people who have taught the [Primary Connections] curriculum before” and get their advice on how to “do it better” (Mrs N).

The upper primary teachers would have liked to have time to plan and prepare with the senior Science teachers. “We’re looking at the energy unit…it just didn’t go far enough with these kids” (Mrs T).

Mrs N summed up their feelings: “We need more time to get a good understanding of all the curriculum changes…”you have to fit it all in but you don’t get enough time to do it all well. You feel like you’re trying to just catch your breath”. But you have to keep “moving onto the next thing”.

6.3.3.4 Resources

Teachers are always looking for resources for Science. Resources such as, the Scootle repository has many activities available for teachers but, “there is so much stuff it’s just useless.” A few staff discussed this concern and suggested that it, “would have been better off to have vetted it carefully and put in exemplar learning objects rather than just tossing in anything and everything. It’s just a great grab-bag and I don’t think teachers want a grab-bag” (Mr D).
A list of resources or websites to help teach content was suggested. This was a preliminary way teachers located Science activities and information; some even purchased materials through online websites. They understood the inherent inefficiency of this strategy and time required to continue to do this. In summary, the new curriculum and the new content areas have required teachers to seek online support more frequently.

6.3.4 Support for Primary Teachers

Primary teachers are known to use a range of teaching strategies, management techniques and resources. When teachers are required to use new curriculum materials, new teaching approaches and unfamiliar content with no prior training, they will typically default to their normal routines and resources for support (Johnson, 2007). This is not an optimal solution for curricular reform or change. The case teachers provided suggestions for support, but none came to fruition. One suggestion was to have colleagues who have taught with the curriculum previously come in to share and model for them. Even to the point of sounding a bit desperate one teacher stated, “just someone who’s had the experience in teaching it or was actually running it through the year with professional development” (Mrs N). There was a strong desire to have a thorough look at the curriculum components and break it down to make sense of it.

The Deputy Principal’s support was important. Although he did not provide professional development in Science, the fact that he indicated that the schedule and teachers were “overloaded”, made them feel better about not being quite up to personal and professional expectations at that time.

Alternatively, staff support within the school was a possibility. Teachers indicated each knew the other teachers’ strengths and interests and felt they could seek assistance from each other if needed. However, it was mentioned that one would need the confidence to go up to a fellow staff member to seek assistance. “You know the staff who has the expertise you need and so long as you’ve got the personal confidence to go up and ask....” (Mrs T). It was felt that generally, teachers were supportive of each other, but sometimes
professional pride got in the way of seeking assistance. Often teachers bounce ideas off each other in staff rooms and break times and this is a less threatening approach for someone with low confidence.

Teacher aide time was another suggestion; it was seen as a solution to Science teaching pressures. This school made a decision that aides were not to be used for gathering resources for teachers. Instead, they were used to support one-to-one work or small group work with students. It was argued that time restraints during the day made gathering materials difficult. As Mrs T pointed out: “I’d like more freedom in how I could use my teacher aide time because if I could get them to collect a lot of the gear, which would save me an enormous amount of time and stress”.

Professional development in Science teaching was seen to be comprised of: learning to understand the philosophy behind the *Australian Curriculum: Science*, the teaching strategies to be utilised, the Science knowledge required, how to use Science materials and the expected ways of assessing student understanding. These teachers indicated they would respect support from their peers. This may be due to the way they cooperatively plan and share their teaching loads. Peer coaching, when led by knowledgeable staff, has been found to be quite successful (Showers, 1985, 1996); and when it is part of the school ethos it may develop improved practice when sustained for long periods.

This school had a strong sense of ability and freedom to solve problems. The staff believed Science was an important subject; and had the means to work with colleagues to answer some of their questions about the general curriculum and its delivery. However, Science knowledge was still needed and desired by the teachers. They were keen to do their own research to find out information about Science concepts; having high confidence in their ability to discover how to teach the *Australian Curriculum: Science*. The teachers were quite happy with the *Primary Connections* resources that provided much of the existing information to support teachers. In summary, the teachers believed in themselves and their ability to plan, prepare and seek assistance from colleagues. They had the confidence to
teach what they felt was suitable and hopefully in alignment with the curriculum expectations.

6.3.4.1 Assessment

The Primary Connections units have assessment tasks embedded into the units of work. The assessments are typically connected to the curriculum tasks and provide on-going feedback to the teacher. The final task is designed to be an investigation that incorporates all the information learned from the unit to reveal students’ understandings and abilities to follow investigative processes.

Interestingly, these case teachers have incorporated a variety of assessment procedures. These included rubrics and observations in the lower primary years, Science journals and discussions in Year 4 and “experiments laid out in the traditional assignment format with a task sheet, research a topic, or multiple experiments and fill in an observation sheet” in the upper primary years. None of the case teachers followed the assessment process as it was designed in Primary Connections. According to Mrs T, when teachers are under pressure they choose simple assessment: “It’s all step by step when you’re under an overload. I think we can still be improving on that assessment area yet.”

6.3.4.2 The Deputy Principal’s Impression of their Implementation Progress

By the end of 2012, and after a year using the new curriculum, the Deputy indicated that the implementation process did not go as smoothly as he would have liked. “There are greater pressures upon us that have made this curriculum a real challenge”. For example, some of the factors he believed had an impact on implementation were:

- Amount of time available
- Need for a longer trial period
- NAPLAN and NAPSAL tests “hanging over their heads”
- Parents “feel pressure and are numbers driven” and want results.
- Independent schools’ market is a competitive one and schools need to perform well.
The Deputy Principal believed that these factors and others needed to be considered more by the people who are administering ACARA for future development of the curriculum. He suggested a slower roll out, whereby the new curriculum would be introduced in Foundation and Year One then move up the year-levels one year at a time. As the Deputy/HoC stated: “I think a more sensible way to have gone about implementation of all of Australian Curriculum would have been to have started with a prep year in one year rather than all years, maybe one subject and roll it out little by little and give teachers post-trial opportunities to then slowly begin implementation because I think one of the things I’m hearing at – not [only] in my school but lots of other schools and from colleagues around is that teachers are feeling really overburdened by this.”

An additional concern for new curriculum rollout, not mentioned by the Deputy Principal, is the number of subject areas that are new and require changes to content knowledge or teaching strategies (Hord & Huling-Austin, 1986). The fact that four main curriculum areas were released simultaneously with the expectation to begin teaching them all, across all year levels, increased stress significantly. All subject areas demanded time to be understood, to learn the content, teaching strategies and assessment expectations. Although the Primary Connections materials could be considered educative curriculum materials, as they contain enough information to assist and inform teachers about how to use the materials and teach with the inquiry approach, the program would be more effective if used with other forms of support and professional development (Davis & Krajcik, 2005).

The last time this school provided Science professional development occurred when the Essential Learnings came out in 2007 and the curriculum needed to be transitioned to these. When the Deputy Principal decided to purchase the Primary Connections Science resources, he took the approach that “Primary Connections, it’s a fairly reasonable support tool.” His view then was that professional development was not required for it. “We have to look at priorities from an administration point of view. The
emphasis this year is on the Art and Science of Teaching [Marzano] and rolling out some of that very good pedagogical stuff because we believe that that’s critical, irrespective of the curriculum.” In other words, teachers can follow the curriculum and teach it. The focus will be on improving pedagogy because that will ultimately affect all subject areas.

This school demonstrated cooperative working conditions amidst frustration and lack of support. As with the state school, the teachers planned and taught Science lessons as best they could within the school support structures and with the resources available. However, the implementation lacked time, substance and direction.

These teachers were keen to teach Science and use the new Australian Curriculum: Science. Only one of the three teachers followed the Science units as set out in the Primary Connections resources. Even so, this teacher made adjustments and added further activities to support student learning. The others attempted to use the new Science materials but only used what they wanted to incorporate, then sought activities elsewhere. This kind of approach to teaching the Primary Connections resources meant the integrity of the units was being challenged and the chance of disjointed learning was greater. Teachers with substantial Science knowledge may be able to create similar learning situations as are presented in the Science resources, but two of these teacher participants had little to no Science education background and little to no Science professional development. Poor Science knowledge and poor professional development in combination lead to unchanged outcomes in Science teaching (Desimone et. al., 2002; Johnson, 2007; Guskey, 2002; Parise & Spillane, 2010).

A Summary reflecting the situation of this school, along with the other schools in this study, is presented in Chapter 8: Looking at Three Schools. Chapter 8 was created to provide a summary that would assist the reader to view each school as a whole and to make comparisons among the schools.
7 CATHOLIC SCHOOL

7.1 Bronfenbrenner’s Mesosystem

The interactions and processes at the mesosystem level for this Catholic school were very different to those at the State School and the Independent School. A brief description of the school context leads into the school curriculum processes just prior to and during the 2012 implementation year. This information informed the first research question:

What school contextual factors do the school leaders see as being most relevant to making changes in the implementation of the Australian Curriculum: Science and in Science teaching?

7.1.1 The Primary Catholic School: Pre Implementation

This was a regional P-12 Catholic school. The high school was located on the same campus with the primary school; however both campuses ran largely independently. This school, like the other two, catered to a range of student abilities from those with special needs to gifted students. Teachers’ experiences ranged from beginning to over 30 years of teaching experience. Twenty-six teachers participated in the Pre implementation surveys to obtain their general response and understandings. Only 11 participated in the Post survey because only 11 still taught the new Australian Curriculum: Science. This school worked in year level teams and divided up the subject areas, thus reducing the load for new curriculum learning, planning and implementation.

7.1.1.1 Prior to the Australian Curriculum

Several years ago, the Head of Curriculum (HoC), Mr P, went to an in-service session with an established Science education researcher. He remembered the presenter talking about ‘Cows Moo Softly’ and researchable questions and other things surrounding inquiry in Science. Mr P spoke to him about primary Science teaching. The discussion confirmed his personal thinking about Science and reinforced in him the importance of inquiry in Science. Mr P always believed that Science needed to be more than just conveying
facts. Now, he felt supported by an experienced researcher in Science Education with the same beliefs. Mr P noticed that some curriculum, like the new Australian Curriculum, while it may refer to the use of inquiry, was still up to the individual teachers to teach with an inquiry focus; he commented: “I think you still can happily ignore that [component] and not see the intent of it.” While Mr P has some Science knowledge and Science teaching skills, he found it difficult to help his teachers develop the understanding about the longevity that inquiry often requires.

The HoC (Mr P) in this Catholic School was involved with staff curriculum development for 10 years. He was an integral part of the planning and professional development in this school. “In the beginning we were just telling” the students what to do and how to do it. There was no process in Science for allowing students to discover and investigate. To instigate change, the HoC led the teachers to a more complete understanding of the concepts they already knew by expanding on their knowledge and understanding of those concepts during professional development sessions. Several years ago, he began to introduce ideas they were not as familiar with, such as: constructivist approach to teaching, investigations, Science concepts, data collection, interpretation and more. Slowly he changed and shaped their understanding of Science teaching. Effective pedagogy was the ultimate goal and was woven in little by little with the discussion of Science concepts and how to get children to understand them. One of the hardest habits to change was teachers’ desire to give children the answers.

This school adopted the Primary Connections Science materials when the current Head of Curriculum (Mr P) began working at the school. There was little Science training before this time. The Five E inquiry approach embedded in these materials was new to the teachers and needed time and patience to establish. Many teachers continued to reverse the Explain and Explore Phases, so the telling was at the beginning as in a traditional approach. Mr P has discovered “it takes a long, long time” for teachers to change their habits. He observed: “The difficulty is probably teacher level of
knowledge, teacher use of language including the problems associated with that, and last on skills such as observing and inquiry [teaching].”

7.1.1.2 Introduction to the New Curriculum

As part of the introduction to the new curriculum structure, this Catholic School spent time learning the new language of the new curriculum; strands, substrands, descriptors, elaborations, etc. Mr P helped facilitate this understanding by developing a hands-on approach (with a self-made puzzle) to facilitate understanding the new names of sections of the curriculum as well as the levels within the materials and the intentions of each section. He compared the content elaborations of the old and new curriculum to determine the changes and the impacts it would have on year-levels and teaching. Then he helped staff to do the same. Plans were made to make some adjustments to the support that he saw teachers would need. This school had a routine in place for planning and teacher support. This entailed, small year-level meetings and planning sessions with the HoC and librarian. Teacher release was scheduled in year-level rotations twice each term in lieu of staff meetings. This school had a strategic plan that worked towards developing teaching and learning skills for all teachers in all subject areas.

Teachers tested out some of the new Australian Curriculum during the early implementation period. C2C was not an option since, as a non-state school, they had no access to it at that time. Their students were already scoring well on national exams so the pressure to switch to the new curriculum immediately was not there. Teachers gradually trialled and became familiar with the new curriculum in all subject areas, receiving assistance from the HoC during team planning and from their peers during weekly planning. While a few survey responses were left unanswered, the survey revealed 88% (22/25) of the 26 teachers said there was ‘some, to very much’, preparation by the school to prepare them for the new Australian Curriculum: Science. In addition, 78% (18/23) said they ‘spent time personally planning for the new Science curriculum’. Overall, 92% (23/25) responded with some ‘feeling of preparedness to teach the new Science curriculum’.
This Catholic school relied heavily on *Primary Connections* because it provided background information and misconception information related to the topics. The curriculum leader decided to continue with the *Primary Connections* revised version for its alignment to the new *Australian Curriculum: Science*. He stated that the teachers were not strong in Science and should not be expected to make sure the alignment was there. Furthermore, he believed the *Primary Connections* was a starting point to the planning and as teachers became more confident, they would become more divergent. It was his belief that the pedagogy of Science shines through the *Primary Connections* and is an invaluable component. “*Primary Connections* made sure the pedagogy came first, otherwise, I think you’re in danger of just delivering something…a whole packet of ideas, and you can be very much back where you were. The Science is telling” (HoC). This school used educative Science materials in a manner beneficial for the staff (Davis & Krajcik, 2005). That is, appropriate, collaborative, and long-term professional development assisted in the feeling of staff preparedness to teach Science.

Table 9 presents Pre- and Post-data about teachers’ perceptions of the planning, preparation, professional development and resources for the *Australian Curriculum: Science*. The Table also represents survey responses from 26 teachers at the beginning, just prior to implementation and from 11 teachers after one year of implementation. The change in number is due to the staff decision to share the planning and teaching load by dividing up the subjects to be taught. The 11 post responses were from teachers who taught the *Australian Curriculum: Science* during the first year of implementation. The numbers represent the sum of the positive responses (4 agree or 5 strongly agree on a five–point scale). These were then converted to percentages. Some responses were left unanswered.
Table 9  Catholic School Teachers’ ratings of Preparation for Implementation of the Australian Curriculum: Science

<table>
<thead>
<tr>
<th>Section B</th>
<th>Catholic School PRE %, n=26</th>
<th>Catholic School POST %, n=11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Looking Forward to new curriculum</td>
<td>12 (3/25)</td>
<td>60 (6/10)</td>
</tr>
<tr>
<td>Extent of School planning and preparation</td>
<td>48 (12/25)</td>
<td>80 (8/10)</td>
</tr>
<tr>
<td>Extent of Personal planning</td>
<td>17 (4/23)</td>
<td>80 (8/10)</td>
</tr>
<tr>
<td>Felt prepared to teach Science</td>
<td>32 (8/25)</td>
<td>70 (7/10)</td>
</tr>
<tr>
<td>Have the Science resources to teach</td>
<td>42 (10/24)</td>
<td>50 (5/10)</td>
</tr>
<tr>
<td>Workshop PD in school beneficial</td>
<td>44 (10/23)</td>
<td>50 (5/10)</td>
</tr>
<tr>
<td>Ed system PD beneficial to help Science teaching</td>
<td>4 (1/24)</td>
<td>22 (2/9)</td>
</tr>
<tr>
<td>School PD beneficial to help Science teaching</td>
<td>33 (8/24)</td>
<td>40 (4/10)</td>
</tr>
<tr>
<td>PD sufficient to feel confident to implement Science</td>
<td>16 (4/25)</td>
<td>30 (3/10)</td>
</tr>
</tbody>
</table>

7.1.1.3 Step-by-Step Development

At the beginning of the implementation year the HoC set ‘big picture’ plans that he gradually moved the teachers towards. For example, change is an overarching idea in Science (Australian Curriculum: Science). It spans several year-levels and appears in many strands. He tried to help the teachers see that curriculum is not just about the specific content focus that has been sectioned out to teach, but rather the development of a greater and more complete picture or comprehensive understanding, including misconceptions. Another main focus is the language of Science. “I believe planning day is often about getting language right in the teachers first, because their own language sometimes undermines what they’re trying
to do” (Head of Curriculum). The professional development in this school was strategically planned for all subject areas. Teachers had received Science support and development over the last 10 years, with the support not only specific to curriculum demands, but also specific to staff and student needs.

7.1.1.4 The Head of Curriculum Viewpoint

After several years of on-going Science professional development, the HoC believed his teachers were only about halfway towards reaching the point of being a staff who all understood the Science concepts and the ways of teaching Science that are most suitable for children to learn and construct knowledge. The HoC was determined to continue providing professional development in the usual manner each year. Progress was being made and Science was viewed as important to the leadership. Therefore, the teachers spent time learning and preparing for Science as they would literacy and numeracy. In this school, Science was valued and given equal time and consideration.

7.2 Bronfenbrenner’s Microsystem: Catholic School Pre Implementation

The Microsystem represents the teacher and student interactions as well as teacher and teacher interactions. The impact of political and school decisions can be seen through the classroom teachings and interactions. The classroom teacher concerns, and implementation actions, are discussed after developing a clearer context of the teacher participants’ characteristics and their classroom environments. This section examines the second research question:

To what extent do the teachers feel confident to teach Science and feel prepared to implement the new Australian Curriculum: Science (including initial training and subsequent professional development)?

7.2.1 Teacher Characteristics and Classroom Context

The following descriptions of the volunteers were derived from the survey sections A, C and D results, the interviews and classroom observations. The
section aims to provide an overview and description of the case study
teachers in relation to their teaching background, education, description of
their classroom and their perceptions of science and science teaching.

7.2.1.1 Year 5: Mrs M

Mrs M had 6 years’ experience teaching Year 5. Mrs M had no high school
Science experience, claiming it was too hard but completed two courses in
environmental Science during university. As a child, Mrs M attended a one-
teacher school in Toowoomba. She believed it influenced her Science
teaching philosophy. She had memories of the school being well resourced
and being involved in Science inquiry learning. She participated in three
hours of professional development in the last five years. Mrs M shared her
teaching with Mrs A so that she could also work as the IT coordinator in the
school. They divided up the subject areas; however, both taught Science.
Mrs M began the unit then the other teacher finished with review activities.
They worked closely to decide what to do.

Mrs M’s survey responses indicated that she was somewhat ‘looking forward
to the new Science curriculum’ (3 on a five-point scale) and felt the school
had ‘greatly prepared’ (5) her for teaching it (Appendix J). Mrs M enjoyed
Science and felt it was ‘important’ (4) but did not feel very ‘confident’ to
 teach it. She rated her self-confidence at ‘2’ on a seven-point scale. She
had strong beliefs (5 on a five-point scale) about ‘child centeredness’, ‘open
discussion’ and ‘emphasising content’.

7.2.1.2 Mrs M’s Classroom

Mrs M had 30 students split evenly between genders. She described her
class as “dynamic” and having “noise, colour and movement”. She believed
her students were kinaesthetic learners showing a range of abilities. She
had two very low achieving students, but they did not require an
Individualised Learning Plan. The classroom had groups of four to six
children sitting together, there was student work displayed over the walls
and the boards, and piles of materials all around. A small room connected
to this classroom, was long and narrow and contained two long bench tops
and supplies. This was an extra area for student group work. Outside the classroom door was a covered patio area that had plenty of floor space and bench seating.

7.2.1.3 Year 5: Mrs A

Mrs A was a Year 5 teacher with 26 years’ experience. She previously taught Years 1, 2 and 3. Mrs A had biology during high school and no Science courses at university. She participated in 3 hours of Science professional development. Mrs A was placed in Year five for the first time in 26 years. She was not confident to teach Science with someone watching her; therefore, she pulled out of the project.

7.2.1.4 Year 7: Mr C

Mr C had 31 years’ experience teaching in Years 3-7. He was the Year 7 teacher during this study. Mr C had chemistry and physics courses during high school and completed one course each of biology, chemistry, physics, earth and space and environmental science while at university. He did not feel as though anything in his past had particularly contributed to his ability to teach Science. Mr C participated in five hours of Science professional development in the last five years. Mr C taught all the Year 7 students for Science. He believed the Science teaching arrangement allowed the teachers to teach to their interests and strengths.

Mr C’s survey results indicated that he was only somewhat ‘interested in the new curriculum’, ‘somewhat prepared by the school and district’ and only had some of the necessary ‘resources for teaching Science’ (Appendix J). Mr C rated himself ‘4’ on the seven-point scale for ‘confidence’ to teach Science and only slightly rated higher (5) for found Science ‘enjoyable’, ‘rewarding’ and ‘important’. His beliefs about Science teaching were inconsistent, in that he rated the importance of teaching ‘Science content’, ‘Science topics’ and ‘Science processes’ at the same level (‘4’ agree out of ‘5’ strongly agree). These three ways of teaching follow different philosophies of pedagogy. Finally, Mr C had a ‘child centred’ focus but while he believed students
should do Science in groups, he believed all groups should be doing the same activity.

7.2.1.5 Mr C’s Classroom

Mr C taught Science to all the Year 7 students. The observed class had 26 students - 13 girls and 13 boys. His room was situated with groups of four to five desks with some in small groups and others with four desks in a row. The room was organised with schedules and upcoming events listed on the board. The room was organised and tidy with samples of student work on the walls. There was a small room attached, containing some supplies and computers for student work. Outside the door was a substantial undercover area for spill over space and activities. Two of the students were hearing impaired with cochlear ear implants, four to five from the entire Year 7 cohort were on Individualised Learning Plans (ILP) and one child was accelerated.

7.2.2 Preparing to Teach the New Science Curriculum

The Catholic School teachers were not very excited about the new curriculum. Only 12% (3/25) indicated on the survey they were either ‘very much’ or ‘greatly looking forward to the new curriculum’. Mr C summed up their feelings as follows: “After [several] years of getting to know the last curriculum, here’s a new one. There’s another reason to shun it, put it on the back burner. It’s only because of people like our Curriculum Coordinator putting it in our faces that Science even gets a look in”.

Implementation of new curriculum is a long-term process. This school continued its usual processes for planning and preparing for curricular changes and challenges for the year. On designated days one year-level of teachers at a time met to discuss main curricular concepts to be taught, links between subjects and subject integration ideas. Meetings with the HoC and librarian also transpired during this day to assist with planning. Questions could be asked and resource needs checked. This process kept the HoC up to date with staff needs and concerns surrounding the curriculum.
7.2.2.1 Primary Connections in the Catholic School

While the teachers had been using the Primary Connections units for a number of years, they had particular practices and thoughts about these curriculum documents. The teachers believed the writers had good Science knowledge and understanding of children and their thinking from level to level and concept to concept. However, regardless of that, teachers still decided to “cherry pick bits and pieces out of each one” (Mr C). One of the experienced teachers believed it was due to the fact that “teachers avoid anything that’s messy”, regardless of the subject. He believed Science should be taught in a practical manner, “not that I always do it, but that’s the way I perceive Science should be taught.” To resource the practical side of science teaching, this teacher wondered if it would be the job of the curriculum writers to design a kit of concrete materials containing all the components required for teaching a unit of Science. In addition, the new curriculum that reflects expectations by year-level, was well received by teachers. To Mr C, this was much clearer than the previous state curriculum that was written in modules and described science concepts to be developed across a few year-levels rather than year-by-year. This was also reflected in the revised Primary Connections’ resources.

The Primary Connections was redesigned to align with the Australian Curriculum and now provides resources by year-level. In the past teachers often taught what they were interested in teaching from the modules. There was very little thoughtful sequencing or development of concepts. The Primary Connections “provided a clear sequence that works well”. (Mrs M)

Once the teachers became familiar with a unit, that is after they taught a unit 2-3 times, they were ready to take it a bit further. They could expand on the activities because they understood the science content and background information better. As teachers spent time with a content area, they became comfortable and began to work out ways of improving and finessing areas. They also began to change their pedagogy. According to the HoC, the curriculum is all about a, “list of content knowledge and skills.”
You don’t get pedagogy” (HoC). However, *Primary Connections* has a way of making sure the pedagogy is part of the curriculum (Skamp & Peers, 2012).

Science misconceptions are another aspect that is difficult. Teachers have identified they need to overcome their own misconceptions first so they can explain concepts correctly and not transfer their own misconceptions to their students. “How do I put activities or experiments in front of kids in a way that will generate the correct concepts not the misconceptions or just reinforce old ones [misconceptions]? So most of my time is in research and understanding that sort of thing” (Mr C).

The teachers believed it took more time to plan for Science than other topics. As Mr C explained: “Proportionately, there is more effort involved in planning for a Science hour than there is for an English hour”. It is clear the district has a greater focus on Literacy and Numeracy because “you’re provided with resources and the kids have textbooks that support [Literacy and Numeracy] teaching. Science has nothing”. Locating and gathering concrete materials were determined to be some of the hardest parts of Science teaching. Teachers were looking for activities that would work and make sense for students (Appleton, 2002). Even with the *Primary Connections* units to follow, sometimes the teachers looked for additional or alternative activities for the students.

The types of materials available at the school will impact on teachers’ planning and teaching. Mr C stated that “one of the biggest supports that a teacher can have, is [enough concrete materials] for the experiments that the [whole] class can participate” rather than just enough for a demonstration.

Also, the time and effort to locate those concrete materials may influence the Science teaching, as indicated by the HoC: “I think one of the big problems with Science is trying to get all the materials that they need. I think a lot of the time, that’s the thing that will stop teachers from doing the Science. They just don’t have the time to get [concrete materials] together.”
7.2.3 Confidence to Use and Teach the New Science Curriculum

The Catholic School teachers appeared to have substantial changes in their attitudes and confidence towards teaching Science (see Table 10 below). However, the greatest change was the way they chose to handle teaching the new *Australian Curriculum: Science*. In the beginning the staff were split about their feelings towards teaching Science. The new curriculum provided an opportunity for the staff to make changes to their teaching situation by dividing up the subject areas to reduce the planning load. Thus the teachers who had a stronger preference for Science could choose to teach Science. Therefore, the Post results indicated a higher percentage of teachers with positive feelings towards Science. In addition, there was relief when the staff discovered they would continue to be able to use the familiar *Primary Connections Science* resources. While Science was valued at this school, it was also given the required amount of teaching time according to curriculum documents. The teachers were very aware of the time regulations for each subject.

It is contradictory to previous research findings (Harlen & Holroyd, 1997; Murphy, Neil & Beggs, 2007; Hoy & Spero, 2005) that reduced confidence could be a result of increased professional development and support. These teachers had relatively lower responses to Science teaching in the Pre-implementation period and those who taught the new Science curriculum for the first year still had low confidence levels when compared with the other participant schools after one year with the new Australian Curriculum. It is possible that their deeper level of knowledge of Science concepts and knowledge of Science misconceptions contributed to a greater awareness of the limitations of their teaching and student learning outcomes.

The following table represents survey responses from 26 teachers at the beginning, just prior to implementation and from the 11 teachers involved after one year of implementation. The change in number is due to staff decisions to share the planning and teaching load by dividing up the subjects to be taught. The 11 Post responses were from teachers who
taught the *Australian Curriculum: Science* during the first year of implementation. The numbers represent the sum of the positive responses (5, 6 or 7 on a seven-point scale). These were then converted to percentages.

Table 10  Catholic School Teachers’ Ratings of Personal Experiences in Science Pre and Post the implementation of the *Australian Curriculum: Science*

<table>
<thead>
<tr>
<th>Survey Section C</th>
<th>PRE Implementation (26 teachers)</th>
<th>1 year POST Implementation (11 teachers)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>n/26</td>
</tr>
<tr>
<td>Try to teach more often</td>
<td>58 (15/26)</td>
<td>46 (5/11)</td>
</tr>
<tr>
<td>Science is Worthwhile</td>
<td>77 (20/26)</td>
<td>91 (10/11)</td>
</tr>
<tr>
<td>Science makes me Happy</td>
<td>54 (14/26)</td>
<td>91 (10/11)</td>
</tr>
<tr>
<td>I feel Confident</td>
<td>39 (10/26)</td>
<td>64 (7/11)</td>
</tr>
<tr>
<td>Science is Enjoyable</td>
<td>50 (13/26)</td>
<td>64 (7/11)</td>
</tr>
<tr>
<td>Science is Rewarding</td>
<td>46 (12/26)</td>
<td>80 (8/11)</td>
</tr>
<tr>
<td>Science is Important</td>
<td>62 (16/26)</td>
<td>82 (9/11)</td>
</tr>
</tbody>
</table>

### 7.3 After One Year of Implementation

This section used classroom observations to identify teachers’ actions when planning and teaching the new *Australian Curriculum: Science* and survey responses from the 11 who taught science throughout the study period. Their actions also revealed their beliefs about Science and Science teaching. Interview responses were also included and acted as a third data source to compare actions and statements. This section examines the third and fourth research questions.

Third sub-question:

Which beliefs about teaching Science do the teachers hold, how frequently do they teach Science, and what teaching strategies do they commonly use when teaching Science?

#### 7.3.1 Beliefs about Science Teaching and Learning

The Catholic School teachers showed noticeable changes in teaching beliefs by the end of the year in regard to two broad topics. An increase
occurred in the areas of teacher demonstration and student observation and experimentation. This is further supported by the observations and interviews. The observations revealed teachers tended to follow a more guided inquiry approach. The interviews provided further understanding that the main purposes for guided inquiry were class control due to time constraints and the restricted availability of some resources. Demonstration, observation and experimentation fit well into an inquiry process. Another point of interest is their high rating for ‘content focus’ and lower rating for ‘process focus’. This may be due to a lack of understanding of Science processes (inquiry) or the time involved in completing the Science processes. It may also be influenced by the fact that teachers had been working on improving their own content knowledge during planning and preparation sessions. The idea of ‘open discussions’ has maintained 100% representation and was seen as ‘highly valued’.

### 7.3.2 Case Study Teaching Approaches in the Catholic School

These teachers had several years of professional development in Science. Classroom observations demonstrated variety and individuality in their approaches while still maintaining some degree of an inquiry approach (see Appendix F). Teachers incorporated teaching strategies such as utilising prior knowledge, inquiry focus, determining misconceptions, adding further activities to the *Primary Connections* Units and incorporating ICT into their Science routines.

#### 7.3.2.1 Utilising Prior knowledge

All the teachers believed prior knowledge was important but only 55% (6/11) indicated they always ‘sought student understanding before beginning a unit of work’. As part of her IT role, Mrs M taught students how to make iMovies. She also incorporated IT skills in Science where students demonstrated their prior understanding of how light travelled and how we see things through a mini movie. Mrs M began the Light unit by having students demonstrate their knowledge of light and shadows while exploring
with puppets and light. Students made a simple puppet show that demonstrated their understanding of ways to use light and shadow.

Mr C identified prior knowledge of forces when students wrote what they knew about an image of a boy on a skateboard. Students were able to respond with words, sentences, arrows and pictures. He used this information to plan the upcoming unit.

7.3.2.2 Inquiry

This school indicated that about 60% (6/10) of the teachers believed a ‘process’ or ‘inquiry approach’ was the way to teach Science. For example, Mr C followed a helicopter activity found in Primary Connections. This activity was designed as an investigation. Mr C arranged for students to choose an investigation from two predetermined questions and led them through a guided inquiry with demonstrations. The investigation was completed once and data were recorded and shared. There was no chance to redesign the investigation or change the question due to weather conditions. The students followed the basic steps but did not complete their inquiry.

7.3.2.3 Misconceptions

Mrs M identified misconceptions with an early activity. Students drew a tree, an eye and the sun. They were to explain how people see. This was recorded in their drawing and as a video. At the end of the unit, students revisited their video to decide if it was still what they believed. If not they could remake the video.

Mr C’s skateboard picture and lesson (described in prior knowledge above) also gave him an indication of any student misconceptions about forces.

7.3.2.4 Adding on to Primary Connections

Mrs M tried to incorporate local resources to enhance the unit on Light and Shadows. She hoped to take students to the senior school to spend time in a dark room where there was no light.
Mr C researched his topic to find additional suitable and age appropriate activities that would keep students engaged while teaching Science concepts. He found Lego kits utilising simple machines. These were integrated as part of an explore lesson on forces.

7.3.2.5 Using ICT

Mrs M often incorporated the laptop and videos to enhance the Science learning. Use of the devices and software programs were always demonstrated prior to use. When she completed a unit she had students compile and edit the video recordings of their learning for their summative report.

Mr C incorporated laptops when Year 7 students were to record the investigation data and create a graph. This information was then included as part of a typed scientific report.

The teachers at this school identified greater alignment with effective approaches to teaching Science such as: following a process approach, using observation, deliberately teaching Science content and using teacher demonstrations over less effective approaches such as: following a topic approach. However, most teachers preferred to have the same activity completed by all groups (73%, 8/11). It seems they believed a whole class approach was more expedient particularly when resources were lacking. Observations also revealed that these teachers were using a more guided approach to science inquiry. So students were not at the stage of creating their own open inquiry investigations that often lead to groups doing different investigations.

The following table (Table 11) represents survey responses from 26 teachers at the beginning, just prior to implementation and from 11 teachers after one year of implementation. The change in number is due to the staff decision to share the planning and teaching load by dividing up the subjects to be taught. The 11 post responses were from teachers who taught the Australian Curriculum: Science during the first year of implementation.
numbers represent the sum of the positive responses (4 agree or 5 strongly agree on the five–point scale). These were then converted to percentages.

Table 11 Catholic School Teachers’ Ratings of Beliefs about Teaching Science Pre and Post the implementation of the *Australian Curriculum: Science*

<table>
<thead>
<tr>
<th>Survey Section D</th>
<th>PRE Agree (4) or Strongly Agree (5)</th>
<th>POST Agree (4) or Strongly Agree (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beliefs about Teaching Science - Catholic school</td>
<td>% n/26</td>
<td>% n/11</td>
</tr>
<tr>
<td>The structure of the Science course should be based on process not content.</td>
<td>71 (17/24)</td>
<td>60 (6/10)</td>
</tr>
<tr>
<td>There should be an emphasis on teaching Science through Science topics rather than concepts.</td>
<td>48 (12/25)</td>
<td>40 (4/10)</td>
</tr>
<tr>
<td>The teacher should emphasis the content matter of the lesson.</td>
<td>96 (25/26)</td>
<td>91 (10/11)</td>
</tr>
<tr>
<td>Science should be based on student observation and experiment.</td>
<td>79 (19/24)</td>
<td>90 (9/10)</td>
</tr>
<tr>
<td>Science lessons should be demonstrated by the teacher to the class.</td>
<td>58 (15/26)</td>
<td>73 (8/11)</td>
</tr>
<tr>
<td>There should be different activities carried out by different groups in class.</td>
<td>54 (14/26)</td>
<td>27 (3/11)</td>
</tr>
<tr>
<td>There should be open discussions among students to communicate their work.</td>
<td>100 (26/26)</td>
<td>100 (11/11)</td>
</tr>
</tbody>
</table>

7.3.3 Teacher Implementation Processes

The manner in which teachers implemented the new Australian Curriculum depended to some degree upon their beliefs about teaching and their understanding of Science teaching strategies.
The fourth set of sub-questions:

After one year from the release of the *Australian Curriculum: Science*,

a) What have schools and teachers done to implement the curriculum?

b) How has the implementation of the new Science curriculum impacted on the school and teacher actions about how to teach Science and

c) What actions do teachers believe should occur to progress implementation?

This school spent a number of weeks assisting teachers with understanding the new Australian Curriculum. The implementation year began similarly to previous years with the HoC planning and leading professional development. The majority of the teachers (91%, 22/24) indicated the school provided professional development to help implement the *Australian Curriculum: Science* and 91% (21/23) felt the professional development was beneficial.

This Catholic School had a clear planning structure in place. The administration set targets and learning area foci for the year. Instead of attending a staff meeting, planning time was scheduled for teams of three teachers every four weeks. One release day every term was also scheduled for teachers to meet with the other year level teachers and plan. Mrs M explained: “If it wasn’t blocked together, each of us would be released in a separate hour, do our own thing and never talk to each other about what’s going on. Unless we decide to stay after school to meet about something important” “Everyone’s involved with all the subjects which is good because that’s where you’re getting everyone’s ideas”.

Year level meetings were designed for teachers to get support from the HoC, librarian and their team of year level teachers. Teams decided how they would organise themselves, and decided how they would approach each subject area. Problem solving as a group was common; and teachers were
able to draw from their experiences and knowledge bases to address concerns creatively.

For example, during the introduction to the Australian Curriculum, the teachers pulled apart the strands of the new curriculum to look at the elaborations and gain a better understanding of what was to be taught. These teachers identified inconsistencies in the curriculum. As Mr C explained the: “Science doesn’t seem to be developmental from one year to the other. They seem to be separate entities”. For example, there are many concepts or topics that are only taught once, such as electricity, light, and living/non-living things. He did not see much connection between year-levels and topics where concepts can be gradually built upon. He compared this idea to concepts in Mathematics where multiplication, for example is continually built upon and students’ understandings become more complex. Mr C felt that Science gave the impression that you only have “one chance to get it right” with the students or they would go away not understanding the concepts with no further opportunities available. This added pressure to teach well and make sure students understood the basic concepts.

7.3.4 Support for Primary Teachers

The Head of Curriculum was the main person at the school to support teachers in Science. His support took various forms. He would demonstrate teaching strategies, model teaching in their classrooms, discuss concerns and offer books to assist the teachers.

Colleagues were another way for teachers to obtain assistance. Except, it seemed to be assumed that all teachers are in the same position in regards to Science understanding. Mr C summed it up with: “No one knows the answers. I wouldn’t go to a colleague with a Science question. No I just wouldn’t. I wouldn’t go to a colleague with Science questions for fear of embarrassing both myself and them going…I don’t know either, what do we do?” These teachers were asking the hard questions. Questions about Science concepts and why things happen. These types of questions would expose their understanding or lack thereof.
The Internet was a possibility, but locating Science concepts explained simply in a way that was suitable for primary teachers and primary students was difficult. Mr C suggested places like the BBC that are quite useful but not necessarily aligned with the Australian Curriculum. Teachers felt it would be useful to have some animated Science explanations “where I don’t have to be the teacher with the knowledge” (Mr C).

Other suggestions included book resources. As Mr C explained: “What teachers need are not textbooks but books that contain how to and what to teach for Science across every year-level”. For example, “A little dictionary that says, here are the definitions, but they’re just words. A kid can repeat back and write down a large object has more inertia than a small object” without really knowing what that means. Books like Science dictionaries are seen as useful but not necessarily for assisting with investigations. Finding suitable books was difficult.

Mrs M suggested sharing between schools. In other words, schools now have to teach the same content; so, when a school in the same region has found helpful resources or ideas, there should be some easy way to communicate these. When teachers or schools identify, for example, people who visit schools and can help teach content, places for excursions and businesses which will support schools in some way, there should be a way to share this information so all can benefit.

An extra person in the room to help with inquiry activities and investigations was suggested. When the outdoors are being utilised as a learning place, or in larger classes of students an extra person is beneficial. The idea of seeking parents to assist in the upper primary classrooms was raised. Mrs M felt: “having a few extra people in the classroom shows that you really care about the kids’ experiments and [helps] you investigate and work at their pace.” Doing investigations means you have students moving around and doing different things at different times. Mr C viewed this as a reason for teachers to return to didactic teaching: “I think that’s the trickiest thing. Maybe that’s why people tend to go back to the…I’m going to teach, you’re going to write, or you’re going to do after I talk.”
7.3.4.1 Concrete Materials

Collecting concrete materials were seen as time consuming and something that may stop teachers from teaching Science. The teachers (100%) indicated that ‘this school provided some, to all, of the resources’ prior to and after the new curriculum. To assist teachers, this school decided to set up a concrete materials box for each unit that was taught from Foundation to Year 7. To facilitate the use of the resources, the librarian, the Curriculum leader and some helpers replenished the materials. Teachers only needed to check out the box and return it with the list of materials that needed replacing. The HoC found that over the past five years, teachers increasingly used the boxed units. He was confident that over the four terms, most of the teachers were teaching the required four units of Science. “It hasn’t been the case in the past. People would say, I’ll teach one this semester, but now they’re saying, hang on, we really need to do four” over the year. This practice has continued with the introduction to the Australian Curriculum: Science.

In summary, the structured school processes and procedures of the school enabled teachers to develop understanding of curriculum changes. The teachers continued to have year level meetings to plan and share together throughout the year. They had the opportunity to problem solve curriculum and student concerns. The teachers accessed the Head of Curriculum for support as well as books and online resources. Professional development in Science continued to occur. Some teachers accessed parents to assist during Science. This school made only minor adjustments to meet the needs of the new curriculum. Teachers were able to continue with the established routines and planning processes, while gaining an understanding of the new curriculum thus maintaining some stability.

7.3.4.2 Assessment

The teachers used the Primary Connections materials, which contained sample assessment that was embedded into the unit. This was sometimes followed or used as a guide for one teacher. Mr C would adapt the activities if he chose to incorporate different activities into the unit. However, he
would try to follow the 5 E inquiry process to acquire final assessment based upon a completed investigation.

Mrs M followed another approach when assessing her students. Since she had a technology interest, she would utilise this skill and have students record the summation of their daily learning activities as mini movies. At the end of the unit, the students would combine all the movies as evidence of each student’s understandings. In this way she included evidence of formative data to demonstrate progress at the summative level. These were made available to parents.

It is evident that there was a mixed approach to assessment. Nevertheless, there was a stronger belief in process and inquiry skills, as well as enacted inquiry processes at this school than the other two schools. They were in a position to build on their previous learning and experiences from the Primary Connections resources and materials.

A Summary reflecting the situation of this school, along with the other schools in this study, is presented in Chapter 8: Looking at Three Schools. Chapter 8 was created to provide a summary that would assist the reader to view each school as a whole and to make comparisons among the schools.
8 LOOKING AT THREE SCHOOLS

It is beyond the scope of this study to determine if the implementation procedures were successful in rolling out the new *Australian Curriculum: Science* to achieve particular outcomes for students. This study only sought to examine the self-reported and observed procedures and strategies that were followed, and whether the teachers felt prepared to teach the new *Australian Curriculum: Science*. When the teachers are prepared and supported during curriculum change, they are more likely to teach the required curriculum well and achieve satisfactory student outcomes (DeMonte, 2013). This section responds briefly to the main research question in regard to the three regional schools and provides a summary of each school.

In what ways does a new national *Australian Curriculum: Science* provide impetus, at school and teacher levels, for Science curriculum change and for improving Science teaching, and to what extent does such impetus influence changes in practice?

The three schools are located in the same region in Queensland; however, the schools and teachers have demonstrated a range of implementation procedures and strategies. The teachers have also demonstrated a range of responses with many feeling under prepared to teach Science.

The three schools and their teachers regardless of the school sector they belonged to, were subject to the same political discussions and debates around the *Australian Curriculum* changes. Each school was subject to the same implementation schedule set by the state government. The Queensland schools were under high levels of implementing authority, constraint and regulation to follow prescribed policies and procedures. There was little freedom to implement a new curriculum in another manner involving the rollout of reading, writing (English), Mathematics and Science all at once. The History curriculum was expected to be implemented immediately following the previous three. The remaining five subject areas were being developed and were soon to be released.
This strict set of implementation procedures and timelines demonstrated a lack of interest and knowledge at the state level, in regard to how teachers and the schools need to prepare for new curriculum and the changes within each curriculum (Fullan, 2007, 2009). The timeline was highly restrictive and limited the ability of some schools, to manage implementation carefully and efficiently. Each school implemented the new *Australian Curriculum: Science*. However, only a superficial level of implementation was achieved in some schools where teachers would use the new terminology, but didn’t necessarily demonstrate effective implementation. Some schools did not reach a level where teachers developed an understanding of the intentions of each subject area and the necessary changes made to content, teaching strategies, resources and the online features of the curriculum. However, another approach to curriculum implementation as reported by Hipkins et al., (2011) is to see “implementation of change as a process of iterative adaptation (p. 5)” where change can occur over time in order to build capacity. This type of approach was observed in the Catholic School.

The previous chapters described individual school cases to gain a better understanding of the data within each school context. The tables below present the variance in implementation at the three primary schools both prior to teaching with the new *Australian Curriculum: Science* and after using it for a year. An overview of the three schools will be presented followed by an individual summary of each school.

Table 12 (below) presents the pre and post survey results from teachers’ ratings of the Science implementation processes in their schools and classrooms. The percentages represent the combination of ‘very much’ (4) to ‘greatly’ (5) responses. This level of response was chosen because the extent of curriculum change was enough to require substantial professional development.

Overall, there wasn’t much interest in the new *Australian Curriculum: Science*. The amount of support and planning differed greatly between the Independent School and the other two schools. The Independent School with several 0% ratings appeared to be very under supported and underprepared.
The Catholic School appeared to be receiving the most support, preparation and resources/materials to teach.

The State School and the Catholic School received professional development, which seems to have increased teachers’ feeling of being prepared to teach. However, none of the Schools were very confident. It does appear though, that professional development may have influenced the level of confidence in the State and Catholic Schools.

After the Science Spark support finished in the State School, about 50% of the teachers clearly felt like they could teach science and would have the resources to teach. Whereas the Catholic School, with the regular on-going workshops in science, felt the most prepared to teach Science. They also felt the school planning and personal planning were useful. The high level of negative responses by the Independent School teachers may be due to lack of professional development and Science focus in the school.

An additional feature was that, while the teachers in the Independent School showed a high ranking for looking forward to the new curriculum, they showed the lowest levels of satisfaction with the professional development and support that they received at system and school levels.
Table 12 Teachers’ Ratings of preparation for Science implementation Pre and Post the implementation of the *Australian Curriculum: Science*

<table>
<thead>
<tr>
<th>Section B</th>
<th>State School PRE %, n=10</th>
<th>State School POST %, n=14</th>
<th>Independent School PRE %, n=14</th>
<th>Independent School POST %, n=8</th>
<th>Catholic School PRE %, n=26</th>
<th>Catholic School POST %, n=11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Looking Forward to new curriculum</td>
<td>30 (3/10)</td>
<td>25 (3/12)</td>
<td>43 (6/14)</td>
<td>0 (0/8)</td>
<td>12 (3/25)</td>
<td>60 (6/10)</td>
</tr>
<tr>
<td>Extent of School planning and preparation</td>
<td>22 (2/10)</td>
<td>8 (1/12)</td>
<td>0 (0/14)</td>
<td>13 (1/8)</td>
<td>48 (12/25)</td>
<td>80 (8/10)</td>
</tr>
<tr>
<td>Extent of Personal planning</td>
<td>78 (7/9)</td>
<td>42 (5/12)</td>
<td>14 (2/14)</td>
<td>25 (2/8)</td>
<td>17 (4/23)</td>
<td>80 (8/10)</td>
</tr>
<tr>
<td>Felt prepared to teach Science</td>
<td>56 (5/9)</td>
<td>58 (7/12)</td>
<td>14 (2/14)</td>
<td>13 (1/8)</td>
<td>32 (8/25)</td>
<td>70 (7/10)</td>
</tr>
<tr>
<td>Have the Science resources to teach</td>
<td>11 (1/9)</td>
<td>50 (6/12)</td>
<td>0 (0/14)</td>
<td>13 (1/8)</td>
<td>42 (10/24)</td>
<td>50 (5/10)</td>
</tr>
<tr>
<td>Workshop PD in school beneficial</td>
<td>22 (2/9)</td>
<td>27 (3/11)</td>
<td>0 (0/14)</td>
<td>17 (1/8)</td>
<td>44 (10/23)</td>
<td>50 (5/10)</td>
</tr>
<tr>
<td>Ed system PD beneficial to help Science teaching</td>
<td>13 (1/8)</td>
<td>8 (1/12)</td>
<td>0 (0/14)</td>
<td>0 (0/8)</td>
<td>4 (1/24)</td>
<td>22 (2/9)</td>
</tr>
<tr>
<td>School PD beneficial to help Science teaching</td>
<td>20 (2/10)</td>
<td>0 (0/12)</td>
<td>0 (0/14)</td>
<td>0 (0/8)</td>
<td>33 (8/24)</td>
<td>40 (4/10)</td>
</tr>
<tr>
<td>PD sufficient to feel confident to implement Science</td>
<td>33 (3/9)</td>
<td>9 (1/11)</td>
<td>0 (0/14)</td>
<td>0 (0/7)</td>
<td>16 (4/25)</td>
<td>30 (3/10)</td>
</tr>
</tbody>
</table>
The following Table (Table 13) presents the pre and post survey results about teachers’ beliefs about Science teaching. The percentages represent the combination of Agree (4) and Strongly Agree (5) responses. Table 13 also allows comparison of the beliefs by all classroom teachers about how Science should be taught by the teachers in each school. Nearly all teachers felt it was important to have discussions during Science. However, all three schools scored relatively low in views about teaching with a process/inquiry approach. This is likely due to the lack of professional learning in this area. Teachers at both the State and Independent Schools were unable to explain if they were following a science process or inquiry process. The two non-state schools believed observations in Science were valuable and only the Catholic School felt it was important to emphasise deliberately the content matter. It is interesting that the State School rated higher in teacher demonstrations and teaching with groups doing different activities or investigations when this was not observed in classroom teaching. Perhaps some of the professional development with the Science Spark teacher encouraged this type of teaching. It also seems that more responses for demonstration, observation and experiments occurred in the State and Catholic schools because they were learning that these components are part of an inquiry process that should be included in Science teaching. Further, they received information about the structure of the Science curriculum and terminology used in the Science curriculum. In addition, teaching content rated higher with the State and Catholic Schools and may also be due to learning content during the professional development.
### Table 13  Teachers' Ratings of Beliefs about Teaching Science Pre and Post the implementation of the *Australian Curriculum: Science*

<table>
<thead>
<tr>
<th>Section D Beliefs about Science Teaching</th>
<th>State School PRE Implementation, %, n=14</th>
<th>State School POST Implementation, %, n=14</th>
<th>Independent School PRE Implementation, %, n=8</th>
<th>Independent School POST Implementation, %, n=26</th>
<th>Catholic School PRE Implementation, %, n=11</th>
<th>Catholic School POST Implementation, %, n=11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science should be based on process not content.</td>
<td>50 (5/10)</td>
<td>50 (6/12)</td>
<td>86 (12/13)</td>
<td>50 (4/8)</td>
<td>71 (17/24)</td>
<td>60 (6/10)</td>
</tr>
<tr>
<td>Emphasize the content matter of the lesson.</td>
<td>100 (10/10)</td>
<td>58 (7/12)</td>
<td>62 (8/13)</td>
<td>63 (5/8)</td>
<td>96 (25/26)</td>
<td>91 (10/11)</td>
</tr>
<tr>
<td>Lessons based on student observation and experiment.</td>
<td>40 (4/10)</td>
<td>58 (7/12)</td>
<td>62 (8/13)</td>
<td>88 (7/8)</td>
<td>79 (19/24)</td>
<td>90 (9/10)</td>
</tr>
<tr>
<td>Should have demonstrations by the teacher to the class.</td>
<td>50 (5/10)</td>
<td>73 (8/11)</td>
<td>36 (5/14)</td>
<td>38 (3/8)</td>
<td>58 (15/26)</td>
<td>73 (8/11)</td>
</tr>
<tr>
<td>Different activities carried out by different groups in class.</td>
<td>40 (4/10)</td>
<td>64 (7/11)</td>
<td>42 (6/14)</td>
<td>25 (2/8)</td>
<td>54 (14/26)</td>
<td>27 (3/11)</td>
</tr>
<tr>
<td>Open discussions among students to communicate their work.</td>
<td>100 (10/10)</td>
<td>92 (11/12)</td>
<td>100 (14/14)</td>
<td>100 (8/8)</td>
<td>100 (26/26)</td>
<td>100 (11/11)</td>
</tr>
</tbody>
</table>

Table 14 below represents the teachers’ ratings of their personal experiences with science. The scale was from one to seven with opportunity to move towards extreme ends. For example, one refers to an extreme discontent to three being a mild discontent. Four is neutral and five to seven are positive to extremely positive levels. In Table 14, percentages represent the combination of the positive levels (5 to 7).

Table 14 also presents the impact that personal experiences in Science have had on shaping teachers’ thinking about Science over the year. The Independent School is interesting because it consistently rates Science highly. The ‘teach more often’ category increased probably due to their
newer and more adaptable curriculum materials. However, their ‘important’
category decreased substantially. This is most likely due to the lack of
attention and low priority given to Science by school leadership.

Both the State School and the Catholic School had ratings that increased in
most categories. The larger increases for the Catholic School were likely due
to the initial disappointment in having a change in Science curriculum after
several years of professional development in the previous Science
curriculum, but being later relieved to find they were still going to use their
familiar Science materials in revised form.

Table 14  Teachers’ ratings of personal experiences in Science Pre and Post
the implementation of the *Australian Curriculum: Science*

<table>
<thead>
<tr>
<th>Section C Personal experiences in Science:</th>
<th>State School PRE implementation, %, n=10</th>
<th>State School POST implementation, %, n=14</th>
<th>Independent School PRE implementation, %, n=14</th>
<th>Independent School POST implementation, %, n=8</th>
<th>Catholic School PRE implementation, %, n=26</th>
<th>Catholic School POST implementation, %, n=11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Try to teach more often</td>
<td>60 (6/10)</td>
<td>58 (7/12)</td>
<td>62 (8/13)</td>
<td>88 (7/8)</td>
<td>58 (15/26)</td>
<td>46 (5/11)</td>
</tr>
<tr>
<td>Science is Worthwhile</td>
<td>60 (6/10)</td>
<td>83 (10/12)</td>
<td>93 (12/13)</td>
<td>88 (7/8)</td>
<td>77 (20/26)</td>
<td>91 (10/11)</td>
</tr>
<tr>
<td>I feel Happy</td>
<td>70 (7/10)</td>
<td>83 (10/12)</td>
<td>77 (10/13)</td>
<td>88 (7/8)</td>
<td>54 (14/26)</td>
<td>91 (10/11)</td>
</tr>
<tr>
<td>I feel Confident</td>
<td>70 (7/10)</td>
<td>83 (10/12)</td>
<td>85 (11/13)</td>
<td>75 (6/8)</td>
<td>39 (10/26)</td>
<td>64 (7/11)</td>
</tr>
<tr>
<td>Science is Enjoyable</td>
<td>70 (7/10)</td>
<td>67 (8/12)</td>
<td>85 (11/13)</td>
<td>88 (7/8)</td>
<td>50 (13/26)</td>
<td>64 (7/11)</td>
</tr>
<tr>
<td>Science is Rewarding</td>
<td>70 (7/10)</td>
<td>92 (11/12)</td>
<td>85 (11/13)</td>
<td>75 (6/8)</td>
<td>46 (12/26)</td>
<td>80 (8/11)</td>
</tr>
<tr>
<td>Science is Important</td>
<td>70 (7/10)</td>
<td>83 (10/12)</td>
<td>92 (12/13)</td>
<td>63 (5/8)</td>
<td>62 (16/26)</td>
<td>82 (9/11)</td>
</tr>
</tbody>
</table>

Detailed comparative quantitative analyses were limited by the relatively
small sample size of teacher respondents to the survey questions (N=50 Pre
and N=33 Post implementation across the three schools) and assumptions of
normality for parametric statistical inferential comparisons were not able to
be met in this largely qualitatively structured study. However, the non-parametric Kruskal-Wallis Test (see Appendix C) was able to be used, with limited interpretation, to compare teacher responses across the three schools. No within school comparisons could be made. A number of differences were noted between the Independent School, the State School and the Catholic School that most likely were due to the varied professional development, the science focus or priority and a science support person within the school.

These differences are reflected and elaborated in the broader range of qualitative data.

8.1 A Brief Summary of Each School

8.1.1 State School

The State School planning and implementation processes only touched the surface of change required for effective long-term teaching and learning of the new Australian Curriculum: Science. The State School teachers’ perceptions of the value of Science were relatively high prior to and after the implementation of the new Australian Curriculum: Science. However, they were not particularly looking forward to the new curriculum (30%). This could be attributed to the low priority of science in the school and the time and effort to prepare for science teaching. While there was professional development provided initially in the form of Science Spark teachers, they rated their ‘personal planning’ time higher than the effectiveness of the professional development provided by the school and the state government authority. In addition, teacher surveys showed that the professional development and its effectiveness decreased during the year of implementation. The fact that these teachers were not interested in Science professional development and chose not to attend many of the Science Sparks’ workshops may have contributed to the low rating of professional development effectiveness. Interestingly though, they felt they were fairly well (56-58%) prepared to teach the new Australian Curriculum: Science. The Science “teaching beliefs” Table 13 indicates a movement in some of those
beliefs towards Science teaching practices that are more aligned with effective teaching practices. For example, teachers’ beliefs about Science teaching moved towards more group work and teacher demonstration and less focus on content delivery of facts and memorising content (Roehrig & Kruse, 2005).

Beliefs and Actions about Teaching Science

However, while teachers felt confident and positive about Science, once they were in the classroom teaching Science, they were not teaching with an inquiry-based approach. Many of them knew this was the required approach, but did not know how to teach this way. The observations revealed that one experienced teacher, Mr B, preferred his old materials and ways of teaching (Varelas, Pappa & Rife, 2006). Another teacher, Mrs L, was trying to use and follow the new curriculum expectations but was unable to follow an inquiry approach. Mrs S was closest to an inquiry approach but still included stand-alone didactic lessons. In as much as inquiry involves use of short and simple activities, this was as close as they were to a complete inquiry approach. The continuous investigative approach with new questions that develop as new discoveries are made was missing from the State School teachers’ Science teaching. These teachers still sought stand-alone activities that could begin and end in one lesson time frame. In other words, the way they knew to teach Science previously was still the way they preferred to teach Science. Therefore, the Science Spark instruction and other planning and preparation sessions produced little to no change in the teaching and learning of Science in this State Primary School. Consequently, once the Science Spark teacher left the school and the focus was no longer on science, teachers reduced the amount of time spent on planning for science from 78% to 42%. However, the Science Spark did seem to raise the level of understanding and confidence to use the new curriculum documents, which is what the majority of the teachers wanted to know. However, this left the State School teachers still lacking in understanding how to teach Science with an inquiry or process approach as required in the Australian Curriculum: Science.
Further, the school leadership and HoC were unable to assist with Science professional learning due to their limited Science pedagogical and content knowledge. However, the HoC would support teachers in subject areas where she did have knowledge of the content and teaching strategies.

### 8.1.2 Independent School

The Independent School demonstrated little to no positive change over the year of implementation due to the lack of planning and preparation for the new Science Curriculum. The majority of the Independent School teachers were not looking forward to the new *Australian Curriculum: Science*. This may be partly due to the frustrations with the previous school Science curriculum changes mentioned earlier and the lack of support with the current Science curriculum. With no school professional development or support their ‘extent of personal planning’ in the beginning was only 14%. Unfortunately, a year after using the curriculum these teachers were less interested in the new *Australian Curriculum: Science*. This is not to say that they disliked the *Primary Connections*. To the contrary, they liked the curriculum resources. The concern for them was the extra amount of self-preparation and learning, locating concrete materials and preparing for lessons. The Independent School teachers viewed science as requiring more effort and time than other subjects. The lack of professional development and no school priority accorded to science had caused frustration and anxiety towards science.

Hence, their ratings for ‘preparation’, ‘looking forward to’ and support with the new Science curriculum further decreased. The teachers at this school were not given any extra assistance with the Science curriculum except for a reputable set of curriculum documents, *Primary Connections*, to guide their instruction. The teachers were able to consult with colleagues if needed, but none were identified as Science specialists, except for the high school teachers who only provided assistance when individual teachers sought it. Thus, the lack of priority in the school only marginally increased their personal planning time.
The primary teachers had high regard for Science and found it very ‘enjoyable’ (85-88%). They had high ‘confidence’ levels (85% to 75%) considering they had no professional development to use this new curriculum. It can only be assumed that the previous professional development with the old curriculum helped to increase their confidence. However, it would seem that some teachers, who do not realise there is a need to change teaching strategies may maintain high levels of confidence. The low scores for teacher ‘demonstration’ (36% to 38%) meant they did not feel they had the knowledge to demonstrate effectively for students. In addition, ratings for using a ‘process approach’ dropped during implementation. Prior to implementation 86% of teachers rated the ‘process approach’ to teaching as being ‘high’. After using the curriculum without professional development, about half of them believed there should be a ‘process’ or inquiry approach, but this view did not align with the high numbers (88%) who believed in providing student ‘observations’ and ‘experiments’ which are included in the process approach.

When considering the classroom observations of Science teaching, it was probably more likely that the teachers did not understand what ‘process approach’ meant. Mrs N followed no process/inquiry approach when teaching Science and Mrs T admitted she did not know the inquiry approach but was willing to learn. Mr D completed many aspects of an inquiry approach while teaching during his Science unit. Another aspect of Science teaching is related to delivery of content; however, there was no change in teacher beliefs about content teaching over the period.

While these teachers had Primary Connections resources that were known to be suitable and effective for primary teachers, they did not have the associated professional development designed to maximise the effectiveness of the teaching and learning environment, by developing skills and knowledge with the teacher first. Without development, these teachers used the materials and combined the information with their specific prior knowledge to create teaching and learning environments that made sense to them; and also kept them feeling relatively successful and ‘in control’ of the
learning. This explains their high regard for Science, but poor Science process/inquiry teaching. Therefore, the lack of professional development combined with the new Science materials and the limited staff or self-support, provided only minimal change in Science teaching and understanding the inquiry pedagogy. In fact, this coincided with their attitude towards Science as ‘important’ dropping noticeably. The decisions made by the Independent School leadership would seem to have had a negative impact on Science teaching and learning in this school. This low priority level of Science in the school influenced the understanding of process skills and inquiry teaching with the new Australian Curriculum: Science and may ultimately influence student learning outcomes.

8.1.3 Catholic School

The Catholic School used a collaborative and capacity building process to develop teacher knowledge and understanding in the teaching of the new Australian Curriculum: Science. The Catholic School teachers were not looking forward to the new curriculum (12%). After discovering that they would not need to change the curriculum documents they had been trained with, and that these materials would be updated to align with the new curriculum, their ratings of the new curriculum increased noticeably (60%). The teachers at this school had received the most sustained professional development of all three schools. It is interesting to note that the professional development and professional learning these teachers have received has not yielded high results in their levels of confidence. However, their view of, and use, of process/inquiry approaches was higher than the other schools. This is mostly likely related to the on-going professional development and the time to practice this approach. There were also higher levels of teaching Science content (96-91%). This too is likely due to the professional development in Science. These teachers spent more time learning and practicing new approaches than the teachers in the other schools. The observations indicate they still have not fully embraced the inquiry approach to teaching Science.
The inquiry approach demands time and organisation. It also expects concepts to be investigated from different perspectives and viewpoints so as to gain a fuller understanding of a concept. This means teachers need to understand how to investigate through different viewpoints and also how to continue an investigation over several lessons and several days. Mrs M did not follow an inquiry approach, but was happy to instruct about the Science concepts then have students complete a simple investigation/activity to demonstrate the Science concept. Each day she had a new concept to present. On the other hand, Mr C was willing to continue investigations on to another day if needed, but only when the school schedule would allow it. Other school activities needed to be considered too.

This Catholic School also moved into another area of Science that the other schools did not; misconceptions/preconceptions in Science. The teachers were including the idea of determining students’ prior knowledge and misconceptions as well as their own prior knowledge and misconceptions in their regular Science planning. This also brought a higher level of concern for teachers as they knew it was important for them to provide particular activities and investigations to correct any misconceptions or risk developing others or even letting students continue with their original misconception/preconception. It seems this level of understanding of Science caused the confidence levels to drop a little because they saw the evidence of misconceptions as putting more pressure on their Science teaching capacity. These teachers discovered they too have misconceptions/preconceptions that can impact on the effectiveness of their Science teaching. Therefore, after a number of years of professional development, their confidence levels initially dropped, but their knowledge of Science concepts and their teaching styles were more in line with expected Science teaching practices.

8.1.4 Summary

Banner, Donnelly and Ryder (2012) found that it is possible for teachers and individual organisations to interpret curriculum information according to their own agendas, thus allowing multiple interpretations and
implementation outcomes. This study supports this finding. In addition, implementing several curriculum areas simultaneously makes it difficult for schools to prepare teachers adequately. The allocated time frame allowed only scant time for preparation to implement the new *Australian Curriculum: Science*. Schools and teachers did the best they could to implement the new curriculum with the prior knowledge, experiences and resources they brought to the situation.

The Catholic School had the most successful results in regard to teaching and learning with the new *Australian Curriculum: Science*. A closer look at their processes identified a few main practices:

a) The leadership had some knowledge of Science concepts, and current teaching and learning approaches.

b) The leadership included Science as a priority.

c) The leadership became involved with staff professional learning.

d) Time was a valuable component of the professional development.

e) Teachers learned about Science individually, in small groups and large groups.

f) The Science planning and learning was connected to the classroom and the students.

The Catholic School’s approach to preparation for the new *Australian Curriculum: Science* aligned well with studies of school capacity building (Fullan, 2007; King & Newmann, 2001) and professional learning communities (Vescio, Ross, & Adams, 2008).
9 DISCUSSION

9.1 Introduction
The purpose of this study was to examine the implementation of a new Australian Curriculum: Science, in the state of Queensland: in particular, the support provided by Queensland Education system and school leaders and how teachers engaged with the implementation of the national curriculum.

In the previous four chapters, the findings of the study were outlined. The data identified a need for a longer implementation plan and school support processes that recognise Science as a priority. The data pointed to a need for effective on-going professional learning in Science to improve Science teaching. The data underscored the importance of leadership to build schools’ capacities that may lead towards improved student outcomes. This chapter includes the value of the guiding conceptual model used in the study: Bronfenbrenner’s ecological systems, the effectiveness of the methods, and discussion of the findings and their relationship to the literature. The next section provides an analysis of the conceptual model and its usefulness as a construct to guide the study.

9.2 Bronfenbrenner’s Model
Bronfenbrenner’s model incorporated four nested systems, from the broad, largely cultural macrosystem, to the more personal microsystem (Chapter 1, p. 35). While the current study was mainly concerned with systems and interactions associated with the two inner-most two components of the model (micro and mesosystems), the influences of the exosystem and macrosystem were purely contextual; and set the framework for many of the data events recorded in this study. For instance, the political agendas of Federal and State governments were constantly in mind while focussing on the school and teacher processes observed. The layer most difficult to access and describe explicitly was the outer layer (macrosystem), which included culture, beliefs and idiologies that are overarching for other layers. These beliefs and practices are often implicit and differ within sections of the education and general communities. They are therefore difficult to obtain data about and to describe, especially within the constraints of a focussed
study such as this. Further, observable practices in the political sphere do not necessarily reveal beliefs about teaching and learning and the like, but rather beliefs about education management and fiscal responsibility. For instance, beliefs about schools, teachers, teaching, and learning apparently held by politicians and senior system bureaucrats were revealed by the decision to require schools to implement three new national curricula in one year, and clearly differ from the beliefs held within the schools and teaching communities. Thus, this is a layer that is evident and influential and sets the context within which the schools were operating. In addition, the Researcher identified that there were also alternate beliefs at each layer that had an impact on the practices at those individual layers. That is, there are multiple belief systems in the macrosystem; and these are revealed especially through the people and processes in the other systems, as described below (in relation to Science curriculum implementation in primary schools). Therefore, the Bronfenbrenner Model provided a valuable framework for examination of the research questions, with its layers outlining critical points of information and interaction.

9.3 Methods
The methodology involved a nested case study design that was structured to achieve a broad understanding of the views of staff from three regional schools on the Australian Curriculum: Science implementation, and appropriate elaboration and illustration of these views across a range of selected participants within the schools. Data collection incorporated the use of surveys, classroom observations with field notes and interviews. The surveys provided an overall framework for each school, the new curriculum implementation procedures experienced, and teaching beliefs and practices among staff. With this framework of data, the Researcher was able to determine how the case study teachers’ responses to the interviews and the classroom observations could be positioned within the group of teachers at each school.

The interviews provided the necessary depth of analysis of teachers’ perspectives and the challenges they faced. Classroom observations were
valuable in providing a degree of confirmation that teachers’ reported views and capacities were actualised in classroom planning and Science practice. Field notes compiled during these sessions provided additional examples and illustration of the Science teaching in each school.

Overall, the study design and methods chosen supported the examination of the research questions in the three selected study schools. The methods enabled the examination of fundamental curriculum reform processes in three schools, and the preparedness and professional needs of teaching staff to undertake the required reforms. Future studies could reflect the methods used to involve greater numbers of schools, regions and districts, and participants across schools, in larger-scale quantitative and qualitative studies to confirm the generalisability of the findings of the present study.

9.4 Response to the Research Questions

There were four guiding sub-questions to the study. The next section provides a brief discussion of the findings related to each sub-question.

9.4.1 Research Sub-Question 1

What school contextual factors do the school leaders see as being most relevant to making changes in the implementation of the new *Australian Curriculum: Science* and in Science teaching?

9.4.1.1 School Contextual Factors

The contextual factors refer to the school community, its capacities, needs and requirements. These may be related to school policy and procedure, staff needs, student needs, and curriculum expectations. There were clear contexts identified and also combinations of factors that influenced the implementation of the new *Australian Curriculum: Science*.

This research identified the main factors contributing to the implementation of the new *Australian Curriculum: Science* as: the school leadership characteristics; the school processes and routines - including support (Roehrig, Kruse & Kern, 2007), time and sustained, quality professional development (DeMonte, 2013); and the teacher guides used to support
classroom teaching (Powell & Anderson, 2002). These areas (see sections 5.1, 6.1, 7.1) had impacts on teachers and how their Science teaching and learning aligned with the Australian Curriculum expectations, and are discussed below.

9.4.1.2 Leadership Characteristics

The findings included evidence of school leadership characteristics that impacted upon curriculum implementation and on-going support for teachers. These characteristics identify the extent that administrators considered the following: teachers’ subject knowledge, establishment of effective planning and preparation routines, support for effective professional learning, allowing time and continued support for change, and responding to resource needs. These findings support and add to the research of Lewthwaite (2004) and Fullan (2007). Leadership personnel within schools regularly send messages concerning aspects of curriculum change or reform. The school leadership team in the case study schools had particular school goals that were predetermined and had priority. Within the context of Science, these goals were based upon the scope of the school administrators’ personal knowledge and understanding of teaching Science and teacher learning, along with school priorities and the state priorities.

The State and Independent School administrators had similar backgrounds to the classroom teachers and therefore had particular thoughts about Science and ideas about providing support for it. Since many were lacking specific Science knowledge themselves, they often sought simple solutions to provide the needed support for the teachers. Borne out of good intentions, but due to limited personal Science experiences and Science teaching knowledge, these principals and curriculum leaders frequently constrained the development of Science teaching and learning in their schools. They were not able to contribute positively to the development of Science teaching in their schools. This contrasted to the Catholic School curriculum leader, who had substantial Science knowledge and the ability to develop the teaching staff in both Science concepts and the contemporary teaching strategies. This school had a strong emphasis on Science teaching.
The school administration in the State School and the Independent School lacked the knowledge and skills in Science that could direct their school leadership in Science (Elmore, 2006; Fullan, 2007; Leithwood et al., 2004; Lewthwaite, 2006a), and this affected their ability to provide adequate support and direction for staff within the school. Lewthwaite (2004) concurs that external factors, such as the role of the principal as an instructional leader, impact on the value of Science and the delivery of Science within schools, because they “carry the message” (p. 138) as to whether or not the curriculum change or, in this case, the Science curriculum change, is a priority to be addressed. Further, DuFour and Marzano (2009) supported the presence of a learning leader who helps teachers focus on evidence of learning rather than an instructional leader.

A strategy used by the leadership of the State and Independent Schools was to let the teachers ‘work it out themselves’, by providing curriculum materials that already contained lessons for them to follow. For example, the C2C and Primary Connections units were supposedly designed as ‘ready to teach’ units. The administrators therefore assumed that providing these teacher guides was sufficient, and that professional development was relatively unnecessary, evidencing their lack of understanding of research on the use of teacher guides (see p. 53). For example, Davis and Krajcik (2005) believed that teacher guides or “educative curriculum materials... cannot serve as a panacea” (p. 4). They asserted that workshops or some form of professional development should accompany them in order to achieve the quality teaching value.

In the Catholic School, the Primary Connections materials had been used for six years. It was purchased without the professional development package; however, the HoC provided the professional development for the staff. The Head of Curriculum was satisfied with the progress being made with Science instruction using the Primary Connections materials and he decided to continue using them when the new curriculum rolled out. Therefore, the revised Primary Connections was chosen without further specific professional development; but this was ameliorated by the long-term Science
The data suggest that a wiser decision may have been to initially provide professional development specific to *Primary Connections* (Hackling, Peers, & Prain, 2007). In some ways, the Catholic School decision to initially not provide the professional development that could accompany the *Primary Connections* materials was the same limiting decision as the other schools, but was reduced somewhat by the longer term professional development regime in the Catholic School.

All of these schools demonstrated that they valued Science – some more than others (see sections 5.3, 6.3, 7.3) – but competing capacities, values, and expectations resulted in a lack of funding, time, and commitment to prepare teachers in the use of the Science curriculum materials. Teachers could therefore reasonably conclude that Science was not a high priority, and thus the time they put into Science preparation and teaching was often minimal. What happened in each school was dependent to a large degree, on the extent to which Science had been prioritised and supported by the leadership (Printy, 2010; Sebastian & Allensworth, 2012).

For example, the Catholic School had an established planning and development routine which included the Science curriculum and Science teaching and learning practices (see section 7.1). This was in place and operating well because the curriculum leader had personal Science teaching and learning experiences, enabling him to lead the staff in Science development and understanding (Cosner, 2014). The school values and beliefs about Science were reinforced to help teachers improve their personal knowledge of Science and Science teaching. The leadership consistently modelled positive Science values and beliefs. This led to more aligned and desirable teaching and learning practices in Science. The Catholic School teachers understood that the school ethos supported the teaching of Science and even had particular expectations about Science teaching. Leadership is a driving force in curriculum change and reform (Fullan, 2007; Lewthwaite, 2004). Other driving forces were the teacher beliefs about teaching Science and their knowledge of Science concepts and how to teach Science. Studies by Roehrig et al., (2007) found similar driving forces.
When teachers lacked support by leadership, Roehrig and colleagues found that their teaching was more fragmented and less in line with curriculum expectations. This was discussed in more detail in Chapter 2.

Increasingly, principals and other school leaders are responsible for leading change initiatives in their schools (Fullan, 2007). Their knowledge and engagement within their school community places them in a position that requires leadership and decision-making. Therefore, effective internal leadership is crucial. Dufour and Marzano (2009) contend that principals should focus on working collaboratively with teams of teachers to examine evidence of student learning and identify strategies for improving on those results. Effective implementation of a new curriculum is based upon strong foundations of school leadership, professional learning, and planning embedded in effective school processes. Without strong school leadership, reform processes become uncoordinated, fragmented and allow the following of past practices (Fullan, 2007).

Leithwood (as cited in Fullan, 2007, p.166) identified three core sets of practices that successful leaders engage in:

1) Setting directions (shared vision and group goals, high performance expectations),
2) Developing people (individual support, intellectual / emotional stimulation, modelling) and
3) Redesigning the organisation (collaborative cultures and structures, building productive relations with parents and the community).

Consistent with the findings by Lewthwaite (2004) and Fullan (2007), it is clear that the State School and the Independent School were not able to demonstrate many of the school capacity building criteria and the successful leadership criteria in the implementation of the new Australian Curriculum: Science. The Catholic School demonstrated several of these criteria, leading to a more aligned implementation of the curriculum, increased content knowledge and development of effective teaching and learning strategies.
9.4.1.3 School Planning Processes

The preparation for principals to implement the new curriculum was very limited and followed a number of brief presentation meetings and subsequent emails. The government and state education leaders passed the curriculum implementation responsibility on to principals in a brief and expedient manner and the principals often passed it on to the teachers in a similar way. Timelines dominated decisions and processes (see sections 5.1, 6.1, 7.1).

The particular planning and preparation processes, followed by each case study school, determined the manner in which implementation proceeded. Even though each school could be considered a unique community that may require planning and preparation processes specific to their particular needs, leaders in a school set the internal processes that implied their values regarding Science teaching (Roehrig et al., 2007). The processes set and followed for staff meetings, planning meetings, and professional development activities set the tone, and established the parameters and values of the school leadership. Staff often adopt these values and processes. That is, when the leadership spent time discussing and planning for particular subjects and ignored others, the teachers in their own planning space followed similarly. This was evidenced in all three schools (see sections 5.3, 6.3, 7.3).

Viewing the national and state curriculum websites and their components was a common feature of the three schools when beginning the planning and preparation. However, the State School and the Independent School stopped at that point and handed over the “getting to know” the curriculum phase to the teachers. This included getting to know the prepared guide books and materials. This limited preparation for teaching the new Australian Curriculum: Science had a somewhat negative affect on teachers’ understanding of the content and their delivery of the content (Banner, Donnelly, & Ryder, 2012; Cowie et al., 2009). The Catholic School leadership, on the other hand, continued to develop understanding of the terminology and the breakdown of the sections of the new curriculum areas
during staff meetings. There was a deliberate focus on the intentions of the new curriculum (Cowie et al., 2009; Banner et al., 2012). In addition, the leadership continued to focus on Science content that the teachers found new and difficult for themselves or for the students. This meant there was a more sustained investment made in the teachers to develop concept understanding and pedagogical skills to address Science teaching needs and concerns within their classrooms and the Catholic School (Crowther, Andrews, Morgan & O’Neill, 2012; Cowie et al., 2009). This type of investment improves school capacity (Crowther et al., 2012; Cowie et al., 2009; Fullan, 2007) for immediate curricular changes and any future curricular changes. In contrast to this approach, leaving teachers to discover plans and processes and learn on their own, when time and external supports are limited, only assists teachers to make it through moment to moment challenges, limiting longer term professional development and learning outcomes.

Priorities in schools can be implied from the professional conversations that take place and time spent on them. The only school, among the three cases studied, that prioritised Science was the Catholic School. This school encouraged teachers to believe that Science plays as important a role in planning and preparing, as do literacy and numeracy. Teachers also understood that the leadership were going to support them to develop the necessary new understanding and skills, where they fell short (see sections 7.2.2 and 7.3.4). These are key concerns for teachers and also key for developing overall school capacity (Crowther et al., 2012; Cowie et al., 2009; Fullan, 2007).

The State and Independent School leadership most frequently made decisions based upon financial resources, knowledge resources, and expediency (see sections 5.1 and 6.1). This fragmented and constrained approach worked its way down to the teachers, who felt that this was added pressure for them and required extra time to try to understand the new materials and the teaching approaches involved, without support from more knowledgeable personnel (see section 5.3.4 and 6.3.4). The leadership in
these two schools were not prepared to expend the time, effort, and finances to address the extent to which the new *Australian Curriculum: Science* required a new teaching approach to be developed and understood by teachers. Nor did they allow time for teachers to change from their established modes of teaching and learning in Science.

Each school approached teacher preparation or professional development and professional learning in different ways according to time, school priorities and current understanding of Science. This was similar to findings by Roehrig et al. (2007), who found that the type and amount of professional development influenced implementation within each school. Further, it confirmed previous research (Guskey, 2002; Delmonte, 2013; Yoon, Duncan, Wen-Yu Lee, Scarloss & Shapley, 2007) that identified longevity of effective professional development is an important factor in implementation of Science learning and the teaching strategies employed.

The schools’ leadership teams chose professional learning that would fit into specific timeframes and also meet their particular school priorities. Each school viewed Science as a subject that needed to be taught, and a subject where teachers required some support. The State School provided some professional learning through the Science Spark teacher program, but this was not well accepted by many teachers, so avoidance behaviours set in. The C2C was also mistakenly viewed as an easy to use resource that teachers just needed to follow in order to teach Science. Similarly, the Independent School chose not to provide any professional learning support because the *Primary Connections* materials were viewed as providing the necessary support. The Catholic School made no changes to their established professional learning routines and continued to support teachers in Science throughout the year.

Schools often have entrenched practices. Those entrenched practices can either disable teachers’ initiative and development, or they can empower teachers for learning and creative problem solving (Watters & Ginns, 2000). Bronfenbrenner (1999) referred to this as “Proximal Processes”. That is, the interpersonal interactions between people, their environment and the
curriculum that lead to developmentally effective actions. The Independent School had collaborative planning among teachers embedded in its routines. This made it open to discussions about teaching and the support needed in Science. There is a great deal of research that supports various forms of peer collaboration to improve teaching and student outcomes (Akerson et al., 2009; Birman et al., 2000; Guskey, 2002; King & Newmann, 2000; Prawat, 1992a; Supovitz et al., 2009). A movement towards building a ‘Professional Learning Community’ may have made a difference in the progress of quality Science teaching in the State and Independent schools.

King and Newmann (2000) described a ‘professional community’ as one that has the following components:

(a) Clear shared goals for student learning,
(b) Collaboration and collective responsibility among staff members,
(c) Reflective professional inquiry by staff members, and
(d) Opportunities for staff members to influence the school’s activities and policies. (p. 578)

These components allow teachers to develop skills, teaching strategies, support and resources as they see best fit with the needs of the staff and the students. It is a way to empower teachers, to strengthen each other’s skills and develop strong school capacity in Science. Further, Hord, Roussin, and Sommers (2009) described Professional Learning Communities as placing “quality teaching” as the main focus of teacher learning so that student outcomes are impacted. It is also viewed as a model that fosters collaboration and continuous learning in a school setting, one that encourages “school improvement through organisational and cultural change” (p. 186). This study has contributed to research about the value of professional learning communities as observed with the Catholic School as well as the impact when there is lack of professional learning community characteristics in place.
Building school capacity (Cowie et al., 2009; Fullan, 2007; Newmann et al., 2000; Spillane, 2014) fits within the characteristics of a professional learning community. Building school capacity involves collaboration between staff and school leaders, professional learning, utilising school data, and setting goals. The central point is the pivotal presence and involvement of the principal and school leaders to build successful school capacity.

### 9.4.1.4 Teacher Guides / Curriculum Resources

The curriculum documents chosen by each school influenced implementation of the new *Australian Curriculum: Science*. Materials are often a part of curriculum change and can be in a variety of forms including textbooks, teacher guides, workbooks, video, computer games and internet sites. Fullan (2000) investigated the use of materials in reform movements and found:

> To achieve large scale reform you cannot depend on people’s capacity to bring about substantial change in the short run, so you need to propel the process with high quality teaching and training materials (print, video, electronic). There is still the problem of superficial implementation when new materials are in use, and even new practices in evidence, without the deeper understanding required for substantial and sustained implementation. But you get farther, faster by producing quality materials and establishing a highly interactive infrastructure of pressure and support. Finally, the materials do not have to be treated as prescriptive. Many judgements can and should be made during implementation as long as they are based on evidence linking teacher practices with student performance. (p. 23)

Fullan (2000) clearly identified the need for teacher development to accompany access to high quality materials for successful implementation of curricular reform. In this study, only the *Primary Connections* resources had been extensively trialled and tested and could be considered to be quality Science resources (see p. 52).

In regard to Science resources and materials, the leadership in all schools felt there were enough concrete materials on hand to use for teaching, until there could be a stocktake of materials available or required for the new
curriculum. By the end of 2012, there was still no progress towards identifying school Science resources and the resource needs for Science in the State and Independent Schools. However, the Catholic School started creating Science ‘resource boxes’ with books and concrete materials for each Science unit for teachers to borrow then return for others’ use.

9.4.1.5 Summary

The key factors for implementing new Australian Curriculum: Science are: leadership expertise and vision including viewing Science as valuable and important to support, planning processes that are embedded and effective, and finally, effective and sustained professional development. (DeMonte, 2013; Guskey, 2002; Yoon et al., 2007). Each school had a level of each of those components. However, the relative balance of each determined the outcomes. For example, the Catholic School leadership had some expertise in Science and a vision to see Science teaching and learning in the school reach advanced levels. The HoC shaped those understandings over years of regular staff development and support which led to better outcomes overall.

Schools are subject to influences and decisions made at state and Federal levels. For example, the creation of a mandatory national curriculum was a joint Federal-State decision. The main timeline for beginning the new Australian Curriculum and the roll out of each subject area was at the national level while the detailed trialling timeline for each subject area was left to each state to decide. Decades of research on school reform, including curriculum implementation have identified several factors that influenced implementation (Cowie et al., 2009; Crowther et al., 2012; Fullan, 2007). One of those influences included the overall use of time during implementation. Fullan (2007) noted that “the time line between the initiation decision and start-up is often too short to attend to matters of quality and that “large-scale’ change requires greater attention to front-end quality” (p 91-92). This meant that to attain substantial reform change, there needed to be sustained development of shared meaning and practice over time.
In addition, Fullan (2007) identified that school success with reform initiatives were often based on the strategies and supports provided by the organisation, for example the district or state level. The lack of support and follow through often left schools and teachers open to difficulties, frustration and feelings of incompetence. Additionally, teachers who have been through previous reform initiatives that lacked support and caused frustration seemed to be cynical about the next reform movement. Fullan’s conclusions are reflected in the data reported in this study.

Further, a lack of support towards influencing teaching and learning in a school can impact on the effectiveness of teaching and student learning outcomes (Supovitz et al., 2009). While this was not a focus of the study and no data was collected in this regard, it could be implied as likely, given the findings.

9.4.2 Research Sub-Question 2

To what extent do the teachers feel confident to teach Science and feel prepared to implement the new Australian Curriculum: Science (including initial training and subsequent professional development)?

9.4.2.1 Confidence

Confidence to teach Science impacts on teachers’ preparedness to teach Science. The study data supported evidence that Science content knowledge and positive Science experiences influence teachers’ confidence to teach Science in primary schools (Appleton, 2003; Murphy et al., 2007; Smith & Neale, 1989). In fact it is often noted that more Science professional learning increases confidence and the desire to teach Science (Murphy et al., 2007). Development which included modelled and interactive approaches with Science teaching strategies can influence the way Science is taught, according to Anderson et al., (2014). While this study supports those conclusions, the data from this study also suggested that there seemed to be a point when a teacher began to identify that their knowledge level and teaching practices could have either a positive or negative effect on students’ ability to learn Science. The negative effect usually developed after teachers
learned they had their own misconceptions/alternative conceptions in Science, which may be transferred to their students (Allen, 2014). When this was realised by them, they tended to experience a decline in their level of confidence (see p. 156, 172). This was the case with several of the Catholic School teachers. The data led me to believe that not only did professional learning increase the desire to teach and improve teaching strategies and knowledge, but also once a certain level of knowledge and understanding was acquired, it could lead to a decrease in confidence. Teachers began to realise through professional learning experiences that lack of knowledge and understanding of Science concepts on their part could introduce or maintain Science misconceptions among their students. This was unexpected.

Research has shown that teachers often do not hold views that are consistent with Science (Haefner & Zembal-Saul, 2004); however, there have not been extensive discussions about teachers’ perspectives of their own scientific alternative understandings and the connection to their teaching. However, these teachers stated they wanted to teach well and were worried they would teach a misconception without realising, since they were not very knowledgeable about Science.

Teachers who were also dissatisfied with the previous Science curriculum resources used in the school appeared more eager to have a new Science Curriculum. The Independent School teachers were dissatisfied with the content and professional development of their previous Science Curriculum so they looked forward to the Science curriculum change as they had hoped for something better to be available, compared to their own school designed Science curriculum. Further, the State School teachers also had relatively positive attitudes towards Science. However, they had no history of Science development and professional learning prior to the Science Spark Teacher; so were happy enough to have the new Australian Curriculum: Science.

9.4.2.2 Prepared to Teach the New Science Curriculum

At the beginning of the implementation period, most teachers were worried, and some stressed, by the overwhelming size and scope of the new
curriculum, the number of subjects, and the short implementation
timeframes. Each school organised for implementation in the manner they
felt best suited their schools and staff. For some, an initial Curriculum
website viewing and walk through helped to ease a few concerns. For
others, it led to more concerns since some year-level content had been
moved and changed. Some teachers were worried about their personal
knowledge levels and the available resources for teaching. Three main areas
of teachers’ concerns were related to the curriculum structure, required
Science knowledge, and the prepared curriculum teacher guides including
the digital resources.

Many teachers believed that the *Primary Connections* and the *Australian
Curriculum: Science* was well structured and clear. They thought it was easy
to see what was to be taught at each year-level; and these primary school
teachers liked having an itemised list of what to teach in each school term.
Many also observed that the new *Australian Curriculum: Science* was more
rigid and would oblige teachers to change the way they teach and provide
investigative learning experiences.

Science content knowledge in the *Australian Curriculum: Science* is evident
and itemised. Teachers recognised this and sought support and further
information. Lack of support for some of them affected the amount of time
they spent in preparation, and the quality of their planning and preparation
to teach. These points are in line with, and support, research about
curriculum implementation by DeMonte (2013), Peers et al., (2003) and
others, as presented in Chapters 1 and 2.

The prepared teacher guides and units of work became the source for State
and Independent School teachers to seek most of their direction for teaching
the Science concepts, and to attempt to follow a set of teaching strategies for
Science. However, while relying solely on teacher guides may appear to be
cost and time efficient in the short term, it does not present long-term
dividends in terms of Science knowledge and Science pedagogy. In order to
develop understanding of the intent of the new curriculum and to achieve
whole school change in practice, the school leadership needed to invest in
building school capacity through professional learning communities or other effective professional development. Without a whole school approach, individual teachers will only do what they find fits with their personal, current beliefs and skills (see sections 5.3, 6.3, 7.3). This would likely encourage Science teaching with multiple approaches and lead to varied outcomes.

Experienced teachers have been through iterations of curriculum change in the past (Banner et al., 2009; Fullan, 2001; Hamilton et al., 2003; Ryder & Banner, 2013). To them, this is an expected experience to be weathered. With this perspective and recurring experience, teachers often keep their favourite activities, experiments, readings, and worksheets in a safe place in their rooms to reuse in the future (see p. 134). These actions and attitudes towards Science teaching and curriculum change mean there will be often little to no change in teaching and learning (as with the State and Independent Schools), unless there is a united and on-going school effort to make changes in the offering of the *Australian Curriculum: Science* (as observed with the Catholic School case).

### 9.4.3 Research Sub-Question 3

Which beliefs about teaching Science do the teachers hold, how frequently do they teach Science, and what teaching strategies do they commonly use when teaching the new *Australian Curriculum: Science*?

#### 9.4.3.1 Beliefs and Attitudes About Teaching Science

A study by Fitzgerald, Dawson & Hackling (2013) noted that teachers’ beliefs were strongly intertwined with their practice, so much so that it was difficult to separate the two (how they teach and why they teach that way). This means when a new curriculum and teaching strategies are introduced, not all teachers will have beliefs congruent with the new expectations. Much research points to a connection between teacher beliefs and classroom practice (Fitzgerald et al., 2013; Haney & McArthur, 2002; Levitt, 2002; Roehrig & Kruse, 2005; Roehrig & Luft, 2004), while fewer studies indicate this is a controversial perspective (Simmons et al., 1999).
The teachers in this study held some common beliefs, such as Science is important, rewarding and worthwhile. Science should be hands-on and use open communication. Science takes substantial time to prepare and is often messy.

In addition, each school held slightly different beliefs in regard to teaching Science. For example, the Independent School and the Catholic School teachers had a focus on discovering student prior knowledge before teaching. Teachers from the State School and the Catholic School believed the teacher should demonstrate Science. The Independent School and the Catholic School teachers believed in student observation and experimentation during Science. Teachers from the Catholic School believed there should be an emphasis on content teaching and the use of Science processes.

The nature of the curriculum in conjunction with professional development influenced teacher attitudes and beliefs about Science and Science teaching (Demonte, 2013; Cowie, 2009). Therefore, as (Guskey, 2002) posited, attitudes and beliefs about teaching are often stemmed from classroom experiences. To make change sustainable and able to meet the current demands, changes in beliefs and practices need to be planned for over a long time frame such as three years minimally (Kagan, 1992).

The timeframe for professional development in Science also influenced the beliefs and Science teaching in each school. The Catholic School teachers, with the most sustained and established professional development, were observed to have the most positive alignment to the current practices required to teach the new Australian Curriculum: Science. The State School teachers demonstrated a slight change in beliefs with the small amount of professional development provided. However, the Independent School teachers, with no professional development, demonstrated the least amount of change in beliefs and teaching practice that are required by the Australian Curriculum: Science. Therefore, effective professional development that addresses teachers’ beliefs needs to occur so that teachers can align their beliefs with the current expected practices in the curriculum. When it
comes to curriculum changes the degree of change is related to teachers’ content knowledge and their beliefs about teaching and learning (Roehrig & Kruse, 2005).

9.4.4 Research Sub-Question 4

After one year from the release of the *Australian Curriculum: Science*,

a) What have schools and teachers done to implement the curriculum?

b) How has the implementation of the new Science curriculum impacted on the school and teacher actions about how to teach Science?

c) What actions do teachers believe should occur to progress implementation?

The creation of the new national curriculum and the decision for a rapid timeline to implement several curriculum areas in Queensland, are evidence of external factors imposing beliefs and expectations on schools and teachers.

Implementation processes associated with a new national curriculum seem to have been underestimated. The vision for the new national curriculum to reach all children and be outstanding in quality has set the expectations high. The initial concerns about students’ inadequate Mathematics, English and Science development plus the desire to meet the needs of all children, including those at risk and in poverty are not easy to address and resolve. The issues and problems surrounding implementation of national curriculum such as time, school contexts and processes and professional learning are often underestimated (Fullan, 2000, 2001, 2007, 2009; Hipkins et al., 2011; Lieberman, 2008). These findings are also consistent with those of Berends, Chun, Ikemoto, Stockly, and Briggs (2002), who proposed that the main problems with implementation and continuation of school change and reform are:

- Within-school variance of implementation
- Between school variance of implementation
These were also found to be apparent in all three schools in this study. Each school had different implementation procedures and outcomes. Teachers within the same school even had varying degrees of compliance with and understanding of the new *Australian Curriculum: Science*.

**9.4.4.1 First Year of Implementation in the three schools (4a)**

Implementation of the *Australian Curriculum: Science* took different forms in each of the case study schools. Each school had a set of priorities based upon a combination of state directives, staff strengths and preferences or other decisions made within the schools. These influenced the direction of Science planning and preparation. Whether they used the Science Spark teachers, the prepared teacher guides, or provided extensive professional learning opportunities, the school decisions had an impact, negatively, neutrally, or positively on the Science teaching and learning within their school. However, the schools with embedded and efficient processes and those which prioritised science learning, spent more time planning for Science, thus leading to potentially more positive teaching and learning outcomes.

“Educational change is a dynamic process involving interacting variables over time” (Fullan, 2007, p. 86; DeMonte, 2013; Spillane, 2014; Vescio et al., 2008). The findings indicated multiple variables impacted implementation. Three pivotal variables identified in each school were: a) the school implementation processes; b) the teacher support provided to facilitate understanding of, and how to teach, the *Australian Curriculum: Science*; and c) time. These are discussed below.

**9.4.4.2 School and Teacher Implementation Processes (4b)**

Findings from this study indicated that the State and Independent Schools had insufficient planning and preparation processes in place to assist teachers in understanding the *Australian Curriculum: Science*. A few general staff meetings to present the overview of the curriculum failed to lead teachers to a deep understanding of the philosophy and the purposes for changes in the *Australian Curriculum: Science*. In addition, the planning and
preparation for the *Australian Curriculum: Science* was not thoroughly considered. That is, information about the schools’ existing goals, culture, and teachers’ and students’ capacities were not gathered prior to creating a plan for introducing and implementing major change through the *Australian Curriculum: Science* (see sections 5.2.2, 5.3.3, 6.2.2, 6.3.3).

Previous research (Datnow & Stringfield, 2000) has proposed that successful change is highly complex and a subtle social process, which needs to consider several factors including “characteristics of the change (such as need, clarity, complexity and quality/practicality), local characteristics (such as district, community, principal and teachers) and external factors (such as government and other agencies)” (p. 87). These factors should not be considered in isolation. Fullan (2007) stated these factors over time “form a system of variables that interact to determine success or failure” (p. 86).

Findings from this study lend support for Fullan’s proposition. Only the Catholic School teachers had clear planning and preparation procedures that led to positive long-term change in teaching. The State and Independent School teachers were unclear about the need for change and what kinds of changes were required in Science. The necessary changes in teaching strategies and content knowledge made the change process complex. These then impacted on the quality of the observed classroom program and the effectiveness of the implementation. If change were to occur in a positive way, it needed to begin with efficient professional development in the first three years of implementation (Kırkgöz, 2008).

When considering local factors, the success of change is based upon several influences. First, school districts and regions go through change regularly. Past successes or failures are remembered by staff and have an influence on their attitudes when further change is presented. In this study, some teachers commented on their belief that this new curriculum will come and go; therefore, it was not taken very seriously. Secondly, the community demographics, such as previous experience with Science and previous coursework in Science, impacted on the change. A further factor, as, Fullan (2007), Liethwood et al., (2004), Gurr et al., (2006) and other researchers
(see section 2.5) point out, the principal is a strong influence on change, by serving to ‘legitimate’ the change, and “support teachers psychologically and with resources” (Fullan, 2007, p. 95). However, both the State and Independent School teachers did not see the principal as being involved in the Science curriculum changes in any formative manner. The teacher is the main change agent when teachers have to learn to do something new. New skills are best learned collaboratively with peers working together to exchange ideas, support and encourage each other (DeMonte, 2013; Vescio et al., 2008; Wenger, 2009). The State School teacher did not develop an atmosphere of social learning and peer support to help teachers through the curriculum change. Instead teachers were allowed freedom to discover and learn about the Science curriculum ‘in their own way’. The Independent School teachers only had minimal peer support available.

9.4.4.3 Impact on School and Teacher Actions about how to Teach Science (4b)

School capacity to implement the change varied a great deal. Revealingly, principal leadership that focussed on instruction and learning was important for improving school performance. This was clearly demonstrated in the Catholic School.

District context was a critical variable both in terms of the direct assistance and support provided for schools, and with respect to other school initiatives that clashed or were misaligned with the reform design (see section 5.1.1 and Chapter 6.1.1). This could be considered two ways. One is that each school, State, Independent and Catholic, could be seen as three different districts who have received different amounts of direction and support from their head offices. Each school also had previous timelines and priorities that needed to be reconsidered. Another way to consider this is from the state perspective. Each state made decisions about timelines, support and priorities with the new curriculum, which schools were expected to address. The schools already had pre-existing priorities and agendas that they were forced to reconsider. These outside influences and decisions impacted on
school leadership decisions which in turn influenced teacher decisions when implementing the *Australian Curriculum: Science*.

There are multiple factors involved in the implementation of a new curriculum. While there may not be one perfect way to plan for implementation, there were several identified components that needed to be addressed in order to lead to successful on-going implementation.

As outlined in the Findings (Chapters 5 and 6), the data reveal that the State and Independent School teachers and school leaders were poorly prepared for the implementation of the *Australian Curriculum: Science*.

However, the data from the Catholic School (Chapter 7) revealed that positive progress in Science teaching and learning at the Catholic School had to do with the Science training and knowledge of the Head of Curriculum and his close working relationship with the teachers (Printy, 2010), the school planning and preparation processes and the on-going professional learning in Science (Akerson et al., 2009; Dass & Yager, 2009).

9.4.4.3.1 Teacher Support

The provision of the Science Spark teachers in the State Schools was perceived by the State Government to address the Science learning requirements, so State Schools could spend time on other concerns (see section 5.1). In this study, the State School had received limited previous support and limited Science Spark support. Findings indicated that the freedom given to teachers to choose to participate in the professional development improved neither their Science understanding nor the Science inquiry processes needed for effective Science teaching and learning. This finding is supported by Corcoran et al., (2003) who proposed that Years Foundation – Year 8 teachers need at least 100 hours of professional development to be competent and confident teaching with an inquiry approach in Science teaching. This includes the development of Science concepts, teaching strategies and classroom management skills. However, (Powell & Anderson, 2002) posited that change in teachers does not necessarily occur based solely upon the curriculum materials or the
professional development, but rather on an individual basis. That is, ‘time and means’ (p.131) must be built into the processes to encourage individual growth and change in teaching habits. This was well demonstrated in the Catholic school processes through regularly planned team meetings with the curriculum leader and the specific connection to that year level content and teaching expectations. Further, Powell and Anderson (2002) noted that the Science knowledge and teaching strategies to be learnt require deeper and more complex learning to occur thus requiring time and explicit learning opportunities. Sending teachers off to explore the curriculum is not considered an explicit learning opportunity. Neither is having an option to attend a learning workshop with the Science Spark teacher. If a teacher’s philosophy and beliefs about Science teaching do not align with the curriculum philosophies, teachers will tend to make their own interpretations based on their own theories and beliefs about teaching (Tobin & McRobbie, 1997).

Further, Corcoran et al. (2003) identified that teachers with degrees in Science did not require as much professional development. For example, one State School teacher, Mrs S, had a relatively stronger background Science knowledge compared to colleagues, Mr B and Mrs L. Having less Science background, Mrs L drew her knowledge from the curriculum itself but had difficulty making the Science information understandable for students. Mr B preferred to use his previously ‘tried and true’ materials and worksheets for Science, which did not lead to learning through inquiry and an appreciation of scientific process skills.

It is important to note that participants may not realise that their style of teaching does not align with the inquiry focus for Science teaching and learning. For example, in this study, Mr B responded to questions and identified himself as a person who enjoys and knows Science, but observations revealed less appropriate Science teaching strategies and a lack of Science concept knowledge. This is generally supported by Gee (2005) who proposed that certain teacher behaviours and teacher identity information may be limited by the individual’s access to certain discourses,
such as: a traditional Science teaching discourse or a teacher as a classroom authority discourse rather than an inquiry approach to Science teaching discourse.

Similarities were evident in the Independent School where Mr D had more Science background and knowledge than the other case study teachers in the school. His approach to teaching included more of an inquiry approach to learning than the other teachers. Mrs N and Mrs T found Science concepts more difficult firstly to understand, then secondly to teach. Lack of Science support can cause teachers to remain unchanged in their Science knowledge and Science teaching strategies (DeMonte, 2013; Parise & Spillane, 2010).

Even the Catholic School teachers, who had had years of Science professional development, had concerns about teaching Science. The breadth and depth of required Science knowledge, for teachers who had little Science coursework at high school and university, can be overwhelming. It seemed to them that Science is a never-ending pot of information that sometimes changes. However, the on-going professional learning support provided in the Catholic School was slowly building Science concept knowledge and Science teaching strategies despite some teachers’ perceptions of inadequacy.

It would seem that the lack of Science courses in many university teacher education programs, combined with inadequate or insufficient Science teaching in the schools (Newton & Newton, 2001; Wallace & Louden, 1992), had placed these primary teachers in an unfavourable position for teaching the *Australian Curriculum: Science* in the manner intended. Their lack of prior Science knowledge impacted on their ability to understand adequately and teach the *Australian Curriculum: Science*. It can be concluded that the case study teachers needed more professional help and time to learn Science concepts, new ways of presenting content, and new ways of interacting with students in order for the *Australian Curriculum: Science* to be taught and learnt as intended by its designers.
9.4.4.3.2 Time

There were many aspects of time that impacted on the curriculum implementation. It began with the political agenda that established timeframes for implementation. The decision to implement three major curriculum areas at once, with more scheduled in following years, added extra stress to all school staff. The list of what was needed to plan and prepare was apparently endless. Part of the difficulty for teachers was locating time within the teaching week to plan and prepare for the *Australian Curriculum: Science*. Fullan’s (2007) research showed the value of time in making sufficient and effective change required for curriculum change and curriculum reform. Bronfenbrenner (1999, 2006) also identified time as one of the main components of effective change.

In summary, the school processes for professional learning and support are a key component to the implementation of the *Australian Curriculum: Science*. Both the State School and Independent School were not able to plan for and prepare the teachers for the new *Australian Curriculum: Science* implementation by allowing teachers the freedom to investigate the curriculum as they pleased. This allowed for multiple interpretations of the curriculum intent, and lack of understanding of Science concepts and teaching strategies. In addition, the State School teachers had limited support and time with the Science Spark Teacher, and there was no other on-going support for Science in the school. Teachers may have been using the new C2C curriculum resources, but there was inadequate understanding of the Science concepts and teaching strategies. Lack of planning and development allowed the teachers to implement and modify the curriculum according to their individual knowledge and beliefs. Therefore, little to no change occurred in Science teaching in both the State and Independent Schools. It is evident that more time, planning, and support were needed.

9.4.4.4 Actions to Progress Implementation (4c)

The case study teachers saw the curriculum documents, resources, concrete materials and some form of professional development and on-going support
as being critical components in helping them prepare to teach Science and develop skills in teaching Science. The teachers in all three schools preferred to have Science documents that were easy to follow and understand. By the end of the year, the State School teachers’ Science planning consisted of following the C2C lessons and selecting any other resources or ideas from curriculum Sourcebooks they had used in the past. One teacher would have liked to work with other teachers when planning in order to share ideas, but this did not happen; the teachers were used to working independently in the past and continued this strategy. Similarly, the Independent School teachers continued with planning for Science on their own without further professional learning opportunities, limiting their advancement in Science teaching and facilitation of learning.

In contrast, the Catholic School had established, successful procedures for professional learning in Science that had been in place for some years, and these continued as previously. The knowledge and ability of the Head of Curriculum to notice, observe, and then choose learning appropriate to the teachers’ particular needs at the time, kept them moving forward towards a more informed and consolidated approach.

The planning and preparation processes in each school reflected the beliefs held by the leadership. The beliefs often flow down to the teachers and become their beliefs as well. For example, the Catholic school HoC placed Science as a priority for planning and professional learning which led to the teachers also placing it as a priority when planning. These inherent processes or structures within organisations, ‘when taken up explicitly and proactively in the course of the implementation’ will result in a greater chance of producing sustainable results (Altrichter, 2005b, p. 17).

9.4.5 Guiding Research Question

In summation, the overarching research question guiding this study was answered through the previous sub-questions. That question and the summative response is below.
In what ways does a new national *Australian Curriculum: Science* provide impetus, at school and teacher levels, for Science curriculum change and for improving Science teaching, and to what extent does such impetus influence changes in practice?

The impetus at school and teacher levels had its origins in belief-laden decisions at several Bronfenbrenner levels. These decisions provided both a context and impetus for classroom change and improved practice.

### 9.4.5.1 Creation of a New Australian Curriculum

In the beginning, decisions were made at the Federal political level about educational values and beliefs that were to shape the direction of the new Australian Curriculum. A key belief was that there should be, for the first time, a uniform curriculum structure across all States and Territories. This led to the decision to develop new curriculum in all subject areas. Once these were established, they were passed on to the States and Territories to implement. Several associated decisions were made at the state level in Queensland, but values and beliefs behind some of these were unavailable:

Three new subjects were to be implemented in one year, another one the following year and more in subsequent years. Beliefs behind this decision can only be surmised, but political expediency is probable.

Schools were to be responsible for necessary professional development. There are no data regarding beliefs behind this decision, other than a declared expectation of greater school autonomy and critical shortages in funding.

Primary teachers needed special help in Science, as they were considered ill equipped in Science teaching (Chapter 2). Accordingly, State School teachers were given access to temporary specialist Science teachers (Science Sparks) and online curriculum guides (Curriculum into the Classroom, C2C). Again, data about why these forms of support were chosen, counter to current research findings as outlined in Chapter 2, are not available.
These value-laden decisions formed a background context for schools (mesosystem) and teachers (microsystem), as they in turn made decisions about implementing the new *Australian Curriculum: Science*.

### 9.4.5.2 School Level Impacts

The school level (mesosystem) was a specific focus of this study, and data were available about the key decisions made, and why they were made. Schools were delegated the responsibility for implementing the *Australian Curriculum: Science* as they saw fit for their school communities, and within the constraints determined by the state government education authority. Within each school, decisions were made regarding curriculum materials, amount and type of professional development, resources required and the time and funding that would be spent on those elements. Schools and school leaders had developed their teaching and learning priorities based upon earlier state and national government influences, and priorities such as literacy and numeracy for NAPLAN testing. Science was not seen as a comparable priority.

The State School expected teachers to use the C2C materials that were considered all-inclusive, and participate in the Science Spark workshops. The Independent School located Science curriculum materials that were believed to be sufficient for teachers to use and teach from, without professional development. The Catholic School continued with their established planning routines regardless of the national curriculum changes (p. 211). The Literature Review presented and discussed the need for rich on-going professional development that focuses on new ways to teach Science as a valuable component to instructional materials (Powell & Anderson, 2002). Both the materials and the professional development should work alongside each other to transform the implementation and the teaching of the new Science curriculum. Of the three case study schools, this was observed only in the Catholic School processes. On-going professional development was an embedded process. Even so, the school still experienced problems arising from inadequate Science content knowledge. When this school placed Science as a priority, the influence on
improved Science teaching and learning in the school was greater and more positive (Chapter 7). School leadership involvement in Science substantially and positively influenced the teacher learning and then the teaching.

Research by Cowie et al., (2009) is relevant. They found that successful approaches to implementation included each subject area as a focus for development. The leadership were also considered key figures. In fact, the leadership influenced teachers’ personal commitment levels and initiated change in professional development expectations by their own active, hands-on involvement.

9.4.5.3 Teacher Level Impacts

Within the overall context of federal and state directives, the following impacted teachers’ actions and decisions about Science: school priorities, leadership priorities, teachers’ knowledge and their personal beliefs/attitudes about Science (Powell & Anderson, 2002). Schools which had routines and policies in place that encouraged and provided time for whole school teacher development, and small group and individual development, demonstrated greater alignment with current views of desirable Science teaching practices (see section 2.5.2). As discussed in the Literature Review, Bronfenbrenner (1999) described proximal processes and DeMonte (2013) identified ‘embedded’ school practices as contributing to high-quality professional learning. Examples of embedded practice that are also supported by this study include:

- Processes integrated into the workday, and part of a continuous improvement cycle;
- An instructional facilitator conducting a model lesson for a group of teachers working on a particular instructional practice; and
- A teacher working with a colleague or teaching coach to plan and execute a lesson (p. 7).

When effective support and professional learning are embedded into the regular school routines (as identified in the Catholic School), the impact on student learning outcomes is greater (DeMonte, 2013; Supovitz et al., 2009).
9.4.5.4 Summary of Leadership and School Priorities

Professional learning, learning communities and developing school capacity are key components to effective curriculum reform and curriculum change. The new Guide to Professional Learning (Education Queensland, 2012) written for Queensland in 2012, identified effective forms of professional learning; however, there was no indication of how this would be rolled out. School leadership may need to be prepared to follow these new approaches. Based upon the results of this study, it would appear that the implementation of the new forms of professional learning will not be strongly supported at present. School leaders will have to find the time and the resources to develop an understanding of the new professional learning approaches on their own. If that is the expectation and resultant outcome, then it is highly unlikely schools will make any changes to their professional development routines. Time was the overriding concern from all three schools in the study. Support at the federal and state level will be needed for school leaders to work towards effective change under curricular reform. Additionally, since many school leaders were previously classroom teachers with limited Science experiences and knowledge, it may be necessary for school leaders to be prepared in collaborative and capacity building exercises for school development to occur.

Another factor that may well be at the crux of poor Science teaching is a lack of Science education throughout schooling and during teacher preparation programs. While there have been recent shifts here, an increase in Science emphasis is still needed.

Bronfenbrenner (1979, 1999) also identified time as a main component to his systems levels; particularly as it related to developing knowledge and changing processes. His research reported that change is a key component to each level and each level has an impact on that change which may have a positive or negative outcome. This study supports Bronfenbrenner’s (1999) findings; that as change is required in a setting, it needs sufficient support, time, collaboration and trust in order to see the required changes occur.
It is clear the government is situated outside the school context and influences school priorities. This study focussed on the school and classroom levels of implementation (Mesosystem and Microsystem), rather than the government levels. It is clear the government’s programs and policies influence school priorities. While these are situated outside the school context, it is likely there are misunderstandings of school processes in regards to new curriculum implementation. This research may help inform future decisions regarding new curriculum implementation, particularly in the field of primary school science.

The study data provide evidence that change is required in schools to facilitate how teachers learn and how opportunities for learning will occur. Lieberman (1995) strongly suggested that the conventional view of staff development, which includes afterschool workshops with pre-packaged presentations that are far removed from the classroom practice, need to be reconsidered. The typical afterschool lectures (often described as professional development by Garet et al., 2001) do little to improve and change teaching practice. School leaders need the knowledge and ability to organise school processes for a more robust collaborative professional learning environment (Lieberman, 1995). Then, they will be able to ultimately lead schools toward improved teaching practices and student outcomes (Cowie et al., 2009; DeMonte, 2013).
10 CONCLUSIONS

10.1 Introduction

The recent creation of the Australian Curriculum led to a national transition from one suite of curricula (state level) to another at a national level. The scale of the curricular changes required for the entire country is a major educational reform. Each state made decisions regarding implementation timeframes, provision of professional development and financial support and personnel. The overall aim of this study was to investigate the particular processes used in three different schools when implementing the new national Australian Curriculum: Science. In particular, the research sought to understand how the contextual factors for each school and their processes influenced the implementation processes and the enactment of the new Australian Curriculum: Science in the classroom. As a result, the research questions guiding the study were:

In what ways does a new national Australian Curriculum: Science provide impetus, at school and teacher levels, for Science curriculum change and for improving Science teaching, and to what extent does such impetus influence changes in practice?
The literature led to particular suppositions that in turn led to the theoretical framework for the study. First, curriculum reform and change is a regular and repeated occurrence in education systems. Second, the principal provides leadership and direction during curricular reform. Third, teachers are often handed new curriculum with little support to make the changes, in this case required in the new *Australian Curriculum: Science*. Fourth, schools are encouraged to follow community of practice or community professional development as a way of providing professional development during curricular reform. With these suppositions in mind, Bronfenbrenner’s ecological systems model was considered as a logical framework that would assist in viewing curriculum implementation through various system lenses. These system lenses extend from the most intimate influences (teacher and classroom) to the most external influences (Government policies and cultural expectations). The new *Australian Curriculum: Science* provided impetus in so far as it provided an opportunity for schools to address Science teaching concerns and alignment with the new curriculum intentions. However, only one of the three schools in the study had some success in addressing Science teaching and their teaching alignment with the new curriculum.

This chapter provides a summary of the study, followed by an outline of the main conclusions, a discussion of implications, recommendations for future studies and finally the limitations of the study.

Summary of the Study

Chapter 1

The Introduction Chapter provided a critical background history and the context of the study prior to and leading up to the creation of the new *Australian Curriculum: Science*.
Chapter 2

The Literature Review Chapter provided an examination and structuring of the literature in connection with the theoretical framework, Bronfenbrenner’s Ecological Systems, and how it helps to structure this study, as well as the major findings, to date, in relation to the study objectives.

Chapter 3

The Research Paradigm and Methods Chapter provided a description and justification of the essentially pragmatic qualitative approach and the methods employed to collect and analyse data.

Chapter 4-8

The Findings Chapters provided an analysis of the data for each case study school from three sectors - State, Independent, and Catholic - for the planning and preparation prior to implementation and data for the first year of implementation of the new Australian Curriculum: Science.

Chapter 9

The Discussion Chapter provided discussion of the study findings with connection to the current literature and the theoretical framework adopted.

10.2 Conclusions of the Study

The findings from this study contribute to the body of research exploring implementation of new Australian Curriculum: Science including the impact of professional learning, school leadership, teacher support, the inter-relationship between teacher, Science knowledge and associated Science pedagogy and capacity building as part of the implementation processes. The following conclusions are derived from the research questions outlined above and in Chapter Two. The conclusions are stated succinctly with the aim of guiding future Science curriculum change in schools and Australian schools in particular.
It was evident from this study that the factors influencing this Science curriculum implementation were multifaceted, and not only related to teachers’ individual strengths and weaknesses, but also included the following:

1. **The professional development and teacher support provided to state school teachers was perceived to be of limited value.**

   While placing secondary teachers in primary schools as visiting experts to help primary teachers, and providing online curriculum guides may have seemed an effective and expedient solution to supporting large numbers of teachers, these were effectively political or bureaucratic solutions that were not informed by current research, and in this study provided only limited support for some teachers.

2. **Teachers’ materials alone provided limited support for these primary teachers.**

   The C2C materials were of limited support for the state school teachers; and the *Primary Connections* materials, without the accompanying professional development, was of limited value for the Independent school teachers.

3. **School leadership priorities impacted on teachers’ priorities.**

   Leadership decisions and chosen priorities considerably influenced teachers’ priorities. Meetings and discussions were centred around particular priorities, such as English and Mathematics outcomes and not those of the Science Curriculum to the same extent. Teachers consequently focussed on the priorities evident in school leadership.

4. **School leadership impacted on whole school change and effective reform implementation (Capacity Building).**

   The Catholic School, of the three schools, had stronger leadership in setting priorities and professional development for Science.
This was reflected in teachers’ tendency to value Science, and the way they showed alignment to the curriculum expectations for teaching and learning in the *Australian Curriculum: Science*. These attitudes and actions appear to be a result of working towards building whole school capacity.

5. **The absence of a Science support person within the State and Independent Schools limited change in Science teaching for generalist teachers in these schools.**  

State School and Independent School teachers informally sought on-going Science support from peers within their schools to fill this need. This lack of systemic Science support led to very limited Science development in these schools.

6. **The state government did not provide appropriate support for the implementation of the new Science Curriculum. In addition, an unrealistic timeframe was set for classroom use.**  

The limited professional development and the extremely fast implementation caused frustration and angst for school administration and teachers. It led to many teachers using prior coping strategies rather than substantive changes in teaching practice.

7. **The new curriculum that was intended to provide a “foundation for high quality teaching to meet the needs of all Australian students” (ACARA) set an ambitious goal that was not realised in some classrooms, reportedly, due to limited or inappropriate teacher support.**  

Many of the teachers did not understand the expectations of the curriculum, and lacked the knowledge and skills to implement it as expected. Teachers, therefore, often continued with the same teaching practices and knowledge they had used in previous years, thus subverting the intentions of the new *Australian Curriculum: Science*. 
8. Decisions made at the outer layers (Bronfenbrenner’s model) impacted upon the decisions and actions made at the inner levels. That is:

a) **Government decisions (macrosystem level)** such as curriculum policy and implementation expectations influenced the decisions and actions at the...

b) **State government (exosystem level)** This level set the context for this study and therefore, influenced decisions and actions around the establishment of vision, leadership, support, and provision of resources including allocating budgets and time. Decisions at this level influenced levels © and (d) below.

c) **The principal and curriculum leaders (mesosystem level)** and their decisions and actions around the **environmental issues (mesosystem level)** that include the school community, procedural structures, resources, support for teachers and their own personal involvement. And finally, those decisions influenced...

d) **Teachers (microsystem level)** and their involvement in decisions, effective professional development, beliefs, attitudes and their ability to teach according to the new *Australian Curriculum: Science* expectations.

The model provided by Bronfenbrenner proved to be effective for understanding the relative influence among factors at all levels – system to classroom, and with the chosen research approach allowed a detailed examination of the perceived preparedness of teachers to undertake this most major of Science education reforms in Australian schools.
10.2.1 Implications

The following implications have been derived from the above conclusions. The Researcher’s view of the school contexts and their implementation procedures have led to the following suggestions.

Professional development and support provided at State and school levels should be informed by current research, and resources provided to facilitate their provision.

A lack of support was evident throughout the implementation process of the new curriculum in two of the three schools. Further, the support that was provided, was often inappropriate to the needs of the teachers, and was inconsistent with appropriate support outlined in the literature. The data indicated that teachers desired some form of in school support and professional learning in Science. The teachers identified both a lack of knowledge and teaching strategies for Science teaching and felt inadequate at times with no place to seek support. Bronfenbrenner identified proximal processes as highly beneficial in developing a person’s skills and understandings. Proximal processes included longevity of time and experiences that gradually increase in complexity to reach a sustainable level and change in practice. There are many research studies that indicate multiple ways for schools to receive the support necessary for effective implementation of new curriculum, new materials, and new teaching strategies that involve proximal processes (Anderson et al., 2014; Cowie et al., 2009; Darling-Hammond, 2008; DeMonte, 2013; Fullan, 2007).

Teachers’ materials provided during curriculum change must include professional development.

The C2C materials and the Primary Connections materials were both viewed as curriculum packages that provided teachers with all they needed to teach Science. However, this a naïve view not supported by research (Davis & Krajcik, 2005). Further, teachers, in the absence of purposeful professional development, did not fully understand the new teaching approaches (Davis
This was particularly evidenced in the State and Independent Schools as those teachers demonstrated difficulty discussing, planning, and teaching Science with an inquiry approach. In addition, some teachers did not fully understand how to teach some of the Science concepts found in the new curriculum. In order to bring about change, effective professional learning needs to become a regular and on-going feature of schools (Guskey, 2002) rather than simple, short, or one-off workshops at the end of a long day of teaching (Cowie et al., 2009; DeMonte, 2013).

**The leadership priorities should include Science because their priorities impact on teachers’ priorities.**

It is expected that the leadership set the vision and direction of the school. Leadership priorities in the three schools determined teachers’ priorities because teachers adopted the same priorities and mostly attended to those priority areas (Gurr et al., 2006). This may improve particular practices, but it may also ignore others. The Catholic School gave equal time to all the subject areas and the teachers did likewise. The State and Independent Schools had English and Mathematics as their priority areas, and the teachers did as well. The lack of support for Science at the state level suggests that Science, despite public statements, is still not viewed as a priority subject area (Masters, 2009). For many years, our society has been trying to lift the image of Science and Science teaching practices for the future advancement of our society and world (United Nations Educational Scientific and Cultural Organisation (UNESCO), 1999). This study suggests that schools are not giving Science the attention our society and the objectives of the *Australian Curriculum: Science*, perceives that it needs. A conclusion that could be reached is that the reduced numbers of students going into Science and technology fields in high school and university studies needs to be taken more seriously at the state education level and the primary school level.
Implementation of a new curriculum requires the school leadership to make decisions that have a positive and effective impact on developing teachers’ understanding and skills (Capacity Building).

There was a perception by the leadership in the State and Independent Schools that their teachers would embrace curriculum change, were capable of interpreting curriculum intentions, and had the skills and knowledge necessary to implement the required changes. Therefore, little or no support was given. This was evident with the State and Independent School cases.

When curricular change occurs due to a need to improve student outcomes and keep up with the changes in teaching practice, then it is important for the school leadership to assess the staff abilities and needs in relation to the new curriculum. Leadership, then, needs to devise processes that will effectively develop knowledge and skills to assist teachers to implement and teach the new curriculum. The Catholic School leadership demonstrated effective processes that prepared the teachers for curriculum change. Perhaps it is necessary to address the skills of school leadership, by providing professional learning in how to build school capacity.

A Science support person within Schools can provide support in Science teaching for the generalist teacher.

The State School and the Independent School teachers reported that they would like to have a ‘Science person’ in the school to approach for support. Without one, they felt frustrated, lacked confidence, and had no ready means to improve their Science teaching skills. The notion of master teachers for each subject area is possible if there are teachers who have the necessary knowledge and current professional learning to work in this capacity. This allows a trusted colleague to provide guidance and instruction as needed, with a collaborative or school community approach.
A realistic timeframe for implementation should allow for development of understanding, professional development and acquisition of resources.

The factor that transcends all levels is the timeframe for implementation. Time was a major contributor to teacher confidence levels, content knowledge and teaching strategies. Time was a main determinant for preparation and planning. Time influenced professional development and resources. Time was shown in this study to be one of the most important missing components to the very large curricular reform that was imposed on the schools and teachers. A more aligned and strategic approach to curriculum implementation from government levels to the teacher level need to be carefully considered. To fragment the decisions and delivery approach at any level, leads to fragmented delivery of the curriculum.

Professional development should include effective teaching strategies for the diverse learners in teachers’ classrooms.

While it is important to meet the needs of all students, and to work towards equity in teaching and learning, it is just as important to prepare teachers in how to do this. When professional development is linked to the classroom where teachers can see results, there is a greater chance of positive and long lasting change. Teachers need time to learn new content, time to learn new teaching strategies, and time to see how students respond and allow for modification until the needs of all students can be successfully met.

Teachers are often described as being resistant to change (McLaughlin, 1987). However, in this study, the teachers appeared to accurately reflect the priorities and limited support established for them by their curriculum authority, school system and school leadership. Teachers can implement productive change but they do need time, resources and support to be sustained and recognised in schools.
Decisions at government and school levels (using Bronfenbrenner’s system) should use research and creative means to build vision, knowledge and practice at the lower levels.

There is naturally and necessarily a benefit of government initiated change, particularly such major change nationally. In its leadership capacity, it sets the framework, the agenda and policy context for other levels of implementation. The need for the required changes should then be seen at the ‘front lines’; in this case, in the classrooms. It would seem obvious then, that as leaders at each level plan to prepare the group for whom they are responsible, they pass the change on so the required change is effective, efficient and resourced. This research study determined that in some cases the leadership (at various levels) made assumptions about the knowledge or capabilities of those they oversee. This led to a large observed variation in implementation and understanding of the expected skills for the implementation of the new *Australian Curriculum: Science*. In order to bring about effective curricular change, it may be necessary to reshape the strategies used when delivering information through a top-down approach (Rinke & Valli, 2010).

All the factors described above are interwoven and overlap. When executed well, they provide a strong model of school development and school capacity. As demonstrated in this study, when there was a disconnection or a weakening in one of those factors, there was a weakening at one of the system levels leading to miscommunication or misinterpretation at other levels thus creating varied implementation outcomes.
10.3 Limitations of the Study

The design of the present study was intended to examine a small number of schools, in depth, to identify critical issues associated with the school and teacher implementation of the new *Australian Curriculum: Science* in primary schools. The study included a small number of primary schools and primary generalist teachers from a local area of one Australian state. While these schools and teachers may have similar experiences to other schools across Australia and other countries, it is a limited and select view of the national Science implementation process. In addition, it was beyond the scope of this study to connect its findings with student achievement data. Limitations may also include the following:

- The role of the Researcher was carefully constructed to allow participation if the participants chose to involve her. A trust relationship was important for open questions, discussions and observations with lessons. However, teachers may have changed some aspects of their teaching due to the Researcher’s presence.

- There is potential for some degree of in-built bias by the teachers who volunteered. Some may have had a need to voice particular concerns about the new curriculum or aspects connected to it.

- The fact that the Catholic school data was collected a little later may be viewed as allowing them more time to learn and implement. However, they were not in session for a couple of the weeks at the end of the year when Post surveys were taken. (This private information cannot be discussed.)

- The schools had families from somewhat different socioeconomic status that may impact on procedures in the school.

- The schools had teachers from different science educational backgrounds and experiences that can impact on practices. However, this diversity is common in schools.
• Only two science lessons were observed for each case study teacher so the conclusions drawn may be limited.

• There may have been varied interpretation of some survey questions thus leading to unexpected responses by some teachers. For example, the term ‘science process’ may have different meanings for some teachers.

The research, within its limitations, was a study of three schools and how they decided to implement the new *Australian Curriculum: Science*. Each school was quite different from the others and had its own unique community of leaders, teachers and students who did the best they could within their school contexts to implement the new *Australian Curriculum: Science*.

**10.4 Further Research**

As indicated in the Discussion chapter, this study has revealed that further research into effective implementation processes during curriculum reform and curriculum change is needed. There are several areas emergent from this that need to be investigated. A key investigation would be to identify the best type of support for primary teachers to improve Science teaching and learning over a longer period of time, rather than a mandated, short-term response to a new curriculum initiative. Related to this is the issue of whether to have Science specialist teachers in primary schools, or continue with the practice of generalist teachers teaching Science as well as the other curriculum areas.

Further research could also be conducted into the effectiveness of using high school teachers to teach in primary schools and/or support primary teachers, and what sort of professional development would help them be more effective in this. Another area for investigation is the extent to which, national high-stakes testing programs and consequent expectations for student achievement levels add to the pressure for teachers and schools to maintain a high level of knowledge in subjects tested, to the detriment of subjects not tested, such as Science.
This study set out to answer the main research question:

In what ways does a new national *Australian Curriculum: Science* provide impetus, at school and teacher levels, for Science curriculum change and for improving Science teaching, and to what extent does such impetus influence changes in practice?

The methods employed helped to successfully identify factors that influenced school and teacher actions during the implementation of the new *Australian Curriculum: Science*. It is clear that the government decisions impacted on school decisions. The lack of budget and a quick rollout meant school leadership had few resources to utilise for teacher development of new teaching strategies and materials, thus leading to superficial changes in some schools. The case school that had a strong and effective professional development routine in place was the only school that made progress towards meeting the intentions of the new *Australian Curriculum: Science*. It became clear that not only the teachers needed support but that the principals and school leaders also need support. It appeared that some leadership personnel might not have the knowledge, skills or time to create an environment that is able to build whole school capacity. Therefore, time, monetary resources, instructional resources, effective professional development and leadership that created an environment of capacity building within the school were found to be the most important factors that influenced change in Science practice.

“If you want to understand something, try to change it.” Walter Dearborn (as cited in Bronfenbrenner, 2009, p. 37)
11 REFERENCES


Australian Curriculum Assessment and Reporting Authority. (2010a). *Charter for the Australian Curriculum, Assessment and Reporting Authority*. Australia: ACARA.


291


curricula are used. Research Report, Monash University, Melbourne, Australia.


http://www.unesco.org/science/wcs/meetings/eur_alberta_98_e.htm


12 APPENDIX

12.1 Appendix A Survey Questions

Survey Questions

Teacher preparedness and support to teach science:
What kind of prior education in science do teachers in primary schools have to teach science? Do they feel they have enough knowledge and confidence to teach the new science curriculum?

Part A: Please respond to the following:

Male □ Female □ Number of years of teaching experience ______

Year level teaching now: ______ Yr levels taught previously: P 1 2 3 4 5 6 7 8 9 10 11 12

Your current role: Classroom teacher: full time / part time
Curriculum leader: full time / part time
Administrator: full time / part time

Indicate the number of semesters you studied the following subjects in years 11 and 12.

Biology 1 2 3 4 Chemistry 1 2 3 4 Physics 1 2 3 4 Other science 1 2 3 4

Indicate the number of semesters you studied the following subjects in University.

Biology 1 2 3 Chemistry 1 2 3 Physics 1 2 3 Earth/space 1 2 3

General Science/Environmental Science 1 2 3

How many science professional development sessions have you undertaken in the last 5 years? ______

<table>
<thead>
<tr>
<th>If you did attend some science professional development sessions or science related activities or workshops in the last 5 years, what was the focus of these?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focus of science PD session or activity</td>
</tr>
<tr>
<td>______________________________________</td>
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<tr>
<td>______________________________________</td>
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<tr>
<td>______________________________________</td>
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<tr>
<td>______________________________________</td>
</tr>
</tbody>
</table>

B Lowe 2012
Part B: Put a tick in the box that best answers the questions with 5 being the highest and one the lowest.

<table>
<thead>
<tr>
<th>Science Curriculum</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>To what extent did you look forward to the new science curriculum?</td>
<td></td>
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</tr>
<tr>
<td>To what extent did your school plan and prepare for the implementation of the new science curriculum?</td>
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<tr>
<td>To what extent did you personally plan and prepare for the implementation of the new science curriculum?</td>
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</tr>
<tr>
<td>To what extent do you feel prepared to teach the new science curriculum?</td>
<td></td>
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</tr>
<tr>
<td>To what extent do you feel that you have the resources to teach the new science curriculum?</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>To what extent are you able to complete the new science units?</td>
<td></td>
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<td></td>
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<tr>
<td>To what extent are you able follow the new science curriculum?</td>
<td></td>
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<tr>
<td>To what extent have you found Professional Development workshops in science to be beneficial in helping you with your science teaching and learning practices?</td>
<td></td>
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<tr>
<td>To what extent has your education system (eg: EQ) provided professional development or other help to implement the new science curriculum?</td>
<td></td>
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<tr>
<td>To what extent has your school provided professional development or other help to implement the new science curriculum?</td>
<td></td>
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</tr>
<tr>
<td>To what extent has the professional development provided by your education system and/or school (if any) been sufficient to help you feel confident enough to implement the new science curriculum?</td>
<td></td>
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<tr>
<td>To what extent have NAPLAN and the national or international testing regimes in science influenced your teaching?</td>
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</tbody>
</table>

In what ways (if at all):
### Part C

How do you rate your personal experiences teaching science? On each of the opposites below, place a tick in the box towards the description which you think describes how you feel about teaching science.

<table>
<thead>
<tr>
<th>Try to teach it more often</th>
<th>Try to avoid teaching it.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very worthwhile</td>
<td>Complete waste of time</td>
</tr>
<tr>
<td>Extremely unhappy</td>
<td>Extremely happy.</td>
</tr>
<tr>
<td>Feel least confident</td>
<td>Feel most confident.</td>
</tr>
<tr>
<td>Most enjoyable</td>
<td>Extremely boring.</td>
</tr>
<tr>
<td>Very undesirable</td>
<td>Very desirable.</td>
</tr>
<tr>
<td>Completely unrewarding</td>
<td>Very rewarding.</td>
</tr>
<tr>
<td>Very unimportant</td>
<td>Very important.</td>
</tr>
</tbody>
</table>

### Section D

#### Beliefs about science teaching

<table>
<thead>
<tr>
<th>Belief</th>
<th>5 strongly agree</th>
<th>4 agree</th>
<th>3 disagree</th>
<th>2 strongly disagree</th>
<th>1 unable to answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>The structure of the science course should be based on the processes (reasoning skills of science) rather than content (science facts).</td>
<td></td>
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<tr>
<td>Practical experience is not essential for the acquisition of scientific knowledge.</td>
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<tr>
<td>Pupils may forget all they learned at school about the facts and principles of science but the experience they gain in carrying out their own practical investigations will last them in good stead forever.</td>
<td></td>
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<tr>
<td>The time allocation for science should be more than the recommended two hours per week.</td>
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<tr>
<td>The pupils should be allowed to work at their own rate to suit their own needs.</td>
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<tr>
<td>The science course should be based on pupil observation and experiment.</td>
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<tr>
<td>A major aim of the science course should be to encourage the development of original ideas in the child.</td>
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</tr>
</tbody>
</table>
What proportion of time in an average one hour science lesson would be spent on:

<table>
<thead>
<tr>
<th>Activity</th>
<th>80-100%</th>
<th>60-79%</th>
<th>40-59%</th>
<th>20-39%</th>
<th>0-19%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher talking</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Children reading</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Children talking in small groups</td>
<td></td>
<td></td>
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<tr>
<td>Children doing activity work with equipment</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Children completing worksheets/reports</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Other:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To what extent do you use the following assessment tools in science?

<table>
<thead>
<tr>
<th>Tool</th>
<th>5 very often</th>
<th>4 often</th>
<th>3 some</th>
<th>2 rarely</th>
<th>1 never</th>
</tr>
</thead>
<tbody>
<tr>
<td>Written tests/quizzes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observation of pupils at work, and taking notes of observations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conferencing with pupils and recording notes</td>
<td></td>
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</tr>
<tr>
<td>Oral presentations by pupils</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Multi-media projects undertaken by pupils</td>
<td></td>
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</tr>
<tr>
<td>Drawings made by pupils</td>
<td></td>
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</tr>
<tr>
<td>Student-student (peer) assessment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Checklist / criteria</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
How often do you usually teach science in a week? (Based on 30 minute sessions; Eg: a 1 hour lesson = 2 sessions)

☐ Once
☐ Twice
☐ 3 times
☐ 4 times
☐ 5+ times
OR ☐ 2-4 week concentrated science teaching then no science for the rest of term.
OR ☐ Other: ________________________________

Do you have a preferred printed or online resource for teaching science? Yes No

If yes, which resource(s)? ________________________________

Thank you for participating and completing the survey. Your time is much appreciated.

⊙ Beverly Lowe
12.2 Appendix B Interviews

12.2.1 Principal/Deputy/Curriculum Coordinator Interview

1. How would you describe the school demographics?
2. What teaching experiences do you have?
3. How long ago?
4. Describe your science teaching at that time.
5. How rigid is the timetable? Is there any check for time allocations?
6. What does the School policy/planning process consists of…..?
7. What processes are in place here to help teachers with implementation of the new curriculum?
8. To what extent is there PD for the new curriculum?
9. How easy do you think it is to implement?
10. What help do teachers need most?
11. What would you expect to see a teacher doing?
12. How would you be able to tell if teachers are implementing correctly?
13. What beliefs do you think your teachers hold towards science? The new curriculum?
14. What strategies do they use to teach science?
15. How frequently do they teach science?
16. What school support is there in place? Equipment….PD…other
17. Is there a Curriculum planning committee?
18. Teacher expectations of you? curriculum policy?
12.2.2 Classroom Teacher Interview

(Further probes may be used)

1. “Draw a science teacher teaching science – label.”
2. “Tell about your classroom.” (students, environment, resources.)
3. “Was there any particular science in your background that has been helpful for your teaching?”
4. “Tell me about your best science lesson this year.” (planning, teaching strategies, assessment, materials)
5. “What are your thoughts about the new science curriculum?” (2011 introduction onwards)
6. “What are your expectations of the principal in regards to curriculum/science curriculum?” (Curriculum policy?) (Curriculum coordinator?)
7. “What does the School policy/planning process consists of….? Where do you fit in?”
8. “Have you received support to help implement the new science curriculum?” (Equipment….suitable PD…other)
9. “What support systems would you like to see in operation?”
10. How easy do you think it is to implement the new science curriculum? Prep time?
11. “What is most appreciated about the new curriculum? Least appreciated?”
12. “What help do you and teachers need most?”
13. “The new curriculum focuses on science concepts. How do you help students to understand these concepts? Where can you go for help?”
14. “When you are involved in science activities and discover you need more time than anticipated what do you do?” (With all that happens in schools, how likely are you to keep to your schedule?)
15. “What strategies do you believe are most suitable for science learning?” (Which do you use to teach science most often?)
16. “Tell me about your assessment procedures for science.” (How do you assess learning? How do you report progress to students and parents?)
17. “In regards to National testing, have you ever seen the reports on student progress? What is your impression?” (Feedback on student results?)
18. “Describe an outstanding science teacher?” (How do teachers become outstanding teachers?)
12.3 Appendix C  Kruskal Wallis Test

Data Collection 1 - Pre Test for difference in each of the dimensions based upon the school the teacher taught at (Kruskal-Wallis Test)

Section B

<table>
<thead>
<tr>
<th>Item</th>
<th>Text</th>
<th>N</th>
<th>Mean Rank</th>
<th>N</th>
<th>Mean Rank</th>
<th>N</th>
<th>Mean Rank</th>
<th>$\chi^2$</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>To what extent did you look forward to the new science curriculum?</td>
<td>14</td>
<td>31.11</td>
<td>10</td>
<td>24.70</td>
<td>25</td>
<td>21.70</td>
<td>4.835</td>
<td>2</td>
<td>.089</td>
</tr>
<tr>
<td>B2</td>
<td>To what extent did your school plan and prepare for the implementation of the new science curriculum?</td>
<td>13</td>
<td>19.12</td>
<td>9</td>
<td>17.72</td>
<td>25</td>
<td>28.80</td>
<td>7.833</td>
<td>2</td>
<td>.020</td>
</tr>
<tr>
<td>B3</td>
<td>To what extent did you personally plan and prepare for the implementation of the new science curriculum?</td>
<td>14</td>
<td>21</td>
<td>9</td>
<td>34.61</td>
<td>23</td>
<td>20.67</td>
<td>9.277</td>
<td>2</td>
<td>.010</td>
</tr>
<tr>
<td>B4</td>
<td>To what extent do you feel prepared to teach the new science curriculum?</td>
<td>14</td>
<td>19.79</td>
<td>9</td>
<td>31.22</td>
<td>25</td>
<td>24.72</td>
<td>4.900</td>
<td>2</td>
<td>.086</td>
</tr>
<tr>
<td>B5</td>
<td>To what extent do you feel that you have the resources to teach the new science curriculum?</td>
<td>14</td>
<td>14.57</td>
<td>9</td>
<td>23.33</td>
<td>24</td>
<td>29.75</td>
<td>15.532</td>
<td>2</td>
<td>.000</td>
</tr>
<tr>
<td>B6</td>
<td>To what extent are you able to complete the new science units?</td>
<td>14</td>
<td>22.75</td>
<td>10</td>
<td>26</td>
<td>24</td>
<td>24.90</td>
<td>.434</td>
<td>2</td>
<td>.805</td>
</tr>
<tr>
<td>B7</td>
<td>To what extent are you able to follow the new science curriculum?</td>
<td>14</td>
<td>23.5</td>
<td>10</td>
<td>24.5</td>
<td>24</td>
<td>25.08</td>
<td>.140</td>
<td>2</td>
<td>.932</td>
</tr>
<tr>
<td>B8</td>
<td>To what extent have you found Professional Development workshops in science to be beneficial in helping you with your science teaching and learning practices?</td>
<td>12</td>
<td>13.5</td>
<td>9</td>
<td>21.17</td>
<td>23</td>
<td>27.72</td>
<td>11.479</td>
<td>2</td>
<td>.003</td>
</tr>
</tbody>
</table>
To what extent has your education system (eg: EQ) provided professional development or other help to implement the new science curriculum?

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<table>
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<tr>
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</thead>
<tbody>
<tr>
<td>B9</td>
<td>To what extent has your education system (eg: EQ) provided professional development or other help to implement the new science curriculum?</td>
<td>14</td>
<td>11.18</td>
<td>8</td>
<td>25.63</td>
<td>24</td>
</tr>
</tbody>
</table>

To what extent has your school provided professional development or other help to implement the new curriculum?

<p>| | | | | | | |</p>
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</thead>
<tbody>
<tr>
<td>B10</td>
<td>To what extent has your school provided professional development or other help to implement the new curriculum?</td>
<td>14</td>
<td>12</td>
<td>10</td>
<td>24.5</td>
<td>24</td>
</tr>
</tbody>
</table>

To what extent has the professional development provided by your education system and/or school (if any) been sufficient to help you feel confident enough to implement the new science curriculum?

<p>| | | | | | | |</p>
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</thead>
<tbody>
<tr>
<td>B11</td>
<td>To what extent has the professional development provided by your education system and/or school (if any) been sufficient to help you feel confident enough to implement the new science curriculum?</td>
<td>14</td>
<td>12.11</td>
<td>9</td>
<td>28.83</td>
<td>25</td>
</tr>
</tbody>
</table>
B12  To what extent have NAPLAN and the national or international testing regimes in science influenced your teaching?

Data Collection 2 - PostTest for difference in each of the dimensions based upon the school the teacher taught at (Kruskal-Wallis Test)

Section B

<table>
<thead>
<tr>
<th>Item</th>
<th>Text</th>
<th>School A</th>
<th>School B</th>
<th>School C</th>
<th>$\chi^2$</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>N Mean</td>
<td>N Mean</td>
<td>N Mean</td>
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<td>Rank</td>
<td>Rank</td>
<td>Rank</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B1</td>
<td>To what extent did you look forward to the new science curriculum?</td>
<td>8</td>
<td>115.44</td>
<td>13</td>
<td>19.00</td>
<td>16</td>
<td>20.78</td>
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<td>B2</td>
<td>To what extent did your school plan and prepare for the implementation of the new science curriculum?</td>
<td>8</td>
<td>13.50</td>
<td>13</td>
<td>12.92</td>
<td>16</td>
<td>26.69</td>
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<td>B3</td>
<td>To what extend did you personally plan and prepare for the implementation of the new science curriculum?</td>
<td>8</td>
<td>15.50</td>
<td>13</td>
<td>18.35</td>
<td>16</td>
<td>21.28</td>
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</table>
B4  To what extent do you feel prepared to teach the new science curriculum?

B5  To what extent do you feel that you have the resources to teach the new science curriculum?

B6  To what extent are you able to complete the new science units?

B7  To what extent are you able to follow the new science curriculum?

B8  To what extent have you found Professional Development workshops in science to be beneficial in helping you with your science teaching and learning practices?
B9  To what extent has your education system (eg: EQ) provided professional development or other help to implement the new science curriculum?

B10 To what extent has your school provided professional development or other help to implement the new curriculum?

B11 To what extent has the professional development provided by your education system and/or school (if any) been sufficient to help you feel confident enough to implement the new science curriculum?
B12 To what extent have NAPLAN and the national or international testing regimes in science influenced your teaching?
INFORMATION LETTER TO PARTICIPANT

TITLE OF PROJECT: Responses to and changes in school and science teaching practice arising from the required implementation of a new primary science curriculum

PRINCIPAL RESEARCHER: Beverly Lowe

University of the Sunshine Coast
07 5459 4766
blowe@usc.edu.au

SUPERVISOR: Merv Hyde and Kenneth Appleton

University of the Sunshine Coast
mhyde@usc.edu.au appletok@westnet.com.au

Dear Principal,

I am inviting your school and your teachers to participate in a research project about the ways in which your school has decided to implement the new science curriculum. This project aims to identify the influences the new curriculum has had and continues to have on schools and primary teachers’ understandings of the science content, teaching strategies and personal implementation of the new science curriculum through the use of questionnaires, observations and interviews. The questions on the questionnaire and the interviews are non-intrusive and are not personally invasive. The questions ask teachers to recall past experiences starting with the onset of the new science curriculum and leading to the current stage in the implementation of the new science curriculum. Access to past documents regarding the new science curriculum and its implementation within your school will be helpful. I would also like to observe how the school continues to handle science curriculum issues through observations of meetings, plans and goals for implementation as well
as prearranged classroom observations. I will be seeking three teachers to work with as case studies.

The voluntary interviews will be audio taped. If agreed by all, the planning meetings will be audio taped. All information will be confidential.

Why is this research being done?

I am completing my PhD in the area of science education, and work with preservice teachers in the Bachelor of Education program at the University of the Sunshine Coast in science. I want to improve the knowledge and pedagogy of new teachers entering the field of education as well as be able to provide a service to practicing teachers needing to improve knowledge and skills in the area of maths and science. In a recent review of research, the Masters’ report identified concerns about the level of teachers’ professional preparation, content knowledge, pedagogical capacity and confidence to teach science in primary schools.

Are there any benefits/risks involved in this research?

There are no risks involved with this research. I am happy to give the principal and teachers copies of the information (surveys, interviews and observations) to check for accuracy and make any needed changes. Papers written will also be given to the participating schools that may help inform them about current practices/beliefs of three regional Sunshine Coast schools and future directions needed in the area of science for primary schools.

What would you have to do?

The principal would need to arrange for the researcher to speak at a staff meeting to inform the teachers about the project and enlist their participation. If this is not possible, then we will negotiate an alternative method. The pre and post surveys will take 10-15 minutes to be completed by all participating staff at the beginning of the project and again in one year. I will need three teachers (preferably one from each year level, 4-6, and different stages of experience) to volunteer to participate in negotiated observations of teaching, planning meetings, etc. over a term and also have two 20-minute interviews with the same three teachers. I would like to interview the principal and curriculum leader at the beginning of the project and again a year later. I would like to be able to observe curriculum planning meetings that include science curriculum at various times throughout the year.
How will your confidentiality be protected?

The surveys will have codes written on them for the purposes of cross checking for change over time and seeking follow up clarification. The principal and deputy will not be in the room during the surveys, interviews and observations. We will discuss the possibility that other staff in the school may discover which individual teachers are participating. If this worries a teacher, they don’t need to participate. Teachers will have the ability to check transcripts for accuracy and the ability to make changes to those transcripts so they are comfortable with the statements. Notes/audio-tapes from the discussions will be kept in a locked cupboard when not in use. The research when written will not mention the names of schools or teachers but will refer to the schools as regional schools in Queensland. When referring to teachers in the writings, fictitious names will be used. When referring to schools, a number or letter may be allocated.

Your consent

By signing the consent form you are indicating your willingness for your school/ school staff to participate in the research project as it is explained in this letter. Participation by teachers is completely voluntary, and teachers are free to refuse consent altogether without having to justify that decision, or to withdraw their consent after first giving it and discontinue participation in the study at any time without giving a reason.

More questions?

Any questions regarding this project should be directed to Beverly Lowe, 07 5459 4766 or blowe@usc.edu.au

Ethics

This study has been approved by the Human Research Ethics Committee of the University of the Sunshine Coast.

Complaints about the research

If you have a complaint or concern about the conduct of this research, or if you have any query that the Investigator has not been able to satisfy, you may write to, or contact the Chair of the Human Research Ethics Committee at: Chairperson of the Human Research Ethics Committee at the University of the Sunshine Coast.

Address: c/- The Research Ethics Officer
           Office of Research
           Phone: (07) 5459 4574
           Fax: (07) 5430 1177
The researchers and the University of the Sunshine Coast appreciate and thank you for your participation in this research.

What do you have to do?

Please read this Information Statement and be sure you understand it. If you would like to participate, please complete the attached consent form and return to the researcher. Keep the Information Statement for your records.

Thank you for considering this invitation and I look forward to hearing from you.

Signature

Principal Researcher: ……………………………

Please keep this document for your records
Dear Parents,

Your school is participating in my research study for my PhD. I have been a primary teacher for 26 years in the USA and Australia combined. I am currently working and studying at the University of the Sunshine Coast. My project focuses on the implementation of the new science curriculum.

**Project Title:** *Responses to and changes in school and science teaching practice arising from the required implementation of a new primary science curriculum*

I will be on campus working with staff and visiting classrooms for the next several months. My work is with the staff and not your child or children. I will only be working with your child/children if the classroom teacher asks me to do some teaching. Classrooms and children will not be videoed, photographed or tape recorded.

Warm regards,

Beverly Lowe
Lecturer in Education
University of the Sunshine Coast
12.5 Appendix E  Consent Forms

12.5.1 School Consent Form

Project Title: Preparation and support of primary school teachers to teach science and the effect it has on classroom practice.

Research Organisation: University of the Sunshine Coast

Contact Details: Beverly Lowe blowe@usc.edu.au 5459 4766

- I have read the Information Statement and understand the aims, procedures, and risks of this project, as described to me in the information statement.

- I have had the opportunity to ask questions about the study, and I am satisfied with the answers I received.

- I am willing for this school / the teachers to be involved in the research project, as described.

- I understand that participation in the project is entirely voluntarily.

- I understand that the teachers are free to withdraw participation at any time, without affecting the relationship with the research team/organisation.

- I understand that the results of this research may be presented in a PhD and journal articles and that the participants and the school will not be identified in publications resulting from the study.

- I understand that the school will be provided with a copy of the findings from this research upon its completion.
• I understand I need to keep a copy of the information sheet for future queries.

<table>
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<tr>
<th>Name of School:</th>
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<td>Principal’s Name</td>
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Please return this form to Beverly Lowe, (07) 5459 4766.
**12.5.2  Consent Form for Teachers**

**Consent Form for Teachers**

**Project Title:** Preparation and support of primary school teachers to teach science and the effect it has on classroom practice.

**Research Organisation:** University of the Sunshine Coast

**Contact Details:** Beverly Lowe  blowe@usc.edu.au  5459 4766

- I have read the Information Statement and understand the aims, procedures, and risks of this project, as described to me in the information statement.

- I have had the opportunity to ask questions about the study, and I am satisfied with the answers I received.

- I am willing to be involved in the research project, as described.

- I understand that participation in the project is entirely voluntarily.

- I understand that I am free to withdraw participation at any time, without affecting the relationship with the research team/organisation.

- I understand that the results of this research may be presented in a PhD and journal articles and that the participants and the school will not be identified in publications resulting from the study.
• I understand that the school will be provided with a copy of the findings from this research upon its completion.

• I understand I need to keep a copy of the information sheet for future queries.

<table>
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<th>Name</th>
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<td>(Teachers, years 4-7)</td>
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<th>Signature</th>
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Please return this form to Beverly Lowe, (07) 5459 4766.
Appendix F Field Note Samples

Mrs L: State School

1:00 arrival yr 5 class studying solids, liquids, gases

1:10 met with L - last week she had ice that she heated with a dryer, it turned to liquid then continued drying it to watch it go to gas caught on a surface and dripped into a cup today they will do an activity inspired from the student teacher: mixing milk with red bull

1:20 students enter from recess
L finishes up morning tasks
A student bitten several times is sent home
A crying child is dealt with

12:50 class goes to science lab to do an “experiment” on matter (Solids, liquids and gases) Groups of 4-5 students at tables

The lesson began with a review of the “ice experiment” (Teacher led)
She then explained the process of the milk and red bull experiment.
Students wrote the objective (copied form board) and their own prediction
The materials were listed (750 mL milk, 250 mL red bull, 1 litre jug, paper towels)
Students were given the materials and asked to sort out the job of pouring
They observed for a few minutes
They switched tables to see the other groups outcomes with different types of milk
The results were written on the board and copied by students.
2:30 time is up. School is out. The litre containers were kept until tomorrow to follow up.

The student teacher will continue with the results by sharing the YouTube experiment completed by another class and compare results.

The YouTube clip does not describe what is happening or go into the science behind the chemical change.

I was unable to view whether or not the link with solids, liquids and gases and particle model will be made.

There are 27 students in the class, 23 today
Students were very talkative. L needed to regain attention several times.
Second lesson
1:15  students return from recess
Roll is taken - one child suspended that morning.
Students review solids liquids gases from earlier activity
Learning place brought up to show particle images of each state of matter
1:35  Students go to science lab
six tables with 4-5 students at each.  L goes over each activity.
Focus is on investigating gas
1. balloons and mass of gas
2. upside down cups, one with tissue and one over a ping pong ball pushed into tub of water.
3. large bottle , funnel, plastecene create an air bubble in middle of bottle

C2C sheets with instructions were given out with materials.

Students were to write predictions.... Some not sure what they were going to do until they began then made predictions.
Students completed each activity by moving form table to table.
L and I moved around to observe, and ask questions.
Students had no idea what would happen except some new the tissue would not get wet but could not say why. After they did the ping pong ball one they could see the air pocket and explain. Some who had some science understanding could begin to explain what happened n the different activities.
Many students could tell what happened but not explain it. Time was not given to explain during this session. They were to finish the next day.

L said she predicted the outcomes and purposes of each when she read through the activities. She used a glass bottle instead of a plastic soda bottle as the instructions listed. She believed it would still work even though she did not try it out.
L seems to have a good understanding of the concepts when she explains them. She likes to use the lab and get the students to do hands-on activities. She tries to get them to write up predictions and basic experiment information such as the objective, predictions and outcomes.
L purchases many of the items to do the experiment out of her own pocket.
12.6.2  Mrs S: State School

1:00 students have recess, S gets supplies out of car then gets some food unit; Push and Pull, forces and friction
She is not happy with the unit. She finds it boring and is looking for activities that will better engage the students.

1:20 vocab listed on board to copy and define: push, pull, force, friction
students go outside for fruit can activity (cans full of fruit and juice): push
students sat on the ground to observe and listen to instructions.

S demonstrated how to push the can with little force and with a lot of force. Students were divided into groups to feel the Forces themselves. Students quickly tired of it and began to toss and kick the cans. In some groups it led to trouble and others, with guidance, discussed differences and what they thought was causing the changes in how the can rolled.
After about 15 minutes S called them back to briefly discuss their findings and draw a cartoon showing what they did and saw.

tug of war: pull

Children where divided into four groups to play tug of war. No discussion took place about forces or pulls. They had two goes then it was time to pack up and go home.

Discussion and further write up would occur the next day.

S and I discussed the activities and how the students were not very engaged in the can activity and easily taken off track. Some were interested in how the fruit moved and set the can off balance. We saw how it could lead into safety, car crashes, seat belt use, etc. We
mentioned the use of bikes, skate boards, roller blades to also demonstrate the push and pull.

We discussed next weeks activities: pulling buckets with sand rocks etc across different surfaces.

I suggested a friction activity using jelly that I would be happy to lead. She liked the idea. We planned for each of us to run an activity.
1:15 S brought students in from lunch, took roll, had students pack up the room.
1:25 We left with their bags to do an activity on the oval.

S organized another tug of war.

Two ropes, 4 teams divided by child choice.
They played one time normally.
Losers were given plastic gloves
Will this help?...many thought so.
The same team lost again.
Gloves were given to the winners and liquid soap applied to their hands.
Will this help?
The usual winners finally lost.
Friction needed to pull Discussion

Sitting outside many students were not interested in discussing....distracted.

2:00 We moved to the science lab where I was to run the jelly activity.

Six groups randomly chosen with coloured sticks.
Students have one minute to move as many jelly cubes to another bowl as they can using shop sticks.
Discussed results and strategies used.
Added vegetable oil and repeated the process.
Discussed the results. Some tried ideas from others in first activity.

Introduced lubrication...new word for them. Compared with tug of war.
Asked students to think of other things that use lubrication and why.
Discussed friction at two points with tug of war....do we want lubrication? Why?
Students Identified a need for friction and a need for less friction at times.

2:30  School dismissed
S tried a catapult activity from the set of force activities I gave her.

It used friction ideas to make it work.
Students tried the catapults without weights and the catapults moved too much to work.

The added weights and found friction helped it to work.

Last semester S tried a polymer activity with the students after doing some work with materials. She had them time the polymer from a metre high and record results then compare with others. This was video taped with the ipad given for teacher to use with their teaching.
10 year 6 students in attendance
first time to teach this unit. (chemical science – reversible and irreversible) B is reinforcing this unit from earlier this year when a student teacher taught it.
1:00 lunchroom conversations...reports busy time, trying to keep students on track
1:15 students return from lunch....silent reading
B asks a student to arrange tables and get some photocopying done for him.
Informs yr 7 they are to have a graduation practice soon.
1:25 B directs yr 6 students to move to the long table and bring science books. He hands out a prepared information sheet on oxidation. Some work with steel wool and rusting has occurred previously. Bob read the sheet aloud and stopped occasionally to give examples and elaborate.
1:55 Students were given a window pain activity to choose the main vocabulary then summarize the information in their own words. This is to be without looking at the sheet and also typed.
Students seemed to have a decent grasp of the vocabulary used during discussions. (matter, oxidation, atom, molecules)
2:10 B gathered students together again to give them a sneak peek at the upcoming final science exam. He walked them through each page so they understood what is covered and what to study. It contains matching and definitions for Chemical and physical change, macro and microscopic.
There are also real life examples of physical and chemical change events they are to correctly categorize as Chemical or physical.

B said he tried to do the temperature activity with steel wool during oxidation but it didn’t work so students couldn’t graph the outcome. He also had a vinegar and bicarb activity for students to try. B often integrates reading with science. Students complete nonfiction science reading sheets. He likes to move between science and SOSE formats when teaching science.
Next day 13 year 6 students (yr 7 is working with the student teacher at a large table)

Science exam (he felt I would like to see an exam even though I asked to see him teach.)
Students were asked to take out pencil, glue and scissors
They were moved so there was space between them.
Students were handed the 3 part test and given explanations.

While students were testing we chatted.

I asked about the success of the vinegar activity.

B said: it went well.... used sequencing with the scientific report (aim, hypothesis, etc). strong scaffolding. Students haven’t had much work with investigations and fair testing until yr 6. A few understand it well others are just getting the ideas together. The students followed the steps and the crystals grew. They wrote a science report about it.

He has no students identified as special needs but there are three ESL students who struggle.

About 7 of his students are new to the school this year. Transient population.

My observations and our discussions revealed that he prefers to use his stash of reading related science worksheets and vocabulary sheets. He is adamant that students must learn the facts before high school. He will say he does experiments but cannot give examples of any. His teaching style appears to be one of control, individualized seating and individualized work. It is mostly quiet.

His content knowledge appears to be developed from his work with the Science Sourcebooks. He has favourite activities he prefers to use each year. He does not understand the inquiry approach to teaching science.
Yr 4 class, 30 students, sitting in tables of 5

1:00 students enter from recess. They sit to read silently for 15 minutes then switch classes.

Doug teaches the yr four science Topic: Beneath our Feet - Primary Connections with adaptations

1:20 D reviews last weeks activity on observing. He prompts with questions. He reminds students about the soil they collected and added water to last term. It has been settling for the last few weeks.

Today they will take their group soil jar and make observations, draw those observations and describe their observations. Students also measured the soil layers in mm.

He models how to do this on the white board and his own jar.

He thinks out loud and asks questions as he goes through each step.

D encourages group discussion and thinking.

One Student gets their jar and other pass out books.
They begin to draw their jars and make observations.

There is low level talking. Everyone is on task.

The student teacher, D and I move from table to table to observe and ask students questions. Students are just beginning to observe small details and record them. This is still new and difficult. Prompts and reminders are needed.

2:15 Positive feedback was given to students. They were asked to make a title and write two sentences about what they learned about soil. Some of these were shared.

Science books were collected.
1:00 students return from lunch
silent reading
switch yr 4 classes
D is repeating a lesson that a substitute gave. Who he says is very good and
knows her science well. Students didn’t seem to understand the abstract
nature of soil having different compositions from the top layer to many
kilometers below our feet. Students still drew illustrations of the layers
containing bones, worms, litter etc many kilometers deep.

D decided to reteach the last lesson.

1:15 He reviewed the last lesson with students and asked for their
descriptions of what is below their feet. He talked about their drawings. He
wants them to rethink what they have drawn.

1:30 He takes them for another walk to a landform on campus that reveals
about 5m of the soil where a road was cut into the hill.

D leads them to observe what they see and re-describe the composition at
different levels.

1:45 Back in the classroom, D leads a discussion around what they saw.
And to reinterpret what it means for our land. He leads them to compare it
to Uluru and other large landforms. How did those landforms become a
large formation? What do they consist of?

2:05 He takes them to a sand pit on campus and demonstrates with rocks
sand and water the effects of rain on the top soil. He asks them to do the
same in small groups and to explain what is happening. He goes around to
each group to check their understanding and explanations. Children keep
redoing and changing their rocks and sand. They change how they “rain” on them too.

Students understand the idea of large formations containing rock at their core and the outer layer containing many loose particles/materials that easily move.....erosion.

2:30 recess
1:00 After lunch teacher read a book to students about the environment changing to an urban area with no natural environment to be seen. One creature saved a plant and eventually the urban area live cooperatively within a natural environment that is cared for.

Unit: Primary Connections: up, down and all around _ focus is on natural and man made

N lead discussion around item found in the environment as time passed. A similar book was read last week.

1:20 Students made a circle, hoops were placed in the middle as a Venn diagram. N gave two students the job of making signs for circles: natural and man made.

One sign placed in each hoop. The middle is for not sure. N gave students items like plastic insects, sticks, rocks, seed packets, flowers, etc to place in the hoops. As the activity went on some discussion occurred as to which place to put them and why, it did not begin that way. A couple of times, N’s response to the placement indicated the student needed to rethink their choice. By the end, sound reasons for the categories had emerged.

1:45 Students were given a cut out sheet on the same activity with different items to place in a Venn diagram. While this is going on, students were taken a group at a time to go plant seeds in the new garden and also place some of the nonliving items in the garden too.

2:10 Finally all students placed a bean seed in soil in a see through cup of their own to grow.

Children were given choices and ability to make decisions on the garden for themselves. A photo of the garden began the series of photos to demonstrate change over time.

There are 22 students, 3 ADHD, 2 ASD 16 boys and 6 girls

Her knowledge of biology is good. She uses practical experiences and observations. Her knowledge of how to teach other topics, according to her is not as complete.
N has continued with the study of Up Down all Around, yr 1

1:00 She began with a senses song
She showed them quick videos of a tree going through the seasons and a landscape going through all the seasons (including snow and autumn orange leaves) She reviewed seasons in an oral fashion. Two boys were asked to sit by me who couldn’t sit without bothering others.
Students were given 4 poster papers of different colours and several cut out coloured pictures of things that would fit into the season categories. Each poster was for one season. In groups, students had to discuss which season to put the pictures.

1:45 I worked with one group. Behavior issues around who was going to do what and agreeing, were at times difficult for students. This would put them off task. With an adult there, they would refocus and talk about the pictures. Students needed someone to ask them why they think it should go there in order to understand their thinking and help them to consider other ideas. Without an adult they often would place a picture where they wanted it to go without discussion.

Deeper level thinking needs to be facilitated.

2:30 recess duty
12.6.6 Mrs T Independent School

Primary connections unit Micro Organisms

12:45 Students have returned from lunch on a Friday afternoon. While students are settling in from their various jobs, T prepares a YouTube on the scientific method with Monty Python. The clip goes through a silly rendition of creating a question, making a hypothesis, and prediction, then setting up the experiment and making conclusions. This is discussed then a song played called: the scientific method to a rap tune. It is repeated and students join in. Tonya has reorganized a yeast investigation and the trays of equipment are on the floor ready to be distributed.

1:10 T has students choose their won groups and one student for each group gets their tray of materials. T writes on the board what goes into each of the four tubes then the question. (students are fiddling with equipment) She explains how to put it all together. They are asked to make a prediction come to her for the warm water when ready, shake and put on balloon. Everyone gets to work.

She and I and the student teacher walked around to observe, assist. I observed and asked questions. Students seemed to have an idea of what yeast is and what it would do. Some thought they were doing something similar to brewing beer (one father brews his own). Many thought adding yeast to warm water regardless of adding sugar, would make the balloon inflate.

2:00 When all tubes were prepared, labeled and set aside for wait time, students returned to desks to write up the experiment. They were to copy the question, tube ingredients and write their predictions.

2:20 they put it away, stacked chairs, and sat on floor to discuss. When asked what their predictions were, many said they were making beer. One boy said the sugar would dissolve and the balloon would inflate. Another student said the yeast is alive and when it mixes with warm water it will make a gas and inflate the balloon.

T asked me what I would have done. I told the class I would have made a prediction for each tube since each tube had different ingredients. Then
I would need to watch carefully to see what the different ingredients do. I didn’t want to tell too much more and influence the normal direction.

2:30 Students went to recess. I met with T and the student teacher afterwards. She intended to do further work on the ‘experiment’ and wanted to know what I thought. I suggested she help students to have close observations of the interactions between ingredients to promote a deeper understanding. We discussed dissolving, producing carbon dioxide and particle theory. Her knowledge was minimal.
This was a continuation of the first lesson.

1:00 Today they were looking at investigating the effect of temperature of water on yeast and sugar.

T identified the investigation from primary connections to complete. She told the class the question they were going to answer. What happens when different water temperatures are used? She connected this with prior study of biomes with creatures in very different temperature ranges.

It was decided by the class they would use hot, warm and cold water. They knew the results from the warm water. They needed to predict what would happen with hot and cold water. They were going to get cold water from the cold bubbler and hot water from the kettle of boiled water. Warm would be slightly heated up water from another kettle.

1:30 Students were asked to get their balloons and 3 tubes while she passed out the other materials. I asked her if she thought they would remember how much sugar and yeast to put into the tubes to be sure they were doing fair tests. We quickly discussed the implications of not reminding them. (possibly having to redo the experiment....which would still be a good learning experience. Did she have time to let it go?) Tonya decided to remind them and go over fair test ideas.

2-2:30 Students were more engaged and clearer about the processes and tasks this time. Many predicted that the hot water would cause the balloon to inflate more than the warm and maybe even pop. Some understood the idea of the yeast and sugar causing a chemical reaction and producing a gas. Many still used terms like yeast breathing and eating. This was accepted language. T incorporated one of my ideas from last week when she asked what I would do. The students were not giving her the expected prediction responses since they were caught up on “beer”. The focus question was worded in such a way that it was difficult to give one prediction when each tube had different ingredients. I said to the students I would predict what would happen in each one and describe exactly what I might see, smell, feel, etc. She asked them to predict for each tube. Students also began to describe more.

The students did not focus on the beer idea like last time.

2:30 Recess

The discussion and write up of results could not be finished. This would occur on Monday.

After students finished setting it up. The teacher and I discussed the investigation. We covered vocab, behavior, further variables, yeast
getting stuck in tubes, difficulty of mixing, possible alternatives, distributing materials, connections made, her good questioning, and linking to other knowledge and grouping in tables. We also discussed the expectation for yr 6 students to be able to plan an investigation on their own by the end of year 6 and how to get them to that point starting from the beginning of the year.

T wants to improve her science teaching and knowledge. She is willing to have a go. With students who have behavior issues, it makes beginning science investigations challenging. She has an easy going demeanor and a fantastic rapport with the students. While she can get them back on track, they are easily distracted.
Mrs M: Catholic School

Yr 5 part time also IT coordinator in school

Began the science unit on Light

Explored Puppets and puppet shows with shadow
Taught students how to make imovies to use to demonstrate their understanding of how light travels and how we see things

Misconceptions were evident and lead the next few weeks of teaching.

Follow the primary connections curriculum....does not look at ACARA since it is pre-aligned.

Wants to take students to the senior school to spend time in a dark room and see how film develops.

A teaches the other half of the time. She will take over the science unit from here.

Observation 1

M gave a quick review and said they would be doing an activity where they would learn about refraction. She showed them a you tube clip of two children doing a “magic trick” they put a coin in the bottom of the bowl and on a certain angle the coin is not seen. When water is added to the bowl, the coin comes into view. Refraction is discussed. M explains they are going to do the same thing....pretend they are magicians doing a magic trick. They are to duplicate the activity and explain why we can see the coin appear. Children are to video themselves doing this and make it into a movie. ( a pretaught skill)

With a partner, Children use imac pro and the equipment to practice and record their results. There is no planning....just off the cuff.

Observation 2

The unit study was about materials and light. Vocab: translucent, opaque and transparent. These words and materials were demonstrated and described by the teacher. Students were asked to find materials from around the room that fit into each category and explain why. This too is then put on movie. Lights out...torches, a light table, lamps, etc were
used for students to place against the materials. No word wall was used. Students caught onto the idea put would forget the words.

Students later created a puppet show to demonstrate some knowledge of light and materials. While IT is used abundantly, there is a tendency for students to recreate what the teacher has demonstrated. The true inquiry process is not followed. Students mostly explore and explain.

All movies are kept and later combined as one to demonstrate the unit learnings. At the end, students are given the opportunity to go back and relook at the first drawing and movie of how we see. If they think it is no longer correct, they may make a new movie to correct their thinking and place at the end explaining why they made the change. There is a consideration of prior knowledge and misconceptions.

She often models her lessons but generally does not follow an investigative approach to teaching. She does encourage inquiry.

A is a first year teacher and was too nervous to have someone come in to
Observation 1

C has already implemented an activity that students demonstrated prior knowledge through. It contained images of a child on a skate board and space to write what they new about forces.
C has a broad range of student responses.
He is the science teacher for the other two yr 7 classes.

The unit is about forces. The school uses Primary Connections but he is not using it for this unit. He checks with Acara to see the main concepts to be studied.
I observed a 45 minute lesson. He began with a concept map around forces as a class activity. He guided the student Reponses so they included what he wanted to be included on the white board. This is to e the starting point of turning it into questions for the unit. (15 min)

He gave the students opportunity to explore through building with leggos. He had kits for creating fans, vehicles, cranes, merry -go-rounds… C went around helping children with construction and thinking about how the parts worked.

26 students: 13 girls and 13 boys.
Observation 2  Wednesday 30 May

C planned for students to have their final task as a helicopter drop. This task is the elaborate and evaluate combined. Students have spent the last few weeks learning about forces through a variety of activities.

Today C reviewed with them fair testing and led them in a discussion about variables, and cows moo softly. He told them they would do a fair test on paper helicopters like they made for a lower grade but without the art work. Work in groups of 2-3. He gave them helicopter templates and allowed them to choose their test. Blade length or mass. They planned their fair test with his guidance. They created a data chart for three drops with his guidance. No prediction made. They used stop watches to measure drop time.

After sheets were ready to record data they went to the playground to mount equipment and drop helicopters. The day was rather windy and interfered greatly with the drops that it was stopped until the next science next time.

3 June

The class had better luck with the wind and were able to continue their fair tests. The wind did have some affect on the drops. The times were a bit scattered. Overall, they could see that shorter blades and more staples (mass) caused a quicker drop.

There were some variations in drop or release, stop watch use and wind as they will discuss in the next class. The main idea is to understand and use fair testing as best they can.
12.7 Appendix G  Selected Interview Excerpts

12.7.1  School planning

The background to that is after eight years of giving teachers two planning days, a term or a semester, has their teaching improved or changed or are they just better planned.

I tend to think that they might be better with their planning so they might have this nice document, but may not have actually improved or changed their pedagogy at all. They're still teaching exactly the same way that they used to. I don't know that I want to give two days for a nice frilly document.

If I went to C in regards to things on science, I'm not too sure for example, she would have the answers to those questions in regards to some of those questions you're asking in regards the science. She would probably need - I'd say she'd probably direct me to - steer me towards another individual in regards to it, who was more science-minded or science - and those particular questions. She'd only probably have what's in front of her in regards to the C2C. But if I was after some specific idea on a particular topic, then I'd have to probably go further afield.

Well when I first arrived I got a folder that previously the staff had done up outlining each subject and what they wanted content wise for the year. Then of course you've got C2C which is the expectation that is followed to an extent, but planning wise it seems to be up to the discretion of the individual teacher so I'd like to be able to talk, especially if I had a composite, to go to my composite other half and say can we streamline this a little bit better, a little bit so it's clearer for us and for the children. Once that's in place then it can just be recycled and small bits chopped and
changed. It's not such a big deal every year you go to do it.

It's just as factor of the size of the school, the number of staff that have to come to some sort of consensus and agreement, and getting opportunities to do that. It’s hard enough now just to get three teachers across three classrooms, to agree on the direction. I feel fortunate to always have been since being here, worked in a team that’s always worked like that. But I know it’s not necessarily true across the entire school. There’s lots of teams and personalities are personalities.

Okay, it starts with some professional development at the beginning of the year, we'll set out targets or what our learning area focus is going to be for the year. But as well as that there’s planning time given to the teams of three teachers, every four weeks, instead of staff meeting to meet. Planning time is given to us in the form of one release day every term, to meet and plan for the entire next term.

That's unusual, I mean we do sacrifice three hours of our non contact time, but that only comes about because it’s blocked. So having those three hours blocked together each week, which is why I could meet with you now. Allows us to normally just every week, talk about how things are going, where we’re going next and meet as a team. Because if it wasn’t blocked together, each of us would be released in a separate hour, do our own thing and never talk to each other about what’s going on. Unless we said let’s all stay after school and meet and talk
about this issue. You only do that when there’s an issue or a problem.

No, actually so we do get the whole day, it's great. So you do actually get time to plan the whole lot, all the subjects you get. It might be the same as last year but you've changed a few things. Yeah, everyone's involved with all the subjects which is good because that's where you're getting everyone’s ideas rather than, this is my idea let's do this. So it works really well.

the librarian will sit in with it as well so that we've got ideas for resources that are available. Part of my role is technology. So I'll try to get to everyone as well and talk to them about what they can use technology wise. It is good having extra people sitting in librarian support or whoever will sit in as well and just say, look this is what could be done for special needs and that.

So I think and I think it works well, the more people involved with that planning it seems to be the best way. Yeah.

Pretty much since its inception, so the last at least five or six years. Because of the new science curriculum coming out, we're in the process of replacing units with ones that are supportive of the Australian curriculum.

They did that on purpose. So, given that, we had a missing link there in some ways. I can't be everywhere at all times and in all places, so Primary Connections are their way to make sure the pedagogy came first, otherwise I think you're in
danger of just delivering something, a whole big packet of ideas, and you can be very much back where you were. The science is telling.

That involved certain staff for science, certain staff for mathematics, certain staff for English, et cetera. So people were able to put their hand up as to their area of interest and we changed to then alignment with Essential Learnings. So as a result of that then I tied all the loose ends together and wrote a curriculum document based on what they'd given me, based on what Essential's expectations were at the time. That then ended up being the science – Our science curriculum document with reference to QSA et cetera. Then every teacher got their science curriculum, turned to grade four or whatever they were doing and they could see what they were to plan and teach in that year, in that semester or in that term, whatever.

So that was one transition and then really the transition from that to ACARA has probably been similar in some regard in the sense that we were looking at what are we currently doing, what do we need to be doing in terms of what ACARA are saying, but rather than have a key reference group or a curriculum reference group for science we did a collective - I did a collective planning - series of activities, I guess, that were guided questions again that enabled teachers to look at here's ACARA, here's what we've got, highlight for me where things are missing, the gaps, et cetera, so that I can go and tie the loose ends together as well.
We've had a few PD sessions last year but that was just what he called auditing. Basically looking at our programs that we had last year and looking at what was to come and looking at the difference. You had to fill out this form. I'm sure they just got chucked in the bin. It was a waste of time. Everybody knew it was a waste of time and it proved nothing.

It would have been far more sensible just to sit down with the new curriculum. Right, let's go ahead and let's plan it and if there's stuff there that we can use from previous years great, let's put it in. But yeah, the PD that we did have on the new curriculum was next to useless and just a waste of time basically. So it's more or less been up to us, just as individual professionals to get it together.
12.7.2 Implementation

I think implementation, to me, is about what actually happens after you implement it, you know what I mean? It's easy to implement something, it's more difficult or it's more challenging to measure then the success of the implementation. I think that's such a long-term process and you've got - we were sitting around this morning talking about geography, a whole new ballgame, and wondering how much teachers will be spun out by a whole new set of demands.

I think the difficulty here, to me it's probably three-pronged. Number one is the teacher level of knowledge. Number two is the teacher use of language and all of the problems that come from that. Number three - and I think probably this is where we're doing alright - is the focus not just on knowledge but on skill, on observing in the lower primary, on enquiry, on investigations, on that kind of thing. They're the three.

I think that there needed to be more time in trial for this and the other Australian curriculums rather than by this date we start. I say that with no great honorary degree or anything behind me other than on-the-ground experience going through these phases time and again. I think that - this isn't little, old me in a tiny little world in a bubble here.

I think a more sensible way to have gone about implementation of all of Australian curriculum would have

345
been to have started with a prep year in one year rather than all years, maybe one subject and roll it out little by little and give teachers post-trial opportunities to then slowly begin implementation because I think one of the things I'm hearing at - not in my school but lots of other schools and from colleagues around is that teachers are feeling really overburdened by this.

We're kind of trying - we kind of feel like we're grappling at straws to hand on and to ensure that there's some level of understanding and movement towards alignment. I do think that, yes, I beg your pardon, the processes are too swift and that, you know - I mean, we feel - as an administrator, I feel pressure because we've got NAPLAN dangling over our head. Every five seconds we turn around and there's a [NAPSAL] science and literacy testing process coming up. We've got that hanging over our head.

So we feel pressure because our parents feel pressure. Our parents are numbers-driven. Our parents are what NAPLAN says or my school says must be read as gospel. As an educator, we know that's not the full picture. Nonetheless, in an independent school's market, that is very competitive. We have to look at all of these things on balance. If I'm making sort of reasonable sense, there are broader pictures.

I think they're still finding their way. I think the C2C they might like because it is a definite plan. They might like it because there are resources there. It might also still be very overwhelming.
and I think they need to - we've taken a real softly, softly approach with it to let them find their feet.

I suppose the next step is to going back to the National Curriculum putting it on the table and then drawing out from that how are we going to resource that, what do we need as a school instead of leaving it up to the individuals to reinvent each year.

So there was no real nice way to do it.

We're not finished we're not there yet. We haven't done enough and I think the curriculum team had to - were able to step back because once that was essentially in place, curriculum, the bigger question is the pedagogy. So that's not a curriculum team's job, that's a teacher's job and the teaching team's job. I was very confident that as a curriculum team we got the big picture in place, which was missing. It was all a bit over the - we brought that altogether. We made one umbrella. We were really clear about those sorts of - and we talked to the staff about it and that 2010 essentially.

It depends on what I know and how comfortable I feel and my children. I do tend to be the deciding factor in the success of a unit plan. I'm not going to put stuff on the C2C being the answer or not the answer, it's how I use it. I think the issue with the C2C was that right at the start it was that blanket statement, you need to do it unless you're [unclear] curriculum. Well that just put everyone on the wrong foot.
from the beginning and then it was an excellent way to make naughty teachers do what you wanted them to do, but that doesn't actually change anything anyway because if they're really a naughty teacher you're doing your own thing.

You're just saying you're doing it. So what's the point. You've just created another hassle in your whole school and you...

So we try and access as much as possible and pick the best from everywhere. But it's a small school and when you're a small school, it's really hard to get extra time to let staff do it. So we talk as much as possible but it's difficult. It's difficult.

You just looked at it and went, huge, huge and you sort of thought -you didn't realise the depth of it because it's been worked upon and worked upon and so it's getting bigger and bigger and bigger and I think they're trying to improve it but I think there's a long way to go.

That there was a curriculum coming out and that we all had to follow it. I think there was a breakdown of some of the people thought that you had to follow everything and you had to do everything and I think people stressed about it. I looked at it, I did the best I could but I knew that there was no way in the world I'd be able to teach all of that. I thought I'd do what I can and I took what I thought would work on board and what I just thought no. I just
12.7.3 Concerns

Yeah, it's quite threatening to say do this in a way that's going to be pedagogically sound and get results and the kids science concepts developed. But also in a way that's - it's just got to be easy, science isn't easy for teachers. I'm sure you've heard this from people?

So the foundations are poor and we just perpetuate the same problem by taking our scientists away to university and then off into science jobs. Primary school teacher is not seen as a science job by any stretch of the imagination.

Often the answer isn't [unclear] the internet, it's like I'm going to Google this and I'm going to find out stuff. But it's hard to find science concept explained in a way that is suitable for teachers and 11 year olds. How do you Google the question, how do I explain to 11 year olds about such and such.

For our teachers here and I think the teachers at my last - and for me as a teacher, I think what we don't have enough of is the knowledge of science. As primary school teachers we're trained, we can teach anything, really we can. For some subjects we need to go home, teach ourselves before and then we can come in and we'll teach it and we'll do a damn good job. But, science is such - and I think too there's a bit of a stigma around science being a specialist subject.
Some of that specialised knowledge is really kept till high school because that's more when it needs to be done but it's come down and especially when you're in [unclear prep] you know it's - they're giving a physics piece of knowledge that they need to get across. Yes, floating, sinking, but still you know you're doing physics in prep. When that was first even floated as an idea we all freaked out, what's it even mean, I don't know how to teach physics.

Of course we do, when we think about it in terms of what it actually means but in - what do we need: I think teachers need more scientific knowledge and then we can make that work for our students. I think that's what primary teachers do best. We know our kids because we have them all the time. We know them, we know how we can - we know their styles and their needs but if we don't get the content sometimes we struggle in making sure. So we might just do a surface job through no fault of our own.

We feel like that's probably what that meant when in actual fact it was much deeper and it really connects long-term to this knowledge that comes up in grade 7, I think sometimes we miss that. That's what we need.

That would be great. I mean I'd love to have it so that - I often find in classrooms, having teams of say three or four kids. I'd actually prefer them to work on different, that's doing - every one of those is doing something completely different; mainly because if that's a science experiment, then getting that equipment for that one group is easily enough done. But getting it for a whole class of kids, paper
helicopters, I'd choose that because we could make it every week we can have the equipment.

But if we're going to do something that involves going and buying a bit more complicated resource. Access to a microscope or even one that's hooked to the computer or whatever. Not every kid can work on it at the same time, and having four separate lessons operate here here here and here. Every week rotate round, and then draw all that together at the end. I found is the only way I can get science done in classrooms, where it's based on hands on stuff. Because yeah I don't know whether you've seen the classroom. There's stacks of glasses stacked…

That's from last term, just going down to Crazy Clarks and buying 32 glass cups, so I could put mix sets of beads and sands and iron filings and whatever. To make it simple enough that I've got the equipment, but not so complicated that I don't allow kids to participate because the equipments not there. I'm not provided with 32 sets of things to do that with. So one of the biggest supports that a teacher can have, is what are the experiments that you can do as a class. Where every child can participate hands on, without it being a problem to resource.
More than what’s been doing, nothing really. It’s a good balance of here’s where you should go, now it’s up to you to follow it up. The difficult part as I alluded to before, is actually finding the physical resources. I don’t think it’s a curriculum coordinators role to go and find those resources necessarily. But yeah, a list of places to go, websites like you suggested that was helpful. But does the website that has the [ACARA] sign [unclear] on it, I think it should have links like that. But it will be do they keep them up to date.

The best option would be, to make it so easy and appealing for teachers to want to teach science, that’s the way in. Because in English, whole heaps of resources and effort is put into making that run well in schools. Lots of support is given in the form of - for primary schools - some text books are very helpful at times when you need guidance and structure, there it is. There’s nothing that says here’s science and it’s easy and fun for you to teach. Here’s science and we’re going to make it hard for you.

Finally after, I don’t know how long the last curriculum was around, after 15 years of getting to know the last curriculum, here’s a new one. There’s another reason to shun it, put it on the back burner, and it’s only because of people like our curriculum coordinator. Putting it in our faces, that science even gets a look in.
there was opportunity for them to, as I said before, get their head around what are the inclusions of that. I guess we've really kind of taken the approach that, with PrimaryConnections, it's a fairly reasonable support tool. Beyond that, we don't have anything at the present moment. We've not done any PD on that. I know that that's certainly an area that we need to look at. It's something that on balance, we have to look at priorities from an administration point of view…

Look, the true answer is we don't have any overtly apparent PD on it. We have had PD in the past, albeit it was when Judy was here. It was as we were transitioning to essentials. A lot of the concepts and things that she did can still apply now. Whilst we haven't got a currency of science PD with implementation now, we have had some in the past. So, as I say, it's kind of, you know, looking at all things on balance.

That's pretty much it. So just some professional development of what it actually looks like and what it is. It would be helpful. For each year level, just to sit down...

I'm not trusting a guru to tell me that - what's on the C2C and thinks is the perfect way of teaching that particular, specific concept of science. But, let's hope - that could be - only a higher body would do it, whether that's right or wrong.
Well, I mean I've done my own looking in my own time but it's not like we've had any real professional development about it or anything so..

We rely on the regional office for their PD.

We also had the Science Spark initiative which has only just finished.

It depends in regards to what's a push in that particular year, in regards to the Department of Education. The big push last year was science. Now their science advisors are back in the classroom.

Next year we're following the Marzano framework.
We are attempting to streamline a little bit more the co-ordination between junior and secondary but again it's a time issue. Particularly this year, I guess we just felt very overloaded with the massive changes all throughout. Just to find time to liaise with the secondary staff has been a challenge but the current head of science is very keen to help out wherever she can. It's just the challenge of co-ordinating our timetables.

We actually did a session over there early in the year, just on the whole occupational health and safety regarding using the science labs. So that was useful and so they're actually keen for us to make use of the facilities.

We've had a few PD sessions last year but that was just what he called auditing. Basically looking at our programs that we had last year and looking at what was to come and looking at the difference. You had to fill out this form. I'm sure they just got chucked in the bin. It was a waste of time. Everybody knew it was a waste of time and it proved nothing.

It would have been far more sensible just to sit down with the new curriculum. Right, let's go ahead and let's plan it and if there's stuff there that we can use from previous years great, let's put it in. But yeah, the PD that we did have on the new curriculum was next to useless and just a waste of time basically. So it's more or less been up to us, just as individual professionals to get it together.
The background to that is after eight years of giving teachers two planning days, a term or a semester, has their teaching improved or changed or are they just better planned.

I tend to think that they might be better with their planning so they might have this nice document, but may not have actually improved or changed their pedagogy at all. They’re still teaching exactly the same way that they used to. I don’t know that I want to give two days for a nice frilly document

If I went to HoC in regards to things on science, I’m not too sure for example, she would have the answers to those questions in regards to some of those questions you’re asking in regards the science. She would probably need - I’d say she’d probably direct me to - steer me towards another individual in regards to it, who was more science-minded or science - and those particular questions. She’d only probably have what’s in front of her in regards to the C2C. But if I was after some specific idea on a particular topic, then I’d have to probably go further afield.

We will just - for our set up, it’ll have to be continued for the next lesson. So it’s not ignored and cut short and say oh we don’t have time to do that, it’s like this lesson will carry over into next time. I don’t - in the traditional primary school I would have gone let’s just do a little half hour lesson of English and do a little bit more science. Whereas in our setup I go, we’ll just move it to the next lesson, it doesn’t get dropped if that’s some - that was one of the options wasn’t it. You could just say no I’m not doing it.
Interviewee: That will mean there is a price to pay at the end of the unit, I might not finish the unit. So in the small scale, from lesson to lesson, yes I’ll push into the next one. But [unclear] gets a bit shorter. Although I will still go across into a new term with the same unit if I need to. But I only have them for a year, so there’s got to be a cut off point

I guess the only thing I noticed was that what used to be integrated is now separate. I find that hard because we’re time poor. But also if you can make links between subjects it often helps the kids also to feel that they’re learning because they’re using that knowledge across subjects rather than doing science, and I’m doing maths and I’m doing - so I guess that’s the only thing. I think previously things used to be a lot more integrated and now...

Just get going, unless it’s backing onto a lunch break or end of the day. We just get going, because it’s something that especially if you’re halfway through, it’s something that you can’t really stop and then come back to later. Things like the technology lessons that we’re doing it at the moment with the science concepts and we’ve only got that 45 minutes, then we’ll come back and revisit it the week after because yeah, it usually backs onto afternoon tea, but always making sure that we’re coming back to it. We always need more time.

and it’s the time factor. Because some of those hands-on things in an hour and a half you’ve barely got enough time. I work through the processes of what we’re doing, how we’re going to do it, the safety issues, and all that sort of stuff.

Oh gosh I don’t know. It depends, if you’re talking writing units as well, that’s hours. But on a weekly basis there’s got to be a good couple of hours of preparation time. Even just getting materials - it’s
hard to tell, when you wander over and you pick this up and you get that and you ring somebody and talk to somebody and you go on looking for stuff on - I don't know. I honestly...

It was really only my brighter kids because of the time factor. That was the main thing was the time factor.

I'd like to have more planning time to really nut it out, how that looks in the classroom, to really understand the whole thing because you read the description and you go yeah that's all cool but what does it look like in the classroom, [so it is] important.

I mean because we've just purely gone off primary connections really this year, so I do like the five E's model but we don't get a lot of time really. The day is jam-packed and the week is so jam-packed that you don't get enough time to do everything well as well as you'd like to. So you do constantly feel like you're trying to just catch your breath and you feel like you're moving onto the next thing. All the lessons don't flow as well as I would like them because I feel like I have to do - if it's [seasons] then I have to fit [chains]. All this kind of stuff, you have to fit it all in but you don't get enough time to do it all well, so that's how I feel at the moment.

It's just those little things that are daily frustrations that are time wasters

The thing that would be a bonus would be the time to access the resources; to maybe go and - like S yesterday - to go and have an extra 15, 30 minutes to go and see what else she could find that was related to that. But in saying that, we could do that with every other KLA couldn't we.

Probably again time. Time so that they're aware of it all, aware of what they need to know. Time also so that they're not only - like
Sonia the year 4 teacher she also needs to know what they've done in year 3 or two and three and what they're going to do in five and six. That's probably to me the biggest understanding that we all need now.

You don't get it. It's got to be in your own time.

We do four duties a week. I have leadership meetings. You have meetings with other things and then you get...

You get non-contact that's not there or it's been moved or shifted or – then things crashed online or...

Getting time to get everything together.
Examples of teaching science

Examples of inquiry teaching

State School SURVEY:
Science should be based on process
Pre 50%  Post 50%
Lessons should be based on observation and experiment  Pre 40%  Post 58%

INTERVIEW  Yr 5  State School
Science Spark teaching demonstration: They had to make their own windmill to turn, so spin a block of like playdoh stuff - plasticine - and we kept making the plasticine bigger to see if it would keep moving and we used the fan to blow. It was just an experiment to see if they could create one. I can't even remember what lesson it was related to but gee it was fun and it was amazing what they came up with and they're still on display up there. We made filters too, using gravel and we experimented with those. This year we made the moon crater but that - it didn't - that was a C2C experiment and it wasn't really all that.

OBSERVATION FIELD NOTES from co-planned lesson.
State School  Yr 4  tug of war.
#1 Two ropes, 4 teams divided by child choice. They played one time normally.
#2 Losers were given plastic gloves: Will this help? many thought so. The same team lost again. #5 Gloves were given to the winners and liquid soap applied to their hands. Will this help? The usual winners finally lost. Discussion: friction needed to pull.
Examples of teaching science

Teaching science through literacy

Inadequate understanding of science concepts

OBSERVATION Yr 6/7 State School

Mr B set up several small containers with steel wool, various liquids and a thermometer. Students previously attempted to measure and record the change in temperature from the heat created with the chemical change. He didn’t realize the amount of heat would be too small to measure. (The metals combined with exposure to the liquids and air were not the focus of the investigation.) Bob read the oxidation sheet aloud and stopped occasionally to give examples and elaborate. 1.35 Students were given a window pane activity to choose the main vocabulary then summarise the information in their own words. This is to be without looking at the sheet read from and also typed.

State School SURVEY:
Science should be based on content
Pre 100% Post 58%
Lessons should be based on observation and experiment Pre 40% Post 58%

INTERVIEW Yr 5 State School

When we looked at the three states of matter and it was- how do you tell if there’s air, how do you know if there’s air in the - “when air is moving”. It’s the deeper thought process. There were only a few in the classroom that could say it was because of a flag flying or a tree moving or things like that. It is one of the easier ones to do because we can just go outside and see so much of the effect of air: pressing properties of air... takes up space, has mass...
12.10 Appendix J Case Teacher Survey: Personal Ratings

Case Study Teachers' individual responses to Survey Questions.

Section B: Preparation for Implementation

These Tables demonstrate the case teachers were typical teachers compared with the entire school. The numbers represent the personal response for Likert rating chosen out of 5 for both Pre and Post.

<table>
<thead>
<tr>
<th>Section B</th>
<th>Mrs L (Yr 5)</th>
<th>Mr B (Yr 6/7)</th>
<th>Mrs S (Yr 4)</th>
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<tbody>
<tr>
<td>Preparation for Implementation State School</td>
<td>PRE/POST Ratings on a five-point scale</td>
<td>PRE/POST Ratings on a five-point scale</td>
<td>PRE/POST Ratings on a five-point scale</td>
</tr>
<tr>
<td>Looking Forward to new curriculum</td>
<td>3/3</td>
<td>4/4</td>
<td>3/3</td>
</tr>
<tr>
<td>Extent of School planning and preparation</td>
<td>4/3</td>
<td>4/3</td>
<td>2/2</td>
</tr>
<tr>
<td>Extent of Personal planning</td>
<td>4/3</td>
<td>4/3</td>
<td>3/3</td>
</tr>
<tr>
<td>Felt prepared to teach Science</td>
<td>3/3</td>
<td>4/3</td>
<td>4/4</td>
</tr>
<tr>
<td>Have the science resources to teach</td>
<td>3/3</td>
<td>4/3</td>
<td>3/2</td>
</tr>
<tr>
<td>Workshop PD in school beneficial</td>
<td>4/3</td>
<td>3/3</td>
<td>3/2</td>
</tr>
<tr>
<td>Ed system PD beneficial to help science teaching</td>
<td>3/3</td>
<td>3/3</td>
<td>2/2</td>
</tr>
<tr>
<td>School PD beneficial to help science teaching</td>
<td>3/3</td>
<td>4/3</td>
<td>2/2</td>
</tr>
<tr>
<td>PD sufficient to feel confident to implement science</td>
<td>3/3</td>
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</tbody>
</table>
### Section B

#### Preparation for Implementation

<table>
<thead>
<tr>
<th>Mrs N (Yr 1)</th>
<th>Mr D (Yr 4)</th>
<th>Mrs Y (Yr 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRE/POST</td>
<td>PRE/POST</td>
<td>PRE/POST</td>
</tr>
<tr>
<td><strong>Independent School</strong></td>
<td></td>
<td></td>
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<tr>
<td>Looking Forward to new curriculum</td>
<td>3/2</td>
<td>4/3</td>
</tr>
<tr>
<td>Extent of School planning and preparation</td>
<td>3/3</td>
<td>3/1</td>
</tr>
<tr>
<td>Extent of Personal planning</td>
<td>3/3</td>
<td>4/4</td>
</tr>
<tr>
<td>Felt prepared to teach Science</td>
<td>3/3</td>
<td>3/4</td>
</tr>
<tr>
<td>Have the science resources to teach</td>
<td>3/2</td>
<td>3/3</td>
</tr>
<tr>
<td>Workshop PD in school beneficial</td>
<td>--</td>
<td>1/1</td>
</tr>
<tr>
<td>Ed system PD beneficial to help science teaching</td>
<td>1/2</td>
<td>1/1</td>
</tr>
<tr>
<td>School PD beneficial to help science teaching</td>
<td>1/2</td>
<td>1/1</td>
</tr>
<tr>
<td>PD sufficient to feel confident to implement science</td>
<td>1/2</td>
<td>1/1</td>
</tr>
</tbody>
</table>

#### Catholic School

<table>
<thead>
<tr>
<th>Mrs M (Yr 5)</th>
<th>Mr C (Yr 6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRE/POST</td>
<td>PRE/POST</td>
</tr>
<tr>
<td><strong>Catholic School</strong></td>
<td></td>
</tr>
<tr>
<td>Looking Forward to new curriculum</td>
<td>3/4</td>
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<tr>
<td>Extent of School planning and preparation</td>
<td>4/4</td>
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<tr>
<td>Extent of Personal planning</td>
<td>3/4</td>
</tr>
<tr>
<td>Felt prepared to teach Science</td>
<td>3/4</td>
</tr>
<tr>
<td>Have the science resources to teach</td>
<td>4/5</td>
</tr>
</tbody>
</table>
Section C: Experience with Science

These Tables demonstrate the case teachers were typical teachers compared with the entire school. The numbers represent the personal response rating chosen out of 7 (semantic differential) for both Pre and Post.

<table>
<thead>
<tr>
<th>Section C</th>
<th>Personal experiences in Science – State School</th>
<th>Min L (Yr 3)</th>
<th>Mr B (Yr 6/7)</th>
<th>Mr S (Yr 8)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PRE/POST</strong></td>
<td><strong>PRE/POST</strong></td>
<td><strong>PRE/POST</strong></td>
<td><strong>PRE/POST</strong></td>
<td><strong>PRE/POST</strong></td>
</tr>
<tr>
<td>Try to teach more often</td>
<td>3/4</td>
<td>2/3</td>
<td>3/3</td>
<td>2/3</td>
</tr>
<tr>
<td>Science is Worthwhile</td>
<td>4/5</td>
<td>5/6</td>
<td>5/6</td>
<td>6/6</td>
</tr>
<tr>
<td>Science makes me Happy</td>
<td>4/5</td>
<td>6/6</td>
<td>6/6</td>
<td>7/7</td>
</tr>
<tr>
<td>I feel Confident</td>
<td>4/5</td>
<td>6/6</td>
<td>6/6</td>
<td>6/6</td>
</tr>
<tr>
<td>Science is Enjoyable</td>
<td>5/5</td>
<td>6/6</td>
<td>7/7</td>
<td>6/6</td>
</tr>
<tr>
<td>Science is Rewarding</td>
<td>6/6</td>
<td>6/6</td>
<td>6/6</td>
<td>6/6</td>
</tr>
<tr>
<td>Science is Important</td>
<td>6/6</td>
<td>6/6</td>
<td>6/6</td>
<td>6/6</td>
</tr>
</tbody>
</table>
### Section C

**Personal experiences in Science – Independent School**

<table>
<thead>
<tr>
<th></th>
<th>Mrs N (Yr 1) PRE/POST Ratings on a seven-point scale</th>
<th>Mr D (Yr 4) PRE/POST Ratings on a seven-point scale</th>
<th>Mrs T (Yr 6) PRE/POST Ratings on a seven-point scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Try to teach more often</td>
<td>4/5</td>
<td>6/6</td>
<td>7/9</td>
</tr>
<tr>
<td>Science is Worthwhile</td>
<td>6/6</td>
<td>5/6</td>
<td>7/7</td>
</tr>
<tr>
<td>Science makes me Happy</td>
<td>5/6</td>
<td>6/6</td>
<td>5/5</td>
</tr>
<tr>
<td>I feel Confident</td>
<td>5/4</td>
<td>6/6</td>
<td>5/4</td>
</tr>
<tr>
<td>Science is Enjoyable</td>
<td>6/5</td>
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<td>6/5</td>
</tr>
<tr>
<td>Science is Rewarding</td>
<td>5/6</td>
<td>4/3</td>
<td>6/5</td>
</tr>
<tr>
<td>Science is Important</td>
<td>5/5</td>
<td>6/6</td>
<td>7/6</td>
</tr>
</tbody>
</table>

### Section C

**Personal experiences in Science – Catholic School**

<table>
<thead>
<tr>
<th></th>
<th>Mrs M (Yr 5) PRE/POST Ratings on a seven-point scale</th>
<th>Mr C (Yr 6) PRE/POST Ratings on a seven-point scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Try to teach more often</td>
<td>5/5</td>
<td>4/7</td>
</tr>
<tr>
<td>Science is Worthwhile</td>
<td>6/5</td>
<td>5/7</td>
</tr>
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<td>Science makes me Happy</td>
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<td>4/5</td>
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<tr>
<td>I feel Confident</td>
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<tr>
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</tr>
<tr>
<td>Science is Important</td>
<td>6/7</td>
<td>5/7</td>
</tr>
</tbody>
</table>
Section D: Beliefs about Science Teaching

These tables demonstrate the case teachers were typical teachers compared with the entire school. The numbers represent the personal response for the Likert rating chosen out of 5 for both Pre and Post.

<table>
<thead>
<tr>
<th>Section D Beliefs about Science Teaching – State School</th>
<th>Mrs L (Yr: 5) PRE/POST Ratings on a five-point scale</th>
<th>Mr B (Yr: 6/7) PRE/POST Ratings on a five-point scale</th>
<th>Mrs S (Yr: 4) PRE/POST Ratings on a five-point scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science should be based on process not content.</td>
<td>3/4</td>
<td>4/4</td>
<td>5/5</td>
</tr>
<tr>
<td>teaching Science through Science topics rather than concepts.</td>
<td>3/3</td>
<td>4/4</td>
<td>3/3</td>
</tr>
<tr>
<td>emphasize the content matter of the lesson.</td>
<td>4/3</td>
<td>4/4</td>
<td>4/4</td>
</tr>
<tr>
<td>Lessons based on student observation and experiment.</td>
<td>4/1</td>
<td>3/4</td>
<td>4/4</td>
</tr>
<tr>
<td>should have demonstrations by the teacher in the class.</td>
<td>3/-</td>
<td>4/4</td>
<td>4/4</td>
</tr>
<tr>
<td>Different activities carried out by different groups in class.</td>
<td>3/5</td>
<td>4/4</td>
<td>3/2</td>
</tr>
<tr>
<td>open discussions among students to communicate their work.</td>
<td>4/4</td>
<td>5/4</td>
<td>4/4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section D Beliefs about Science Teaching – Independent School</th>
<th>Mrs N (Yr: 1) PRE/POST Ratings on a five-point scale</th>
<th>Mr D (Yr: 4) PRE/POST Ratings on a five-point scale</th>
<th>Mrs T (Yr: 6) PRE/POST Ratings on a five-point scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science should be based on process not content.</td>
<td>4/5</td>
<td>4/5</td>
<td>2/3</td>
</tr>
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<td>teaching Science through Science topics rather than concepts.</td>
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<td>1/1</td>
<td>1/2</td>
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<td>5/5</td>
<td>4/4</td>
</tr>
<tr>
<td>Section D Beliefs about Science Teaching – Catholic School</td>
<td>Ms M (Yr 5) PRE/POST Ratings on a five-point scale</td>
<td>Mr C (Yr 6) PRE/POST Ratings on a five-point scale</td>
<td></td>
</tr>
<tr>
<td>----------------------------------------------------------</td>
<td>--------------------------------------------------</td>
<td>--------------------------------------------------</td>
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</tr>
<tr>
<td>Science should be based on <strong>process not content</strong>.</td>
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