MyScience : communities of practice around the teaching and learning of primary science

Georgina Anne Forbes

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Note to reader

Table 3.8 and Table 7.1 (below) are key reference documents for this thesis.

It is recommended that they are positioned alongside the thesis if read on an electronic device, or that the additional laminated page is used if reading a hard copy of the thesis.

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<table>
<thead>
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<th>ATTRIBUTE NUMBER (#)</th>
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<tr>
<td>1</td>
<td>Domain</td>
<td>Science is inquiry based (uses specific methods labeled ‘scientific’)</td>
</tr>
<tr>
<td></td>
<td>Acknowledged shared interest area in which members collectively learn from each other.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Community</td>
<td>Science is tentative</td>
</tr>
<tr>
<td></td>
<td>Members who are collaboratively engaged in activities and discussion related to the domain.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Practice</td>
<td>Science is developmental (builds on the findings of others)</td>
</tr>
<tr>
<td></td>
<td>What members ‘do’ when they interact</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Reification</td>
<td>Science is subjective</td>
</tr>
<tr>
<td></td>
<td>Products and processes that reflect the CoP’s domain.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Science is creative</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Science is collaborative</td>
</tr>
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MyScience: Communities of Practice around the Teaching and Learning of Primary Science

Georgina Anne Forbes
BSc (Hons), MScAgr, BEd

A thesis submitted in fulfillment of the requirements for the degree of Doctor of Philosophy in the School of Education, Southern Cross University

February 2014
THESIS DECLARATION

I certify that the work presented in this thesis is, to the best of my knowledge and belief, original, except as acknowledged in the text, and that the material has not been submitted, either in whole or in part, for a degree at this or any other university.

I acknowledge that I have read and understood the University's rules, requirements, procedures and policy relating to my higher degree research award and to my thesis. I certify that I have complied with the rules, requirements, procedures and policy of the University.

Anne Forbes

February 1st, 2014
ABSTRACT

*MyScience* is an initiative in primary science education where participation in a community of practice is integral to the learning process. The underlying purpose of this interpretive study was to determine fresh insights into improving science practice in primary school classrooms, where there are ongoing and substantial concerns around the effective—and frequently even the very act of—delivery of primary science education in schools.

The aim of the research was to explore and understand the ‘lived experiences’ (Van Manen, 1997) of participants’ involvement in *MyScience* with a view to interpreting the meanings that participants attached to their social and human involvement in the phenomenon of *MyScience*. Key stakeholders—mentors, primary teachers and primary students—were the participants, whose differing conceptions of the same experienced phenomenon (*MyScience*) were observed, elicited, collected, analysed, interpreted and described by using aspects of phenomenography, as developed by Marton (1981). Data included participants’ perceptions obtained from interview responses, field notes, as well as conversations and email exchanges between participants and the researcher. Participants from three metropolitan primary schools in Sydney, New South Wales, Australia included: eight primary teachers, twenty-seven primary students and twenty mentors with science expertise (six astronomers, five engineers, four secondary science teachers and five Year 9 secondary science students).

The main research question was:

*What are stakeholders’ perceptions of their involvement in MyScience and how does being in a ‘community of practice’ (CoP) around ‘investigating scientifically’ influence their views about science, science learning and science teaching?*

Participants’ views were analysed by using attributes associated with both ‘communities of practice’ (CoP) and the ‘nature of science’. Findings reveal new understandings about the evolving characteristics associated with the development of such school-community collaborations as well as affordances and barriers that may influence their further growth. Key findings from the study gave rise to thirteen assertions underpinned by eight key factors associated with the *MyScience* framework (‘framework factors’) and *MyScience* participation (‘participation factors’). Involvement in *MyScience* transformed many participants’ views of science, science learning and science teaching. Affirmation of stakeholder relationships was
found to be critical for the successful development of *MyScience* communities of science practice (CoPs), as were: accommodating the range of needs of traditional and transformational teachers, encouraging teachers to persist with the CoP learning approach, and turning tacit knowledge into explicit knowledge. *MyScience* was found to be an initiative that offers an effective way for school communities to embed authentic science practices within their curricula.
LIST OF PUBLICATIONS and CONFERENCE PRESENTATIONS

The following publications and conference papers are related to this thesis:

**Related to Chapters 1 & 2**


**Related to Chapter 4**


**Related to Chapter 5**


**Related to Chapter 6**


**Related to Chapter 7**

ACKNOWLEDGEMENTS

There are a number of people that I wish to acknowledge for their guidance and support during the preparation of this thesis.

I am especially indebted to my supervisor Adjunct Professor Keith Skamp, who has guided my learning journey with an extraordinary compilation of unfailing availability, patience, attention to detail, and depth of research knowledge in the field of primary science education.

My deep appreciation and thanks go to my husband Greg and my children –Bill, Alex, Miri and Owen– who have provided me with boundless belief, encouragement and support on my PhD journey.

I would also like to acknowledge the ongoing interest and support provided by Professor Marea Nicholson at the Australian Catholic University when, at times, it seemed that there would be no end in sight to the journey through ‘PhD land’.

Finally, this research would have been impossible without the willing participation of the teachers, students and mentors particularly Bonita Mendis and Professor Andrew Hopkins, whose involvement and interest in the MyScience initiative has been, and continues to be, invaluable.
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Chapter One

Introduction

This study explored the ‘lived experiences’ of participants’ involvement in the MyScience program—a primary science education initiative in which being in a community of practice is integral to the learning process. The underlying aim of this interpretive study was to determine fresh insights into improving science practice in primary school classrooms, where there are ongoing and substantial concerns around the effective—and frequently even the very act of—delivery of primary science education in schools.

This chapter introduces the study and addresses:

1.1 the origin of the research context and related aspects of the researcher’s biography.
1.2 the research context.
1.3 the purpose of the research.
1.4 the research questions.
1.5 the significance of the research.
1.6 the framework of the thesis.

1.1 The origin of the research context and related aspects of the researcher’s biography

Life experiences shape the way that we think about, interact with and view the world, and therefore also have significant potential to influence what we research and which methodologies we employ. It is therefore prescient for the reader to have an awareness of the researcher’s background to better understand how this particular project came about and to situate the role of the researcher within that context.

The researcher’s interest in education began in 1986 when her first child started school. At the time the family were living in the city of Rochester, located in upstate New York in the United States, close to the Canadian border (Niagara Falls). Cobblestone School was selected for its friendly, child-centred, flexible approach to learning which is described on the school’s website http://www.cobblestone.org/programs/academics/ as follows:
At Cobblestone, our student-responsive, interdisciplinary approach to learning through inquiry encourages critical thinking and fosters motivation, anchoring learning in a meaningful context.

This approach to learning was the antithesis of the traditional schooling experience of the researcher in Australia and England. By 1990, with her third child of school age, the school staff offered the researcher a teaching position, despite her having had no formal teacher training. Thus began a magical career where the researcher learned the art of teaching, through being immersed in the Cobblestone ‘way’ of doing things – first as a parent, and then as a teacher. Underpinning the researcher’s background were science related undergraduate (BSc in Biological Sciences) and postgraduate (MScAgr in Plant Pathology) degrees.

Upon returning to Australia in 1994 (with child number four), the researcher’s subsequent forays into primary teaching, and eventually into primary science education and research were significantly impacted by her experiences of ‘walking the walk’ of the ‘Cobblestone philosophy’ –where teachers step back, allow students to pursue learning in areas of personal interest, resulting in deep engagement, motivation and fulfillment for all.

**History of the development of MyScience**

*MyScience* was conceived out of an identified need. Early in 2006, the Science Foundation for Physics of the University of Sydney convened a meeting to initiate discussion around ways for the university to provide significant support for primary science education. A project team was established comprising representatives from the Foundation (Chris Stewart and later Adam Selinger), the NSW Department of Education and Training (NSWDET) (Anne Forbes and Gerry McCloughan), and IBM (Bettina Cutler). The Australian Catholic University (ACU) also became a foundational partner when Forbes joined that university’s staff. To date, the program has been funded by small donations and sizeable in-kind support from the four founding partners –ACU, IBM, Western Sydney Region of the NSW DET, and the Science Foundation for Physics.

A *MyScience* pilot began in 2006 with a program in two primary schools –one in the Western Sydney Region (WSR), and one in the Northern Sydney Region (NSR) of NSW DET. By 2010, *MyScience* had expanded to include nine primary schools in both the Catholic (Parramatta Catholic Education Office) and public education sectors, thirty
primary teachers, over 1000 primary students (Grades 1-6 across all ability levels) and 140 volunteer scientist mentors. Anne Forbes, NSW School of Education, ACU and Gerry McCloughan, WSR, NSW DET, designed and described (Forbes & McCloughan, 2010) the educational model that underpins the MyScience program. The period 2006 – 2008 saw the development and implementation of a ‘hub approach’, where feeder primary schools were encouraged to work with their local secondary school. This strategy enabled mentors with science expertise to be more easily sourced from the local area i.e., secondary school science teachers and secondary school science students, rather than transporting undergraduate and postgraduate science students to participating schools as had been the practice in the initial implementation of the program. The ‘hub approach’ also facilitated the development of primary-secondary school relationships, which was a desired outcome for both primary and secondary school staff, and to ease the transition of older primary students into their secondary schooling years.

In 2008, MyScience won the national B-HERT (Business and Higher Education Round Table) Award for Best Collaboration in Education and Training. In 2009, the Ian Potter Foundation generously provided a $50,000 grant to develop and trial an online professional development resource for primary teachers in order to facilitate the expansion of the program. This program –named the MyScience Professional Learning Toolkit– is openly available through the MyScience website www.myscience.com.au

The years 2009 and 2010 were a period of consolidation during which the project team explored opportunities and support for scaling up MyScience. In 2011 ACU decided to incorporate MyScience as part of the suite of Equity Pathways programs in their ACUGate (ACU Gain Access to Education) flagship that aims to raise awareness of the higher education learning environment through collaborative relationships between University representatives, teachers, parents and community members. Support provided by ACU Equity Pathways Officers in Sydney, Canberra, Brisbane and Melbourne as well as financial support to re-structure and renew the website has enabled MyScience to be expanded nationally into more primary-secondary school partnerships and to enlist the support of additional mentors. Table 1 presents participation data for schools and mentors from 2006-2013 in Sydney, NSW, Australia.
**Table 1**

*MyScience* participation numbers in Sydney, NSW, Australia from 2006-2013

<table>
<thead>
<tr>
<th></th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary schools</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary teachers</td>
<td>5</td>
<td>16</td>
<td>26</td>
<td>35</td>
<td>30</td>
<td>23</td>
<td>20</td>
<td>21</td>
</tr>
<tr>
<td>Primary students</td>
<td>150</td>
<td>500</td>
<td>780</td>
<td>1050</td>
<td>900</td>
<td>690</td>
<td>600</td>
<td>620</td>
</tr>
<tr>
<td>Scientist mentors*</td>
<td>15</td>
<td>40</td>
<td>100</td>
<td>120</td>
<td>100</td>
<td>100</td>
<td>90</td>
<td>91</td>
</tr>
<tr>
<td><strong>Secondary schools</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary science teacher mentors</td>
<td>-</td>
<td>3</td>
<td>7</td>
<td>3</td>
<td>7</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Secondary science student mentors</td>
<td>-</td>
<td>12 (Yr 10)</td>
<td>25 (Yr 9/10)</td>
<td>15 (Yr 9/10)</td>
<td>14 (Yr 9/11)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

* Scientist mentors comprised: university and industry research scientists and engineers, undergraduate and postgraduate science students, and parents and local school community members with science expertise.

The *MyScience* Educational Model is presented in Section 2.5 of the Literature Review (Chapter 2), and so is not detailed here.
1.2 The research context

In response to concerns about improving and widening school delivery of primary science education, a number of school-community linked initiatives that made use of mentors with science expertise have been initiated and researched in several countries including the United States (Wilson, Krakowsky & Herget, 2010), New Zealand (Bolstad & Bull, 2013) and Australia (Forbes & McCloughan, 2010; Howitt, Rennie, Heard & Yuncken, 2009; Rennie, 2012). Within Australia, another strategy for improving primary science education has been school-based reforms. One of these, the Science in Schools Research Project (later renamed the School Innovation in Science Project (SIS)) (Tytler, 2009) resulted in the development of SIS components that characterized effective primary science, one of which was to link the classroom with the broader community (Tytler, 2003). The success of SIS school-community projects were likely catalysts for independent calls by Tytler (2007) and Rennie (2007) to research the conditions under which effective community-linked projects became embedded in school science programs. These ‘calls’ were timely, occurring around the inception of MyScience (in 2006) (Forbes & McCloughan, 2010).

MyScience –was and still– is a school-based community-linked initiative, conceived out of an identified need to provide support for primary science education. As described in the previous Section 1.1, the researcher was involved in the design of the MyScience educational model and its implementation in a number of schools. Observations (by the researcher in the field) appeared to indicate that participants were interacting in communities of practice (CoP) while working scientifically. These factors, combined with Tytler’s (2007) and Rennie’s (2007) ‘calls’, sparked an interest in the researcher to design an in-depth study of participants’ views of their involvement in MyScience - with a view that the findings may lead to a ‘model’ of science learning related to engagement in CoPs.

1.3 The purpose of the research

As described earlier, the purpose of this study was to determine fresh insights into improving science practice in primary school classrooms. The study explored the “lived experiences” of participants’ involvement in the MyScience program, where interviews were used as the main “means for exploring and gathering experiential narrative material” for the researcher to develop a “deeper and richer understanding” of what it means to be ‘doing MyScience’ (Van Manen, 1997, p. 66). Data included participants’ perceptions, field notes, as well as conversations and email exchanges between participants and the
researcher. Participants from three Sydney metropolitan primary schools included: eight primary teachers, twenty-seven primary students, and twenty mentors with science expertise (six astronomers, five engineers, four secondary science teachers and five Year 9 secondary science students) – fifty-five participants in total.

Participants’ views were analysed, in part, by using attributes associated with both ‘communities of practice’ and the ‘nature of science’. The findings revealed new understandings about the evolving characteristics associated with the development of such school-community collaborations as well as affordances and barriers that may influence their further growth. Involvement in MyScience transformed many participants’ views of science, science learning and science teaching. The details of the findings and their pedagogical implications are presented in this thesis.

1.4 The research questions

The research questions were framed to delve into notions of the interplay between participation in CoPs associated with the nature of science (NOS) and how this influenced participants’ views. The research questions are also justified in Chapter 2, which provides a summary of relevant science education research literature.

The main research question was:

What are stakeholders’ perceptions of their involvement in MyScience and how does being in a ‘community of practice’ around ‘investigating scientifically’ influence their views about science, science learning and science teaching?

The contributing questions, analysed separately for mentors, teachers, and students respectively, were as follows:

What are mentors’ perceptions of their involvement in MyScience and how does being in a ‘community of practice’ around ‘investigating scientifically’ influence their views about science, science learning and science teaching?

What are teachers’ perceptions of their involvement in MyScience and how does being in a ‘community of practice’ around ‘investigating scientifically’ influence their views about science, science learning and science teaching?
What are students’ perceptions of their involvement in MyScience and how does being in a ‘community of practice’ around ‘investigating scientifically’ influence their views about science, science learning and science teaching?

1.5 Significance of the research

This study is important because it will add to knowledge about metropolitan school-based science education communities of practice and what makes them ‘tick’, and suggests ways to improve the teaching and learning of primary science education in schools. The researcher was unable to locate any research that used a conceptual framework about ‘communities of practice’ in a study about science education. Therefore, this will be the first time that such a study has been carried out.

This is the first study to utilise communities of practice with the nature of science within a school-based community-linked initiative. It provides perspectives from mentors, primary teachers and students to develop a framework for the effective teaching and learning of science. Such a framework has wide application for similar types of programs, such as the national Scientists in Schools program.

Results from the study may be used to inform science business organizations about the merits—or otherwise—of having their employees participate as scientist mentors in community-school linked programs such as MyScience. The results may raise the profile of science education in participating school communities through the participation of the students and teacher. As participants reflect on their participation in MyScience and in the study, it may encourage more students to pursue science study in the non-compulsory years of schooling. Furthermore, mentors pursuing science careers through their opportunity to experience science in educational settings may choose to pursue careers in science teaching.

MyScience provides participants across the educational spectrum—primary and secondary students, primary and secondary pre-service and in-service teachers, as well as undergraduate and postgraduate students in science and engineering— with opportunities for deep, authentic engagement with science education. Ultimately, all participants will gain increased awareness for the place of science and science education in today’s society.

In Chapter 7 a ‘model’ for how successful MyScience CoPs might flourish is presented, which may aid the implementation and development of similar initiatives in other settings.
1.6 Framework of the thesis

In this and other chapters, a few highlighting features such as **bold**, *italics*, underlining—or dashed underlining—, and margin notes, have been included in the text to draw the reader’s attention to points of significance or to assist with ‘holding a thought or idea’ across several paragraphs or pages. These notations are explained in more detail in the relevant sections of the thesis. American Psychological Association (APA) protocols have been followed as closely as possible (American Psychological Association, 2010) where references are included or cited. At other times, the researcher has modified some of the APA formatting and punctuation protocols to afford a degree of ‘artistic license’.¹

This chapter has situated the researcher within the context of the development of *MyScience*. The *MyScience* Educational Model has been outlined and the need for a research study of this kind has been stated. From this, the research questions were articulated followed by a discussion of the significance of the research.

Chapter 2 presents a wide-ranging review of the research literature in a number of fields related to the proposed study and includes: the current status and thinking about primary science education globally, nationally (Australia), and locally (New South Wales); reform approaches that have been implemented in schools in Australia, the United States and New Zealand particularly school-science community programs; communities of practice—what they are, how they support learning and where they have been used; the nature of science related to science education; and research related to: teachers’, students’ and scientists’ perceptions, and factors that influence their science learning and science practices. This chapter also provides a conceptual framework for the study.

¹ For example:

- The use of text in brackets ‘[ ]’ in quotations (from the research literature and from participants’ interview responses) identifies that it was added by the researcher—as recommended on page 94 of the American Psychological Association manual (2010).
- Direct quotations of 40 or more words are in 11pt font with 1.5 line spacing rather than 12pt and double line spacing.
- *MyScience* is not italicized within participants’ quotes.
- The use of ‘—’ within sentences denotes elements of similar significance which have been added to amplify the intent of the sentence They are preceded by and followed by a space e.g., ‘The research design—Chapter 3—outlines …’
Chapter One

The research design –Chapter 3– outlines the methodology and the methods underpinning the study and provides a detailed account of how the research questions were used to determine: the type of data to collect; the steps, procedures and methods to collect and analyse the data; and how the data were used to answer the research questions. Ethical considerations, efforts to enhance the quality of the findings, and the strengths and limitations of the study are also presented.

Chapters 4, 5 and 6 present the findings and discussion of participants’ perceptions of their involvement in MyScience (related to the research question) of the key stakeholder groups – mentors, primary teachers, and primary students respectively following the detailed analytical procedures presented in Chapter 3. Associated pedagogical implications are also included in each of these chapters.

Chapter 7 draws together the interpreted findings of the interviewed participants in the three preceding chapters, and discusses potential future implications for science education practices. A cautionary reminder of the limitations of a study of this nature is presented, with suggestions for future research, a final conclusion and reflection.
Chapter 2

Literature Review

2.1 Introduction and chapter structure

As discussed in Chapter 1, this research study addressed the development of communities of science practice in primary school classrooms focusing on stakeholders’ views of their involvement and its influence on their perceptions of science, learning science, and teaching science. To inform and underpin this study a review of the literature was carried out in the following areas:

- the current status and thinking about primary science education: globally, nationally (Australia), and locally (New South Wales; Section 2.2);
- reform approaches that have been trialled to rectify issues in primary science education (Section 2.3);
- communities of practice – what they are, how they support learning, contexts where they have been used (Section 2.4);
- the role of participants’ perceptions in influencing science learning, and science practices in teachers, scientists, students (Section 2.5);
- MyScience: the educational model (Section 2.6);
- how the literature review underpins the components of the research questions (Section 2.7).

The purpose of this review is to provide a context and justification for this particular research study in light of missing or incomplete information in the published research literature related to primary science education reforms in urban school-community initiatives.

2.2 The current status and thinking about primary science education: globally, nationally (Australia), and locally (New South Wales)

Two key reasons why science education is held in such high esteem by most governments in the developed world relate to economic concerns and priorities. Firstly, there is the traditional role of science education in motivating and preparing students to progress to further studies in careers related to science, technology, engineering, education, and mathematics – areas, which underpin research and development in a wide variety of fields.
And secondly, there is the belief that everyone else should be scientifically and technologically literate so that informed decisions and actions are made with a view to sustainable development in an increasingly populated world with finite resources (Fensham, 2008; Office of the Chief Scientist, 2012). Developing students’ skills in scientific literacy has become a key driver in the development of science curricula, resources, and activities to support the teaching of science in schools (Goodrum, Hackling & Rennie, 2001; Harlen, 2011; Skamp, 2012a; Tytler, 2007).

Historically, it is only in the past forty years that primary science education has become part of the mandatory primary curriculum in many countries, including Australia (Aubusson, 2011; Connor, 2007). This move has been underpinned by research findings indicating that young children develop scientific ideas (with or without explicit science teaching) and attitudes towards science well before they reach their secondary years of schooling (Harlen, 2008, 2011; Logan & Skamp, 2008).

Within Australia, despite mandatory government requirements to deliver primary science education, the subject area is frequently marginalised or not taught at all (Goodrum et al., 2001; Tytler, 2007). The default position of traditional school science education practices (teacher as director, learning of de-contextualised conceptual knowledge through acquisition, and practical exercises to demonstrate known phenomena) continues to enjoy an extraordinary level of “resilience” and popularity in primary and secondary school curricula (Tytler, 2007, p. 3). Concurrently, and in all likelihood, as a consequence of these teaching approaches, many Western students have little or no interest or engagement in science (Fensham, 2008; Lyons, 2006; Tytler, 2007). Compounding factors influencing the effective implementation of primary science education have been researched and described by many researchers (cf. Fitzgerald & Schneider, 2013; Harlen, 2011; Morgan, 2012; Skamp, 2012a) and include: primary teachers’ lack of science skills, knowledge and understanding; the lauded and de-contextualised position of literacy and numeracy in the overcrowded primary curriculum underpinned by high stakes testing regimens such as the ‘National Assessment Program – Literacy and Numeracy’ (NAPLAN; 2013); the lack of science resources for hands-on experiences; and a lack of understanding and support for implementation of the ‘nature of science’ (NOS) by education policy makers, education authorities, education curriculum developers, school principals and school teachers. Furthermore, even when primary science education is being delivered in Australian schools, there is a mismatch
between the “ideal or intended curriculum and the actual or implemented curriculum” (Goodrum et al., 2001, p. xiv).

Within primary schools in New South Wales (NSW), the state in which this research study was conducted, science is taught as part of a science and technology (as in ‘design technology’) syllabus (NSW Board of Studies, 2013a). This requirement further compromises the time available for the teaching of science and adds to the many demands placed on NSW primary teachers.

Faced with these challenges a number of initiatives to progress the teaching and learning of primary science in Australia have been trialled and implemented, and are presented in the following section.

2.3 Approaches that have been tried to rectify issues in primary science education in Australian schools, with mention of similar programs in the United States and New Zealand

To assist the reader with navigating Section 2.3, Table 2.1 presents a summary of the key literature discussed in the text.
Table 2.1. Summary of resources and research in Section 2.3 related to recent (1990-2013) Australian primary science education reform measures (including similar programs in the United States and New Zealand)

<table>
<thead>
<tr>
<th>Section 2.31 Australian primary science education resources in the past twenty years</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of initiative</strong></td>
</tr>
<tr>
<td>experiential science activities – excursion/incursions</td>
</tr>
<tr>
<td>award schemes</td>
</tr>
<tr>
<td>curriculum materials e.g., <em>Australian Curriculum: Science</em>, and professional learning programs e.g., <em>Primary Connections</em></td>
</tr>
<tr>
<td>school-based reform programs</td>
</tr>
<tr>
<td>in-school support by people with science expertise</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section 2.32 School-community science initiatives</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Author(s) and date</strong></td>
</tr>
<tr>
<td>Office of Chief Scientist (2012)</td>
</tr>
<tr>
<td>Howitt, Rennie, Heard &amp; Yuncken (2009)</td>
</tr>
<tr>
<td>Rennie (2012)</td>
</tr>
<tr>
<td>Wilson, Krakowsky &amp; Herget (2010)</td>
</tr>
<tr>
<td>Bolstad &amp; Bull (2013)</td>
</tr>
<tr>
<td>Forbes &amp; McCloughan (2010)</td>
</tr>
<tr>
<td><strong>Name of initiative</strong></td>
</tr>
<tr>
<td><em>Science Collaborations in Schools</em> including <em>Scientists in Schools</em> (Australia)</td>
</tr>
<tr>
<td>Evaluation of <em>Scientists in Schools</em></td>
</tr>
<tr>
<td>Evaluation of <em>Scientists in Schools</em></td>
</tr>
<tr>
<td><em>Teaching Opportunities for Partners in Science</em> (United States)</td>
</tr>
<tr>
<td>School-science community linked initiatives (New Zealand)</td>
</tr>
<tr>
<td><em>MyScience</em> (Australia)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section 2.33 School-based science education reforms in Australia</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Author(s) and date</strong></td>
</tr>
<tr>
<td>PEEL website (2013)</td>
</tr>
<tr>
<td>Tytler (2009)</td>
</tr>
<tr>
<td>Forbes &amp; McCloughan (2010)</td>
</tr>
<tr>
<td><strong>Name of initiative</strong></td>
</tr>
<tr>
<td><em>Project for Enhancing Effective Learning (PEEL)</em></td>
</tr>
<tr>
<td><em>Science in School Research Project</em> later renamed <em>School Innovation in Science Project</em></td>
</tr>
<tr>
<td>Australian School Innovation in Science, Technology and Mathematics (ASISTM) Projects</td>
</tr>
<tr>
<td><em>MyScience</em></td>
</tr>
</tbody>
</table>
2.3.1 Australian primary science education resources and professional learning programs in the past twenty years

Many teacher resources and professional learning programs have been developed and implemented in Australia over the past twenty years in response to concerns about improving and widening school delivery of primary science education. Support and opportunities for primary teachers and students may be broadly grouped in the following list of significant initiatives as follows:

- experiential science activities through excursions and/or incursions by providers such as: Questacon (2013), state science centres, museums, Commonwealth Scientific and Industrial Research Organisation (CSIRO) Education (2013);
- participation in science activities/investigations that are externally validated such as: National Science Week (2013), BHP Billiton Awards (2013), Science Teachers’ Association of New South Wales (STANSW) Young Scientist Awards (2013), CREativity in Science and Technology (CREST) awards (2013);
- access to, and use of online or paper based curriculum and other resource materials, such as those provided by: Australian Curriculum Assessment and Reporting Authority (ACARA) (2013b), ABC Science Unit (2013), CSIRO Education (2013), Primary Investigations (Aubusson & Steele, 2002), Primary Connections (Australian Academy of Science, 2013) – with significant professional learning programs accompanying the two latter initiatives;
- participation in school-based model reform programs to improve science teaching and learning in schools such as: School Innovation in Science (SIS) (Tytler, 2009), MyScience (Forbes & McCloughan, 2010; Project for Enhancing Effective Learning (PEEL) (2013);
- in-school support of primary teachers and primary students by people with science expertise such as: Scientists in Schools (2013), MyScience (Forbes & McCloughan, 2010; Forbes & Skamp, 2013a; Forbes & Skamp, 2013b).

Two significant initiatives in the past 5-10 years within Australia to support primary teachers in their classroom implementation of science are: the Australian Academy of Science’s (2013) Primary Connections program, and the Australian Curriculum: Science (ACARA, 2013b). Each of these will now be discussed focusing on their impact on teachers’ practices.
Primary Connections is a suite of teacher resources supported by a professional learning program developed by the Academy of Science to support primary teachers in the classroom implementation of science integrated with literacy. In a comprehensive review of the Primary Connections initiative, Skamp concluded that the resources offered several benefits including that they “had a very real and positive influence on most (if not all) responding teachers’ thoughts about the nature of inquiry-oriented and constructivist-based science learning at the primary level, as in the 5E model” (2012b, p. iv) and that

... the joy experienced in teaching Primary Connections units had a positive impact on teachers’ confidence to teach primary science … [which] … was in part related to their students’ obvious interest in science and the impact of the units on their students’ learning (2012b, p. v).

Thirty-one Primary Connections units are available for teachers to use, and have been aligned with the second significant initiative: the Australian Curriculum: Science.

ACARA, in response to the identified need – described earlier to focus on improving teachers’ and students’ understanding of the nature, development, use and influence of science, added a new strand into the science curriculum ‘mix’ named Science as a Human Endeavour or SHE. This key aspect of science education supplements and complements the customary pair of strands: Science Understanding (SU) and Science Inquiry Skills (SIS). Supporting documentation states that there is to be a focus on students developing a scientific view of the world, as follows:

Together, the three strands of the science curriculum provide students with understanding, knowledge and skills through which they can develop a scientific view of the world. Students are challenged to explore science, its concepts, nature and uses through clearly described inquiry processes (ACARA, 2013c, 2nd paragraph).

The Australian Curriculum: Science documents provided the foundation upon which the NSW Board of Studies developed the new NSW K-10 science syllabus. The K-6 Science and Technology syllabus (to be implemented in all NSW schools by 2015), and the 7-10 Science syllabus (to be implemented in all schools in 2014) (NSW Board of Studies, 2013b) therefore include the mandatory element of Science as Human Endeavour. A significant challenge for teachers is how to integrate this aspect of science education into their teaching
programs and students’ experiences. Two initiatives providing a way for this to happen include *Scientists in Schools* (2013) and *MyScience* (Forbes & McCloughan, 2010; Forbes & Skamp, 2013a; Forbes & Skamp, 2013b), both of which are outlined in Sections 2.3.2 and 2.6 respectively.

### 2.3.2 School-community science initiatives

In a recent report titled *Mathematics, engineering and science in the national interest*, the Australian Chief Scientist –Professor Ian Chubb– proposed a solution to the dilemma of incorporating SHE into school science education through a ‘Science Collaborations in Schools’ suite of programs to enhance “teacher capabilities, student learning and (to highlight) the relevance of science and mathematics as exciting career options to students” (Office of the Chief Scientist, 2012, p. 40). A key aspect of this approach is the “exposure (of teachers and students) to career mathematicians, engineers and scientists working in areas of national importance for Australia” (2012, p. 40) –coincidentally providing a seamless way to integrate the SHE strand of the new science curriculum, and to focus on what it means to be ‘doing real science in schools’, rather than memorization of canonical science concepts (Tytler, 2007).

The *Scientists in Schools* (2013) program, initiated in Australia in 2007 –and part of the ‘Science Collaboration in Schools’ suite of programs described earlier– is a strategy designed to establish and maintain “sustained and ongoing partnerships between scientists and school communities as a means of developing more scientifically literate citizens” (Howitt, Rennie, Heard & Yuncken, 2009, p. 35). The authors commented that, “the most common type of contribution made by the scientist involved visits to the school to give presentations to the students” (2009, p. 36), and reported a variety of benefits for participants including the following:

*Teachers benefitted* by increased knowledge and understanding of real-world, contemporary science; increased opportunities for professional learning through communication with scientists and other teachers; increased access to resources; increased awareness of the types and variety of careers available in the science; and increased motivation.

*Scientists benefitted* through communication with teachers and other scientists about their work; improved methods of communication with students; increased motivation and enthusiasm in their job; legitimisation of the partnership in their workplace; and better understanding of the community’s awareness and perceptions of science, scientists and their work.
Students benefitted by increased knowledge and understanding of real-world, contemporary science; opportunities to experience real science with real scientists; and an increased awareness of the type and variety of careers available in the sciences” (2009, p. 38, emphasis added).

Rennie’s evaluation of the Scientists in Schools project found that there were “measurable increases in perceived confidence for scientists in communicating science, and in teachers’ confidence in teaching science and being confident of their science knowledge” (2012, p. 79). Positive impacts of the program related to “bringing the practice of real world science to students and teachers, enabling scientists to act as mentors and role models for students, and inspiring and motivating teachers and students in the teaching and learning of science” (2012, p. 79). Scientists in Schools was viewed as a valuable resource for the implementation of the new national science curriculum –particularly the ‘Science as a Human Endeavour’ and Science Inquiry Skills’ strands as described in ACARA (2013b). Rennie’s (2012) findings can be directly related to the various components of this study’s research questions, especially around the impact on MyScience participants of interactions with people who had science expertise.

A similar outreach program (to that of the Australian Scientists in Schools project) occurs in the United States and is named Teaching Opportunities for Partners in Science (TOPS). Retired engineers and scientists volunteer their time to: assist teachers in grades K-8 with preparation and delivery of lessons; provide content knowledge to teachers when needed; motivate students with career and educational models, and information; and educate families through science events (Wilson, Krakowsky & Herget, 2010). Findings related to this program are described in Section 2.5.10.

Bolstad and Bull (2013) researched school-science community programs in New Zealand and identified at least six reasons for schools to engage with the science community which included the notions of the science community providing: current science knowledge; “authentic and relevant” science experiences that engage, motivate and interest learners; role models that may “inspire learners or help them to ‘see themselves’ and their identities reflected in science”; and insight into the complexity of addressing “real world challenges” (p. x). The school-science community initiatives aimed to strengthen “partnerships between schools and the science community to support students’ science learning and engagement … in real contexts of genuine relevance to the community ” (2013, pp. ix, xi). “Essential dimension(s) of effective engagements” were found to be partners’ abilities to form
… strong working relationships and to co-develop the details of the engagement[s] initiatives in ways that effectively identify and support learners’, teachers’ and communities’ science-learning needs … and of all parties having a clear sense of the desired purpose[s] or ‘ends’ for school–science-community engagements (2013, p. xi, emphasis in original).

Immersion and repeated engagements were found to be important temporal aspects of effective initiatives.

Bolstad and Bull argued in agreement with aspects of SHE research described earlier –that

… connections with the science community can support students to develop a more accurate insight into the realities of contemporary science, particularly by learning with scientists and undertaking real science research which … can be more open-ended, complex, ‘messy’ and does not have predetermined answers (2013, p. 27).

Furthermore, these types of initiatives were deemed to support the movement towards focusing science education practices “on learning about science, and how it is practised in the contemporary world—the ‘nature of science’ (NoS) [sic]” (2013, emphasis in original). Surprisingly, without actually mentioning the notion of ‘communities of practice’ (CoP) yet still using terminology normally associated with CoPs such as ‘apprenticeship’, ‘novice’, ‘working at the peripheries of…’, and ‘member of that community’, these authors described school-science community engagements as reflecting “a sociocultural apprenticeship model of learning where learners are seen as ‘novices’ who are working at the peripheries of, and developing towards a deeper knowledge and understanding of, what it takes to be a fully-fledged member of that community” (2013, p. 27). This notion will be further addressed in Section 2.3.4.

In terms of the flow-on effects for school science teaching and learning, most of the school-science community initiatives in New Zealand were designed to support science learning for students. However, within the research report, minimal student perspectives (data) of their science learning were evident. Teachers reported that they had learned more about their students’ capabilities: “seeing what motivates students, seeing new capabilities or aspirations in students that they had not previously seen, holding higher expectations that students can succeed in the sciences”; and their own science understandings: “developing understanding of the nature of science, or thinking differently about particular science issues in relation to learners or the local community” (2013, p. 44). Benefits for participating scientists, lecturers, and tertiary science students included that they
… became better at communicating science, and developing their teaching abilities. They found it personally rewarding and motivating to contribute to better science learning opportunities for school learners. … A final benefit [was] the opportunity to contribute to growing the next generation of scientists and other people who will work in, with and alongside the science community (2013, pp. 44-45).

MyScience makes use of people with science expertise (Forbes & McCloughan, 2010) and therefore fits with the ‘school-science community’ category as per Bolstad and Bull (2013) above. It is a school-based reform initiative for primary schools and is described in Section 2.6.

2.3.3 School-based science education reforms in Australia

School based reforms in primary science education in Australia have been few and far between. The Project for Enhancing Effective Learning (2013) began in 1985 and still had a following in 50 or more schools nationally at the time of writing. Using science and other subjects as a context, teachers used metacognitive strategies (thinking about thinking) to enhance learning.

The Science in Schools Research Project, later renamed the School Innovation in Science Project (SIS) was implemented and researched during 2000-2004 in more than 200 Victorian primary and secondary schools. Described by Tytler as “the largest school science initiative of its kind in Australia for decades” (2009, p. 9), the goal was to develop and validate a set of components that could be used to describe effective teaching practices to inform school and teacher change to improve science teaching and learning. Eight SIS Components and their subcomponents were identified, providing teachers with a shared vision, and a set of criteria for reflection, discussion, and emulation in their own practice. The SIS components are as follows:

1. Students are encouraged to actively engage with ideas and evidence
2. Students are challenged to develop meaningful understandings
3. Science is linked with students’ lives and interests
4. Students’ individual learning needs and preferences are catered for
5. Assessment is embedded within the science learning strategy
6. The nature of science is represented in its different aspects
7. The classroom is linked with the broader community
8. Learning technologies are exploited for their learning potentialities
Another key aspect of the SIS initiative was to develop a process (the SIS Strategy) giving “ownership and responsibility … to the participating schools” (Tytler, 2009 p. 1782) – a notion that is also implicit to the development of MyScience communities of science practice (Forbes & McCloughan, 2010). “The development of the (SIS) change strategy and understanding the process of change within schools were major research foci” (Tytler, 2009 p. 1794), with outcomes for primary schools in the SIS initiative that included: science having a higher profile in the school and local community; greater articulation of science in the curriculum; more resources; increased confidence in the teaching of science; and increased use of hands-on and exploratory approaches to teaching by teachers. SIS school-community projects were particularly successful, gaining national awards related to exemplary schooling, and attracting funding for environmental projects. Independent calls were made by Tytler (2007) and Rennie (2007) to research the conditions under which effective community-linked projects became embedded in school science programs – validating a research niche for MyScience, and how different CoPs developed and evolved.

In an analysis of rural community-school initiatives in Victoria, Australia, Tytler, Symington, Kirkwood and Malcolm (2008) found that they “were successful in engaging students in significant learning” (p.17), and that they “offer significant professional development opportunities for teachers, as they learn to represent locally-based contemporary science practices in the curriculum” (p.18). A selection of Australian School Innovation in Science, Technology and Mathematics (ASISTM) projects were subsequently analysed by Tytler, Symington, Smith and Rodrigues (2008) using an ‘Innovations Framework’. The innovation implicit in ASISTM was found to be “the alignment of teachers and outside experts in a partnership around a project that represents contemporary practice. Thus in many projects the actors [individuals, organizations, resources, environment] provided insight for students into contemporary science and professional learning in the discipline for teachers” (2008, p. 12). The findings from both of these studies signify a link between school-community initiatives and the research questions for this study.
Chapter Two

*MyScience* (Forbes & McCloughan, 2010)\(^2\) is a school-based science education reform initiative that has been implemented in selected NSW schools since 2006. *MyScience*

... uses a distinctive team approach, with primary teachers, primary students and volunteer mentor scientists working collaboratively as students conduct authentic scientific investigations to find answers to their own questions ... Structures to support teacher professional learning, teaching and learning practices and school-community engagement are profoundly integrated in the underpinning educational model (Forbes & McCloughan, 2010, p. 24).

*MyScience* has a focus on *learning as participation* where participants learn by being active members of a classroom community of learners who are investigating in a scientific manner, rather than a focus on *learning as acquisition* (of, for example, facts and concepts), which is the more common view of learning (Scott, Asoko & Leach, 2007). The idea is that participants view themselves as participating in the practices of science listed above and therefore deeply experience science as a human endeavour. Since *MyScience* is the context for this research project, the findings will be revealed sequentially in the body of the thesis and not detailed here. An overview of *MyScience* and how it was initiated are described in Chapter 1, and the summarized findings are described in Chapter 7.

### 2.3.4 Summary of approaches that have been tried to rectify issues in primary science education in Australian schools

These examples provide clear evidence of research forays into community-linked projects in rural and regional settings, but not into community-linked projects in metropolitan schools. Effective school-science community programs occur when participants know that they need to work together, on mutually agreed activities, with a clearly defined outcome or purpose, where everyone’s needs are being met—all the hallmarks of a community of practice which are discussed in Section 2.4.

By 2007, the question of what remained of the SIS initiative was raised by Tytler and he stated: “the ongoing legacy of SIS is the classroom practice of teachers, the artefacts produced in individual schools, and the culture of planning in the science team that changed considerably with SIS” (2009, p. 1804). These ‘legacies’, and the notion of ‘teachers and outside experts in a partnership around a project’—described earlier—correlate with the

\(^2\) Additional publications: Forbes and Skamp (2013a), and Forbes and Skamp (2013b) grew out of this study's findings, comprehensive details of which, are presented in Chapters 4-7 of this thesis.
classic elements of a community of practice (CoP) as described by Wenger (2013), and are similar to Bolstad and Bull’s “sociocultural apprenticeship model of learning” (2013, p. 27). In other words, both the New Zealand (Bolstad & Bull, 2013) and Tytler’s (2009) SIS community-linked initiatives bear the hallmarks of CoPs, even though CoP attributes—as defined by CoP researchers and detailed in the following section— are not addressed by these authors. This research study uses a community of practice conceptual framework, which is described in Chapter 3, Section 3.4.1, and so addresses this ‘gap’ in the research. Communities of practice and how they have been used to support learning are discussed in the following section.

2.4 Communities of practice: what they are, how they support learning, contexts where they have been used

To assist the reader with navigating Section 2.4, Table 2.2 presents a summary of the key literature discussed in the text.
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<tr>
<td>Lave &amp; Wenger (1991)</td>
<td>communities of practice, apprenticeship, situated learning, legitimate peripheral participation, trajectory</td>
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<td>Buysse, Sparkman &amp; Wesley (2003)</td>
<td>participatory framework, distributed learning, diverse expertise of participants</td>
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<td>Lindkvist (2005)</td>
<td>knowledge in CoPs resides in practice, situated learning</td>
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**Section 2.4.2**

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**Section 2.4.3**

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<td>Lederman (1992)</td>
<td>definition and parameters of ‘values and assumptions inherent to the development of scientific knowledge’</td>
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<td>Fensham &amp; Marton (1992), Marton, Fensham &amp; Chaiklin (1994)</td>
<td>scientific intuition, intuitive thinking</td>
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2.4.1 Bases and initial attributes of communities of practice

Ideas about communities of practice are grounded in social constructivism (Brown, Collins & Duguid, 1989; Vygotsky, 1978). Lave and Wenger’s seminal work studied apprenticeship as a learning model where learning was embedded in practice settings such as the sharing of knowledge within a scientific research organisation. Newcomers to a group moved along a ‘trajectory’ of learning from a position of ‘legitimate peripheral participation’ to a more central and core role within the learning and practice of the community as they gained and developed their expertise, ultimately becoming old-timers. Learning was ‘situated’ within the social context of the community, where ‘situated learning’ was described as the relationship between practice and learning and provided Lave and Wenger’s framework for understanding knowledge development by newcomers. As newcomers gained experiences and insights into the practices of the community their role became more central to the functioning of the community and they in turn could then pass on their knowledge and expertise of their community’s practice(s), thus perpetuating the learning of the community.

It was through participation in activities that group members were afforded exposure to the community of practice’s inherent knowledge, learning and identities (e.g., being a scientist; Carlone, 2004). Wenger published several articles related to the successful cultivation of CoPs with a particularly concise and visual depiction (2002) of the ‘key elements’ (domain, community and practice) and ‘critical success factors’ for developing and cultivating CoPs.

The notion of situated cognition proposed by Brown, Collins and Duguid (1989) used many examples from Lave’s early research into apprentices and how they learned, and then applied the findings to school students learning in classrooms. They stated that students learn best when they physically, socially and cognitively interact with others in activities that reflect real world practices of the discipline within which the learning is located.

Buysse, Sparkman and Wesley (2003) commented that the community of practice framework involves

… rethinking the locus of learning from an individual mind to a process that unfolds within a participatory framework. As a result, learning is viewed as distributed within the community in which people with diverse expertise (i.e. experts, novices and those in between) are transformed through their own actions and those of other participants (p. 266, emphasis added).

Etienne Wenger married Beverley Trayner in September 2011 and changed his name to Etienne Wenger-Trayner.
Lindkvist (2005) went further, adding that knowledge in CoPs is “decentred” or distributed, and “resides in practice” (p. 1195), where it then “creeps into and occupies the community members when they work together” (p. 1196). Lindkvist described this type of learning as “situated learning” (2005, p. 1204).

Wenger-Trayner defines communities of practice as “groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly” (2013, paragraph 1). He identified three elements –the domain, the community and the practice– that need to develop simultaneously in order for a community of practice to emerge. A CoP has an identity defined by a shared domain of interest, with membership implying a commitment to the domain. The community comprises members who interact and engage in shared activities, help each other, and share information with each other. They build relationships that enable them to learn from each other. The practice is the shared repertoire of resources and experiences that members develop and use and include activities such as stories, tools, experiences, and ways to solve problems. These shared interactions develop over time.

2.4.2 Changing notions of a CoP

Wenger’s ideas about learning in communities of practice changed. Firstly, to develop a CoP, members need to interact with each other and see each other as participants (Wenger 1998a); secondly, a CoP is a social learning system where part of belonging involves “knowing, learning and sharing knowledge”; and, thirdly, a person’s CoP identity is “a lived experience of belonging (or not belonging)” (Wenger, 2000, pp. 238-239). Interactivity as a core element for learning was a change from earlier conceptions about the novice-expert relationship with the novice as the ‘learner’. An individual’s learning within a CoP now included “engaging in and contributing to the practices of their communities” (Wenger, 1998a p. 7) and that learning “changes who we are by changing our ability to participate, to belong, to negotiate meaning” (1998a, p. 226) – particularly through participation and reification (the creation and/or sharing of artifacts, resources, ideas, explanations related to the domain). Wenger (1998b) stated that reciprocal learning between participants engendered collaboration and a sense of belonging to the CoP.

Learning and practice were no longer considered separate spaces of human endeavour—a position that has also been argued by Hodkinson and Hodkinson (2004)—and is consistent with a shift in emphasis from the dimension of learning as acquiring science concepts to that
of learning as participation (Scott, Asoko & Leach, 2007).

Palinscar, Magnusson, Marano, Ford and Brown (1998) described the notion behind a community of practice as providing

... a context that fosters learning and development through individuals’ participation in the activities of the community. Community members transform their understandings, roles, and responsibilities as they collaborate with knowledgeable others in carrying out activities that constitute the practices of the community (p. 10).

2.4.3 ‘Communities of practice’ and ‘communities of learners’

Learning approaches that foster ‘learning as participation’ have been described by several researchers including Brown (1997), Brown and Campione (1996), Rogoff (1994), Shoenfield (2004), Shulman and Sherin (2004), and Shulman and Shulman (2004) in the context of ‘communities of learners’ (CoL). As with communities of practice, Rogoff (1994) stated that learning in a CoL “occurs as people participate in shared endeavors [sic] with others, with all playing active but often asymmetrical roles in sociocultural activity” (p. 209) and that there were benefits associated with students developing skills around coordination, leadership, and taking responsibility for their own learning:

In communities of learners, students appear to learn how to coordinate with, support, and lead others, to become responsible and organized in their management of their own learning, and to be able to build on their inherent interests to learn in new areas and to sustain motivation to learn (1994, p. 225).

The difference between a CoL and a CoP is specificity. As described earlier, CoP participants identify with an articulated shared domain of interest, their membership is a declaration of their commitment to the domain, and through interactions with other similarly motivated participants they build relationships that enable them to learn from each other. In a CoL, the community and practice aspects of a CoP are evident but a clearly identifiable domain is not apparent. Therefore, in schools that adopt a CoL approach “the instructional discourse … is conversational … adults’ roles are supportive and provide leadership … (and students) learn to take responsibility for their contribution to their own learning and to the group’s functioning” (1994, p. 214). It could be argued that Rogoff’s CoL does have a domain –the shared interest in learning together– but since this notion is also the practice of the CoL, Wenger’s definition of a CoP remains distinctive. This notion is supported by
Wubbels (2007) who proposed that CoPs and CoLs are differentiated based on “whether practice or learning is the first concern of the community” (p. 229).

The goal for Brown’s (1997) program of research into ‘Fostering Communities of Learners’ (FCL) was to have primary students “think deeply about serious matters” (p. 399). Her early research investigated children’s zones of proximal development (ZPD) based on work by Vygotsky (1978) and evolved to include the development of a “reading comprehension program (named) reciprocal teaching (RT) that involved both the content and the culture of learning” (Brown, 1997 p. 402). She found that RT groups showed signs of “minilearning” communities, which had a focus on not only “understanding and interpreting texts [Wenger’s CoP attribute ‘domain’] … but also on establishing an interpretive community [Wenger’s CoP attribute: practice’]” (1997). Brown’s notion of a CoL therefore does have a specific domain –a reading comprehension program– and so would fall into Wenger’s definition of a CoP.

2.4.4 Zones of Proximal Development, CoP and teachers’ professional learning

Murphy (2012) connected the notion of ZPD with sociocultural learning. Once again, based on the work of Lev Semenovich Vygotsky (1896-1934), she asserted that “sociocultural theory applied to science learning … presupposes that learning occurs first between people and then in the individual … [and that] scientific concepts are formed … by combining experiences with intellectual operations guided by language” (p. 177). Thus, the learner is seen to have agency and the sharing of ideas exposes the teacher to the “different levels of understanding [that need] to be addressed” (p. 185), and provides a means for designing learning sequences within students’ ZPD.

Warford (2011) applied ZPD to teacher education, naming it the “zone of proximal teacher development (ZPTD)” (p. 252, emphasis in original). His stages of teacher development were: self-assistance, expert other assistance, internalization and recursion with the last often accompanied by “discomfort, stress, conflict, sadness and loss” (p. 256) as new information was incorporated into conceptual understanding. The research findings of Brown (1997), Murphy (2012) and Warford (2011) indicate connections between the notions of: learning as participation in CoPs, ZPD, and teacher professional learning. This was also found in to be the case in this study and is discussed in Chapter 7, Section 7.3.
A number of researchers have linked teachers, students’ and scientists’ learning with membership in groups. Relevant findings will be detailed in Section 2.5.

### 2.4.5 ‘Identity’, ‘practice’ and ‘participation’ in a CoP

Identity, practice and participation are interconnected in a CoP. A strong sense of identity and therefore of belonging comes about through deep connections with others through shared temporal interactions within a CoP (Wenger, 1998a). Identity and practice are connected and changed identities will develop when learners engage with different discursive practices of a discipline or field (e.g., its discourse, tools) and take on new roles within the CoP. This situated learning is essential and without it students do not think of themselves as CoP participants (Carlone, 2004). Referring to “a community of practice such as the science classroom”, Tan and Barton (2007) also argued that “identities are constructed socially within communities of practice… [and] students develop identities through engaging with the practices and tasks of the science class” (p. 568).

Gee (2001) researched the notion of identity in communities of learners (CoL), defining it as “being recognized as a certain ‘kind of person’ in a given context” (p.99). He distinguished four perspectives: N-identity (nature), I-identity (institutional), D-identity (discursive) and A-identity (affective) that he used as analytical lenses in his research. Gee linked participation in a CoL to his notion of A-identity because the “practices and the ways in which learners share and co-participate in them are meant to create a distinctive identity for learners … an identity in terms of which they are proactive inquirers and responsible for each other's learning” (2001, p. 107). In other words, Gee’s A-identity is to do with how a person “orients” themselves to the group’s “practices and activities” and then whether they generate “an affinity with others who share those practices” (2001, p. 108). This could be aligned with Wenger’s notion of a participant who enters a CoP as a newcomer, and over time develops a deeper sense of belonging to the CoP through interactions with others, thus linking the notion of identity with CoP participation.

For Etienne Wenger, the guru of CoPs and how they enable learning, learning is regarded as a central tenet to human identity with a primary focus on learning as social participation, where an individual constructs their identity as an active participant in the practices of social communities. He believes that people continuously create their shared identity through engaging in and contributing to the practices of their communities and the motivation to become a more central participant in a community of practice can provide a powerful
incentive for learning. Additional factors influencing learning in CoPs are discussed in Section 2.5.

2.4.6 Use of ‘communities of practice’ as a construct for analyzing learning

Hodkinson and Hodkinson (2004) researched secondary teachers’ learning in four different disciplines while at school using Lave and Wenger’s (1991) work associated with situated learning and communities of practice. They found the CoP construct to be helpful for analyzing teachers’ learning, particularly the level of collaboration between individuals and the learning culture within the different subject areas, with “those in the collaborative departments [having] an additional dimension to their learning” (2004, p. 29), thus linking the notions of CoPs, situated learning and learning as social participation.

Other researchers to have used communities of practice as an analytical construct include Borg (2009), Glazer and Hanafin (2006), Kienle and Wessner (2005), Koliba and Gadjia (2009) and Wenger (1998a). Wenger (1998a) identified three dimensions of practice: mutual engagement, a joint enterprise and a shared repertoire – which he regarded as key attributes of a community of practice. Kienle and Wessner (2005) used a community of practice perspective to analyse scientific community functionality and found that “in comparison to communities in the corporate context, scientific communities are more heterogeneous and the groups operate relatively independently … [where] learning involves participating in different communities and switching the role of novice and expert depending on the current situation” (p. 284). Glazer and Hannafin (2006) reported on a school based professional learning model where teachers’ mutual engagement in a ‘collaborative apprenticeship model’ fostered reciprocal interactions. Borg (2009) researched the development of a teacher community of practice, using a “community of practice lens … to view [her] data through two constructs” (p. 97) both of which were derived from Wenger (1998a). The first construct was Wenger’s (1998a) three dimensions of practice: mutual engagement, a joint enterprise and a shared repertoire – regarded as key attributes of a community of practice. The second construct was Wenger’s (1998a) list of fourteen indicators – used to identify behaviours, relationships, interactions and artefacts concomitant with a community of practice. Borg (2009) used the two constructs as pre-determined codes in her qualitative data analysis. Koliba and Gajda (2009) used CoPs as a theoretical construct and recommended researching the structures and practices that facilitate, sustain or strain CoP functionality such as: communication modes, the quality of dialogue and the quality of knowledge created and
used within CoPs. This position was underpinned by the view that “[t]he success or failure of a given CoP will likely be contingent upon both internal factors (the ability of CoPs members to collaborate) and external factors (how the CoP’s activity connects to and supports organizational or network objectives)” (2009, p. 115).

In summary, a successful CoP contains participants (the community) whose sense of belonging is due to an appreciation and awareness of productive, valued and shared interactions with others (the practice) around an acknowledged area of interest (the domain). A strong sense of belonging engenders the development of the community’s practice and this in turn engenders learning. Less successful communities of practice occur where participants do not have a strong sense of identity or belonging. A diversity of views and expertise amongst participants allows for learning to be distributed throughout the CoP. The research literature connects the notions of communities of practice with situated learning, learning as social participation, learning as participation in CoPs, ZPD, teacher professional learning and how CoPs develop and evolve. These notions also underpin the findings reported in this thesis. The learning of students, teachers and scientists within CoPs is described in more detail in Section 2.5.

2.4.7 CoPs and science learning

Two related characteristics of a CoP focussed on science learning have been identified by Kelly (2008) and Lederman (1992) and include: the discursive practices of science i.e., the ways that members engage and participate in the knowledge, conventions and practices of the science community (Kelly, 2008); and that a justified outcome of a learning trajectory for school participants within a CoP focussed on science would be “the development of an ‘adequate understanding of the nature of science’ or an understanding of ‘science as a way of knowing’” –the objective for science learning which had consensus and “strong agreement” in Lederman’s review (1992, p. 331). These are important findings, as they link the notion of the development of the NOS with participation in the discursive practices of science. It also signals the importance of teachers and other people working with students having an understanding of the NOS so that students are exposed to authentic discursive practices of science. This notion is expanded in Section 2.5.
Chapter Two

2.4.8 Attributes of the Nature of Science as a CoP characteristic

Key characteristics of the nature of science (NOS) have been identified by several researchers and are exemplified by Lederman’s (1992) definition and parameters, which refer to “the values and assumptions inherent to the development of scientific knowledge” (p. 331). Attributes of the NOS have been applied to primary school settings by a number of researchers (cf. Girod & Twyman, 2009; Liu & Lederman, 2007; Murcia & Schibeci, 1999) and include that science is: (1) inquiry based (uses the scientific method); (2) tentative, (3) developmental (builds on the findings of others), (4) subjective, (5) creative, and (6) collaborative.

The notion of scientific intuition, or ‘intuitive thinking’ was investigated by Fensham and Marton (1992) who, after reviewing several studies found that actual scientific research was much “messier” than expected and the notion of intuition was invoked to describe “[scientific] developments [as] more the product of hunches and improbable connections than a series of logical and rational steps” (p. 115). Rather than using this authentic approach with students however, the authors asserted that “science teachers and the supporting curriculum materials generally take a step-by-step approach to science topics”, with few “science teachers model[ling] intuition to their students or … recognis[ing] intuition in their students if and when they think in that way” (1992, p.120).

An analysis of seventy-two Nobel laureate’s discussions about scientific intuition by Marton, Fensham and Chaiklin (1994) revealed three ways of using the word ‘intuition’: as an outcome (11%) - 'having an intuition', 'having the intuition', 'many intuitions are wrong'; as an act or event (28%) - 'it happens all the time, 'when someone gets an idea that...', 'being right for the wrong reasons'; or as a capability (39%) - 'using intuition', 'having intuition', 'being born with intuition' (p. 460). The development of scientific intuition was considered to be influenced by the “knowledge about and/or experience of the specific phenomenon” (1994, p. 465). The researchers drew parallels between Nobel laureates and beginning school students’ intuitive grasp of phenomena occurring because of their “intense and varied experience of the phenomenon over a long period of time” (1994, p. 471) and commented that: “intuitive understanding is hardly a prominent and common feature of science learning in schools” (1994, p. 472). Teachers modeling of scientific ways of thinking, talking and working are discussed in more detail in the following section: Section 2.5, which also
presents literature related to the role of participants’ perceptions in influencing their learning and practices, particularly related to the nature of science.

2.5 Role of participants’ perceptions in influencing science learning and science teaching practices from research related to: teachers, scientists-as-mentors and students

To assist the reader with navigating the sections related to teachers (Sections 2.5.1 – 2.5.8), Table 2.3 presents a summary of the key literature discussed in the text.
**Table 2.3. Summary of research related to teachers’ perceptions of the factors influencing science learning and science teaching practices presented in Section 2.5 (2.5.1-2.5.8)**

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<tr>
<td>Dobey &amp; Shafer (1984)</td>
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</tr>
<tr>
<td>Harris and Rooks (2010), Carbone, Haun-Frank &amp; Kimmel (2010), Harlen (2008), Skamp (2012a)</td>
<td>inquiry learning as preferred teaching approach in primary classrooms</td>
</tr>
<tr>
<td>Appleton (2003)</td>
<td>low level of science background knowledge linked to doing ‘activities that work’</td>
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<td>Key concept(s)</td>
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<tr>
<td>Guskey (1986, 2002)</td>
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</tr>
<tr>
<td>Appleton &amp; Kindt (2002)</td>
<td>link between teachers’ personal beliefs about their ability to teach, and their ability to produce positive student outcomes and self-efficacy</td>
</tr>
<tr>
<td>Levitt (2001), Skamp (2012a)</td>
<td>teachers’ beliefs in new approaches to teaching and learning science influenced by observing students learning</td>
</tr>
<tr>
<td>Lumpe, Hanley &amp; Czerniak (2000)</td>
<td>teachers’ beliefs ‘are powerful motivation agents that lead to action agendas’</td>
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<th>Section 2.5.3</th>
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<tr>
<td>Watkins (2010)</td>
<td>comparison of primary and secondary science teaching practices</td>
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<td>Bryan (2012)</td>
<td>teachers’ preferred teaching style in science influenced students’ exposure and ways of thinking about science</td>
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<tr>
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<td>Key concept(s)</td>
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<tr>
<td>Borko (2004)</td>
<td>classrooms and activities therein influence teachers’ learning</td>
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<td>Glazer &amp; Hamafin (2006)</td>
<td>classroom-based teacher professional learning in CoP</td>
</tr>
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<td>Fitzgerald, Dawson &amp; Hackling (2013)</td>
<td>influence of classroom environmental factors on teacher beliefs</td>
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<td>Mansour (2013)</td>
<td>influence of context on teachers’ beliefs and practices</td>
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### Section 2.5.5  Teachers’ beliefs about the nature of science

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<tr>
<th>Author(s) and date</th>
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<tr>
<td>Brickhouse (1990), Cunningham (1998)</td>
<td>influence of beliefs about how scientists’ construct knowledge on teachers’ views of how students should learn science</td>
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<tr>
<td>Lederman (1992, 1999)</td>
<td>students’ and teachers’ conceptions of the NOS, influence on students of teachers’ use of scientific discourse</td>
</tr>
<tr>
<td>Abd-El-Khalick &amp; Lederman (2004)</td>
<td>teachers need to use explicit, reflective NOS activities with students for optimal student NOS learning</td>
</tr>
<tr>
<td>Brown (1997), Metz (2008)</td>
<td>explicit use of scientific discourse by teachers enabled student NOS learning</td>
</tr>
<tr>
<td>Lederman &amp; Lederman (2012)</td>
<td>student-centred contexts need to be used over an extended time for the development of student and teacher NOS understandings</td>
</tr>
<tr>
<td>Cunningham (1998)</td>
<td>teachers’ NOS understandings influenced social culture and context of classrooms</td>
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<tr>
<td>Wilson &amp; Berne (1999)</td>
<td>teacher participation in community of science practice resulted in teachers developing NOS understandings</td>
</tr>
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<td>Hughes, Molyneaux &amp; Dixon (2012)</td>
<td>role of scientist mentors on teachers’ development of NOS understandings</td>
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### Section 2.5.6  CoPs and teachers’ professional learning

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<thead>
<tr>
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<th>Key concept(s)</th>
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<td>Perry, Walton &amp; Calder (1999)</td>
<td>CoP framework used (in literacy context) for teacher professional learning. Initial surprise and anxiety replaced by ‘empowerment’</td>
</tr>
<tr>
<td>Opfer &amp; Pedder (2011)</td>
<td>‘dissonance as a catalyst for change’</td>
</tr>
<tr>
<td>Warford (2011)</td>
<td>linking of ‘zone of proximal teacher development’ with CoPs</td>
</tr>
<tr>
<td>Howe &amp; Stubbs (2003)</td>
<td>CoP facilitated the development of leadership skills in science teachers</td>
</tr>
<tr>
<td>Shulman &amp; Shulman (2004)</td>
<td>membership in CoL enhanced teacher learning</td>
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### Section 2.5.7  Teacher factors influencing students’ opportunities to experience authentic science activities

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<thead>
<tr>
<th>Author(s) and date</th>
<th>Key concept(s)</th>
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<tbody>
<tr>
<td>Harris &amp; Rooks (2010)</td>
<td>teachers need awareness of the practices of scientists, teachers need to adopt the role of a facilitator</td>
</tr>
<tr>
<td>Wallace &amp; Loughran (2012)</td>
<td>teachers need to listen to, and learn from students</td>
</tr>
<tr>
<td>Wubbels &amp; Brekelmans (2012)</td>
<td>teachers need to be confident in their ability to influence student learning outcomes</td>
</tr>
<tr>
<td>Carlone, Haun-Frank &amp; Kimmel (2010), Murphy, Murphy &amp; Kilfeather (2011)</td>
<td>significance of teachers’ ability to link ‘in-school’ and ‘out-of-school’ science</td>
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### Section 2.5.8  The significance of time for effective teacher professional learning

<table>
<thead>
<tr>
<th>Author(s) and date</th>
<th>Key concept(s)</th>
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<tbody>
<tr>
<td>Rennie (2010)</td>
<td>time needed for teachers to adopt new ideas and practices</td>
</tr>
<tr>
<td>Opfer &amp; Pedder (2011)</td>
<td>teacher professional learning requires time</td>
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</table>
2.5.1 Introduction to the role of teachers’ perceptions in influencing science learning and science teaching practices

A number of researchers have found that teachers profoundly influence the way that students learn science. For example, Dobey and Shafer (1984) reported that primary teachers with ‘intermediate science knowledge’ (compared with no knowledge or full knowledge) “demonstrated attributes and behaviors conducive to inquiry learning” (p. 490). Fast forward twenty years, and with inquiry learning the preferred teaching approach in primary classrooms in the developed world (Harris and Rooks, 2010; Carlone, Haun-Frank and Kimmel, 2010; Harlen, 2008; Skamp, 2012a), it would appear that teachers with ‘intermediate science knowledge’ would be a desired outcome from professional learning programs – but how might this come about? Appleton (2003) reported that primary teachers, who typically lacked science background knowledge and confidence to teach science, often used ‘activities that work’. These activities were categorized as “fun activities which the students could do, got them involved, were fairly safe for the teacher in management and science content terms, were predictable in outcome, and would teach the students something without much teacher intervention” (2003, p. 6). Clearly, the notion of activities requiring limited ‘teacher intervention’ is problematic since primary teachers’ engagement, interest and sense of efficacy in science impact their ability to engage and guide their students. So, as with the first example related to ‘intermediate knowledge’, how might these teachers be introduced to different ways of thinking about and implementing science teaching in their classrooms? Many factors have been found to influence primary teachers’ attitudes and beliefs related to science, science teaching and science learning. As these are key components of the research question underpinning this doctoral research, relevant research addressing these factors is addressed in this section. Furthermore, teacher professional learning and science reform programs (see Section 2.3), such as MyScience, need to take account of these factors.

2.5.2 Interaction of classroom practices and teachers’ perceptions about the value of changing their practices

Teachers’ classroom practices were found by Guskey (1986) to induce a ‘cascade effect’. When teachers modified what they did in their classrooms, this resulted in different student learning outcomes, which then influenced teachers’ beliefs and attitudes. Motivating teachers to change their classroom practices is therefore key to this sequence of events.
Guskey (2002) further developed his thinking around teacher professional development and teacher change stating that:

… significant change in teachers’ attitudes and beliefs occurs primarily after they gain evidence of improvements in student learning … the experience of successful implementation … changes teachers’ attitudes and beliefs. They believe it works because they have seen it work, and that experience shapes their attitudes and beliefs (p. 383, emphasis added).

His proposed model of teacher change was

… predicated on the idea that change is primarily an experientially based learning process for teachers. Practices that are found to work - that is, those that teachers find useful in helping students attain desired learning outcomes are retained and repeated. Those that do not work or yield no tangible evidence of success are generally abandoned. Demonstrable results in terms of student learning outcomes are the key to the endurance of any change in instructional practice. Attitudes and beliefs about teaching in general are also largely derived from classroom experience (p. 384, emphasis added).

Guskey’s teachers changed their attitudes and beliefs following their direct experience and evidence of students’ changed learning outcomes. Appleton and Kindt (2002) went further, linking “teachers’ personal beliefs about their ability to teach and their ability to produce positive outcomes for children” to self-efficacy, describing it as “an affective element developed through successful experiences in coping with stressful situations such as practicum teaching and early beginning teaching experiences” (p. 44).

In a study of sixteen primary teachers in the United States, Levitt (2001) found that their beliefs regarding the teaching and learning of science could be “summarized by three categories along a continuum: traditional, transitional, and transformational” with those at the transformational ‘end’ demonstrating “the closest alignment with the recommendations for science education reform as well as consistency between espoused beliefs and classroom practices” (p. 8). As with Guskey’s findings described earlier, Levitt (2001) found that a significant factor influencing teachers’ beliefs in new approaches to the teaching and learning of science was observing their students learning, a finding also made by Skamp (2012a). When Levitt’s teachers changed their classroom practice this perpetuated evolution in their beliefs, with time being a significant factor for reflection and learning from experience.
Other researchers to investigate how teachers’ perceptions of science, science learning and science teaching influence their classroom decisions and actions included Lumpe, Hanley and Czerniak (2000) who looked into the impact of environmental factors and/or people who were perceived, by teachers, to influence science teaching. They stated that: “People’s beliefs are powerful motivation agents that lead to action agendas … [and therefore] … researchers must consider both the real status of educational support in conjunction with the teachers’ perceptions of this support” (2000, p. 287). The researchers found that there were twenty-eight categories of factors and people that participants perceived to influence science teaching. Of particular note were context factors that

… displayed large discrepancies between the teachers’ enable [sic] beliefs and their likelihood beliefs. For example, the teachers possessed much higher enable beliefs than likelihood beliefs about the physical configuration of their classrooms, availability of science equipment, planning time, funding, and class size. For this group of teachers, there was a belief that these factors would help, but the teachers did not believe that they would occur (2000, p. 282).

2.5.3 The influence of teachers’ practices on student learning

Teachers’ beliefs profoundly influence their choice of science education teaching practices and a ‘classic’ example of teachers’ “contrasting styles of pedagogy” may be found by comparing primary and secondary school science teachers (Watkins, 2010, p.34). Watkins commented that “some of the most effective pedagogy can be found from primary non-specialists, whereas secondary specialists often employ some of the more conservative approaches” (2010, p. 34). Bryan (2012) found that teachers’ preferred teaching style directly impacted students’ exposure to, and ways of thinking about, science. So, teachers who

… believed that science involves highly systematic methods that lead to conclusions matching reality tended to include teaching practices such as lectures, multimedia presentations, whole-class guided questioning, text reading, and completion of worksheets. On the other hand, when teachers held beliefs that were congruous with a social constructivist view about science, they utilized practices that enabled students to engage in student-directed, open-ended scientific inquiry projects in which students designed their own methods to develop and evaluate knowledge claims (2012, p. 481).

A key issue is therefore how to change teachers’ perceptions and actual practices associated with their role in science classrooms so that students have more authentic opportunities to
learn about science. The didactic approach of many secondary science teachers is not conducive to this outcome and so ways to link secondary science teachers’ science knowledge with primary teachers’ pedagogical practices may be a way forward (as was done in this study by including secondary science teachers as mentors).

In a research study looking at secondary science teachers’ perceptions of primary science curriculum and design in Victoria, Australia Jeans and Farnsworth (1993) reported that the teachers “generally had favourable attitudes to primary science education and considered that cooperation would be useful” (p. 118), and were keen to have continuity across the primary-secondary interface. The researchers also commented about the significance of teachers’ “knowledge and beliefs about science education [as] a significant factor in how they respond to innovation and change and in their willingness to be involved in program development and renewal” (1993, p. 118) – in line with the findings discussed in the previous section: Section 2.5.2.

2.5.4 The influence of context on teachers’ learning

Teacher learning in classrooms was explored through a situated perspective by Borko (2004) who found that: “the contexts and activities in which people learn become a fundamental part of what they learn … suggest[ing] that teachers’ own classrooms are powerful contexts for their learning” (p. 7). This was supported by findings from Glazer and Hannafin (2006) who researched the effect of situated teacher professional development within school settings and found that reciprocal interactions in a CoP where teachers took responsibility for each other’s learning and development were “an example of mutual engagement in a community of practice” (p. 181) – linking to one of Wenger’s (1998a) CoP attributes described earlier in Section 2.4.6, and hence of relevance to this study. Similarly, Fitzgerald, Dawson and Hackling (2013) researched the beliefs and practices of four effective Australian primary science teachers finding that it was teachers’ beliefs and classroom environmental factors, which significantly influenced how and why they taught science in particular ways. Mansour (2013) also found that context influenced the correlation between teachers’ beliefs and practices. In summary, teachers’ beliefs and attitudes have been found to be influenced by student learning, which, in turn, are influenced by teachers’ classroom practices. The classroom context was found to provide a powerful learning environment for teachers of primary science.
2.5.5 Teachers’ beliefs about the nature of science (NOS)

A key factor found to impact classroom instruction practices was teachers’ beliefs about the nature of science (NOS). Brickhouse (1990) reported that “teachers’ views of how scientists construct knowledge were consistent with their beliefs about how students should learn science” (p. 59), a view also supported by Cunningham (1998). This finding clearly has important implications for science education pedagogy.

Lederman’s (1992) review of research related to students’ and teachers’ conceptions of the nature of science found that most “students did not possess adequate conceptions of the nature of science or scientific reasoning” (p. 335) and that “the most important variables [found to] influence students’ beliefs about the nature of science [were teacher initiated] specific instructional behaviors, activities, and decisions implemented within the context of a lesson” (p. 351). Citing findings from a study by Zeidler and Lederman in 1989 into teacher-student interactions, Lederman reported that the students of teachers who used ‘ordinary language’ when explaining or discussing science concepts tended to perceive “scientific knowledge as true, real, existing independently of personal experience, and where some scientific objects (e.g., atoms, light, ions) have the same ontological status as ordinary objects (e.g., chair, table)” (1989, p. 348). The students of teachers who “were careful to use precise language with appropriate qualifications” tended to perceive “the practical utility of scientific explanations, the role of human imagination and creativity in the development of scientific knowledge, the tentative nature of science, and the utility of arbitrary constructs and models” (1989, p. 348). In other words, students who were exposed to scientific discourse during instruction were more likely to have accepted views of the nature of science, a point that was raised earlier (in Section 2.4.7) related to research by Kelly (2008) and Lederman (1992) where the development of NOS understandings was linked to students participating in the discursive practices of science.

Lederman (1999) continued with this line of research and found that, despite teachers’ deep understandings of the NOS, this was not translated effectively into classroom practice and so students did not develop an understanding of the NOS. He concluded that it was “important for teachers to address the nature of science explicitly instead of assuming that its mere modeling will accomplish the desired outcomes” (p. 928). Similarly, Abd-El-Khalick and Lederman (2004), in a review of the international literature related to instruction for pre-service and in-service teachers, deduced that learners’ understanding of the NOS improved more when NOS factors were explicitly promoted in reflective teaching sequences as a
“‘cognitive’ learning outcome” (p. 691). These authors promoted the use of explicit, reflective activities with conceptual frameworks for optimal NOS learning by teachers and that simply “possessing adequate understandings of NOS is not sufficient to enable teachers to enhance students’ conceptions of the scientific enterprise” (2004, p. 696, emphasis added).

Brown (1997) reported that adults (teachers and discipline experts) explicitly using discussion, questioning and reflection when interacting with students are role models for students to include these practices in their own learning processes. Metz (2008) described two science activities: the “Amazon Ant thought experiment” (pp. 145-148) and “testing seed structure and the mode of seed dispersal” (pp. 148-151) where a teacher successfully introduced students to the practices of scientific inquiry and to the “knowledge-building practices of prediction, data analysis, and explanation” (p. 151) by including NOS attributes in their teaching.

In 2012, Lederman and Lederman added to the literature about how to teach students about the NOS stating that student-centred contexts should be used and that an “extended period of time [was required] to develop students’ understandings, as well as teachers’ understandings and relevant instructional skills” (2012, p. 347). They found that teachers “progressive development of classroom practice lagged behind the progressive development of knowledge” (2012, p.356) and so optimal professional development needed “to be long term, frequent and intensive” (2012, p. 358) – as mentioned later by Rennie (2010) and Opfer and Pedder (2011) in Section 2.5.6.

Cunningham (1998) found that teachers’ understandings of the NOS influenced the social, culture and context of classrooms. Teachers with strong ‘sociological understandings of science’ fostered classrooms which had community traits such as “group work, collaboration and interdependence, division of labour, and social negotiation …”, resulting in greater student involvement in the creation of scientific knowledge (1998, p. 248). A similar outcome, but with reverse sequencing of activities was reported by Wilson and Berne (1999) in their review of research on teacher learning through professional development. Significantly, they reported findings by Rosebery and her colleagues where teacher participation in communities of science practice resulted in teachers developing an understanding of the nature of science through being involved in scientific discourses and practices with their colleague teachers.
Hughes, Molyneaux and Dixon (2012) researched the role of scientist mentors on teachers’ participating in summer science Research Experiences for Teachers (RET) programs. Each RET program varied slightly but all provided teachers with an opportunity to work with practicing scientists. The scientist mentors modelled authentic practices i.e., the NOS, and “depending on their choices of mentoring style, [could] be the teachers’ guide in crossing the boundaries between real-world science and classroom science” (p. 917). The authors acknowledged that RET participants were situated in an “apprenticeship [which was] focused on teachers’ increased understanding of scientific processes in order to better translate these processes to their students” (2012, p. 918). Teachers and scientist mentors with a closer working relationship (the mentoring style) were more able “to translate authentic scientific inquiry strategies to their classrooms” (2012, p. 933). The type of relationships were therefore a significant factor for enabling teachers to translate authentic scientific strategies into their classrooms and segues into research related to scientists, which is presented in Section 2.6.

In summary, teachers’ understandings and knowledge of the NOS profoundly influenced their perceptions of science, science learning and science teaching. Teacher professional learning within communities of science practice enhanced teachers’ NOS understandings and teachers who explicitly used NOS practices in their classrooms enhanced their students’ NOS understandings. These findings have significance because they are all linked with this PhD study.

2.5.6 CoP and teachers’ professional learning

Following on with the theme of communities of practice (CoP) in teacher professional learning, Perry, Walton and Calder (1999) used a CoP framework (within a literacy context) to provide primary teachers with research-informed best practice in a program which included: “guided and sustained development activities to reshape instruction in ways that enhance students’ learning”, and opportunities for collaboration since “teachers learn best when they collaborate with one another” (p. 218) –a notion supported by many researchers such as Opfer and Pedder (2010) and Harlen (2011).

Perry, Walton and Calder reported that:

Initially teachers were surprised and anxious about our approach to teacher development. However, as time passed, there appeared to be a developing sense of empowerment, and an
appreciation of the time and support provided for teachers to develop as professionals (1999, p. 223).

This is an example of teacher efficacy being improved through a participatory approach to professional learning, which participants initially found to be rather challenging (‘surprised and anxious’).

The notion of “dissonance as a catalyst for change when practices and beliefs do not align” was commented on by Opfer and Pedder (2011, p. 393) in the context of teacher professional learning, with the caveat that “if the dissonance among beliefs, practices, knowledge, and experience is too large, teachers may dismiss new ideas as inappropriate to their situations” (p. 389). Therefore, a little dissonance, discomfort or anxiety is ‘good’ but too much is ‘bad’ for teacher engagement and learning.

This idea of learning within a particular ‘zone’ aligns with Vygotsky’s notion of the Zone of Proximal Development (ZPD), which Warford (2011) applied to teacher education, naming it the “zone of proximal teacher development (ZPTD)” (p. 252, emphasis in original). Warford also linked the notion of ZPD with CoPs via the notion of ‘experts’ stating that: “The ZPD measures the distance between what a learner is able to do and a proximal level that they might attain through the guidance of an expert-other” (2011, p. 252) connecting the notion of CoP newcomers learning through ‘legitimate peripheral participation’ (Lave and Wenger, 1991) from more experienced ‘expert-others’. They learn when they are in their ZPD. If the ZPD is too large or too small then learning is compromised. In other words, CoP frameworks afford metaphorical ‘learning spaces’ into which participants may choose to step or engage with others at a level commensurate with their ZPD.

Similarly, the creation of a community of practice was found to be one of four factors that facilitated the development of leadership skills in science teachers (Howe and Stubbs, 2003), while Shulman and Shulman (2004) linked the notion of membership of a community of learners (CoL) to teacher learning, identifying that teacher “learning proceeds most effectively if it is accompanied by metacognitive awareness and analysis of one’s own learning processes, and is supported by membership in a learning community” (p. 267). It can be seen, from these examples, that involvement in CoPs and CoLs positively influenced teachers’ professional learning and is therefore linked to this doctoral study.
Chapter Two

2.5.7 Teacher factors influencing students’ opportunities to experience authentic science activities

Based on new directions in inquiry science instruction in the US (and elsewhere in the world), Harris and Rooks (2010) asserted that “students are more likely to advance in their understanding of science when they have opportunities to participate in science as practice” (p. 229). This, however, requires teachers to have NOS understandings themselves (as discussed previously) and that “[t]eachers can be challenged in enacting authentic science tasks if they are not familiar with the practices of scientists and have never participated in authentic scientific activity themselves” (2010, p. 233). This indicates that primary teachers are likely to benefit from interacting with people with science expertise – as they do in this doctoral study. The authors also commented that a key dilemma for teachers in inquiry classrooms is “how much guidance or independence to give students” advocating the notion of “pervasive management” (2010, p. 232) and asserted that a ‘science as practice’ perspective requires teachers to re-conceptualise classroom management. They found that teachers who used ‘pervasive management’ in their classrooms achieved greater student learning because teachers used “effective scaffolding that support[ed] students in integrating and applying ideas. Students assume[d] more responsibility as they collaborate[d] and communicate[d] around authentic tasks and investigations, and participate[d] in a community of scientific practice” (2010, p. 230).

Wallace and Loughran (2012) proposed a ‘two-way street’ for learning in science classrooms. They described the importance of teachers “listening to, and therefore learning from, their students” (p. 299) and that “[b]eing sensitive to the ‘student voice’ is a fundamental element that underpins quality in science teaching” (p. 300). Similarly, Wubbels and Brekelmans (2012) identified the importance of teacher-student relationships in science classrooms stating that: “The more positively teachers think about their potential to influence student outcomes, the more they achieve a positive classroom atmosphere in their teaching” (p. 1250).

Teachers who introduced new ideas/practices to their workplaces were described by Carlone, Haun-Frank and Kimmel (2010) as ‘tempered radicals’, linking them with the notion of Aikenhead’s (1996) ‘border crossers’ and Wenger’s (1998a) ‘culture brokers’. Murphy, Murphy and Kilfeather (2011) reported that students taught by NOS trained teachers had better understandings of the links between school science activities and ‘real
world’ science practices presumably due to their enhanced ability to act as border crossers for students between the two ‘worlds’ of ‘in-school’ and ‘out-of-school’ science.

In summary, students need opportunities to participate in authentic science activities, guided by teachers with NOS knowledge and understandings and an awareness of how to link ‘in-school’ with ‘out-of-school’ science. Teacher-student interactions need to be reciprocal and teachers need to be confident in their ability to influence student learning outcomes.

2.5.8 The significance of time for effective teacher professional learning

The notion of teachers needing time to embrace new ideas and practices was eloquently phrased by Rennie (2010) who stated: “Changing pedagogical thinking requires ongoing reflection about teaching and student learning, so that learning, rather than teaching, becomes the focus of teachers’ thinking about their practice” (p. v). Opfer and Pedder (2011) concurred with this view stating that: “[t]eachers need time to develop, absorb, discuss, and practice new knowledge [and activities, which] need to be sustained and intensive rather than brief and sporadic” (p. 384). They also noted that teacher professional development and therefore learning “needs to have learning embedded in professional lives and working conditions” (2011, p. 376). These findings concur with comments by Bolstad and Bull (2013) who reported that immersion and repeated engagements were found to be important temporal aspects of effective school-science community initiatives (see Section 2.3.2).

2.5.9 Teachers’ perceptions about science, learning science and teaching science: overview of key influencing factors

In summary, the reviewed literature related to teachers showed that they play a critical and central role in students’ learning in science. Contributing factors included teachers having a ‘just right’ amount of science knowledge, and using inquiry-based, student-centred classroom practices. Teachers were more likely to adopt new or unfamiliar teaching approaches when they directly observed or experienced evidence of student learning in their own classrooms, had enough time to consider and adapt their teaching approaches accordingly and when they were involved in CoPs with their colleagues. Teachers’ views about the NOS profoundly influenced their science teaching practices so that those with strong sociological understandings of science fostered classrooms with community traits. Much of the research literature related to teacher professional learning in science education indicates that initiatives should be iterative, school-based, immersive and participatory. The
notion of ‘classroom-based, progressive professional learning’ is an integral aspect of participant teachers’ experiences in this PhD study and all of the aspects in Section 2.5 contributed to interpreting the research design and findings, especially in Chapter 5 where teacher perceptions were the focus.

2.5.10 The role of scientists-as-mentors’ perceptions in influencing science learning and science teaching practices

As mentioned previously in Section 2.3.2 schools often make use of local community people with science expertise who work with teachers and/or students, inside or outside the classroom, on aspects of school education related to science. This necessarily links the classroom with the broader science community (Tytler, 2003) providing valued opportunities for teachers and students to be exposed to the ways that scientists think, talk about and do science i.e. the NOS.

Four research studies related to knowledgeable science experts interacting with primary students/teachers in ongoing classroom investigations were located (Bolstad & Bull, 2013; Howitt et al., 2009; Rennie, 2012; Wilson et al., 2010) and each of these are discussed in the following section of this literature review.

Some of the research findings related to participants’ views of their involvement in school-community linked initiatives using local people’s science and engineering expertise have been described earlier in Section 2.3.2 related to: the Scientists in Schools (SiS) project in Australia (Howitt et al., 2009; Rennie, 2012), the Teaching Opportunities for Partners in Science program in the United States (Wilson et al., 2010) and a variety of school-science community programs in New Zealand (Bolstad & Bull, 2013). Since this part of Section 2.5 relates specifically to scientists’ perceptions of their involvement in such initiatives, these will be highlighted next.

Howitt et al.’s (2009) report on the SiS project indicated that “the most common type of contribution made by the scientist involved visits to the school to give presentations to the students” (p. 36). Rennie’s (2012) evaluation of the project found that there were “measurable increases in perceived confidence for scientists in communicating science” (p. 79). Positive impacts of the program related to “bringing the practice of real world science to students and teachers, enabling scientists to act as mentors and role models for students, and inspiring and motivating teachers and students in the teaching and learning of science”
SiS was viewed as a valuable resource for the implementation of the new national science curriculum – particularly the ‘Science as a Human Endeavour’ and Science Inquiry Skills’ strands (ACARA, 2013b).

Wilson et al. (2010) reported on a US based program named Teaching Opportunities for Partners in Science or TOPS. Comments posted on the TOPS website from initial evaluations identified “numerous benefits for the Science Partners [the scientists and engineers who were mentors] … include[d] enhanced interest in science education, finding new applications for their science knowledge, and the development of a network of their peers after retirement”.

In summary, scientists’ and engineers’ perceptions of their involvement in school-community initiatives were that they became more confident in communicating science and they perceived that they: brought the real world of science to teachers and students; acted as mentors and role models to students; provided science inspiration and motivation to students and teachers; became more knowledgeable themselves about science education; found new ways to apply their science knowledge; and developed networks with other scientists and engineers.

A detailed study of the views of participating scientists and engineers as mentors has been published, in part, by Forbes and Skamp (2013a). The authors reported:

In general these scientists expressed a desire to positively influence primary students’ views about science as a human endeavour … They saw themselves as integral members of the MyScience CoP and valued their relationships with students and teachers … [they] have particular views of other CoP members’ roles … have varied motivations and expectations about their MyScience involvement … and perceive both strengths and limitations in MyScience as a mechanism for learning through participation (2013a, p. 1012).

This thesis extends that work (see Chapter 4 – mentors’ views), adds information to the research fields of communities of science practice and school-science community initiatives, and presents other participants’ views (Chapter 5 – primary teachers’ views, Chapter 6 – primary students’ views) of their involvement in initiatives with scientist-as-mentors.

Gee (2001) found that university scientists viewed themselves in terms of their identity as “proactive inquirers and responsible for each other's learning” (p. 107). This is an interesting perception since membership of a workplace where this trait is useful, may enhance
scientists’ abilities to help others (students and teachers) learn about science. In the following, factors that influence students’ science attitudes and achievement will be explored.

2.5.11 Factors influencing student motivation and engagement in school science

To assist the reader with navigating the sections related to students (Sections 2.5.11 – 2.5.15), Table 2.4 presents a summary of the key literature discussed in the text.
### Table 2.4. Summary of research related to students’ perceptions of the factors influencing science learning and science teaching practices presented in Section 2.5 (2.5.11-2.5.15)

<table>
<thead>
<tr>
<th>Section 2.5.11</th>
<th>Factors influencing student motivation and engagement in school science</th>
</tr>
</thead>
<tbody>
<tr>
<td>Author(s) and date</td>
<td>Key concept(s)</td>
</tr>
<tr>
<td>Shibeci &amp; Riley (1986)</td>
<td>student attitudes towards science, gender, race and home environment influence student achievement in science</td>
</tr>
<tr>
<td>Osborne, Simons &amp; Collins (2003)</td>
<td>student gender, teacher quality and personal autonomy are significant factors influencing student attitudes towards science; ‘attitude precedes behaviour’ i.e., enjoyment and interest likely to lead to positive commitment</td>
</tr>
<tr>
<td>Kerr &amp; Murphy (2012), Skamp (2007)</td>
<td>significance of meaningful hands-on science experiences for students learning and engagement in school science</td>
</tr>
<tr>
<td>Palmer (2005)</td>
<td>‘motivation as a necessary prerequisite and co-requisite for learning’ in science</td>
</tr>
<tr>
<td>Tytler &amp; Osborne (2012)</td>
<td>significance of gender, teacher quality and pre-adolescent experiences on student interest in science</td>
</tr>
<tr>
<td>Office of the Chief Scientist (2012)</td>
<td>significance of inspirational teaching on student interest in science</td>
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<th>Section 2.5.12</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Author(s) and date</td>
<td>Key concept(s)</td>
</tr>
<tr>
<td>Hanrahan (1998)</td>
<td>deep engagement in science influenced by teachers’ level of control</td>
</tr>
<tr>
<td>Darby (2005)</td>
<td>the influence of teachers’ ‘instructional’ and ‘relational’ pedagogical practices on students’ engagement in science</td>
</tr>
<tr>
<td>Lyons (2006)</td>
<td>the influence of ‘traditional science teaching approaches’ on student interest in science in Australia, England and Sweden</td>
</tr>
<tr>
<td>Logan &amp; Skamp (2008)</td>
<td>the influence of teaching approach, classroom environment and ‘student voice’ on primary students’ attitudes and interest when transitioning into secondary science; student perception that ‘if having fun, will pay more attention’</td>
</tr>
<tr>
<td>Kerr &amp; Murphy (2012)</td>
<td>involving students in practical, experimental science helped to maintain primary students’ interest in science as they aged</td>
</tr>
<tr>
<td>Wallace &amp; Louhgran (2012)</td>
<td>need for teachers to heed ‘student voice’</td>
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<tr>
<th>Section 2.5.13</th>
<th>Students’ science identity and learning in science</th>
</tr>
</thead>
<tbody>
<tr>
<td>Author(s) and date</td>
<td>Key concept(s)</td>
</tr>
<tr>
<td>Brown, Reveles &amp; Kelly (2005)</td>
<td>link between student learning and discursive identity</td>
</tr>
<tr>
<td>Tan &amp; Barton (2007)</td>
<td>development of science identity formation and CoP membership, influence of context and ‘types of discourse’ on identity formation</td>
</tr>
<tr>
<td>Osborne, Simons &amp; Collins (2003)</td>
<td>link between community membership, science identity and view of science</td>
</tr>
<tr>
<td>Lee (2002)</td>
<td>impact of context on female secondary and tertiary students’ science identities</td>
</tr>
</tbody>
</table>
### Section 2.5.14  
**Student learning about the NOS**

<table>
<thead>
<tr>
<th>Author(s) and date</th>
<th>Key concept(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carey &amp; Smith (1993)</td>
<td>influence of standard curriculum on students’ development of knowledge and understandings about the NOS</td>
</tr>
<tr>
<td>Smith, Maclin, Houghton &amp; Hennessey (2000)</td>
<td>influence of traditional or constructivist teaching approach on students’ development of knowledge and understandings about the NOS</td>
</tr>
<tr>
<td>Girod &amp; Twyman (2009)</td>
<td>influence of blended literacy and science unit and an inquiry science unit on students’ development of knowledge and understandings about the NOS, science conceptual understandings and science identity</td>
</tr>
<tr>
<td>Akerson, Buck, Donnelly, Nargund-Joshi, &amp; Weiland (2011)</td>
<td>influence of integrated curriculum on students’ development of knowledge and understandings about the NOS</td>
</tr>
<tr>
<td>Akerson, Nargund-Joshi, Weiland, Pongsanon &amp; Avsar (2013)</td>
<td>influence of explicit NOS instruction on low and high achievement students’ development of knowledge and understandings about the NOS</td>
</tr>
<tr>
<td>Murphy, Murphy &amp; Kilfeather (2011)</td>
<td>influence of NOS trained teachers on students’ development of knowledge and understandings about the NOS</td>
</tr>
<tr>
<td>Feasey (2012)</td>
<td>notion of students using ‘concepts of evidence’ to develop knowledge and understandings about the NOS</td>
</tr>
<tr>
<td>Olson (2008)</td>
<td>influence of teachers implementing a ‘step-by-step method’ with associated questions on students’ development of knowledge and understandings about the NOS</td>
</tr>
<tr>
<td>Harlen (2009)</td>
<td>notion of student and teacher roles using: ‘starting ideas through discussion, testing against evidence gathered through enquiry and argumentation, participating in assessing progress, reflecting on learning and outcomes’</td>
</tr>
<tr>
<td>Hume &amp; Coll (2010)</td>
<td>influence of too much fair testing and lack of in-depth investigations on students developing NOS knowledge and understandings</td>
</tr>
<tr>
<td>Murphy, Murphy &amp; Veale (2012)</td>
<td>influence of teacher-led, prescribed activities on students developing NOS knowledge and understandings</td>
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</table>

### Section 2.5.15  
**The influence of participation in communities on students’ science learning**

<table>
<thead>
<tr>
<th>Author(s) and date</th>
<th>Key concept(s)</th>
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<tbody>
<tr>
<td>Rogoff (1994)</td>
<td>the influence of CoL participation on student NOS learning</td>
</tr>
<tr>
<td>Driver, Asoko, Leach, Mortimer &amp; Scott (1994)</td>
<td>notion of students developing science knowledge and understandings through a process of enculturation</td>
</tr>
<tr>
<td>Metz (1995), Kelly (2008)</td>
<td>influence of communities of discourse, social interactions, discursive practices on students’ science learning</td>
</tr>
<tr>
<td>Oliveira (2009)</td>
<td>importance of symmetry in discourse structures of teachers and students for student learning through increased ownership and agency</td>
</tr>
<tr>
<td>Zoller &amp; Nahum (2012)</td>
<td>influence of explaining science ideas to others on students’ abilities to think in science</td>
</tr>
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</table>
Using data from 1976-1977 Schibeci and Riley (1986) established that student attitudes towards science (along with gender, race, and the home environment) substantially influenced student achievement in science. Nearly forty years later, it appears that little has changed—as reported by Osborne, Simon and Collins (2003)– who reviewed the literature related to student attitudes towards science and highlighted the “crucial importance of gender and the quality of teaching” (p. 1049). They reported that “boys have a consistently more positive attitude to school science than girls” (2003, p. 1062) and that good teachers were characterised as “being enthusiastic about their subject, setting it in everyday contexts … running well-ordered and stimulating science lessons [and] were also sympathetic and willing to spend time … talking with the students about science, careers and individual problems” (2003, p. 1068). Significantly, the authors added that:

The essential premise permeating much of the research is that attitude precedes behaviour. … Feelings of enjoyment and interest in science combined with success in junior science courses are likely to lead to a positive commitment toward science that is enduring (2003, p. 1072, emphasis added).

Osborne et al. identified personal autonomy as a critical aspect of student motivation and engagement and reported that “the most positive attitudes [in students] were associated with a high level of involvement, very high level of personal support, strong positive relationships with classmates, and the use of a variety of teaching strategies and unusual learning activities” (2003, p. 1067).

Kerr and Murphy (2012) reported that “the message from boys and girls of all ages [in the literature] is a resounding thumbs-up for practical, investigative science” (p. 646), while Skamp (2007) explored the links between hands-on, hearts-on and minds-on science experiences to enhance students’ learning, interest in engagement in school science and emphasised that all three should be included and evident in teachers’ pedagogy for effective science learning and teaching.

In an international review of research on the links between constructivist learning approaches – considered “the dominant paradigm of learning in science” (Palmer, 2005, p. 1853) – and motivation, the author stated that:

… the reconstruction of meaning requires effort on the part of the learner. If effort is required for learning then it follows that motivation is also required, because students will not make that effort unless they are motivated to do so. Motivation would therefore be required to initially arouse
students to want to participate in learning, and it would also be needed throughout the whole process until knowledge construction has been completed. Constructivist theory thus implicates motivation as a necessary prerequisite and co-requisite for learning (2005, p. 1855).

These comments are notable for two reasons: learning requires effort and effort requires motivation. A precedent for these to occur is that students have to firstly be interested. Palmer (2008) investigated sources of situational interest, “a short-term form of motivation which occurs when a specific situation stimulates the focused attention of students” (p. 147), and found that the main source was novelty. Clearly, this aspect of motivation is beneficial as it engages students’ interest, but in the longer term a deeper form of interest – personal interest – “when students want to learn about science topics” is mentioned as “a major affective goal in science” by Skamp (2012, p. 25, emphasis added).

Tytler and Osborne’s (2012) review of the research literature related to students’ attitudes and aspirations identified three factors as the major determinants of student interest in school science: gender (e.g., attention to ethics and science in everyday life appeals to girls); the quality of teaching (“good subject knowledge … dialogic approach” (p. 608)); and pre-adolescent experiences (e.g., exposure to science careers). Parental interest and support promoted higher student efficacy and were significant factors for high school students choosing to study physical sciences. Classroom activities that were found to be valuable for promoting ‘flow’ were “well structured … [where students were] given adequate opportunities to demonstrate their skills and knowledge as autonomous individuals” (2012, p. 605), again focusing on student independence. Furthermore, the authors asserted that

… greater attention needs to be given to representing the practices of science and their social implications than traditionally has been the case. In a number of countries, this has led to projects designed to encourage more links between practising scientists and school science classrooms … [and that] … there is a need for further research into the impact of these public science resources on student attitudes to and engagement with science … since students cannot aspire to that which they have never seen (2012, pp. 616, 618).

In a recent report by the Office of the Chief Scientist (2012) into the status of Australian mathematics, engineering and science (MES), inspirational teaching was ranked as the highest factor influencing quality and raising student interest levels: “Students generally commented that the teaching of science was too didactic, even boring … scientific facts
were not related to [students’ lives] and practical classes were largely about recipes or watching teachers following recipes, with little time for reflection”. This was attributed to science not being taught “as it is actually practiced: hypothesis, experimentation, observation, interpretation and debate” (2012, p. 9).

In summary, students’ attitudes towards science influence achievement in science. Attitudes are influenced by a number of factors including: student gender, the teaching approach, teacher enthusiasm, the ability of teachers to link learning with students’ everyday lives, student autonomy, parental science interest and science career expectations, and the influence of family and peers. Students’ perceptions of their involvement in science-related activities in MyScience are a key aspect of this doctoral study and the reported findings in this section provide useful insights to assist with interpreting their views.

**Section 2.5.12 The role of teaching approaches on students’ attitudes towards science: students’ perspectives**

The research literature has clearly identified that students’ attitudes towards science significantly impact their interest and engagement in science. Teachers (what they do in science classrooms and how they do it) feature prominently in many of the published findings in this area of research. Hanrahan (1998) found that students’ feelings of self-worth (affirmed by the teacher) and autonomy were key for their deep engagement in science learning, with students’ “level of cognitive engagement [being] affected by two interrelated factors: the control the teacher had over almost all activities, and student beliefs about learning in this context” (p. 737). The key message from Hanrahan’s (1998) paper was that even when students were highly motivated to learn, this did not occur at a deep level because they lacked autonomy. The teacher seemed to be unaware of the significance of student autonomy as a preferred teaching and learning strategy for these students, and links with findings reported by Osborne et al. (2003) in the previous section (Section 2.5.11).

Science students’ perceptions of teachers’ ways of teaching science were found, by Darby (2005), to play a critical role in maintaining student interest and engagement in science. Teachers’ science discursive strategies were found to fall into two main areas: *instructional pedagogy* –how students were drawn into the science learning process; and *relational pedagogy* –how teachers’ passion and ability to provide a ‘comfortable’ and supportive learning environment enabled students’ science learning.
Lyons (2006) compared students’ interest in science in three different schooling systems: Sweden, England and Australia. He found that traditional science teaching approaches (de-contextualised, fact memorization, teacher-centred pedagogy) were a significant factor contributing to Western secondary students having little or no interest or engagement in science, with parental science interest and science career expectations also featuring strongly. Lyons stated that “conceptions about science and school science are internal, ongoing constructions of each student … whose perceptions, beliefs, and responses are influenced by his or her experiences and environment” (2006, p. 594), which also include non-school factors such as family and peers, linking with the earlier findings by Shibeci and Riley (1986) in Section 2.5.11.

A study into students’ attitudes and interest in science across the primary-secondary transition by Logan and Skamp (2008) found that these attributes were generally maintained. The teacher’s pedagogical approach, classroom environment and student voice (listening to and heeding it) were identified as key contributing factors. Students “especially enjoyed activities where they had the opportunity to design their own experiments, carry out fair tests, and suggest hypotheses” (2008, p. 509) with one student commenting: “If students are having fun [while they are learning] they will pay attention more” (2008, p. 510). By way of contrast, Kerr and Murphy (2012) reviewed the international literature related to primary students’ attitudes towards science and found that as students aged, positive attitudes towards science tended to decrease, unless students were involved in practical, experimental science.

Wallace and Loughran concurred with Logan and Skamp’s (2008) notion of “being sensitive to the ‘student voice’ [citing it as] a fundamental element that underpins quality in science teaching” (2012, p. 300). They stated that there is also value in “teachers listening to, and therefore learning from, their students … just as it is anticipated that students learn from their teachers, so too it should be expected that science teachers learn from their students” (2012, p. 299).

Student-student interactions were also found to be important for interest, engagement and learning in science. Murphy, Varley and Veale (2012) found that students enjoyed working with their friends in science. Metz reported that social interactions “within the science classroom can help children make their ideas explicit and subject them to criticism” (1995, p. 108). Smith, Maclin, Houghton and Hennessey (2000) found that Year 6 students viewed
“social interactions as vitally important to the learning and knowledge acquisition processes” (p. 402) particularly around the notions of “understanding] that scientific knowledge grows out of and depends on the prior ideas they and others hold [and that] knowledge-building efforts are enhanced by collaboration and consensus building” (2000, p. 399). These authors also commented that social interactions widened “the range of ideas students consider[ed], which often led them to develop more complex views” (2000, p. 402).

In summary, students’ interest and engagement in science are influenced by a number of the same factors that impact student attitudes i.e., student autonomy, teachers’ actions in the classroom, parental science interest, parental science career expectations, and a classroom environment where students are able to interact socially to develop their science ideas and understandings. Skamp found that “primary and middle school students need to be engaged before they will effectively learn” signaling the importance of factors influencing students’ interest and engagement (2007, p. 19). What is interesting, and links to findings in Section 2.2 where many Western students have little or no interest or engagement in science, is that teachers’ choices about how they teach science in their classrooms do not appear to coincide with what students perceive as important, interesting or engaging. These two positions need to become more aligned if primary science education is to nurture and develop students’ personal interest in this field and is a key focus for MyScience the context for this research study.

**Section 2.5.13 Students’ science identity and learning in science**

The development of students’ science identity was found to influence students’ learning in science. Brown, Reveles and Kelly (2005) looked at the development of students’ discursive identity within school science lessons. They posited that since language provides “the means to construct interactions … [it] … has the power to indicate group affiliation and membership [and can be] conceptualized as an active resource for identity construction … [affording] individuals [with] some agency to select discourses” of their choosing (2005, pp. 780, 783-784). They added the following, all of which positions individuals’ science discourse, science identity, science agency and science learning as being recursively connected:

… science learning involves learning to construct one’s discursive identity in order to participate in science and its associated discourse [and that] a scientific identity is demonstrated through
students’ engagement in the classroom conversations, as well as the broader discursive practices that lead to the development of new conceptual knowledge (2005, p. 270).

Tan and Barton (2007) asserted that “identity formation is a critical dimension of how and why students engage in science to varying degrees” (p. 567) and, significantly, that “identities are constructed socially within communities of practice” (p. 568). This notion was also reported by Osborne et al. (2003) who stated that students need to experience a “felt commitment, a bond with a community” in order to experience a “change in identity” towards a more positive view of science (p. 1073).

Tan and Barton preferred to use the term *identities in practice* rather than *identities* because of the “significant influence [of the] contextual factors of the specific community in practice” (2007, p. 569). They found that different contexts resulted in students “expanding [their] identity kit” to include “a repertoire of identities in practice” demonstrating the fluidity of identity and that non school science contexts such as “a positive learning experience on a field trip with the science teacher” could increase a student’s agency in science classes (2007, p. 570). Identity construction therefore requires the participation of others, not only as people with whom to interact, but also people who recognise and acknowledge someone as a ‘science person’. Tan and Barton found that “girls’ identities may change depending on the context within which they are doing science, depending on who they are with, where they are, and what is motivating them to engage in a certain practice at a particular moment” (2007, p. 571) and that the types of discourse between participants in a community of science practice also contribute to student engagement and identity formation. The researchers found that science teachers played a key role in shaping the classroom environment, which then impacted students’ sense of belonging and learning, for instance by not embarrassing students, or by carefully selecting where students were seated. Teachers had a significant role in improving student learning through contextualizing science concepts with students’ life experiences. Friends and colleagues were also found to be key members of the CoP, who provided nurturing support through taking the time to explain questions, and by making time for thinking and articulating answers for less dominant students. In summary, participation in CoPs was found to be important for developing students’ science identity and therefore directly links with aspects of this PhD study.
Lee (2002) researched high school and university students’ identities related to science, mathematics and engineering (SME) and found that a key reason for girls dropping out of university level SME courses was due to “hostile” educational settings (p. 349), and that students need “many role opportunities” to develop and sustain a ‘future scientist’ identity (p. 352).

An interesting study by Carlone (2004) found that school-based measures of success such as high grades and university admission success prevented girls from developing authentic science identities in a reform-based secondary school physics program designed around situated learning practices. The socio-historical legacy of school science had more tenacity than the researcher expected - the students preferred the traditional approach. Students were more concerned about maintaining their “good” student identities than science learner identities (2004, p. 411).

A similar study (to that of Carlone, 2004) by Farland-Smith (2007) looked at middle school girls’ science identity formation in the context of working “side-by-side” with scientists over a period of five days. The participation of real scientists was a key element of the research study, which was designed to “create a transformative experience for young female students in hopes of broadening their perceptions about scientists, where they work and what they do” (p. 416). It was found that participating students’ attitudes and perceptions of science and scientists were broadened and improved as a result of these interactions, along with an appreciation of ‘Science as a Human Endeavour’. Farland-Smith asserted that changes in perception lead to changes in identity.

In a related study, Finson (2002) reviewed the literature related to students’ perceptions of scientists through the ‘Draw a Scientist Test’ known as the DAST. Several intervention studies on school and university students (usually where students interacted with scientists) showed a reduction of stereotypical images of scientists with the most positive results occurring when interactions transpired over an extended period of time. A key finding was that “the less stereotypical the image one holds, the more probable it is that one will opt to take more science classes and subsequently consider entering a profession in the sciences” (2002, p. 343).

Similarly, American upper primary and lower secondary students at a summer science camp were introduced to the nature of science and scientists. Pre and post comparisons using the DAST indicated that the camp helped the children to realize the human nature of scientists
particularly related to scientists’ hobbies and phobias, with changes being attributed to the age and gender of the camp scientists (Leblebicioglu, Metin, Yardimci, & Cetin, 2011). It is therefore clear that students’ ‘science identity’ formation is intrinsically linked to the types of activities in which they participate and the types of people with whom they are interacting. This has direct relevance to this study, which involved students interacting with scientists-as-mentors and is discussed in both Chapter 4 (related to scientists as mentors) and Chapter 5 (related to students’ interaction with mentors). The influence of the quality of ‘classroom science talk’ on students’ science learning, are expanded in the following section related to students’ learning about the NOS.

Section 2.5.14 Student learning about the NOS

Learning about the practices of science is to learn about the NOS. As outlined earlier, Lederman’s (1992) research review identified teachers’ classroom practices as key to developing students’ conceptions of the nature of science and relates to Tan and Barton’s (2007) findings about students’ science identity formation being influenced by the different contexts in which science is practised. Carey and Smith (1993) advocated that students should learn about the NOS through their schooling experiences, which in their view was mostly lacking. They stated that:

… the standard curriculum fails to address the motivation or justification for using [process] skills in constructing scientific knowledge. Students are not challenged to utilize these process skills in exploring, developing, and evaluating their own ideas about natural phenomena. Rather, instruction in the skills and methods of science is conceived outside the context of genuine inquiry. Thus, there is no context for addressing the nature and purpose of scientific inquiry or the nature of scientific knowledge (1993, p. 245).

Smith, Maclin, Houghton and Hennessey (2000) researched Year 6 students’ development of ideas about the NOS, which they described as their epistemology of science. Two cohorts were taught with either a traditional or constructivist approach to science with the latter developing the most sophisticated NOS views. Contributing factors for students’ NOS development included: authentic inquiry, generative problems, representing ideas in multiple ways, collegial learning communities and metacognitive discourse.

Girod and Twyman (2009) researched the impact of two curriculum approaches –a blended literacy and science unit, and an inquiry science unit– on primary students’: interest in science, science identity, science conceptual understandings, and affect towards science.
They developed a simplified NOS construct suitable for young learners, which included: “(1) science has method(s), (2) science is based on method [sic] and data, (3) science uses observation, tools, and data, (4) people do science and work together, (5) science requires tentative nature of science knowledge, (6) imagination and creativity are used in science” (2009, p. 19). (These constructs were used, in part, to develop NOS attributes for interpreting participants’ interview responses in this research study.) The authors found that students using the blended curriculum had statistically significant higher NOS understandings, higher science conceptual understandings and a higher sense of science identity. The researchers thought that this could be due to students’ greater immersion in “reading, writing and talking like a scientist … [rather than] just acting as one as was done in the inquiry-oriented curriculum” (2009, p. 25). There were no significant differences between the two groups on measures of affect and interest although the inquiry students had slightly higher scores. The researchers surmise that this may be due to a focus on hands-on experiences.

Akerson, Buck, Donnelly, Nargund-Joshi and Weiland found that early years students developed NOS conceptions when they were

… taught these ideas through science investigations that emphasize[d] these ideas and connect[ed] them to content taught at those grade levels. … [S]tudents appeared to be better able to conceptualize scientific creativity, tentativeness, observation and inference as well as empirical NOS than the subjective and social cultural NOS (2011, p. 548).

Following on from these findings, Akerson, Nargund-Joshi, Weiland, Pongsanon and Avsar (2013) investigated the impact of explicit NOS instruction on Year 3 primary students of differing achievement levels. They found that low-achieving students “more readily conceptualize[d] the more concrete NOS aspects such as empirical data and the distinction between observation and inference” while high achieving students developed “more abstract ideas such as the subjective, creative, and tentative NOS” (2013, p. 31).

Murphy, Murphy and Kilfeather (2011) found that students taught by NOS trained teachers developed more elaborate notions of the NOS particularly around aspects of ‘science as a human endeavour’ such as scientists “trying their best … sometimes getting it wrong … getting different answers” (p. 283). These students regarded their school science activities as authentic – that they were really ‘doing science’, with the authors concluding that NOS activities help children to link school science to scientific processes in the ‘real world’.
Feasey has written and researched extensively on ‘thinking and working scientifically’ in primary school settings, which is directly related to the NOS. She identified a number of “tools of the trade” which students need to master to be able to ‘do science’ which include: “using equipment; measuring; recording information, including drawing tables; communicating information, including drawing graphs; and identifying possible risks and controlling obvious risks” (2012, p. 62). To use these skills effectively students need to understand what it means to ‘think scientifically’. Feasey detailed “concepts of evidence” from work by Gott and Duggan in 1995 that are critical for the development of students’ understanding of what it means to ‘do science’ because “when children work without that understanding, they do so only at a mechanistic level, superficially going through the motions of doing and using skills that sometimes characterize primary science practical work and comprise nothing more than busy work” (2012, pp. 62-63). The ‘concepts of evidence’ include ideas and decisions related to: the design of the test; measurement; data handling; and evaluation of evidence (data).

The idea of what it means the ‘think and work scientifically’ has also been addressed by Olson who asserted that:

The important NOS idea that science is a human endeavor [sic] means far more than people doing science – scientists are human and must wrestle with ideas and data that are not at all straightforward. Making sense out of the very messy natural world isn’t easy for scientists and it’s not easy for our students (2008, pp. 44-45).

If teachers, through their pedagogical practices convey the notion that science requires following “a step-by-step method” and the questions asked of them are along the lines of “What does the data tell you? and What does that prove?” (2008, p.43) then they will develop erroneous understandings of the NOS.

Harlen (2009) identified four perspectives from the research literature that she regarded as key to effective science learning for students: “constructivism, argumentation, enquiry and formative assessment” (p. 39). Within these perspectives, Harlen articulated teacher and student roles and described the ideal science teaching and learning scenario as one where: “pupils reveal to themselves, their peers and their teacher their starting ideas through discussion, test them against evidence gathered through enquiry and argumentation, participate in assessing their progress and reflect on their learning processes and outcomes” (2009, p. 40).
Despite the best of intentions to have science curricula designed to provide students with opportunities to experience and gain an appreciation for the NOS, this does not always happen. Hume and Coll (2010) reported on an investigation of New Zealand students’ experiences of their science curriculum and found that impeding factors included: an overemphasis on fair-testing and limited opportunities for students to perform in depth investigations in different contexts.

A similar situation was found in Ireland. Murphy et al. (2012) reported on a national study of Irish primary students’ views of school science and found that students enjoyed hands-on activities but that “there seemed to be few opportunities for children to explore or investigate their own questions or solve their own scientific problems … teacher-led and prescribed activities appeared to be the norm” (pp. 425, 432). Student skill levels for predicting, observing and measuring were limited but were more developed for working collaboratively.

In summary, the optimal conditions identified in the research literature in which students learn about the NOS include: school-based, constructivist teaching approaches by teachers who have a deep understanding of the NOS and are able to facilitate students’ learning in meaningful inquiry oriented contexts –notions that have relevance for this research study.

2.5.15 The influence of participation in communities on students’ science learning

It is discouraging that, despite overwhelming research evidence of the increased effectiveness of student-centred inquiry approaches to learning for promoting students’ scientific understanding and skills and students’ interest in science, many countries persist with teacher-directed modes of primary science education. One of the reasons for this relates to teachers needing to re-conceptualise classroom management when using a ‘science as practice’ perspective. Harris and Rooks (2010) found that teachers who used ‘pervasive management’ in their classrooms achieved greater student learning as discussed earlier in Section 2.5.7.

The notion of students learning about the practices of science through social participation in ‘communities of learners’ was advanced by Rogoff (1994) who stated that “students learn the information as they collaborate with other children and with adults in carrying out activities with purposes connected explicitly with the history and current practices of the community” (pp. 210-211).
Driver, Asoko, Leach, Mortimer and Scott (1994) argued that the development of science knowledge is a process of enculturation because scientific knowledge is discursive in nature. They stressed the importance in science education of appreciating that “scientific knowledge is both symbolic in nature and socially negotiated” and that “the objects of science are not the phenomena of nature but constructs that are advanced by the scientific community to interpret nature” (p. 5). They stated that “learning science involves being initiated into scientific ways of knowing” (1994, p. 6) and occurs in science classroom communities “characterized by distinct discursive practices … [where] students are socialized into a particular community of knowledge” (1994, p. 9). Specifically they identified that “learning science in the classroom involves children entering a new community of discourse, a new culture; [and that] the teacher is the often hard-pressed tour guide mediating between children's everyday world and the world of science” (1995, p. 11), which is also a learning process for the teacher.

A number of studies have looked at the ability of primary students to undertake and participate in sophisticated reasoning and abstract thought patterns related to science concepts. Metz (1995) found that communities of discourse enabled “remarkably rich scientific reasoning on the part of young children” (1995, p. 102) and that “social interaction within the science classroom can help children make their ideas explicit and subject them to criticism” (1995, p. 108). Kelly (2008) identified

… language and communication [as] essential elements in science learning [so] science learning can be viewed as developing a repertoire of discursive practices with which to engage in the knowledge and practices of various social groups. … [and it is] through participation, [that] learners transform these communities, knowledge and themselves (p. 329).

Symmetry in the discourse structures of teacher-student interactions was found by Oliveira (2009) to “allow teachers and students to be on a more equal footing and share authority. As a result, students [were] afforded the opportunity to develop and maintain a sense of authority, ownership, and agency over their science learning experiences” (2009, p. 250), corroborating the importance of student autonomy for their motivation, engagement, attitudes and interest in school science reported by other researchers (Osborne et al., 2003; Hanrahan, 1998; Logan & Skamp, 2008).
Students’ abilities to think in science were enhanced when they explained their science ideas to others (Zoller & Nahum, 2012) and this was attributed to the explainer having

… to think about the problem in question in new ways, translating it in different terms, or generating new examples. These socio-cognitive activities induce the explainer to clarify related concepts, to elaborate on them, and to reconceptualize whatever is involved in some other manner. Thus, by actively interacting with peers and teachers and having relevant information, students will be able to accomplish much deeper understanding rather than just memorizing the subject matter (2012, p. 216).

2.5.16 Students’ perceptions about science, learning science and teaching science: overview of key influencing factors

In summary, the reviewed literature related to students revealed that science attitudes were influenced by: student gender, the teaching approach, teacher enthusiasm, the ability of teachers to link learning with students’ everyday lives, student autonomy, parental science interest and science career expectations, and the influence of family and peers. Student attitudes influenced their interest and engagement with science and included: teachers’ actions in the classroom, parental science interest and parental science career expectations, as well as the classroom environment and student autonomy. Students’ science identity was found to influence science learning, which was socially constructed within particular contexts, while doing activities with others. Teachers played a key role in determining the participants (whether, for instance, professional scientists or technologists were involved), the types of interactions, the style of discourse, and the ‘feel’ of the classroom environment. Student learning about the NOS was enhanced when they participated in: scientific discourse, constructivist teaching approaches, immersion in the practices of science, integration of science across other subject areas, and in-depth student-led opportunities for investigation. Student participation in communities of learners was found to enhance learning about the practices of science so long as students perceived that they had equal participation in the discussion and activities.
2.5.17 Where to from here with primary science education reform initiatives?

The reviewed literature to this point indicates that future primary science education reform initiatives need to principally address primary teachers’ lack of science skills, knowledge and understanding, and how to provide an engaging teaching approach for students which provides opportunities for collaborative, student-led scientific investigations steeped in scientific discourse. Teachers are key to the successful implementation of school-based programs and are more likely to adopt and successfully implement new pedagogical practices when: the reforms are implemented in their own classrooms; student learning is directly experienced and observed; and ample time is provided for acclimation to the new ideas and practices. Interactions between people with science expertise, primary teachers, and primary students provide benefits for all, particularly related to teachers and students being exposed to Science as a Human Endeavour, and the authentic practices of science (NOS). With the exception of MyScience, Australian and New Zealand school-science community initiatives have been described in the science education literature without invoking the notion of communities of practice (even though the language and vocabulary of CoPs is peppered throughout) and have therefore side-stepped using a CoP framework as an analytical construct, an approach that has been used in this PhD research study.

2.6 The MyScience educational model

The MyScience educational model was developed and trialled over the past 7 years specifically in response to government recognition of science education as a national priority in Australia and one of the first four curriculum areas addressed in the development of the National Curriculum. It was also designed to address many of the aforementioned hurdles facing school science education reform particularly the fact that “many primary teachers, both preservice [sic] and inservice, lack confidence in their background knowledge and competence in teaching science” (Fensham, 2008, p. 56).

The key driver in the development of the National Science Curriculum (upon which all state and territory science syllabus documents have been developed) was to develop scientific literacy, in the primary years of schooling through “recognising questions that can be investigated scientifically and investigating them” (ACARA, 2013d). Such scientific literacy requires primary teachers to have a knowledge of science concepts associated with curriculum content, and the pedagogical skills to support student interest and learning in science. MyScience could be regarded as innovative and distinctive, in that structures to
support teacher professional learning, teaching and learning practices, and school-community engagement, are profoundly integrated in the underpinning educational model – see Figure 2.1.

**Figure 2.1. The five elements of the MyScience Educational Model**

The rationale of *MyScience* is the notion of creating an integrated and supportive context within which participants’ skills and confidence in ‘investigating scientifically’ are built through scaffolded learning experiences that promote independence and autonomy. The focus on “increasing the use of open-ended activities and students working in groups” (Goodrum & Rennie, 2007, p. 15) with a consequent move “away from teacher delivery of knowledge” and a focus on “discussion, open questioning and higher-order conceptual explanation” (Tytler, 2007, p. 47), has been shown to improve interest in science for primary students and their communities, and will likely lead to improved scientific literacy outcomes, as articulated in Tytler’s *Re-imagining Science Education* (2007).
Professional learning in *MyScience* engages primary teachers in the processes of scaffolded open-ended scientific investigation and supports them to establish purposeful learning environments in their own classrooms within which students ‘investigate scientifically’. These learning environments make use, over time, of well-briefed ‘scientist’ mentors dedicated to student teams, as well as the encouragement of the wider school community. Mentors typically visit their school on three occasions over a period of four to eight weeks per year for approximately one hour and interact with the same two groups of two to three students who are each investigating the answers to their own question around a class theme. Two examples of investigations related to, firstly ‘forces’ and secondly ‘natural disasters’ include: ‘Which shoe sole is the best for icy conditions?’ and ‘What is the best shape for a levee to disperse water from a tsunami?’. Mentors are also invited to attend the celebration of achievement.

*MyScience* aims to establish sustainable communities of practice between schools, industry/business and universities and to stimulate interest and enhance capacities of primary science teachers and students in conducting authentic scientific investigations. Teacher expertise and confidence are advanced through purposeful and continuous professional learning, provided by expert facilitators. Primary students are mentored by people with science expertise in face-to-face classroom sessions. Achievements are acknowledged and showcased in school Science Fairs during National Science Week and then submitted to their Science Teacher Association award scheme, with winning entries advancing to the National BHP Billiton Awards. Through its development over the last 7 years, *MyScience* has provided valuable insights into key aspects of primary science teaching and learning. Research findings on the successful developmental phases of the program have been partially published (Forbes & McCloughan, 2010; Forbes & Skamp, 2013a; Forbes & Skamp, 2013b) and are presented in full in the following chapters of this thesis. *MyScience* has evolved as an urban school-community initiative and research findings suggest likely ‘conditions’ for replicating rural successes and has produced evidence of ‘learning outcomes’ proceeding from its approach. The school-community model underpinning *MyScience* provides an indication of how the initiative could be ‘embedded in the science curriculum’. Furthermore, the *MyScience* project partially addresses Rennie's (2007) call for “more comprehensive evaluation… [of community-based] science programs to judge their effects in both the short and long term, and to examine the reasons for them” (p.184).
This literature review has identified where there are gaps in the published research related to primary science education reforms in urban school-community initiatives, and as indicated in various places in this review, how this study’s research questions and research design are underpinned by the current literature as well as how it is addressing these ‘gaps’. The final section (Section 2.7) details how the literature review addresses aspects of the research questions.

2.7 Summary and how the literature review addresses aspects of the research questions

This review of the research literature has highlighted a number of issues, which led to the research questions outlined in Chapter 1. Although science education is held in high regard by many governments, primary science education continues to have implementation problems globally, nationally and locally in NSW. Many approaches have been developed and implemented in Australia to mitigate compounding factors. The development and implementation of a new Australian Science curriculum has re-focused attention on the notions of Science as a Human Endeavour (SHE) and Science Inquiry Skills (SIS). School based reforms using community-linked initiatives in rural and regional areas have been particularly effective at incorporating aspects of SHE and SIS, and research findings indicated the presence of developing communities of practice although this was not a lens used by researchers. Community-linked initiatives in Australian metropolitan settings have not been researched.

‘Communities of learners’ and ‘communities of practice’ differ with respect to the focus of learning. An identifiable domain of interest indicates the presence of a CoP. Learning in communities of practice (CoP) is influenced by: the setting (learning context); the participants (numbers and types of learners); and the types of interactions between participants (activities, discursive practices) –all of which contribute to participants’ sense of belonging, identity and agency within the CoP, and hence to the functionality of the CoP. Various researchers have linked CoPs with the notions of social constructivism, Vygotsky’s Zone of Proximal Development, learner agency, and teacher professional learning and there has been a call for future CoP research to focus on factors related to Cop development.

As stated in Chapter 1, the research questions relate to mentors’, primary teachers’ and primary students’ perceptions of their involvement in a CoP associated with open-ended scientific investigations and how this influenced their views about science, science learning and science teaching. The research literature associated with each of these aspects is detailed
below in Table 2.5 where the identified sections in this review are aligned with relevant aspects of the research questions.

The remaining chapters in this thesis cover the methodology used to gather and analyse the data (Chapter 3), the interpreted findings of the lived experiences of the interviewed participants (Chapter 4: mentors, Chapter 5: primary teachers, Chapter 6: primary students), and a synthesis of the combined findings (Chapter 7).
Table 2.5. Aspects of the research questions and how they correlate with sections in the literature review

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<tr>
<th>Aspect of research question</th>
<th>Section (number and title) of literature review</th>
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<tr>
<td>Teachers: factors influencing science learning and science teaching practices</td>
<td>2.5.2 Interaction of classroom practices and teachers’ perceptions about the value of changing their practices</td>
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<td>2.5.3 The influence of teachers’ practices on student learning</td>
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<td>2.5.4 The influence of context on teachers’ learning</td>
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<td>2.5.5 Teachers’ beliefs about the nature of science</td>
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<td>2.5.6 CoPs and teachers’ professional learning</td>
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<td>2.5.7 Teacher factors influencing students’ opportunities to experience authentic science activities</td>
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<td>2.5.8 The significance of time for effective teacher professional learning</td>
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<td>2.5.9 Teachers’ perceptions about science, learning science and teaching science: overview of key influencing factors</td>
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<td>Scientists-as-mentors factors influencing science learning and science teaching practices</td>
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<td>Students factors influencing science learning and science teaching practices</td>
<td>2.5.11 Factors influencing student motivation and engagement in school science</td>
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<td>Communities of practice (CoP)</td>
<td>2.4.1 Bases and initial attributes of CoPs</td>
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<td>2.4.2 Changing notions of a CoP</td>
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<td>2.4.3 ‘Communities of practice’ and ‘communities of learners’</td>
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<td>2.4.5 ‘Identity’, ‘practice’ and ‘participation’ in a CoP</td>
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<td>2.4.6 Use of ‘communities of practice’ as a construct for analyzing learning</td>
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<td>2.4.7 CoPs and science learning</td>
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<td>2.4.8 Attributes of the Nature of Science as a CoP characteristic</td>
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4 The main research question is as follows, where ‘stakeholders’ refers to mentors, primary teachers and primary students: What are stakeholders’ perceptions of their involvement in MyScience and how does being in a ‘community of practice’ around ‘investigating scientifically’ influence their views about science, science learning and science teaching?
Chapter 3

Research Design and Methods

3.1 Introduction and chapter structure

This research study was organised “around [its] research questions” as in Punch’s (1998, pp. 41-42) ‘model of research’ (also cf. Bouma & Ling, 2004; Crotty, 1998). Key elements in Punch’s model (also see Bouma & Ling, 2004) include identifying research questions, which are then used to: determine “what data (are) necessary to answer those questions”, plan the research “to collect and analyse those data”, and use “the data to answer the questions” (1998, pp. 41-42).

In this thesis, ‘data’ includes: field notes, interview tapes (and their transcriptions), emails and student work samples (because they had relevance to this inquiry). This perspective on what qualifies as data has been derived from those qualitative researchers such as Erickson (2012) who do not regard field notes, interview tapes (and their transcriptions), videotapes and other documents retrieved from participants as data *per se*: Erickson’s preferred term is “resources for potential data” (p. 1458, emphasis in original). These ‘information sources’ are considered to give rise to, or become data when a decision is made to include them because they have relevance to the inquiry (as is the case for the above sources).

The derivation of the research questions was outlined and justified in Chapters 1 and 2 and will be briefly restated in the following sections (3.3.1 and 3.3.2) to provide salient background information for the reader. This chapter describes the processes used to answer the research questions using the previously mentioned key elements (Punch, 1998) and therefore addresses:

- the type of data that needed to be collected (Section 3.2);
- the design of the steps, procedures and methods to collect (Section 3.3) and analyse the data (Section 3.4);
- how the data was used to answer the research questions (Section 3.5).

This chapter provides an audit trail for this research study (and hence the reader). The ways in which unintentional researcher bias were minimized are outlined and include: the role of the researcher as an observer of participant practices associated with the *MyScience* program’s implementation and progression (Section 3.2); the steps previously described (Sections 3.3, 3.4, 3.5); ethical considerations related to data collection (Section 3.6);
credibility, trustworthiness and transferability of the findings (Section 3.7); and strengths and limitations of the research study (Section 3.8). Section 3.9 provides a summary of the chapter.

3.1.1 Overview of the research context, significance and research questions

As outlined in Chapters 1 and 2, there is an identified need to provide primary teachers with research-based, expert-supported, classroom-located professional learning opportunities in primary science education where students work towards being able to independently question, test and evaluate their developing ideas in science. The aim is to increase primary teachers’ skills, knowledge and efficacy of what it is that scientists ‘do’, so that they may facilitate the development of students’ understandings of the nature of science.

*MyScience* was designed with these elements in mind, but to date, there has not been an in-depth study of participants’ views of their participation or of the learning that may be fostered in such CoP settings. This is important because an understanding of the enabling aspects or barriers for *MyScience* implementation can be used to nurture the development of communities of science practice in primary schools.

The main research question was:

*What are stakeholders’ perceptions of their involvement in MyScience and how does being in a ‘community of practice’ around ‘investigating scientifically’ influence their views about science, science learning and science teaching?*

The contributing questions were:

*What are mentors’ perceptions of their involvement in MyScience and how does being in a ‘community of practice’ around ‘investigating scientifically’ influence their views about science, science learning and science teaching?*

*What are teachers’ perceptions of their involvement in MyScience and how does being in a ‘community of practice’ around ‘investigating scientifically’ influence their views about science, science learning and science teaching?*

*What are students’ perceptions of their involvement in MyScience and how does being in a ‘community of practice’ around ‘investigating scientifically’ influence their views about science, science learning and science teaching?*
These research questions determined responses to the key elements associated with the research design, which are explained in Sections 3.2, 3.3 and 3.4, that is, the nature of the research questions necessarily determined the planning of the research approach, methods and analyses (Punch, 1998).

3.2 The type of data that needed to be collected

The data required to answer the research questions were participants’ views of their MyScience experiences. Key stakeholders – mentors, primary teachers and primary students – were the participants, whose range of conceptions of the same experienced phenomenon (MyScience) were observed, elicited, collected, analysed, interpreted and described using aspects of phenomenography developed by Marton (1981). This research approach was designed to explore the “qualitatively different ways in which people experience, conceptualise, perceive and understand various aspects of, and phenomena in, the world around them” (as cited in Groves & Tytler, 1995, p. 106) and is described in more detail in the following section.

3.2.1 Elements in the research plan

The framework used to guide this research study was multi-layered and aligned with Crotty’s (1998) four ‘elements’ and the nature of their interactivity: epistemology, theoretical perspective, methodology and methods. Decisions concerning these elements are discussed in this section.

At the broadest level the study’s research focus aligned with a qualitative research approach as defined by Denzin and Lincoln (2005) since the research questions, data and the overall research strategy were concerned with studying “things in their natural settings, attempting to make sense of, or interpret phenomena in terms of the meanings people bring to them” (p. 3). It is the foundation upon which the research design, including its methodology and methods were developed.

The next layer in the research plan related to Crotty’s (1998) epistemological stance of “constructionism” where “meaning is not discovered but constructed … by human beings as they engage with the world they are interpreting” (pp. 42-43), and best described this particular study’s focus. In other words, the contributing ‘constructionist’ elements in the research setting consisted of MyScience participants who constructed meaning through their interactions and interpretations with each other and the environment; and the researcher who constructed meaning through interactions and interpretations with participants in the field,
through interactions and interpretations with participants in interview settings and through interpretations of participants’ interview responses during data coding and analysis.

Deriving from constructionism, this study’s methodology was underpinned by the ‘theoretical perspective’ of interpretivism (Crotty, 1998), as it sought to understand the individual and social reality of the MyScience context as perceived by its participants. The aim of the research was to explore and understand the ‘lived experiences’ (Van Manen, 1997) of participants’ involvement in MyScience with a view to interpreting the meanings that participants attached to their social and human involvement in the phenomenon of MyScience. This aim was determined by the researcher to be best fulfilled through an approach which aligned with many of the aspects of phenomenography, as outlined by Limberg (2008), who described phenomenography as discerning the “various dimensions or facets of a phenomenon as it appears to a number of people” (p. 612). Developed by Marton (1981), phenomenography is an interpretive research approach that looks at the different ways people experience or conceive a range of phenomenon.

Phenomenography is related to, but differs from, phenomenology in the following ways: both phenomenography and phenomenology share the term ‘phenomenon’ which is from the Greek word phainomenon which means ‘to make manifest’ or ‘to bring to light’. Phenomenography, with the suffix ‘graph’ is indicative of a process of describing the phenomenon, and phenomenology, with the suffix ‘ology’ is indicative of a process of studying the phenomenon itself. Thus, phenomenography “becomes the act of representing an object of study as [a] qualitatively distinct phenomenon” (Marton & Booth, 1997, p. 110), whereas phenomenology is the process of investigating the phenomenon in order to reveal its structure or principle of organization — the focus “is concerned with capturing the essence of a phenomenon” (Limberg, 2008, p. 612).

Hsu and Roth (2009) used aspects of phenomenography to study secondary school science students’ experiences of their involvement as interns in a science laboratory (an ‘authentic’ science setting) and how they came to feel as though they ‘belonged’ in the science community. In other words, they used phenomenography to understand and identify notions associated with CoPs, providing an evidence-based reason for selecting the approach for this study.

The focus of a phenomenographic study is on the conceptions that a particular group of people have for a given phenomenon, and so, the researcher attempts, as much as possible, to act as a neutral foil for the ideas expressed by the participants of the study (Limberg,
2008). A phenomenographic researcher tends to collect data through interviews, with the selection of interviewees “guided by the interest [of the researcher] to collect rich material about the phenomenon of study … with the object[ive] of identifying and describing variation in experiences of [the] particular phenomenon” (Limberg, 2008, p. 612). Limberg (2008) went on to describe other features of the phenomenographic approach, which included that: interviews are guided by the research question and are semi-structured, interview questions allow interviewees to express their own views on the phenomenon under study, interviews are audio-recorded and transcribed verbatim, the number of interviewed participants is fifteen to thirty people. All of these features were performed in this particular study except that more individuals were interviewed –fifty-five in total– increasing the likelihood of including a greater range of participants’ perspectives.

Booth concurred with many of Limberg’s (2008) descriptions about how to conduct phenomenographic research, with the following elaborated suggestions. She asserted that the probing of understandings held by individuals should be investigated by “looking at the central notions [of the phenomenon] from a number of perspectives in a deep and open interview”. Analysis should be focused

… on identifying a small number of qualitatively distinct descriptive categories\(^5\) of the ways in which the subjects experience [or understand, or conceptualise] the phenomena of interest. [This] consists of studying the interview transcripts, both individually and alongside one another, studying sets of extracts both in and out of their original contexts, seeking distinct similarities and differences. The researcher immerses himself or herself in the material, trying to see the total meaning in what the research subjects said and did, resolving apparent contradictions, knitting together as whole a picture of the meaning of the phenomenon as possible, not only for individual subjects but also for the group. Eventually a spectrum is seen (Booth, 1997, p. 138).

With these caveats in mind, details of the research design for data collection and analysis are presented in the following sections, but firstly, the role of the researcher is explained.

### 3.2.2 The role of the researcher

The researcher had a dual role –as a facilitator for the MyScience program and as an observer of participant practices associated with the program’s implementation and progression. This privileged position allowed for engagement with participants’ ways of thinking and behaving on multiple occasions both formally and informally about the practice

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\(^5\) The descriptive categories correlate with the assertions and aspects (of assertions) described in
of ‘doing’ (Wenger, 2006a) MyScience. During numerous visits to schools and mentor workplaces the researcher was able to observe and note participating mentor, student and teacher conversations, activities and interactions, which, at times, led to insights that the researcher recorded as field notes. The researcher endeavoured to remain unbiased, alert and receptive to all data when ‘in the field’. Shared activities provided a history between the researcher and participants that potentially reduced feelings of anxiety when being interviewed, which was the main data source for this study – and was consistent with that of a phenomenographic study (see previous section: Limberg, 2008). Many participants willingly emailed the researcher with ‘follow up’ post-interview comments or elaborations as requested, indicating that they were comfortable, at ease and willing to communicate their thoughts. Significantly, all participants were informed during MyScience orientation, implementation and interview sessions that the fundamental, underpinning goal for each school was to develop MyScience in a way that best suited their needs. This, it was hoped, would provide a ‘space’ in which interviewees were comfortable with voicing positive and negative views about ‘how things were going’ and to therefore afford the researcher with the opportunity to collect a comprehensive range of insights into the workings of the various MyScience communities of practice.

3.3 Research design for data collection

3.3.1 Participants in the research

For purposes of contrast (Bogdan & Biklen, 2007) participants were sampled from three MyScience schools: a 2010 ‘first-timer’ (Lave & Wenger 1991) Department of Education and Training (DET) primary school (School A) in Northern Sydney Region6, as well as a ‘fourth-timer’ and a ‘fifth-timer’ DET primary school (School B and School C respectively) in Western Sydney Region. All schools had a similar number of students (600-650). The main source of mentors varied for each school and was largely determined by each school’s location and proximity to a sustainable source of mentors. Partnerships were initiated by the researcher in her role as a facilitator of the program.

Demographic information for each of the three participating schools at the time of the study and how this related to MyScience participation is detailed in Table 3.1.

6 At the time of the study, the Sydney metropolitan area comprised four Regions in the government-run public education system.
Table 3.1. School demographic data for this study

<table>
<thead>
<tr>
<th>School code</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSW DET Region</td>
<td>Northern Sydney</td>
<td>Western Sydney</td>
<td>Western Sydney</td>
</tr>
<tr>
<td>Total number of students</td>
<td>628</td>
<td>607</td>
<td>649</td>
</tr>
<tr>
<td>Total number of classes</td>
<td>28</td>
<td>23</td>
<td>24</td>
</tr>
<tr>
<td>Number of MyScience students</td>
<td>60</td>
<td>300</td>
<td>150</td>
</tr>
<tr>
<td>Number and ‘type’ of MyScience classes</td>
<td>2 enrichment classes Year 5/6 &amp; Year 4/5</td>
<td>10 mainstream classes across Year 3-6</td>
<td>5 classes: 2 ‘opportunity classes’ (OC)* and 3 mainstream classes across Years 3-6</td>
</tr>
<tr>
<td>MyScience participation frequency of school</td>
<td>First-timer</td>
<td>Fourth-timer</td>
<td>Fifth-timer</td>
</tr>
<tr>
<td>Main source of mentors</td>
<td>Professional astronomers</td>
<td>Professional engineers &amp; local secondary school science teachers and students</td>
<td>Pre-service secondary school science teachers &amp; local secondary school science teachers and students</td>
</tr>
</tbody>
</table>

* OC classes are a NSW government initiative in primary schools. Each class comprises 30 students in their final two years of primary schooling. Students are academically gifted and have the same teacher over the two years. Demand for each academic placement is high and is determined through a competitive process of internal and external school assessments.

At the time of the study in November 2010 (Forbes & McCloughan, 2010), School A had 628 students in 28 classes and MyScience was being introduced into two enrichment classes: a composite 4/5 (students aged 10–11 years) and a composite 5/6 (11–12 years) class, 60 students in all. School B had 607 students in 23 classes. MyScience had been operating in the school for four years mostly in the Year 3–6 primary classes (9–12 years) involving 300 students. School C was demographically similar to School B and at the time of the study had 649 students in 24 classes. MyScience had been operating in School C for five years, beginning in the two Opportunity Classes (OC) in 2006. Table 3.2 contains a summary of participant and interviewee demographic data for each of the schools in the
study. At the time of writing, Schools A and B (with mentors sourced from company ABC) had thriving communities of practice in four and three Stage 3 (Years 5 and 6) classrooms respectively. School C, with a recent change of Principal was ‘taking a break’.

Table 3.2. Participant and interviewee demographic data in the study

<table>
<thead>
<tr>
<th>School code</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSW DET Region</td>
<td>Northern Sydney</td>
<td>Western Sydney</td>
<td>Western Sydney</td>
<td>3</td>
</tr>
<tr>
<td>Number and ‘type’ of mentors</td>
<td>6 astronomers</td>
<td>22 engineers</td>
<td>29 Pre-service secondary science teachers</td>
<td>85</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8 Pre-service secondary science teachers</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5 school community members*</td>
<td>5 secondary school science teachers</td>
<td>10 secondary school students</td>
<td></td>
</tr>
<tr>
<td>Number of interviewed mentors (Chapter 4)</td>
<td>6 astronomers</td>
<td>5 engineers</td>
<td>4 science teachers, 5 Year 9 students</td>
<td>20</td>
</tr>
<tr>
<td>Number of MyScience teachers</td>
<td>2</td>
<td>10</td>
<td>5</td>
<td>17</td>
</tr>
<tr>
<td>Number of interviewed teachers (Chapter 5)</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Number of MyScience students</td>
<td>60</td>
<td>300</td>
<td>150</td>
<td>510</td>
</tr>
<tr>
<td>Number of interviewed students in Years 5 &amp; 6 (Chapter 6)</td>
<td>9</td>
<td>8</td>
<td>10</td>
<td>27</td>
</tr>
</tbody>
</table>

* These mentors were people with science expertise sourced from the local school community and were typically students’ parents, grandparents or other close relatives, and retired science teachers who lived close to the school.
At the time of the study there were: 85 mentors in the three schools, of which 20 were interviewed; 17 primary teachers of which 8 were interviewed; and 510 primary students of which 27 were interviewed: fifty-five people were interviewed in total. The number of interviewed participants in each stakeholder group was determined by several factors. Creswell (2007) recommended interviewing 5-25 individuals who had experienced the phenomenon (in a phenomenological study) and Limberg (2008) recommended 15 to 30 people (in a phenomenographic study). These recommendations, participants who actually agreed to participate, and the time and resources available to the researcher determined the final number of interviewed participants for the study.

All interviewed participants were allocated pseudonyms as follows: scientist mentors at School A began with the letter ‘S’; engineer mentors at School B began with the letter ‘E’; Year 9 student mentors and secondary science teacher mentors at School C began with the letter ‘C’; primary teachers and primary students at School A began with the letter ‘A’; primary teachers and primary students at School B began with the letter ‘B’; primary teachers and primary students at School C began with the letter ‘C’.

Details of the interviewed participants and how they came to be selected are described in the following and in Section 3.3.2. Table 3.3 contains demographic data for each of the participants in the study. Thirty-three of the fifty-five interviewees (~63%) were first timers, twelve (~23%) were second-timers, four (~8%) were third-timers, four (~8%) were fourth timers and one person (~2%) was a fifth-timer.
Table 3.3. Participant demographic data for each of the interviewed participants in the study

<table>
<thead>
<tr>
<th>School code</th>
<th>Teacher name and gender (M/F)</th>
<th>Schooling year taught</th>
<th># times in MyScience</th>
<th>Classroom experience (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Angela (F)</td>
<td>5/6</td>
<td>1</td>
<td>20+</td>
</tr>
<tr>
<td></td>
<td>Amy (F)</td>
<td>3/4</td>
<td>1</td>
<td>20+</td>
</tr>
<tr>
<td>B</td>
<td>Beth (F)</td>
<td>6</td>
<td>3</td>
<td>20+</td>
</tr>
<tr>
<td></td>
<td>Brian (M)</td>
<td>6</td>
<td>1</td>
<td>15+</td>
</tr>
<tr>
<td></td>
<td>Bridget (F)</td>
<td>4</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Bettina (F)</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>C</td>
<td>Cathy (F)</td>
<td>5/6</td>
<td>4</td>
<td>20+</td>
</tr>
<tr>
<td></td>
<td>Chris (F)</td>
<td>5/6</td>
<td>3</td>
<td>20+</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>School code</th>
<th>Mentor name and gender (M/F)</th>
<th>Adult (A) or student (S)</th>
<th># times in MyScience</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Sam (M)</td>
<td>A</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Scott (M)</td>
<td>A</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Scan (M)</td>
<td>A</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Stan (M)</td>
<td>A</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Sasha (F)</td>
<td>A</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Spencer (M)</td>
<td>A</td>
<td>1</td>
</tr>
<tr>
<td>B</td>
<td>Elana (F)</td>
<td>A</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Eric (M)</td>
<td>A</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Emily (F)</td>
<td>A</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Evan (M)</td>
<td>A</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Ezra (M)</td>
<td>A</td>
<td>1</td>
</tr>
<tr>
<td>C</td>
<td>Carol (F)</td>
<td>A</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Carmel (F)</td>
<td>A</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Colin (M)</td>
<td>A</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Charles (M)</td>
<td>A</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Caitlyn (F)</td>
<td>S</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Candice (F)</td>
<td>S</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Carla (F)</td>
<td>S</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Cassandra (F)</td>
<td>S</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Catherine (F)</td>
<td>S</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>School code</th>
<th>Student name and gender (M/F)</th>
<th>Schooling year</th>
<th># times in MyScience</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Amy (F)</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Adam (M)</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Alex (M)</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Amanda (F)</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Anne (F)</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>April (F)</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Ava (F)</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Alan (M)</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Andrew (M)</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>B</td>
<td>Blake (M)</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Bob (M)</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Brad (M)</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Brett (M)</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Becky (F)</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Bella (F)</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Ben (M)</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Bill (M)</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>C</td>
<td>Carla (F)</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Cassius (M)</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Connor (M)</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Candy (F)</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Carmen (F)</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Callum (M)</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Cameron (M)</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Chad (M)</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Cid (M)</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Clint (M)</td>
<td>6</td>
<td>2</td>
</tr>
</tbody>
</table>
School A participants

All School A participants except one were ‘first-timers’ (Lave & Wenger, 1991) in MyScience. Professional astronomers and local school community members were mentors for the two MyScience classes. The six astronomers (five male and one female) were based approximately five kilometers from the school and all agreed to participate in the research study. They were given the following pseudonyms –Sam, Scott, Sean, Stan, Sasha and Spencer. All mentors were first-timers with the exception of Sam, who had been a mentor on two previous occasions.

In School A the key MyScience teacher (first-timer) was Angela, a Year 5/6 enrichment class teacher with more than 20 years of classroom experience. The only other teacher in School A that participated in MyScience was Amy, also a highly experienced teacher on a Year 3/4 class. Both agreed to be interviewed.

The interviewed students at School A included: five females – one in Year 5 (Amelia) and four in Year 6 (Amanda, Anne, April, Ava); and four males – two in Year 5 (Adam, Alex) and two in Year 6 (Alan, Andrew).

School B participants

Professional engineers were the main source of mentors for School B. They worked for a company, pseudonymously known as ABC, which was located about five kilometres from the school. Six engineers were identified for the study (see the next section –Section 3.3.2– for details of participant selection procedures), and five were available at the time of interviewing. Their pseudonyms were: Elana, Eric, Emily, Evan and Ezra.

The four School B teachers that agreed to be interviewed had experienced MyScience from one to three times and had taught students in Years 3, 4 and 6. The key MyScience teacher (third-timer) was Beth, a Year 6, highly experienced classroom teacher. Additional teachers interviewed at School B included: Bridget, a Year 4 (second-timer) teacher with 5 years of classroom experience; Brian, a Year 6 (first-timer) experienced teacher and Bettina, a Year 3 teacher (first-timer) with 2 years of classroom experience.

All interviewed primary students from School B had previously participated in MyScience at least once, with three students being experienced old-timers: Blake and Bella were on their third, and Ben on his fourth round of participation. As with School A students, these
interviewees were from both Years 5 and 6 but the only two female students (out of a total of eight) – Becky and Bella, were from Year 6.

**School C participants**

Pre-service secondary science teachers, local secondary school science teachers and Year 9 science students were mentors at School C. Pre-service secondary science teachers were only given a single opportunity to experience being a *MyScience* mentor and were not interviewed for this study. School community mentors (see footnote, Table 3.2) were also not interviewed for this study due to labour and time constraints on the researcher. The secondary school was located less than 5 kilometres from School C, resulting in a similar (minimal) travel distance for the mentors at each of the three participating schools.

Four science teachers and five Year 9 students were identified using the procedures described in the following section (Section 3.3.2), so that a range of views of *MyScience* participation was obtained. Participants were given the following pseudonyms – Carol, Carmel and Colin (science teachers), Charles (Deputy Principal and ex Head Science teacher); and Caitlyn, Candice, Carla, Cassandra and Catherine (Year 9 science students): four teachers and five students in total.

The two interviewed School C teachers had both taught the OC classes (Years 5 and 6) and had experienced *MyScience* three or four times. They were therefore typically ‘old-timers’ – similar to Beth and Bridget from School B. Cathy was a Year 5/6 (fourth-timer) experienced teacher and Chris, a Year 5/6 (third-timer) experienced teacher.

As with School A and B students, School C students in this study were from both Years 5 and 6. The three first-timer students were all from Year 5: Carla, Cassius and Connor; while Callum, Cameron, Cid, and Clint (second-timers), Carmen and Chad (fourth-timers), and Candy (fifth-timer) were all Year 6 students.
3.3.2 Selection procedures for participants

Patton stated that: “qualitative inquiry typically focuses in depth on relatively small samples … selected purposefully” and went on to elaborate that “the purpose of purposeful sampling is to select information-rich cases whose study illuminates the questions under study” (1990, p. 169, emphasis in original). Patton described a number of purposeful sampling strategies with the maximum variation sampling strategy identified by the researcher as the one best suited to this study. This sampling technique aimed to identify and interview people with a wide range of MyScience experiences in order to:

… more thoroughly describe the variation in the group and to understand variations in experiences, while also investigating core elements and shared outcomes … [and to also look] for information that elucidates programmatic variation and significant common patterns within that variation (1990, p. 172).

This approach entailed canvassing the views of a wide range of participants and was achieved through snowball or chain sampling –“an approach for locating information-rich key informants” (Patton, 1990, p. 176). This strategy required identifying a key person with knowledge of all participants at their institution who then recommended people for the researcher to approach and invite to participate in the study.

Selection of mentor participants

All of the six astronomers at School A were approached by the researcher and all agreed to participate in the study. The engineers were selected using the two purposive sampling techniques just described: ‘snowball sampling’ and ‘maximum variation sampling’ (Patton 1990) on the advice of the ABC coordinator (Elana) who was asked to identify participants with a range of views of their MyScience participation. Six engineers were invited by the researcher to participate in the study, of whom five agreed to become involved.

Selection of primary teacher participants

In each school, the key MyScience teacher (who was the school contact person for the program) was invited to participate in the research study. The school Principal was asked to recommend additional MyScience teachers with a range of professional development experience, opinions (about their MyScience participation) and gender. All except for two teachers had extensive experience with the program, one of which was the only male participant (Brian). All interviewed teachers were generalist primary classroom teachers.
who, at the start of their MyScience participation, had limited science background knowledge, which is supported by numerous teacher examples and quotes presented in Chapter 5 e.g., Amy p. 181, p. 192, Amy, Beth, Angela, Bridget, p. 192.

**Selection of primary student participants**

The MyScience School Coordinator in each school was asked to identify a gender balance of Year 5 and Year 6 participants with a range of views of their MyScience participation. For School A the identifier was Angela, for School B it was Beth and for School C it was Cathy. All of the teachers were highly experienced (20+ years of teaching – see Table 3.3) and knew their students well. Angela was the only first-timer, with Beth and Cathy having participated in MyScience previously on three, and four, occasions respectively.

**Selection of secondary school teacher and student participants**

Four science teachers and five Year 9 science students were identified using the same sampling techniques used for the engineers and primary students on the advice of the Head Science teacher – Carol – so that a range of views of MyScience participation were obtained. The teachers and students were invited to participate in the study and all agreed.

**3.3.3 Data sources**

In exploring what constituted the MyScience experience a number of data sources were used which included: participant post-participation semi-structured interviews, field observations, emails (see Section 3.3.3.3), and a students’ ‘20 word activity’. These different sources provided data triangulation opportunities, which added “rigor, breadth, complexity, richness and depth” to the study (Denzin & Lincoln, 2005, p. 5). All data sources were associated, or connected with participants’ perceptions of their MyScience involvement and so could be used to corroborate or identify discrepancies. For instance, at times, different people described the same event, activity or conclusion from entirely different perspectives indicating its authenticity such as when Ben, a fourth-timer primary student reflectively commented that MyScience participation had enabled him to apply science knowledge into new contexts (including real world issues) a notion which was also independently raised by Beth, a teacher at his school. Another example involved reflective comments made by one group of stakeholders about themselves, which were corroborated by the researcher’s field observations: teachers from different schools described a
transformation in their own understanding of how to teach science, which was evident from their changed classroom practices and confidence when implementing MyScience in subsequent years. And finally, students’ views of MyScience through interviews were largely corroborated by the findings of the ’20 word activity’. The design, procedures and protocols for data collection from each of these sources are described in the following.

3.3.3.1 Semi-structured interviews

Although a range of data sources were used, interviews were the main source, and aligned with the data collection approach of phenomenography recommended by Limberg (2008). Questions were worded to precipitate participants’ recall of their lived experience of participating in MyScience and to encourage them to describe vignettes that elaborated on their dialogue.

3.3.3.1a Interview question design

Interview questions, and their purpose, are presented in Table 3.4. Their intention was to precipitate participants’ recall of thoughts and phenomena of their lived experience of participating in MyScience and to encourage them to describe vignettes that elaborated on their dialogue. Interviews commenced with some introductory questions, followed by probing and specifying questions to pursue and elaborate initial responses – in line with suggested phenomenographical interviewing protocols by Limberg (2008). Questions were intentionally phrased to avoid hints or statements alluding to the dimensions associated with the community of practice (CoP) conceptual framework of this study. Therefore, attributes\(^7\) associated with communities of practice (CoPs) or the nature of science (NOS), were not ‘planted’ in the minds of the participants and so their responses were considered to be without prejudice. Further, initial questions were ‘broadly framed’ becoming more specific and probing later in the interview – a strategy that is consistent with Kvale’s (2007) interviewing advice.

\(^7\) The derivation and nature of attributes related to ‘communities of practice’ and the ‘nature of science’ are described in detail in Section 3.4.1 and Table 3.6.
Table 3.4. The interview questions and the purpose for asking them

<table>
<thead>
<tr>
<th>INTERVIEW QUESTION</th>
<th>PURPOSE OF INTERVIEW QUESTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. How long have you been doing MyScience?</td>
<td>Duration of involvement, acknowledgement of participation, view of participation in own right.</td>
</tr>
<tr>
<td>2. What does it mean to be ‘doing’ MyScience?</td>
<td>Details about functioning as a member of MyScience, nature of the practice associated with involvement.</td>
</tr>
<tr>
<td>3. What have you got out of doing MyScience?</td>
<td>Personal benefits, hopes, membership views, interactions with others.</td>
</tr>
<tr>
<td>4. What’s the difference between doing MyScience compared with doing ‘normal’ science?</td>
<td>Comparison of MyScience practices compared with other school science practices, nature of ‘doing’, NOS.</td>
</tr>
<tr>
<td>5. What do you think is good or important about the mentors coming in?</td>
<td>View of own role, stories about experiences and interactions.</td>
</tr>
<tr>
<td>6. What do you think the role of the Principal is in MyScience?</td>
<td></td>
</tr>
<tr>
<td>7. What do you think the role of the classroom teacher is in MyScience?</td>
<td>View of other participants’ roles in MyScience.</td>
</tr>
<tr>
<td>8. What do you think the role of the students is in MyScience?</td>
<td></td>
</tr>
<tr>
<td>9. What do you think the role of the parents is in MyScience?</td>
<td></td>
</tr>
<tr>
<td>10. What happens in the Science Fair?</td>
<td>Stories, descriptions of interactions, purpose of Science Fair.</td>
</tr>
<tr>
<td>11. How has MyScience changed for you since you’ve been doing it?</td>
<td>Participation and belonging – notion of peripherality and centrality in functioning of MyScience.</td>
</tr>
<tr>
<td>12. Can you give me a sound bite, or in a nutshell, what is MyScience?</td>
<td>Following previous questions this one should provide a succinct, distilled description of the essence of MyScience.</td>
</tr>
<tr>
<td>13. Is there anything else that you can think of that I haven’t asked you about MyScience that is interesting?</td>
<td>Opportunity to provide supplementary information.</td>
</tr>
</tbody>
</table>

---

8 Holding a Science Fair is the fifth recommended element of the MyScience Educational Model and is described in Chapter 2, Section 2.5.
The interview questions were designed to indirectly provide information related to participants’ views about science, teaching science and learning science, and to therefore contribute towards answering the research questions. Each participant was initially asked how long they had been involved with *MyScience*, what it meant to be ‘doing’ *MyScience* and what they had personally achieved by their involvement. These questions identified if they were *MyScience* ‘newcomers’ or ‘old timers’ (Wenger, 1998a) and whether there were any activities, behaviours or outcomes that the participants viewed as inherently associated with their *MyScience* experience. There were then a series of questions related to the perceived roles of various school stakeholders in *MyScience* as well as participants’ views of their longitudinal experience in *MyScience* and the concluding Science Fair. The penultimate question “Can you give me a sound bite, or in a nutshell, what is *MyScience*?” revisited participants’ perceptions of what it meant to be ‘doing’ MyScience but was asked following considerable dialogue associated with their experiences, with the expectation of eliciting a lucid phrase describing their experience. The final question gave participants the option to expand on and/or to describe aspects of their experiences that had not previously been addressed in the interview.

### 3.3.3.1.b Interview procedures and protocols

Individual face-to-face semi-structured interviews with each of the participants occurred in November 2010, three months after their last MyScience involvement –when they had had ample time to consolidate their thoughts. A typical *MyScience* implementation cycle culminated in a school based Science Fair held during Science Week in August (described earlier in Chapter 2, Section 2.6). All interviews were conducted by the researcher using the same questions in the same order as those in Table 3.4. Interviews were conducted in each participant’s ‘place of work’, at a time of their choosing, in order to minimize disruption to their routines and to be located in a familiar environment.

The interviews lasted between 17 and 75 minutes, with primary students tending to have the shorter interviews. Participants’ responses were taped and then professionally transcribed (using a company named *Outscribe Transcription Services*) for subsequent analysis. Research ethics approvals were obtained and protocols followed in data collection. All participants in the study gave informed consent in writing and were free to withdraw at any time. Section 3.6.2: Ethical Considerations, presents details of the participant recruitment process. Ethical clearance for interviewing participants was obtained from the Southern Cross University Ethics Committee (identified by the code numbers ECN-09-112/August
2009 and ECN-10-153), and the NSW Department of Education and Training (identified by the code number SERAP 2009125). Details related to ethical procedures such as participant Information Letters and Consent Forms are described in Section 3.6.2 and presented in Appendix C.

3.3.3.2 Field observations

As described earlier, the researcher was also a facilitator for the MyScience program, which afforded many opportunities to observe and note participants’ behaviours and practices. These were recorded, at times, in a Research Diary, an extract from which is shown in Appendix A. Occasions when the researcher was in close proximity to participants occurred when she was delivering aspects of the MyScience model (see Chapter 2, Section 2.6 for details) and included: face-to-face collaborative training sessions with teachers, orientation and information sessions to mentors, and class brainstorming sessions with students which were observed by the teacher. The researcher was also often present during mentor school visits as an observer.

3.3.3.3 Emails

Due to the longitudinal, iterative nature of MyScience and the involvement of the researcher as a facilitator, a rapport developed between the adult participants. These relationships enabled follow-up clarification via email, which provided further insights and explanations of teachers’ and mentors’ views and responses to questions about their involvement in the initiative. As an additional source of data they provided triangulation of findings obtained through interviews and field observations.

3.3.3.4 Student ‘20 word’ activity

In order to supplement and to gain deeper insights into interviewed students’ perceptions of their MyScience participation, all students in School A’s Year 5/6 class (n=26) who had Angela as their teacher, were invited (in November, 2010) to participate in an activity (the ’20 word activity’) where they recorded the first twenty words (in order) that they associated with their MyScience experience. Twenty-six students chose to participate. All of their words were entered into an Excel spreadsheet and then analysed for the relationship between their mean rank and the frequency with which the word was cited. These findings are presented in Section 6.2.2.
3.4 Research design for data analysis

Preceding the analysis of the interviews, each transcript was checked against its audio recording for accuracy. Transcribed interviews were imported into the software program, NVivo 8 (QSR International Pty Ltd www.qsrinternational.com/#tab_you), which served as an organizational repository for the data, coding (via ‘nodes’) and interim findings (via ‘memos’). Each interview passed through several iterations of analysis as shown in Table 3.5, the inclusion of which was recommended by Anfara, Brown and Magione (2002). This approach was recommended by Punch (2009) when analyzing qualitative data, and was designed to interpret participants’ experiences and to reduce the considerable quantity of data while maintaining contextual integrity. Both deductive and inductive analyses were conducted –an approach validated by many qualitative researchers such as Patton (2002). The deductive phases (first and second iterations) are described in Sections 3.4.1 and 3.4.2 and an example of how the data were used to answer the research questions is presented in Section 3.5. The data were inductively analysed for arising themes related to the research question and used to create ‘assertions’ and ‘aspects of assertions’ supported by ‘evidence’. This process is detailed in Section 3.5.1.
Table 3.5. Iterations of analysis of interview dialogue

### FIRST ITERATION: PRESPECIFIED CODING USING INTERVIEW QUESTIONS
(within NVivo) – deductive analysis

Sections of interview dialogue were grouped into NVIVO nodes correlating with each interview question (3 interview questions are used as an example below)

<table>
<thead>
<tr>
<th>Node 1. Duration of <em>MyScience</em> participation</th>
<th>Node 2. What does it mean to be doing <em>MyScience</em>?</th>
<th>Node 3. What have you got out of doing <em>MyScience</em>?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration of <em>MyScience</em> participation</td>
<td>What does it mean to be doing <em>MyScience</em>?</td>
<td>What have you got out of doing <em>MyScience</em>?</td>
</tr>
</tbody>
</table>

### SECOND ITERATION: PRESPECIFIED CODING USING ATTRIBUTE GROUPINGS (within NVivo) – deductive analysis

Nodes were developed from interview dialogue associated with ‘community of practice attributes’ and ‘nature of science attributes’

<table>
<thead>
<tr>
<th>COMMUNITY OF PRACTICE ATTRIBUTES</th>
<th>NATURE OF SCIENCE ATTRIBUTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domain</td>
<td>Community</td>
</tr>
<tr>
<td>Inquiry based</td>
<td>Tentative</td>
</tr>
</tbody>
</table>

### THIRD ITERATION: DEVELOPING CODES - ARISING PATTERNS/THEMES RELATED TO RESEARCH QUESTION – inductive analysis

1. Interactions/roles – recognition of teachers’ expertise/role – teacher willingness to accept support /advice from scientists. 2 sources, 2 quotes.
2. Interactions/roles - recognition of teachers’ expertise/role – teacher /scientist interactions – teacher identifies scientist strengths and uses them accordingly. 2 sources, 2 quotes.
4. Learning – teachers – build own scientific knowledge through participation. 2 sources, 4 quotes.
5. Learning – students – scientist role – set up opportunities for student learning. 2 sources, 4 quotes.
6. Learning – students – scientist role – science is fun (will maintain interest in time when science is ‘boring’). 2 sources, 4 quotes.
7. NOS – work of professional scientists – when shared with students – understand their day-to-day activities. 3 sources, 9 quotes.
8. NOS – work of professional scientists – when shared with students – interact with real scientists. 3 sources, 7 quotes.
The first and second iterations of analysis were deductive or ‘pre-specified’ as defined by Punch (2005). Interview Questions (Table 3.4) provided the organizational categories for the first iteration of data analysis, followed by CoP and NOS attributes (Tables 3.6, 3.7 and 3.8) for the second iteration. Both of these steps occurred within the structural framework of the software program NVivo. The third iteration was inductive and involved looking for arising patterns and themes within the rendered data, that is, looking through the data after it was exported from NVivo for further analysis. A summary of each of these phases is described in the following:

First iteration: The interview questions and their purpose were used as organizing categories in this analytical cycle. They were described earlier in Section 3.3.3.1a and Table 3.4.

Second iteration: The derivation and definition of the CoP and NOS attributes used in the second cycle of data analysis, and in the reporting of findings in Chapters 4-7, are described in Section 3.4.1, Tables 3.6, 3.7 and 3.8.

The process for exporting the partially (deductively) analysed data from the NVivo framework is described briefly in Section 3.4.2 and outlined in more detail in Appendix B.

Third iteration: Once exported from NVivo, the data were further analysed (inductively) to look for arising patterns or themes, which were then incorporated into the analytical findings.

By way of explanation of the eight examples in the third iteration of analysis in Table 3.5, Examples 1-3 (listed below) were interpreted as follows:

1) Interactions/roles – recognition of teachers’ expertise/role – teacher willingness to accept support/advice from scientists. 2 sources, 2 quotes.
2) Interactions/roles - recognition of teachers’ expertise/role – teacher/scientist interactions – teacher identifies scientist strengths and uses them accordingly. 2 sources, 2 quotes.

All of these examples had a main organizational category of ‘interactions/roles’ related to ‘recognition of teachers’ expertise/role’. In Example (1), there were two participants (2 sources) who each had something of relevance to say (2 quotes) related to ‘teacher
willingness to accept/support advice from scientists’. In Example 2, there were ‘2 sources’ and ‘2 quotes’ related to ‘teacher/scientist interactions’, related to ‘teacher identifies scientist strengths and uses them accordingly’. In Example 3, there were ‘2 sources’ and ‘3 quotes’ also related to ‘teacher/scientist interactions’ (as in Example 2), but the focus was ‘teacher interactivity/enthusiasm/motivation/involvement’.

Section 3.4.2 and Appendix B present an example of how the analysed data were used to answer the Research Questions using a segment of the Research Findings and Discussion from part of Chapter 3 related to Elana’s views of what it meant to ‘work as a scientist’ related to primary students and teachers. Section 3.5.1 builds on these steps and explicates the development of ‘assertions’, ‘aspects’ and ‘evidence’.

3.4.1 Development of CoP and NOS attribute frameworks as lenses for interpreting interview data

Attribute frameworks derived from the CoP and the NOS literature outlined in Chapter 2, were developed following the collection of the interview data but before the data analysis and then used as lenses to interpret participants’ responses to the interview questions. They provided pre-specified categories for gaining insights into the data from the perspective of answering the research questions and are presented in Table 3.6 (CoP attributes), Table 3.7 (NOS attributes) and a composite collection presented in Table 3.8 (CoP and NOS attributes used in this study). The derivation of the CoP and NOS attributes is described in the following.

3.4.1.1 Derivation of the ‘community of practice attribute framework’

A successful community of practice will contain participants (the community), whose sense of belonging is due to an appreciation and awareness of productive, valued and shared interactions with others (the practice) around an acknowledged area of interest (the domain). As participants become more involved in the CoP they produce artefacts (reification), which support the CoP’s practice and reflect the domain. A strong sense of belonging engenders the development of the community’s practice and this in turn engenders learning. Less successful communities of practice will occur where participants do not have a strong sense of identity or belonging. A diversity of views and expertise amongst participants allows for learning to be distributed throughout the CoP.

Implicit or explicit references to communities of practice attributes, as shown in Table 3.6, were used as a lens by the researcher to assist interpretation of participants’ views of
science, science learning and science teaching, as a consequence of their involvement in *MyScience*. Borg (2009), and Koliba and Gajda (2009) used similar analytical tools and approaches (a CoP lens and a CoP checklist of criteria) in their studies.
Table 3.6. Community of practice attributes found in the *MyScience* initiative

<table>
<thead>
<tr>
<th>COMMUNITY OF PRACTICE ATTRIBUTE</th>
<th>DEFINITION (Wenger-Trayner, 2013)</th>
<th>EXAMPLE in a <em>MYSCIENCE COMMUNITY OF PRACTICE</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>DOMAIN</td>
<td>Acknowledged shared interest area in which members collectively learn from each other</td>
<td>Acknowledged interest in investigating scientifically</td>
</tr>
<tr>
<td></td>
<td>Acknowledged personal learning in investigating scientifically due to the influence of others</td>
<td>Acknowledged others’ learning in investigating scientifically due to own or others’ influence</td>
</tr>
<tr>
<td>COMMUNITY</td>
<td>Members who are collaboratively engaged in activities and discussion related to the domain</td>
<td>Acknowledgement of own role in investigating scientifically</td>
</tr>
<tr>
<td></td>
<td>Acknowledgement of others’ role in investigating scientifically</td>
<td></td>
</tr>
<tr>
<td>PRACTICE</td>
<td>What members ‘do’ when they interact</td>
<td>Description of activities/discussion while doing <em>MyScience</em></td>
</tr>
<tr>
<td>REIFICATION</td>
<td>Products and processes that reflect the CoP’s domain</td>
<td>The creation and/or sharing of artifacts, resources, ideas and explanations related to investigating scientifically</td>
</tr>
</tbody>
</table>
3.4.1.2 Derivation of the ‘nature of science attribute framework’

As described in Chapter 2, a CoP focussed on science learning would have at its core, the discursive practices of science: the ways members engage and participate in the knowledge, conventions and practices of the science community (Kelly, 2008). A justified outcome of a learning trajectory for school participants within a CoP focussed on science would be “the development of an ‘adequate understanding of the nature of science’ or an understanding of ‘science as a way of knowing’”; this is because it was the singular objective for science learning about which Lederman’s review found there was consensus and “strong agreement” (1992, p. 331 – see Chapter 2, Section 2.4.7).

Characteristics of the nature of science (NOS) guided aspects of the design of this study, particularly in the data analysis. A number of researchers have identified key characteristics of the NOS, which essentially fall within Lederman’s definition and parameters, namely, the ‘NOS’ refers to “the values and assumptions inherent to the development of scientific knowledge” (1992, p. 331).

Table 3.7 presents six composite attributes of the NOS applied to primary school settings derived from the work of Girod and Twyman (2009), Liu and Lederman (2007), and Murcia and Schibeci (1999). The six composite attributes are that science is: (1) inquiry based (uses scientific methods); (2) tentative, (3) developmental (builds on the findings of others), (4) subjective, (5) creative, and (6) collaborative. It is acknowledged that several of these NOS characteristics could arguably be aligned against more of the ‘composite collection’ but the key point is that the essence of the NOS is represented by these six attributes. Enmeshed across several of the composite attributes would be scientific intuition, or ‘intuitive thinking’ within scientific contexts (Fensham & Marton, 1992) described in Section 2.4.8.
**Table 3.7. Nature of science characteristics from the work of Murcia and Schibeci (1999), Liu and Lederman (2007)*, and Girod and Twyman (2009)**, with a fourth ‘composite’ column derived from all three papers

|----------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|
| New scientific knowledge is produced as a result of creativity and imagination, coupled with scientific method [3]*** | Scientific knowledge is empirically based (based on and/or derived from observations of the natural world) [2] | Science has method(s) [1]  
Science is based on method and data [2]  
Science uses observation, tools, and data [3]  
Methods mean science is ‘portable’ [6]                                                                 | SCIENCE IS INQUIRY BASED (USES SPECIFIC METHODS LABELED ‘SCIENTIFIC’)                                                                 |
| Scientific knowledge has a temporary status and should not be accepted as unquestionable truth [1] | Scientific knowledge is tentative (subject to change) [1]  
Science requires tentative nature of science knowledge [5]                                                                                        |                                                                                       | SCIENCE IS TENTATIVE                                                                                   |
| Science progresses through continuing research and critical questioning [4]  
Science is dynamic and ongoing, not a static accumulation of information [5]  
Observations of the world are made through coloured lenses built up by prior knowledge, beliefs and theories [6] |                                                                                       |                                                                                       | SCIENCE IS DEVELOPMENTAL (BUILDS ON THE FINDINGS OF OTHERS)                                            |
| Scientists study a world in which they are a part and as such their work is not objective or value free [2] | Scientific knowledge is subjective (theory-laden) [3]                                                                                      |                                                                                       | SCIENCE IS SUBJECTIVE                                                                                   |
| New scientific knowledge is produced as a result of creativity and imagination, coupled with scientific method [3] | Scientific knowledge is partly based on human inference, imagination, and creativity [4]                                             | Imagination and creativity are used [7]                                                                                                    | SCIENCE IS CREATIVE                                                                                     |
| Scientists and the scientific community generally display the professional standards of openness of mind and honesty They are moral and ethical in their approach to their profession [7] | Scientific knowledge is socially and culturally embedded [5]  
People do science and work together [4]                                                                                                         |                                                                                       | SCIENCE IS COLLABORATIVE                                                                                 |
| Observation and inference are quite different [6]  
Scientific theories and laws have a function and are related [7]                                                                                 |                                                                                       |                                                                                       |                                                                                                        |

* Liu and Lederman’s (2007) [*6] and [*7] NOS characteristics are part of the NSW secondary science syllabus and so have not been included in this study, which is focused on primary school settings.

** Girod and Twyman’s attributes were adapted to suit Grade 2 children.

*** Numbers in [ ] in each column identify the original ordinal position of each characteristic within the relevant publication.
Derivation of the ‘composite collection of CoP and NOS attributes framework’

Table 3.8 presents a composite collection of attributes derived from Table 3.6 and Table 3.7. These attributes are referenced in Chapters 4, 5, 6 and 7 as, for instance NOS#1, CoP#3, and have been used as ‘signposts’ to identify where sections of interviews, or explanations within the discussion of each chapter are associated with the identified attribute. Therefore, NOS#1 has been used where there is a link with the notion that: science is inquiry based (uses specific methods labeled ‘scientific’); CoP#3 has been used where there is a link with the notion of practice related to CoPs – what members ‘do’ when they interact. Table 3.8 is a critical referent when reading this thesis and so an additional, laminated, unbound version has been included for the reader’s use. [Table 7.1, which is useful when reading Chapter 7 has also been included on the laminated page.]

Table 3.8. Composite collection of nature of science (NOS) attributes and community of practice (CoP) attributes used in the analysis of MyScience participant data

<table>
<thead>
<tr>
<th>ATTRIBUTE NUMBER (#)</th>
<th>COMMUNITY OF PRACTICE (CoP)</th>
<th>NATURE OF SCIENCE (NOS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attribute</td>
<td>Definition (Wenger, 2013)</td>
<td>Attribute</td>
</tr>
<tr>
<td>1 Domain</td>
<td>Acknowledged shared interest area in which members collectively learn from each other.</td>
<td>Science is inquiry based (uses specific methods labeled ‘scientific’)</td>
</tr>
<tr>
<td>2 Community</td>
<td>Members who are collaboratively engaged in activities and discussion related to the domain.</td>
<td>Science is tentative</td>
</tr>
<tr>
<td>3 Practice</td>
<td>What members ‘do’ when they interact</td>
<td>Science is developmental (builds on the findings of others)</td>
</tr>
<tr>
<td>4 Reification</td>
<td>Products and processes that reflect the CoP’s domain.</td>
<td>Science is subjective</td>
</tr>
<tr>
<td>5</td>
<td>Science is creative</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Science is collaborative</td>
<td></td>
</tr>
</tbody>
</table>
3.4.2 The process for exporting the partially analysed data from the NVivo framework

When each participant’s interview data had been both deductively and inductively analysed related to aspects of the interview questions and the CoP and NOS attributes in Table 3.8, a considerable number of ‘Tree nodes’ were identified within the NVivo structural framework. These nodes were then exported into an Excel spreadsheet and correlated with relevant sections of interview transcripts using the seven steps shown in Table 3.9. Details of this process are described in Appendix B.
Table 3.9. Steps for exporting data from NVivo into an Excel spreadsheet

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Expand all tree nodes</td>
</tr>
<tr>
<td>2</td>
<td>Export List</td>
</tr>
<tr>
<td>3</td>
<td>Tree nodes in Excel</td>
</tr>
<tr>
<td>4</td>
<td>Expand rows to show nodes</td>
</tr>
<tr>
<td>5</td>
<td>Bold column titles</td>
</tr>
<tr>
<td>6</td>
<td>Clear ‘Tree Node’ labels</td>
</tr>
<tr>
<td>7</td>
<td>Retrieve identified quotes/text from NVivo</td>
</tr>
</tbody>
</table>
3.5 How the data was used to answer the research questions

Step 7 in Appendix B (and from Table 3.9) presents the interview data correlated with the Tree Node named ‘work as a scientist’. These words have been extracted and pasted into Table 3.10 below for ease of reference and discussion. The colour coding, italicized words and bracketed numbers are explained below, preceding the table, so that the information contained within the table is easier to interpret.

Table 3.10 contains the data from the interview transcripts of ‘Elana’ and ‘Emily’ in the exact formatting when in NVivo. Each reference has been colour-coded with the participant’s name: yellow for Elana and green for Emily. Direct quotes used in the Mentor Chapter (Chapter 4) are highlighted in blue. Participants’ quotes were used in a similar manner throughout Chapters 4, 5 and 6 to provide evidence of their lived experiences, personal views and particular ways of describing their thoughts.

The italicized words and bracketed numbers signify the following:

- A ‘Reference’ contains a section of the transcript, selected by the researcher that is perceived to correlate with a particular ‘node’. A node is, essentially, a coding category. ‘Tree nodes’ are nodes that may be catalogued in a hierarchical structure, moving from a general category (the parent node) to more specific categories (child nodes). A ‘free node’ is a ‘stand-alone’ node that has no clear logical connection with other nodes. Most of the data in this study was catalogued into tree nodes. The development of tree nodes enabled the researcher to inductively sort, categorise and to become aware of arising themes as the data were analysed. In this way, the researcher gained insights into the data as the layers of detail and complexity unfolded.

- ‘Internals’ are primary data sources within NVIVO. In this study they referred to the audio interview transcripts.

- The bracketed numbers e.g., [0:06:40.6] in ‘Emily, Reference 4’, identified the time (in hours, minutes and seconds) since the beginning of Emily’s interview. This enabled the researcher to quickly and accurately locate and cross-check the transcript with the original recording for the exact words, tone etc. used by the interviewee, thus adding additional insights into the interpretation of the interview responses.
Chapter Three

Table 3.10. Interview data from Elana and Emily at the Tree Node named ‘working as a scientist’

**Elana’s quotes**: P= Participant, I = Interviewer

<Internals\Elana> - § 2 references coded

Reference 1
P: That’s one of the things, that when you are a scientist you are always wanting to have a... you are wanting to be data driven and your measurement techniques and everything are the key, because anyone can have anecdotal things about things being better or worse, but that is the scientist thing to come in and say, “No, no we are going to have the facts and the facts is going to be this.”

I: So when you are doing that with the kids, do you push the line of scientists need measurement? Like you need a measurement or do you just sort of bring that in as an aspect of how you guide them?

P: Yeah, so I wouldn’t say, “This is what scientists would do.” I would just push and say, “But how do you know that it’s better and how are we going to tell people? How are we going to demonstrate that it’s better or worse?” So it could be, I don’t necessarily say that it’s a science thing, except to say that if you are doing an experiment, you need to tell everybody how you are measuring it first and then measure against it. I think fair testing is quite good as well.

I: Yeah.

P: Say, “It’s only fair if you tell people how you are going to measure it first.” Not do the thing and then say, “That one’s better,” so you deconstruct it back to say what made it better and you have got to basically work out beforehand what…

Reference 2
P: We are just normal people.

**Emily’s quotes**: P= Participant, I = Interviewer

<Internals\Emily> - § 4 references coded

Reference 1
My Dad is an engineer, so I grew up in…

I: The household?

P: Pretty much surrounded by engineering. Pretty much there I guess. I’ve always been interested in, in just how things work and I’m always running around, like ‘cause we were in a mining area so…

I: Where was that?

P: Malaysia, tin mining so I’m constantly surrounded by it and just the things that I played with as well. The toys I played with, were always to do with, you know mechanism.

Reference 2
I knew I wanted to do something that was you know, to do with, something do with being creative…

I: Building stuff?

P: Yeah. Just being creative and to design things. So but to come back to where that came from, I wondered whether it was to do with my, the fact you know, had good teachers or whether it was you know just my childhood.

I: Family.

P: And I think that it’s not necessarily enough to have good science teachers who are, I suppose because science is really quite empirical, you, you really as a child need to see how things are applied. And I think because my father was an engineer I could see how the science related to like the world. So I think that’s probably it was a combination of those two things. So you know, you’re saying that you and your husband are heavily science oriented but it’s, I just think it’s a bit abstract when you’re a child to you know, to see science but actually to see it applied. And I think it’s really important to make that
I got really interested in Science I suppose when I was in high school probably because I did quite well in it as well but I particularly was interested in Chemistry first, it made understand why…

I: Everything goes and works.
P: And works, yeah.

P: I’m a design engineer.
I: So you are designing, which is different from the nuts and bolts of chemistry isn’t it?
P: It is but my specialty is using material.
I: Ah, okay so you can look at the reactivity and whatever, stability of materials.
P: Yeah, yeah actually a lot of the mechanical design that you do unfortunately most mechanical engineers aren’t interested in material. They’re interested in physics and mechanisms.
I: They fit totally together?
P: Because it’s just too, it’s just too close principles, like to deal with materials, whereas I’m one of the odd ones that are actually am interested, very much interested in materials. And I always believe if you get the materials right then you can work with those materials. Unfortunately a lot of things are designed badly because they start off with the wrong materials and then they design, you know the geometry for a material that is not suitable and they try and resolve issues that you, you can’t, it’s like trying to stretch a single bed sheet over a double bed. Okay you might sort of get it to fit for a short while but it will always spring back out.
I: Ultimately it won’t, yeah.
P: ’Cause you just can’t change chemistry whereas you can change geometries but you can’t change the chemistry of something.

Limberg (2008) described the objective of phenomenographic analysis as the identification and description of variation in ways of experiencing the phenomenon, and that the research findings are presented as “a limited number of categories of description that illustrate the variation of experiences of the phenomenon” (p. 613). These categories are presented as assertions and aspects (the derivations of which are described in the following) in Tables 4.2, 4.4, 4.5, 5.2 and 6.2. In this study, an assertion correlates with Limberg’s definition of a “category” and an aspect correlates with an “experience” as in “the variation of experiences” (2008, p. 513) – in line with the phenomenographical approach for reporting findings. An example of a ‘category’ is assertion #2: scientists see themselves as valued and integral members of their MyScience community of practice, and value their relationships with teachers and students – see Table 4.1, p. 116.
3.5.1 Assertions, aspects and evidence

Once analysed, the data from each group of participants were presented hierarchically: as a number of assertions, underpinned by aspects, supported by evidence. This is shown in summary form in Table 3.11. Table 3.12 provides an explicit example of the connections between assertions, aspects and evidence based on primary teachers’ findings from Table 5.2 in Chapter 5.

Table 3.11. Number of assertions and aspects representing findings from participants’ views

<table>
<thead>
<tr>
<th>Name of participant group</th>
<th>Number of assertions</th>
<th>Number of aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientist and engineer mentors</td>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td>Secondary science teacher mentors</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Year 9 student mentors</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Primary teachers</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Primary students</td>
<td>2</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 3.12. Example of the connections between an assertion, aspect and evidence from primary teachers’ findings in Table 5.2

<table>
<thead>
<tr>
<th>Category</th>
<th>#</th>
<th>Description of Assertion/Aspect/Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASSERTION</td>
<td>1</td>
<td>Participation in MyScience changed teachers’ views of what it meant to be ‘doing science’ in the primary classroom: these views exemplified CoP and NOS attributes that underpin, in part, the MyScience initiative.</td>
</tr>
<tr>
<td>Aspect</td>
<td>(a)</td>
<td>MyScience legitimized the place of science in the primary curriculum:</td>
</tr>
<tr>
<td>Evidence</td>
<td></td>
<td>- MyScience provided an opportunity to focus on science and resulted in teachers creating resources to support CoP participants.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- MyScience provided an opportunity to integrate literacy, numeracy and information technology (IT) (but this required forward planning).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- MyScience provided an engaging, exciting and interesting way to teach investigative science for both teachers and students that differed markedly to normal school science.</td>
</tr>
</tbody>
</table>
‘Evidence statements’ are summative examples of participant perceptions (derived from interview transcripts) that may be interpreted as corroboration of each assertion. The reported assertions and aspects are the researcher’s interpretations and inferences, from, in part, analysis of participants’ responses to interview questions about their involvement in MyScience and directly relate to the research questions detailed earlier in Section 3.1.1.

Assertions, aspects and evidence related to participants views are reported as follows: scientist and engineer mentors –Section 4.2 and Table 4.2; secondary science teacher mentors –Section 4.3 and Table 4.4; Year 9 science student mentors –Section 4.4 and Table 4.5; primary teachers - Section 5.2 and Table 5.2; and primary students –Section 6.2 and Table 6.2.

3.5.2 Margin notes

To aid the reader with interpreting the findings in Chapters 4, 5, 6 and 7 and with cross-referencing to Table 3.8 (CoP and NOS attributes) and Table 7.1 (‘framework’ and ‘participation’ factors), right hand margin notes have been inserted to correlate with relevant sections of text (identified by dotted underlines – as indicated). For instance, in the example below, ‘the skills of investigating scientifically’ is associated with NOS attribute #1: Science is inquiry based (uses specific methods labeled ‘scientific’)

Chris also felt MyScience gave science “more prominence which I think is really important...” while Cathy saw it as “a way of focusing [her] energies” on the skills of investigating scientifically, which she had previously neglected.

At times, additional margin comments related to CoP and NOS factors in Chapters 4, 5 and 6 such as: ‘collaboration’, ‘old-timers’, ‘perseverance’, ‘border crosser’; and ‘Framework’ and ‘Participation’ factors in Chapter 7 (see Table 7.1) such as: ‘CoP relationships and interactions’, ‘roles and expertise’, ‘M-T relationship’ have been inserted to highlight significant aspects of findings.

3.5.3 Derivation of quotes – inclusion of brackets, deletion of ‘um…, like…’

In the previous section – Section 3.5.2 – [her] has been inserted in the quotation to aid flow and understanding of the quote. Throughout the thesis any words in square brackets, within a quote from a participant, have been selected by the researcher –they are not the participant’s actual words. In the cited example, the quote is written in the past tense ‘Cathy saw’ and so, within the context of the interview (see Appendix D, page 344, line 238) it is plausible to replace ‘my’ with [her] as indicated.
Another example is the quote below from Cathy (a secondary science teacher mentor) in Chapter 4. The source of this quote is presented in Appendix D, pages 345-346, lines 408-531.

The top Year 7 class, when I spoke to them at the start of the year, a number of them had done MyScience … [I]n our Semester One course we have a topic called ‘Investigation’ and up until this year it ha[s] been [a] recipe based investigation, so it really wasn’t [an] investigation, it was … ‘here’s a prac that we can try’ kind of thing. But because a number of them had done MyScience, and because it is mandatory that you do a Stage Four major project with the kids I thought this year we’d try … so I [made] … a scaffold … for them to do … and the top Year 7 class hammered it. They loved it, no dramas. … I had another [mixed ability] Year 7 class… [and] they also got really into it but it was longer process for them.

The quote begins on line 486-487, jumps to 494-501, to 505-506 and then 529-531. Three dots e.g., ‘…’ indicate a break in continuity of the person’s words in a particular sentence. Transcribed sections were selected to represent the intent of Carmel’s responses as clearly as possible, with respect to the research questions.

When an interviewed participant uses many ‘likes’ and ‘ums’ in their responses they have been deleted to improve readability. If a different research focus were in place, for instance, the style of speaking of the interviewees then the 14 ‘ums’ (lines 486, 488, 496, 498, 499, 500, 514, 516, 519, 521, 525, 529, 530) and the 5 ‘likes’ (486, 488, 497, 500, 514, 518) may have been included – a different modus operandi or approach to the data analysis would have been in place.

3.6 Ethical considerations

The following discussion considers a number of issues related to required ethical procedures in a research study of this type and includes: explicating the values and benefits for participants to become involved in the study because this is an aspect of the Information Letter and Consent Form ‘package’ sent to all to invitees; detailing the process of participant consent and anonymity; and providing details of the permissions sought from the necessary ethical bodies associated with the university and the education sector.
3.6.1 Values and Benefits

An aim for this study was to provide insights for the participants and affiliated colleagues into communities of science practice as a model for increasing participants’ engagement, interest and learning about science and science teaching. This goal was addressed through the interview process and in casual discussions between the researcher and participants during school visits. Another potential benefit for participants was the opportunity to be involved with the processes of an educational research study and to gain better understandings of what this entailed.

3.6.2 Participant consent

Participants were selected using the sampling procedures described in Section 3.3.2. The researcher then emailed Participant Information Letters and Consent Forms to all of those aged 18 years or older (each school Principal, scientist mentors, engineer mentors, primary teachers, secondary science teacher mentors), and in the case of primary and secondary student participants, they were provided with hard copies of documents for themselves and to take home to their parents/caregivers. Students received two versions of the forms written with different audiences in mind – one for themselves, and one for their parents. Primary students were invited to attend their interview with a non-speaking friend if they so chose. The purpose and process of the study was clearly outlined in these documents. Only participants who had signed the Consent Form participated in interviews and had their data included in the analysis. All versions of the Information Letters and Consent Forms are located in Appendix C.

3.6.3 Ethical approval

As previously stated, ethical approval for this study was granted by the Human Research Ethics Committee at Southern Cross University and the NSW Department of Education and Training SERAP Committee (ECN-09-112 and SERAP 2009125). Signed consent was obtained from each school Principal, as well as all teacher, student and mentor participants. Student work samples for the ‘20 word activity’, while matched to the class cohort, had no identifying features. The class teacher’s permission to use these documents was also obtained.
3.6.4 Confidentiality

To ensure confidentiality, only the researcher had access to original data and pseudonyms were used for each school, work institution and all participants. The issue of confidentiality was emphasized to participants during data collection, with assurances that this would be maintained during data analysis. All documents used in the analysis were coded and all identifying features removed. Information was stored on the researcher’s personal password-protected computer. Interviews were audio-recorded and uploaded to the researcher’s university password-protected computer. From there, electronic audio recordings were uploaded through a secure system to a professional transcription service: Outscribe Transcription Services. Transcribed documents were then securely downloaded to the researcher’s computer and the documents purged from the company’s computer system upon payment. Transcripts were securely stored on the researcher’s password-protected computer.

3.7 Confidence in the quality of the findings of this research study

There are a variety of ways in which researchers demonstrate ‘quality’ in interpretive research studies. Nearly thirty years ago, Lincoln and Guba (1985) established a common set of criteria for establishing the trustworthiness of a research project and its findings, which included: “credibility – the plausibility and integrity of a study; transferability – whether results might be applied to other contexts than the research setting; dependability – where research processes are clearly defined and open to scrutiny; and confirmability – where the outcomes of the study are demonstrably drawn from the data” (cited in Stringer, 2004, p. 56). More recently, Denzin and Lincoln (2005) suggested four related criteria to verify a research project’s authenticity: trustworthiness, credibility, transferability and confirmability. Creswell and Miller (2000) identified three ‘validity procedures’, which included: identifying and addressing disconfirming evidence, prolonged engagement in the field, and producing thick, rich descriptions, all of which have connections with Denzin and Lincoln’s (2005) four criteria. Freeman, DeMarrais, Preissle, Roulston and St. Pierre (2007) asserted that the term ‘validity’ is “a preferred term for the overall merit of a (qualitative) study” (p. 25) and emphasized the need for researchers to: clearly document procedures used to collect and analyse data; to demonstrate the relationship of claims to data; and to thoughtfully consider the strengths and limitations of the study. The following describes where various aspects of trustworthiness have been incorporated into the thesis, and are highlighted in bold text to aid the reader.
Throughout this thesis the researcher endeavoured to provide detailed information and insights related to: the research context (Chapter 1); the associated research literature (Chapter 2); the research design including methods (Chapter 3); and the findings and discussion of each of the stakeholder groups (Chapters 4-7). Together, these provide evidence of dependability where the research processes are clearly defined and open to scrutiny (Stringer, 2004).

Chapter 1 described the history of the development of *MyScience* and the researcher’s role in the development and implementation of the *MyScience* educational model. This provided evidence of the researcher’s ‘prolonged engagement in the field’ – addressing one of Creswell and Miller’s (2000) validity procedures.

Chapter 3 justified the selection of a phenomenographic research approach to answer the identified research questions, and detailed the methods used to collect, record and analyse data and to then report the findings. Transparency and quality of the research procedures and subsequent findings were addressed by applying Patton’s (2002) analysis processes, documentational tables detailing research procedures (Anfara et al., 2002), searching for and including disconfirming evidence, incorporating researcher reflexivity (defining the researcher’s role), prolonged engagement in the field, collaboration with expert researchers, and triangulation: using different data sources, as well as comparing the views of different participants related to the same event and how their perceptions changed from being a first-timer to an old-timer (Creswell & Miller, 2000)). Research ethics approvals were obtained and protocols followed in data collection, analysis, reporting and storage indicating a required level of external monitoring which added to the ‘quality’ of the research findings.

Chapters 4, 5, 6 and 7 report, justify and discuss findings from the views of key stakeholder groups – mentors, primary teachers and primary students respectively. Thick, information rich descriptions were crafted in Chapters 4, 5, and 6 to provide insights into the lived experiences of the participants, and margin labels with highlighted sections of quotes were used to assist with confirmability to show how the findings were derived from the data.

Chapter 7 brings together emerging inferences from Chapters 4, 5 and 6 through eight recurrent key factors associated with the *MyScience* Educational Model: ‘framework factors’, and factors associated with participation in *MyScience*: ‘participation factors’.
Details of the synthesis of the overall project findings, derived from the detailed findings in Chapters 4, 5 and 6 are presented and explained in Chapter 7.

3.8 Strengths and limitations

The researcher was both an asset and a potential liability in this study. Her key role in the development and implementation of MyScience could be construed as an inherent wish for the program ‘to succeed’. This meant that she had to constantly strive to be impartial and unbiased when interviewing, analyzing data and reporting findings. As a means to address this concern, in the early stages of analysis, and to improve confirmability, interpretations of interview transcripts were checked by an experienced researcher for veracity.

The researcher’s previous professional experiences as a research scientist, primary classroom teacher and primary science and technology teacher enabled her to act as a broker between the worlds of ‘out-of-school’ and ‘in-school’ science. Her experiential understandings provided her with a rare set of insights into the thinking of primary teachers and also of research scientists, potentially enabling a more in-depth interviewing opportunity than would otherwise have been the case.

The limited number of participants, set within a specific context precludes widespread generalisations related to the findings. As Lincoln and Guba (1985) comment, it is for the reader to discern if the findings are transferable to their particular school and community localities, and hence enhance their school’s primary science practice.

On the flip side (what could be viewed as a strength), the limited number of participants were strategically selected in line with published qualitative methodological approaches – for their range of views and for a quantity that was within the researcher’s time constraints– and so could be regarded as an adequate information source for answering the research questions.

Phenomenography as a methodological approach allows “new features of phenomena to appear, carrying new facets and nuances” (Limberg, 2008, p. 613). This knowledge of variation between participant’s ways of experiencing a particular phenomenon, which in this study was participants’ involvement in MyScience, provides insights into the complexity of the development of CoPs and therefore awareness into how to best support the development of such enterprises.
An additional strength of the research study is detailed in Section 3.1.1 related to its significance.

3.9 Summary

The conceptual framework of communities of practice, as articulated by Wenger and others, is the major idea underpinning elements in the research design. The methodological strategy used a perspective that explored the ‘lived experiences’ of the participants (Van Manen, 1997, but also related to Wenger’s CoP concept) to guide data collection from fifty-two participants in three schools. Data were mainly participants’ perceptions of their involvement in the MyScience program, which were analysed using deductive and inductive procedures in order to interpret their views of science, science learning and science teaching as a consequence of being engaged in part of the initiative.

The following three chapters detail the findings and discussion related to key stakeholders as follows:

Chapter 4 – Mentors: including six professional scientists, five professional engineers, four secondary science teachers and five Year 9 science students (MySTics), twenty participants in total;

Chapter 5 – Primary teachers: including two from School A, four from School B and two from School C, eight participants in total;

Chapter 6 – Primary students: including nine from School A, eight from School B and ten from School C, twenty-seven participants in total.
Chapter Four

Mentors’ perceptions of their participation in *MyScience*

4.1 Introduction and chapter structure

As described earlier (Chapters 1 & 3) the main research study was concerned with looking at participants’ views of their involvement in *MyScience* as a ‘community of practice’ (CoP) where participants from different communities came together to work collaboratively on the common venture of ‘investigating scientifically’. Specifically, the study was concerned with how participation in *MyScience* affected participants’ views of science, science learning and science teaching to better understand the complexities of the teaching and learning interface and how participants’ views of their own sense of belonging and/or participating in the *MyScience* CoP changed as they moved from being newcomers – on the periphery of the CoP – to experienced members of the community and thus at the centre of their CoP. The study also fulfils an articulated need for research on the conditions under which schools, universities and businesses can work together sustainably as outlined in Chapter 2.

This Chapter (4) and the two that follow (Chapters 5 & 6) present interpreted findings of the lived experiences of the interviewed participants as follows:

- Chapter 4: mentors (professional astronomers and engineers, secondary school science teachers and Year 9 students),
- Chapter 5: primary teachers,
- Chapter 6: primary students.

Chapter 7 presents a synthesis of the findings from each of these three key stakeholders with a proposed ‘community of science practice’ model for the sustainable implementation of *MyScience*.

Chapter 4 presents the researcher’s interpretations of mentors’ perceptions of their *MyScience* participation. Participants were interviewed and the data analysed according to the procedures described in Chapter 3. All participants (astronomers, engineers, secondary teachers and secondary students) were asked the same interview questions which are presented in Chapter 3, Table 3.4, page 85. ‘Community of practice’ (CoP) and ‘nature of science’ (NOS) lenses were used to analyse and interpret the astronomers’ (n=6), engineers’ (n=5), secondary science teachers’ (n=4) and secondary Year 9 students’ (n=5) perceptions of their involvement in *MyScience*. Relevant literature pertaining to the notion of using
attributes associated with ‘communities of practice’ and the ‘nature of science’ as analytic lenses is detailed in Chapters 2 and 3.

4.1.1 The research question related to mentors

The specific research question that foreshadowed the findings reported in this chapter was:

What are stakeholders’ (here mentors’) perceptions of their involvement in MyScience and how does being in a ‘community of practice’ around ‘investigating scientifically’ influence their views about science, science learning and science teaching?

4.1.2 Definition, role and source of mentors

It is important to note that, within the context of MyScience, people coming into a primary school classroom to work with primary students and teachers were referred to and known as ‘mentors’. As described by Forbes and McCloughan:

mentors provide students with insights into the importance of posing questions, considering possibilities and testing hypotheses. Mentors also provide support to primary students and teachers with science knowledge and advice … [w]hile primary teachers focus on scaffolding the process of investigating scientifically (2010, p.26).

Mentors were sourced from a variety of locations and institutions including local businesses/industries, universities, secondary schools and the school community. The researcher found that schools using locally sourced mentors transitioned into stable and sustainable communities of science practice more quickly than those schools that relied on mentors ‘being flown in’ or sourced externally. Primary and local secondary school partnerships (such as School C in this study) successfully used both secondary students (known as ‘MySTics’ –MyScience Trainees in the classroom) and science teachers as their mentors. These mentors’ perceptions will be presented and discussed within the context of School C in this chapter in Sections 4.3 and 4.4.

4.1.3 The context for the mentor study

Demographic information for each of the three participating schools and participants at the time of the study and how this related to MyScience participation is detailed in Chapter 3, Tables 3.1 and 3.2, pages 76 and 77 respectively.

For purposes of contrast (Bogdan & Biklen, 2007) mentors were sampled from three schools as described in Chapter 3, Sections 3.3.1 and 3.3.2. As a reminder for the reader, an
abbreviated version of the school and the participant contexts follows and then leads into the mentors’ findings.

**School A** was a 2010 ‘first timer’ (Lave & Wenger, 1991) NSW Department of Education and Training (DET) primary school in Northern Sydney Region where astronomers and local school community members were mentors. The six astronomers (five male and one female) were based approximately five kilometers from the school and all agreed to participate in the program. They were given the following pseudonyms – **Sam, Scott, Sean, Stan, Sasha and Spencer**– six participants in total.

**School B** was a ‘fourth timer’ DET primary school in Western Sydney Region where engineers, pre-service secondary science teachers, local secondary school science teachers and Year 9 students were mentors. The engineers with School B work for a company, pseudonymously known as ABC, also located about five kilometres from the school. Six engineers were identified based on the advice of the ABC coordinator (Elana) and five were available at the time of interviewing. They were given the following pseudonyms – **Elana, Eric, Emily, Evan and Ezra**– five participants in total.

**School C** was a ‘fifth’ timer DET primary school in Western Sydney Region where pre-service secondary science teachers, local secondary school science teachers and Year 9 science students were mentors. The secondary school is located less than 5 kilometres from the primary school. There was therefore minimal travel time for all mentors involved with the three schools. Four science teachers and five Year 9 science students were identified using the same sampling techniques as for School B on the advice of the Head Science teacher –Carol– so that a range of views of MyScience participation were obtained. Participants were given the following pseudonyms – **Carol, Carmel, Colin** (teachers), **Charles** (Deputy Principal and ex Head Science teacher), and **Caitlyn, Candice, Carla, Cassandra and Catherine** (Year 9 students): four teachers and five students in total.
4.2 Findings and Discussion: astronomer and engineer mentors

A number of findings emerged from participants’ interviews and these are expressed as nine plausible assertions with supporting evidence.

To aid the reader, assertions #1-5 are those of professional scientists9 (astronomers and engineers) perceptions and Assertions # 6-9 are those of the secondary school mentors (science teachers and Year 9 science students). In line with Anfara et al.’s suggestions to present evidence of ‘methodological rigour and analytical defensibility (in) qualitative research’ (2002, p. 28) each ‘set’ of mentor findings is presented separately (and sequentially) as follows:

1. an ‘overview of findings’;
2. a ‘tabulated summary of assertions, aspects, evidence including relevant NOS and CoP attributes’;
3. each assertion, its aspects and detailed supporting evidence; and
4. a summary of each assertion.

Thus, the astronomers’ and engineers’ views are presented in Section 4.2 and Table 4.1, the secondary science teachers’ views in Section 4.3 and Table 4.4, and the secondary science students’ views in Section 4.4 and Table 4.5. The definition and hierarchy of ‘assertion, aspect and evidence’ in each table and associated findings relate to the data analysis procedure (see Chapter 3, Section 3.5.1) where: ‘evidence statements’ are derived from themes arising from the coding, ‘aspects’ are statements derived from the collection of evidence statements and ‘assertions’ are statements derived from the collection of aspects.

‘In text’ references to assertions are denoted by, for example, [#1] for Assertion #1.

These reported ‘assertions’ and ‘aspects’ are the researcher’s interpretations and inferences, from, in part, analysis of participants’ responses to interview questions about their involvement in MyScience (see the research question in Section 4.1.1). It should be noted that there is overlap between some assertions and aspects with respect to science, science learning and science teaching, and CoP and NOS attributes. For example, the notion of mentors being ‘border crossers’ (CoP activity) in the context of science practices (‘out-of-school’ and ‘in-school’) has a NOS focus and is detailed in Assertion #1(a), while the notion

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9 These findings have been reported in: Forbes, A, & Skamp, K. (2013). Knowing and learning about science in primary school ‘communities of science practice’: The views of participating scientists in the MyScience initiative. Research in Science Education, 43(3), 1005-1028.
of teachers being ‘border crossers’ (CoP activity) in the context of initiating mentors into classroom practices has a CoP focus and is detailed in Assertion #2(b). Another instance relates to the development of students’ ‘scientific intuition’ –a NOS ‘attribute’: In Assertion #1(b) astronomers hope that their presence and interactions with students (CoP activity) will develop students’ ‘scientific intuition’ (NOS focus); in Assertion #2(a) students’ ‘scientific intuition’ is hoped to be advanced through students’ participation in the program –as part of their role– (CoP focus); and in Assertion #4(a) the desire for students to develop scientific intuition is a motivator for astronomers’ participation in the CoP (CoP focus).

As described in Section 3.5.2 and to aid the reader with cross-referencing findings in Sections 4.3 and 4.4 with CoP and NOS attributes in Table 3.8, right hand margin notes have been inserted to correlate with relevant sections of text (identified by dotted underlines – as indicated). The first example in this chapter is as follows:

He was making links between what the children may have experienced (‘doing experiments’ and making ‘observations’) and his work as an astronomer. In so doing he was acting as a ‘border-crosser’10 (Aikenhead, 1996) or ‘culture broker’ (Wenger, 1998a) between the worlds of ‘in-school’ and ‘out-of-school’ science.

4.2.1 Overview of mentors’ views from each of the three schools

An overview of the findings indicates the presence of MyScience communities of science practice in all three schools where learning is viewed as a result of participating in the community of practice (see Chapter 2, Wenger, 1998a).

4.2.2 Overview of astronomers’ and engineers’ views

Participating astronomers and engineers wished to positively influence primary students’ views about science, they were encouraged by their employers to participate in community outreach and most felt that their involvement had been valuable and personally fulfilling [#4]. These professionals viewed themselves, teachers and students as having a synergistic relationship, each with a critical role in the community of practice [#2, #3]. They thought that their interactions with students: exposed students to what scientists ‘look like, how they

10 Here (and in some other places) key words from the interview extracts have been inserted in parentheses to indicate the evidence for the interpretation. In most of the later interpretations the reader will be able to discern from the preceding discussion how they were derived.
Chapter Four

speak and what they think about and do’; that an authentic link was created between the worlds of science ‘in-school’ and ‘out-of-school’; and that it was through these interactions that students’ developed awareness of, and an ability to apply, NOS attributes while investigating scientifically. Some astronomers and engineers hoped that their presence would progress the development of communities of science practice in the classrooms in their absence [#1]. The MyScience framework was viewed as an affordance for developing a community of practice by providing a structure and purpose to guide and enable implementation while teachers’ perceived stress about the amount of work and scientists’ concerns about student questions were viewed as barriers [#5].

Table 4.1 summarises the findings from the astronomer and engineer interviews and identifies related CoP and NOS attributes from Table 3.8.
Table 4.1: Summary of findings from astronomer and engineer interviews where ‘scientists’ refers to the views of participating astronomers and engineers

<table>
<thead>
<tr>
<th>Category</th>
<th>#</th>
<th>Description of Assertion/Aspect/Evidence*</th>
<th>NOS/CoP attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASSERTION 1</td>
<td>1</td>
<td>Scientists believed that their sustained, face-to-face interactions exposed primary students to a range of aspects of science as a human endeavor.</td>
<td>NOS/CoP attributes</td>
</tr>
<tr>
<td>Aspect</td>
<td>(a)</td>
<td>Astronomers and engineers: their human face and their work:</td>
<td></td>
</tr>
<tr>
<td>Evidence*</td>
<td></td>
<td>- Astronomers conveyed aspects of what it means to be a scientist to students.</td>
<td>NOS#1, #6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Astronomers and engineers acted as a border crosser between the worlds of ‘in-school’ and ‘out-of-school’ science.</td>
<td>CoP#2</td>
</tr>
<tr>
<td></td>
<td>(b)</td>
<td>Humans construct scientific knowledge by ‘doing’ science, making discoveries, using scientific intuition and being passionate:</td>
<td></td>
</tr>
<tr>
<td>Evidence</td>
<td></td>
<td>- Scientists wished to convey to students that humans use science as a way to work out how the world works.</td>
<td>NOS#1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Scientists wished for students to develop scientific intuition through interactions with themselves and their peers.</td>
<td>CoP#1</td>
</tr>
<tr>
<td></td>
<td>(c)</td>
<td>Attributes of the nature of science exemplify science as a human endeavor:</td>
<td></td>
</tr>
<tr>
<td>Evidence</td>
<td></td>
<td>- Scientists encouraged scientific discussion, collaboration and creativity amongst students through probing questions.</td>
<td>NOS#1, #2, #5, #6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Scientists used personal experiences to highlight the tentativeness of science to students.</td>
<td></td>
</tr>
<tr>
<td>ASSERTION 2</td>
<td>2</td>
<td>Scientists see themselves as valued and integral members of their MyScience community of practice, and value their relationships with teachers and students.</td>
<td>NOS/CoP attributes</td>
</tr>
<tr>
<td>Aspect</td>
<td>(a)</td>
<td>Scientists’ views of the student-scientist relationship:</td>
<td></td>
</tr>
<tr>
<td>Evidence</td>
<td></td>
<td>- Scientists perceived that they were a resource for students and gained insights into the capabilities of primary students.</td>
<td>NOS#1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Scientists felt valued by students and teachers.</td>
<td>CoP#1, #2</td>
</tr>
<tr>
<td>Aspect</td>
<td>(b)</td>
<td>Scientists’ views of the teacher-scientist relationship:</td>
<td></td>
</tr>
<tr>
<td>Evidence</td>
<td></td>
<td>- Scientists perceived and acknowledged that they were in a partnership with teachers – each playing different and critical roles.</td>
<td>NOS#1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Communities of science practice developed and continued in classrooms in the absence of the mentors.</td>
<td>CoP#2</td>
</tr>
<tr>
<td>ASSERTION 3</td>
<td>3</td>
<td>Scientists’ perceptions of participants’ roles were consistent with a CoP interpretive framework.</td>
<td>NOS/CoP attributes</td>
</tr>
<tr>
<td>Aspect</td>
<td>(a)</td>
<td>Scientists’ views of students:</td>
<td></td>
</tr>
<tr>
<td>Evidence</td>
<td></td>
<td>- Scientists perceived that the students’ role was to interact with scientists and teachers.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Some astronomers initially viewed students’ questions with concern and unease.</td>
<td>CoP#2, #3</td>
</tr>
<tr>
<td>Aspect</td>
<td>(b)</td>
<td>Scientists’ views of teachers:</td>
<td></td>
</tr>
<tr>
<td>Evidence</td>
<td></td>
<td>- Scientists appreciated teacher-generated student scaffolds.</td>
<td>CoP#1, #4</td>
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<tr>
<td></td>
<td></td>
<td>- Scientists appreciated teacher enthusiasm and interest.</td>
<td></td>
</tr>
<tr>
<td>Aspect</td>
<td>(c)</td>
<td>Scientists’ views of the principal and parents:</td>
<td></td>
</tr>
<tr>
<td>Evidence</td>
<td></td>
<td>- The Principal was viewed as an advocate and gate-keeper for MyScience.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Scientists wished for parents to show interest in MyScience activities.</td>
<td>CoP#1</td>
</tr>
<tr>
<td>ASSERTION 4</td>
<td>4</td>
<td>Astronomers and engineers appear to have different motivations and expectations for their involvement in MyScience.</td>
<td>NOS/CoP attributes</td>
</tr>
<tr>
<td>Aspect</td>
<td>(a)</td>
<td>Astronomers’ motivations:</td>
<td></td>
</tr>
<tr>
<td>Evidence</td>
<td></td>
<td>- Astronomers wished to develop scientific intuition and aspects of scientific literacy and to seed interest in and a love of science in students.</td>
<td>NOS#1</td>
</tr>
<tr>
<td>Aspect</td>
<td>(b)</td>
<td>Engineers’ motivations:</td>
<td></td>
</tr>
<tr>
<td>Evidence</td>
<td></td>
<td>- Engineers wished to develop interest in science, seed future career aspirations and to support students to understand links between ‘in-school’ and ‘out-of-school’ science.</td>
<td>CoP#1, #2</td>
</tr>
<tr>
<td>Aspect</td>
<td>(c)</td>
<td>Outreach activities – astronomers’ and engineers’ views:</td>
<td></td>
</tr>
<tr>
<td>Evidence</td>
<td></td>
<td>- MyScience participation was regarded as important and supported by employers of both astronomers and engineers.</td>
<td>NOS#1, #2, #6</td>
</tr>
<tr>
<td>ASSERTION 5</td>
<td>5</td>
<td>Scientists’ linked participants’ learning within MyScience to be due to participation (consistent with a CoP interpretive framework) and identified barriers that need to be addressed.</td>
<td>NOS/CoP attributes</td>
</tr>
<tr>
<td>Aspect</td>
<td>(a)</td>
<td>Enabling aspects of MyScience:</td>
<td></td>
</tr>
<tr>
<td>Evidence</td>
<td></td>
<td>- Serial participation helped teachers build a base of resources, and scientists increased their own knowledge.</td>
<td>NOS#1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- The MyScience educational model provides a framework that brings all participants together with a focus on student-centred learning.</td>
<td>CoP#2</td>
</tr>
<tr>
<td>Aspect</td>
<td>(b)</td>
<td>Barriers to learning ‘as participation’ through a community of practice:</td>
<td></td>
</tr>
<tr>
<td>Evidence</td>
<td></td>
<td>- The work demand on teachers was regarded as an issue.</td>
<td>CoP#2</td>
</tr>
</tbody>
</table>

* Evidence statements are summative examples of participant perceptions (derived from interview transcripts) that may be interpreted as support for aspects underpinning each assertion.
4.2.2.1 Assertion #1 [#1]: Scientists believed that their sustained, face-to-face interactions exposed primary students to a range of aspects of science as a human endeavour (SHE).

It is recommended that the reader refers to Table 3.8: Composite collection of nature of science (NOS) attributes and community of practice (CoP) attributes used in the analysis of MyScience participant data, while reading the findings from Chapter 4. This table is in a removable, laminated sheet as well as on page 96 in Chapter 3.

Three aspects of SHE emerged from the findings and are presented below. Aspect (a) details how mentor interactions with teachers and students showcased the nature of scientists and engineers - their ‘style’ and behaviour - and how mentors linked their ‘out-of-school’ science practices with ‘in-school’ practices; aspect (b) relates to facets of the nature of these mentors’ work activities – their language, thinking and passion for science; and aspect (c) describes nature of science attributes used during mentor-student interactions. Each of these aspects provides evidence for assertion #1. See Section 3.5.1 for the relationship between evidence, aspects and assertions.

Aspect (a): Astronomers and engineers: Their human face and their work

Three inferences/interpretations support this aspect (see ‘evidence’ shown in Table 4.1). They are that firstly, ‘Astronomers conveyed aspects of what it means to be a scientist to students’, and secondly, ‘Astronomers and engineers acted as a border crosser between the worlds of ‘in-school’ and ‘out-of-school’ science’. Furthermore, ‘Scientists’ classroom presence was perceived to reduce students’ stereotypical images of scientists’. The evidence supporting each inference/interpretation follows the inference/interpretation statement (in bold type).

Astronomers conveyed aspects of what it means to be a scientist to students. Astronomers and engineers acted as a border crosser between the worlds of ‘in-school’ and ‘out-of-school’ science. Scientists’ classroom presence was perceived to reduce students’ stereotypical images of scientists.

The interviewed astronomers described how they conveyed aspects of what it means to be a scientist. During school visits Sam said that he:
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... talked about being an astronomer, doing science professionally and basically trying to present it as this is the way people find out about how the world and the universe works and it’s by doing experiments. And in the case of astronomy, the experiments aren’t something we can do in a lab, they’re observations that we can make with telescopes.

He was making links between what the children may have experienced (‘doing experiments’ and making ‘observations’) and his work as an astronomer. In so doing he was acting as a ‘border-crosser’11 (Aikenhead, 1996) or ‘culture broker’ (Jegede & Aikenhead, 1999) between the worlds of ‘in-school’ and ‘out-of-school’ science. Scott had a similar view adding that his involvement in MyScience gave “children the chance to see that you … have a career in science, and that it can be a fun thing to do”. ‘Fun’ was used as an adjective in the context of actually doing an investigation with the students and the enjoyment of discovering new things (with them). Scott was seeing the MyScience venture as collaborative and enjoyable, both of which would engender a sense of participation, of belonging, and of identity (Wenger, 1998a) within the CoP. Spencer, Sean and Stan mentioned that their physical presence in the classroom and their willingness to discuss what they do in their work would help to counter the mainstream view of science “as drudgery with lab coats” and to show students that “we’re just normal people, we’re not wearing lab coats and we … do have social skills” (Stan), and that most science researchers are “young” and “not really old” (Scott).

The engineers expressed similar views, for example, students can see “ … we are just normal people” (Elana). These scientists envisage that their presence will reduce students’ stereotypical images of scientists, a position supported by Leblebicioglu et al. (2011) and Finson (2002), the latter commenting: “the less typical the image one holds, the more probable it is that one will opt to take more science classes and subsequently consider entering a profession in the sciences” (2002, p. 343).

Aspect (b): Humans construct scientific knowledge by ‘doing’ science, making discoveries, using scientific intuition and being passionate

Two inferences/interpretations support this aspect (see ‘evidence’ shown in Table 4.1). They are that firstly, ‘Scientists wished to convey to students that humans use science as a way to work out how the world works’, and secondly, ‘Scientists wished for students to

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11 Here (and in some other places) key words from the interview extracts have been inserted in parentheses to indicate the evidence for the interpretation. In most of the later interpretations the reader will be able to discern from the preceding discussion how they were derived.
develop scientific intuition through interactions with themselves and their peers’. The evidence supporting each inference/interpretation follows the inference/interpretation statement (in bold type).

**Scientists wished to convey to students that humans use science as a way to work out how the world works. Scientists wished for students to develop scientific intuition through interactions with themselves and their peers.**

Scientists were keen for students to gain an awareness that “there is something called science and this is how we work out how the world works” (Sam). Scott agreed, saying that students need to experience this “understanding” but he went further, expressing a desire for students to experience the “addictive” nature of “making that connection”. This relates to a desire to have students experience the actual practices of ‘doing science’ (investigating scientifically) which is inherent in the ‘domain’ attribute [CoP#1] of a MyScience CoP (see Table 3.8). Sam recounted a classroom incident where he witnessed a student “getting that moment of realization” and how important this type of experience had been for him in the past for developing his own deep understanding and scientific intuition, as well as the personal reward that he gained from being part of the event:

… the experiment with the balloon in the freezer –where they could actually measure the circumference of the balloon and see that it had shrunk when the air inside it got cold. And there was one particular girl … who actually, you could tell by the way her face lit up –she just got it. She said ‘Oh the air inside got cold and it shrunk and the balloon got smaller’ and that was that moment of realization when they actually work out something. … That just expression of wonder on their faces is the main reward –that moment of realization. … and so I think giving kids as many opportunities like that to make their own discoveries … so that they can make it their own … They can then build a scientific intuition by seeing how things work for themselves.

This anecdote also suggests that, firstly, science has ‘high and exciting moments’ which students could construe as a ‘facet’ of what could happen when they ‘do’ science and, secondly, how students can develop ‘scientific intuition’ (cf. Fensham & Marton’s (1992) ‘intuitive thinking’).

**Aspect (c): Attributes of the nature of science exemplify science as a human endeavour (SHE)**

Two inferences/interpretations support this aspect (see ‘evidence’ shown in Table 4.1). They are that firstly, ‘Scientists encouraged scientific discussion, collaboration and
creativity amongst students through probing questions’, and secondly, ‘Scientists used personal experiences to highlight the tentativeness of science to students’. The evidence supporting each inference/interpretation follows the inference/interpretation statement (in bold type).

**Scientists encouraged scientific discussion, collaboration and creativity amongst students through probing questions. Scientists used personal experiences to highlight the tentativeness of science to students.**

Sam described how he asked questions to promote scientific discussion, and therefore collaborative interactions around science. He challenged students to “actually have to think, … to come up with an answer … and work out whether that answer [was] reasonable or not” prompting students to qualify their findings and thus experience the ‘collaborative’ essence of the NOS. He also asked questions about their interest areas: “What type of experiment do you want to do, what are you trying to find out about?”, and questions about the ‘scientific inquiry process’: “How do you think you could design an experiment to answer that question? How would you then go about measuring what it is that you’re trying to measure?”

Elana’s recount of the types of questions she would use was similar. She said: “… I wouldn’t say, ‘This is what scientists would do’”, but rather ‘pushed’ students by asking “… [B]ut how do you know that it’s better and how are we going to tell people?” She added: “I don’t necessarily say that it’s a science thing, except to say that if you are doing an experiment, you need to tell everybody how you are measuring it first and then measure against it”.

Sean encouraged the NOS attribute of ‘creativity’ in a discussion related to an unexpected outcome. He challenged students with some unexpected data/information by suggesting that they use a balloon that had been statically charged (by rubbing hair) and to investigate its effects on a stream of water. He explained: “of course they found it was deflected so that really surprised them because it’s outside their experience; they’d never seen something repel water like that before”. Spencer drew parallels with his own experimental data to highlight how rare it is to achieve a good data set –touching on the ‘tentativeness’ of the NOS. He commented:

I talk about the … ups and downs … things like spurious data points … I have very messy data to deal with … and [I] tell them that’s what science is, that’s often the case … good, clean or really clean results are few and far between.
Measurement techniques, appreciating the messiness of science data, and the need for perseverance (‘good, clean or really clean results are few and far between’) are all examples of discursive science practices associated with the ‘doing’ of science which would have come across in the language (‘spurious data points … messy data … that’s often the case …’) of the scientist-student interactions. The notion of scientists helping students to better understand the open-ended, complex and ‘messy’ nature of real-world of science was also noted by Bolstad and Bull (2013, p. 27).

In summary, these scientists were exposing students (and teachers –see Assertion #2) to ‘Science as a Human Endeavour’ through simply being there but also by exemplifying the ‘nature and development of science’ (ACARA, 2013c) through their conversations with students. Here, “human endeavour means far more than people doing science…[humans] must [for example] wrestle with ideas and data” in order to derive meaning (Olson, 2008, p.45). Sean’s example of ‘creativity’ emphasizes this human element, as do Sam, Elana and Spencer’s remarks. Moreover, mentors discussed with students what they did in their professional work (incidentally providing science and engineering career information) and consciously used questions and discussion to promote scientific discourse (‘actually have to think…’, ‘come up with an answer’). Their presence in classrooms challenged media portrayals and misconceptions around their appearance and behaviour. Students were exposed to a number of attributes of the nature of science namely collaboration (‘qualify their findings’), using the scientific inquiry process (‘type of experiment’, ‘trying to find out’, ‘measurement techniques’), creativity (‘really surprised them’) and tentativeness (‘clean results are few and far between’).

4.2.2.2 Assertion #2 [#2]: Scientists see themselves as valued and integral members of their MyScience community of practice, and value their relationships with teachers and students.

It is important to note (and remember) that the interviewed scientists did not describe their involvement in MyScience using CoP terminology such as ‘domain’, ‘community’, and ‘practice’. Inferences, though, related to CoP attributes, can be drawn from their descriptions of the interactions with students and teachers and what they see as the roles of parents and the Principal. As all key stakeholders were aware of the objectives of MyScience prior to voluntarily choosing to join a MyScience community they could be presumed to be ‘on the same page’ in terms of engaging in a common shared interest area or ‘domain’. An acknowledged shared interest area in and of itself does not qualify as a
CoP attribute – there needs to be reciprocal learning between members which engenders a sense of collaboration, of value and of belonging by participants (Wenger, 1998b).

In the following, scientists’ perceptions provide insights into (and are evidence of): the nature of scientist-student relationships –Aspect (a), where scientists perceived that they were a resource for students and gained insights into the capabilities of primary students; and the nature of scientist-teacher relationships –Aspect (b), where scientists felt valued by students and teachers. Each of these aspects underpins Assertion #2. See Section 3.5.1 for the relationship between evidence, aspects and assertions.

**Aspect (a): Scientists’ views of the student-scientist relationship**

Two inferences/interpretations support this aspect (see ‘evidence’ shown in Table 4.1). They are that firstly, ‘Scientists perceived that they were a resource for students and gained insights into the capabilities of primary students’, and secondly, ‘Scientists felt valued by students and teachers’. The evidence supporting each inference/interpretation follows the inference/interpretation statement (in bold type).

**Scientists perceived that they were a resource for students and gained insights into the capabilities of primary students. Scientists felt valued by students and teachers.**

Sam, an astronomer, perceived he was “a resource for the kids to tap into”. He saw students as being:

... the purpose of the whole process and you want to be able to give them as much opportunity to grow, in terms of their understanding of what science is, how science works through the program. The role of the students is to interact with [us] and with their teacher and not be afraid of asking questions and to be encouraged to ask questions so that they can start to build up their own intuition about science.

In other words, Sam had an expectation that students would develop ‘science intuition’ or ‘science know how’ through participation in MyScience – through being a contributing member to their MyScience community.

Engineers commented on the novelty value of having someone “completely new who is focusing all [the children’s] attention” (Ezra), being seen like a “rock star” (Elana), and “… it seems as though they [the children] appreciated that [i.e., the attention, and is] one of the reasons why they were … quite active [and] want[ed] to participate” (Evan). Elana felt the students really valued the scientists’ presence and it made her feel “important to
the kids”. She added “… I think what we are doing is supporting the teachers”. The positive responses from the students generated a feeling in the scientists of belonging to the CoP, and this CoP group included the teachers.

This mutual affective feedback is important for developing a sense of belonging as a member of a CoP and was emphasized by Elana, the engineering company’s coordinator (for the first 3 years of MyScience involvement):

It’s [MyScience] a really, really positive experience and I think it’s very, very, it’s really, really energizing … I always leave the school feeling really, really perky and happy… because … the kids are really happy to see us and they are so open to our … suggestions and they are really, really interested and I think … the teachers are very welcoming and they really appreciate us being there … you really feel that you are making a difference …

These scientists clearly see themselves as playing a significant role in supporting student learning around investigating scientifically, which is supported by findings from Bolstad and Bull who reported that scientists “found it personally rewarding and motivating to contribute to better science learning opportunities for school learners … [and to have] the opportunity to contribute to growing the next generation of scientists” (2013, pp. 44-45). However the scientists also perceived that they had gained new knowledge and understanding about the capabilities of primary school students, that is, reciprocal learning was occurring – an aspect of the domain element of a CoP (Wenger-Trayner, 2013). Sam lauded the students’ capabilities: “people underestimate how bright primary school kids are” a feeling supported by Metz (1995), who stated that: children should be given opportunities to pose questions, gather and interpret data and revise their theories rather than the more common emphasis (in primary schools) on “the processes of observing, ordering, and categorizing the directly perceivable and concrete while relegating scientific investigations to later years” (p. 120).

Sam described that he was impressed

… with how the kids had presented the results of their experiments … how they’d written them up … answered questions about their experiments … that they could explain … what the experiment was that they did, what they were trying to answer, how they did their measurements and what the actual result was, whether the hypothesis was correct or not.

Learning here is participatory and comes about through community members’ interactions. Scientists perceive that students are learning from them (mentors are a
resource, they are ‘new’, they are part of the MyScience CoP, they have special status) and mentors perceive that they are valued (’positive experience’) and also learn from the students (‘about their capabilities to present results …’). This reciprocal participatory learning indicates the presence of a CoP.

**Aspect (b): Scientists’ views of the teacher-scientist relationship**

Two inferences/interpretations support this aspect (see ‘evidence’ shown in Table 4.1). They are that firstly, ‘Scientists perceived and acknowledged that they were in a partnership with teachers – each playing different and critical roles’, and secondly, ‘Communities of science practice developed and continued in classrooms in the absence of the mentors’. The evidence supporting each inference/interpretation follows the inference/interpretation statement (in bold type).

**Scientists perceived and acknowledged that they were in a partnership with teachers – each playing different and critical roles. Communities of science practice developed and continued in classrooms in the absence of the mentors.**

The interviewed scientists recognised and acknowledged that they were in a partnership with teachers:

> The real strength of the MyScience program … is that it brings people with professional experience of how to set up an experiment … question … keep notes … do the analysis and [gives] the kids the opportunity to interact with them … and they [the students] have that expertise to draw on while they’re going through that process which supplements what the teachers can do in the classroom (Sam).

Sam recognised his role in helping students to understand the NOS but also commented on the “critical role” that teachers played in “consolidation” after his visits. The teachers had taken “on board” the scientists’ assistance so that when he returned “weeks later” the children had progressed significantly with their investigations. The teachers had:

> … provided them with the materials, helped them along the way, solved little problems. You come back and the kids have now got an entire experiment running and you maybe help them with a few more problems. Maybe ask them why they’ve done things this way, whether there’s a different way they thought about how to do it.

**Students are here working in a learning community of ‘scientists’ collaborating with teachers even when the scientists are absent due to the earlier efforts of the scientists.**

This three-way dynamic encapsulates the community element of a CoP in which
“members … are collaboratively engaged in activities and discussion related to the [investigating scientifically] domain” (Wenger-Trayner, 2013) and is evidence of CoP attribute #2.

Further recognition of this collaborative CoP dynamic came from Sasha and Elana who both that intimated scientists and teachers need to work together to support students since each contributes in different ways – the teacher with “children guiding experience” (Elana) and the scientists with “the specific information” (Sasha) that they hold. Teachers were recognised for: their astuteness and ability to identify and use scientists’ knowledge and skills effectively in their classrooms (Sam); doing “all the groundwork for setting up the experiments” (Spencer); and “guiding the students when the scientists aren’t there … they’re the glue that holds it all together” (Stan). These scientists appreciated the considerable capabilities of the teachers who laid the groundwork for, and continued the triggering effect of their visits.

Elana’s comment (‘children guiding’) indicates awareness that the school has its own CoP to which she is a ‘newcomer’ and the teacher and students are ‘old timers’. However Elana also indicated a reciprocity in community members acting as border crossers for each other: the scientists are border crossers for the teachers and students between the ‘in-school’ and ‘out-of-school’ science (discussed earlier in Assertion#1(a)), and the teachers are border crossers for the scientists as they come into the classroom. She said,

… not many primary school teachers … have a science background … [and] a lot … will stand back a bit [but] we were able to … reinforce her [a teacher] to say, ‘No, no, okay this is what we need’ … so then she can carry on and reinforce those things … because some outside people have reinforced the fact that this is what scientists do.

This reciprocal border crossing assists students to see how ‘school science’ relates to ‘scientific processes’ in the ‘real world’ (Murphy et al., 2011). It also engenders belonging and inclusivity within the CoP through the practices of the community members around the domain of investigating scientifically.

In summary, these scientists saw themselves as legitimate members of their MyScience CoP, and perceived that they were in a partnership with teachers, with each contributing critical but different types of expertise to the goal of having students participate in scientific investigations. Mentors described their role in MyScience as providing information and support for teachers and students around investigating scientifically, and as a new face in the classroom they were the focus of students’ attention. They appreciated
encouraging responses from students and teachers, and generally found the mentoring experience to be ‘positive and energising’. Teachers and mentors were viewed as being in a partnership with each contributing critical but different types of expertise to the goal of having students participate in scientific investigations. Learning by students, teachers and scientists was reciprocal and viewed as being due to interactions associated with the ‘doing’ of MyScience. As indicated in the following assertion (#3), scientists’ perceptions of their (reciprocal) role became more central as they gained and developed expertise in the practice (the ‘doing’ of MyScience) of the CoP (Lave & Wenger, 1991).

4.2.2.3 Assertion #3 [#3]: Scientists’ perceptions of participants’ roles were consistent with a CoP interpretive framework.

In the following, scientists’ perceptions of stakeholders’ roles provide insights into (and are evidence of) the organisation and functioning of MyScience communities of science practice. Aspect (a) details scientists’ views of the students’ role; Aspect (b) relates to their views of the teachers’ role; and Aspect (c) describes their views of the Principal and parents. Each of these aspects underpin Assertion #3. See Section 3.5.1 for the relationship between evidence, aspects and assertions.

Aspect (a): Scientists’ views of students

Two inferences/interpretations support this aspect (see ‘evidence’ shown in Table 4.1). They are that firstly, ‘Scientists perceived that the students’ role was to interact with scientists and teachers’, and secondly, ‘Some astronomers initially viewed students’ questions with concern and unease’. The evidence supporting each inference/interpretation follows the inference/interpretation statement (in bold type).

Scientists perceived that the students’ role was to interact with scientists and teachers.

Some astronomers initially viewed students’ questions with concern and unease.

Students are “the putty” (Stan) of MyScience and their role is “to interact with the scientists and their teachers [and] not be afraid of asking questions” (Sam). Interestingly, student questions did cause concern and unease for some scientists: “Kids can be scary. Kids can ask all sorts of really probing, personal questions” (Sam) and can “catch you”, unlike at conferences, when “people … ask you questions that you … expect to be asked … the less specific your audience … the more off the wall the questions” (Stan).
Not surprisingly, scientists’ views of students changed as visits increased. “A confidence, a connection” developed over time with the children “asking [more] questions … and [becoming] more interested” (Stan). Social interactions became more fluent and group dynamics more manageable. Sean’s experience was typical: “… the second time I was more aware of keeping tabs on the different groups” and more “conscious of spreading my attention around”.

This growing confidence in mentors’ perceptions of their role within the community of practice relates back to mentor-student relationships (see Assertion #2(a)), suggesting that these mentors’ trajectory of participation and learning has become more central as they gained and developed expertise in the practice (the ‘doing’ of MyScience) of the community of practice (Lave & Wenger, 1991), and could therefore be regarded as an indication that their CoP was fairly robust.

**Aspect (b): Scientists’ views of teachers**

Two inferences/interpretations support this aspect (see ‘evidence’ shown in Table 4.1). They are that firstly, ‘Scientists appreciated teacher-generated student scaffolds’, and secondly, ‘Scientists appreciated teacher enthusiasm and interest’. The evidence supporting each inference/interpretation follows the inference/interpretation statement (in bold type).

**Scientists appreciated teacher-generated student scaffolds. Scientists appreciated teacher enthusiasm and interest.**

As indicated in Assertion #2(b) scientists acknowledged and valued the critical roles that teachers played in MyScience. The activity and interactivity by one teacher made it a “positive experience” for Sam and gave him “confidence”, and appeared to play a key role in his reported sense of belonging and membership within the MyScience CoP. Another example exemplifying the teacher’s role was Elana’s recognition of a teacher-generated student scaffold (a proforma) for the steps of ‘investigating scientifically’ (the CoP domain). The scaffold “was a great leveler because … if you took … [some] … of the writing away [the] kids could spend most of the time thinking and coming up with ideas”. The scaffold was specifically developed to enhance student focus and concentration during the school visits, and to assist the scientists, and is an example of reification – an attribute of a CoP.

Scientists’ perceptions of teachers acting in these ways and immersing themselves more in MyScience could indicate a strengthening of their sense of belonging and participation.
in the CoP and that they are seeing their membership as being more central in the community (Lave & Wenger, 1991). This mutual valuing of each others’ roles and contributions as integral members of a joint enterprise is a fundamental characteristic of a CoP, namely, “groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly” (Wenger-Trayner, 2013).

Not all teachers were as involved as in the above examples, but Eric was the only scientist who did not enjoy the MyScience experience. He thought “… the teachers weren’t really particularly enthralled by the program” and added that “during the visits, the teachers were never around”. His opinion was that the students “weren’t really given good guidance by the teachers [for] each time we came out … [and] did not appear to know how to plan an experiment, for example, … change one thing only at a time and measure …” Eric also considered that the chosen topics were uninteresting and did not hold the students’ attention, and that students had a short attention span. For an investigation he was assisting students with, he added that the unevenness of the ground impeded their experiment: “[students were] trying to roll balls [on] this rough footpath and the ball wouldn’t roll properly for a start, you know”. Given that Eric found fault across such a wide range of issues it could be that he failed to appreciate the nature of science in primary school settings, but his frank comments have served as a salutary reminder of the critical nature of participant behaviour and responsibilities within a successfully functioning CoP. Eric did not feel his presence was valued by the teachers. His views are in sharp contrast to earlier examples of attributes of a CoP.

**Aspect (c): Scientists’ views of the principal and parents**

Two inferences/interpretations support this aspect (see ‘evidence’ shown in Table 4.1). They are that firstly, ‘The Principal was viewed as an advocate and gatekeeper for MyScience’, and secondly, ‘Scientists wished for parents to show interest in MyScience activities’. The evidence supporting each inference/interpretation follows the inference/interpretation statement (in bold type).

*The Principal was viewed as an advocate and gatekeeper for MyScience. Scientists wished for parents to show interest in MyScience activities.*

Astronomers and engineers identified the principal’s key position as the school gatekeeper who “has to support the program” (Sam), a view similarly articulated by Scott,
Spencer and Sasha, along with identifying resources that could be used while *MyScience* was being implemented.

Parents needed to approve of students being involved in *MyScience* but, more importantly, scientists preferred that parents showed an interest in science—specifically, the *MyScience* activities—because, in Sean’s opinion, “if the kids are taking these experiments home they can get their parents involved but … if [the parents aren’t] interested in science [they] can affect the whole outcome”. Scientists emphasized that they didn’t expect parents and the principal to be “all encouraging [about science]” (Stan) but “… you definitely don’t want them being negative” (Spencer). Parents were considered important attendees at the Science Fair, especially when they showed interest (Elana).

Scientists viewed the role of the principal and the parents as important but not central to the functioning of the CoP—their interest and enthusiasm about CoP activities related to the domain of ‘investigating scientifically’ was valued by the scientists. The principal and parents had ‘legitimate peripheral membership’—not from a temporal viewpoint of newcomers moving to a more central role as they gained and developed expertise in practice (as described by Lave & Wenger, 1991), but from an activity viewpoint— they played a peripheral role in terms of their active engagement in CoP functionality.

**In summary**, student participation was the foremost reason for mentor involvement but there were concerns by some mentors about the nature of student questions and the quality of school resources for performing controlled investigations. Mentors reported that their own skills in how to best support students had improved as a consequence of *MyScience* participation. Mentors valued teacher interest and enthusiasm in science as well as their presence in the classroom and where this was not experienced, mentors reported a less positive mentoring experience. Teacher-generated student scaffolds designed to facilitate school visits were appreciated. Parents and the principal were important but not central to the functioning of the community of practice.

**4.2.2.4 Assertion #4 [#4]: Astronomers and engineers appear to have different motivations and expectations for their involvement in MyScience.**

In the following, scientists’ motivations for participating as mentors in *MyScience* are presented. Aspects (a) and (b) detail professional astronomers’ and engineers’ (respectively) personal reasons for participating in the program, while aspect (c) relates to...
outreach policies for participation in such activities by the scientists’ organisations. Each of these aspects underpin Assertion #4. See Section 3.5.1 for the relationship between evidence, aspects and assertions.

**Aspect (a): Astronomers’ motivations**

One inference/interpretation supports this aspect (see ‘evidence’ shown in Table 4.1). It is that, ‘Astronomers wished to develop scientific intuition and aspects of scientific literacy and to seed interest in and a love of science in students’. The evidence supporting the inference/interpretation follows the inference/interpretation statement (in bold type).

*Astronomers wished to develop scientific intuition and aspects of scientific literacy and to seed interest in and a love of science in students.*

Developing ‘scientific intuition’ and aspects of scientific literacy (e.g., evaluating scientific evidence) as capabilities in students were foundational premises for several astronomers’ participation in MyScience. Comments included: “giving kids … many opportunities … to make their own discoveries, to learn something for themselves … [so that] they can then build a scientific intuition” as well as enabling them “to recognise that they can actually find out how the world works and … [to] think for themselves [so that] they can set up an experiment, they can ask a question and they can answer it” (Sam) and to not “be put off by weird results … [but] try to explain them … is it a genuinely weird result or is your experiment flawed” (Spencer).

Five of the six astronomers expressed a desire to seed an interest in, and a love of, science in students. They spoke of aspiring to “try and nurture that enthusiasm” (Stan, and Sam) and for students to realize “what science is about [and that] a lot of it is actually having fun” (Scott), and “there's no use trying to explain something … if they're not interested … in the first place” (Sean). This sentiment is aligned with Skamp’s comment about students developing ‘personal interest’ in science where they “*want* to learn about science topics” (2012a, p. 25, emphasis added).

For these astronomers there are strong affective elements related to the ‘doing’ of science and that science be seen as ‘inquiry based’ by students. They also wish to give students ‘agency’ (so they can ‘think for themselves’) and to help them to realise that they are able to independently ask and answer questions, which are characteristics implicit in the NOS (so that… ‘they can set up an experiment…’).
Aspect (b): Engineers’ motivations

One inference/interpretation supports this aspect (see ‘evidence’ shown in Table 4.1). It is that, ‘Engineers wished to develop interest in science, seed future career aspirations and to support students with understand links between ‘in-school’ and ‘out-of-school’ science’. The evidence supporting the inference/interpretation follows the inference/interpretation statement (in bold type).

*Engineers wished to develop interest in science, seed future career aspirations and to support students with understand links between ‘in-school’ and ‘out-of-school’ science.*

Similar to the astronomers, developing an interest in science and seeding future career aspirations in young learners was mentioned by Ezra and Elana (who referred to the “problem” of “shrinking” engineering faculties). There did not appear to be the depth of inherent passion about science in the engineers’ interview responses (compared with the astronomers’ responses); there was more a notion of wanting to support primary students and teachers (Elana) to “explore science and get more out of their science experience” as well as “build[ing] foundational knowledge for future technologists” (Emily). This shows a desire to work with the teachers and students (as did the astronomers) – a CoP attribute.

A foremost reason for several engineers volunteering as MyScience mentors was to help children better understand the links between, and increase the relevance of ‘in-school’ and ‘out-of-school’ or ‘real world’ science (see Tytler, 2007). Emily felt that her presence provided “both the teachers … and the children [with] access to industry” and “offer[ed] views and methods that … teachers … probably can’t bring to the table for these children”. This exemplifies the requirement for diversity in expertise within a CoP in supporting the community’s development. Both Ezra and Emily saw themselves as having an ‘identity’ within the CoP as ‘culture brokers’ (Jegede & Aikenhead, 1999) simply by virtue of their presence. Elana elaborated on the importance of linking ‘in-school’ with ‘out-of-school’ science. She usually tried “to find some … real world … connection … even if [it was] quite tenuous”. An example she gave was “one with touch where there were these boys who wanted to test whether or not adults or children had the better sense … could [they] distinguish an object by touching it”. She said the discussion extended to using ‘artificial hands’, or ‘robots’ in different situations and that she enjoyed making the link between the school experience and the outside world.
An inherent passion about science was not as apparent in the engineers’ responses and may be related to the parallels between the MyScience CoP domain (investigating scientifically) and the astronomers’ workplace domain (performing scientific investigations). MyScience was seen as depicting “… what science is … just doing an experiment … having an idea, and testing it” (Stan) and exposing students to the nature of science and its processes. The culmination of MyScience is, often, a school based Science Fair. Sam agreed with a colleague’s observation that having students explain their investigations and findings using posters and various artifacts was analogous to the ‘poster session’ presentations that commonly occur at professional research science conferences (Research field notes, 20/08/10 in Appendix A). Students were also exposed to this observation when Sam was asked to address the class by the teacher during his Science Fair visit. The engineers did not mention similar comments.

**Aspect (c): Outreach activities – astronomers’ and engineers’ views**

One inference/interpretation supports this aspect (see ‘evidence’ shown in Table 4.1). It is that, ‘MyScience participation was regarded as important and supported by employers of both astronomers and engineers’. The evidence supporting the inference/interpretation follows the inference/interpretation statement (in bold type).

*MyScience participation was regarded as important and supported by employers of both astronomers and engineers.*

Although there were some different motivations for MyScience involvement, all of these interviewed mentors believed outreach activities were important and their organizations strongly supported their involvement. Reasons for volunteering included a sense of obligation and “social responsibility” (Sasha) to increase community scientific literacy. Sean sourced the issue back to primary school experiences:

> It's interesting to see people have a discussion without having some sort of scientific literacy. I mean just some sort of basic … vocabulary even … or how the scientific method works. They find a paper that refutes some claims of climate change and hold it up as proof, absolute proof, and … scientific knowledge at the bleeding edge is a whole range of views and you've got to take a consensus view…. Quite often consensus views are refuted but … it's … not black or white … it's about probabilities … possibilities … x may happen ...there's a nine in 10 chance it may happen –sure there's a one in 10 chance it may not. … I guess people grow up from primary school age … with their brains not wired to think in this way…

NOS#1

NOS#6

NOS#2
“Primary school is where you really need to encourage just the idea of … ‘What is science?’” (Stan). This goes to the heart of the NOS and implies that if its attributes are made explicit then primary students can learn and apply them, a view supported by research (cf. Akerson et al., 2011; Murphy et al., 2011). This is exemplified in Sean’s comment that science is collaborative, uses a ‘method’, and is tentative.

In support of outreach at ABC a staff survey indicated “we should do more in the community” and that MyScience showed that “we are a human company” (Elana). Participation in MyScience was actively encouraged with successful recruitment drives each year. This company support influenced Evan’s involvement: “without that group [of participating engineers] I wouldn’t do this … I need a few people around me … doing this to make it … less confronting”. Evan seems to be saying that he feels that he is part of a group of engineers within the company and that this sense of belonging helps him to feel more comfortable interacting with the school students.

ABC developed a mentor recruitment poster – see Figure 4.1, which is an example of reification (i.e., products and processes that reflect the CoP’s domain– and used by CoP members), indicating a sense of ownership and belonging to a MyScience CoP.
In summary, these mentors recognised the importance of outreach activities and had varied reasons for volunteering including: a sense of obligation to share their knowledge and to increase science interest and enthusiasm; a sense of hope that being involved as a mentor may ignite and sustain students’ interest in science; and to contribute to the local community.
4.2.2.5 Assertion #5 [#5]: Scientists linked participants’ learning within MyScience to be due to participation (consistent with a CoP interpretive framework) and identified barriers that need to be addressed.

In the following, scientists’ views of MyScience as an enabler or barrier to participatory learning are presented. Aspect (a) details the enabling aspects of the MyScience educational model and include: serial participation, reflecting the nature of science, student ownership and the wide variety of concurrent activities; aspect (b) presents barriers such as the amount of work for teachers, and managing the range of different student investigations. Wenger’s (2002) ‘critical success factors’ for the development of a successful CoP are also discussed with respect to these mentors’ views. Each of these aspects underpins Assertion #5. See Section 3.5.1 for the relationship between evidence, aspects and assertions.

Aspect (a): Enabling aspects of MyScience

Two inferences/interpretations support this aspect (see ‘evidence’ shown in Table 4.1). They are that firstly, ‘Serial participation helped teachers build a base of resources, and scientists increased their own knowledge, and secondly, ‘The MyScience educational model provides a framework that brings all participants together with a focus on student-centred learning’. The evidence supporting each inference/interpretation follows the inference/interpretation statement (in bold type).

Serial participation helped teachers build a base of resources, and scientists increased their own knowledge. The MyScience educational model provides a framework that brings all participants together with a focus on student-centred learning.

Serial MyScience participation by teachers helped them build “a base of resources of their own to draw on for helping the kids to design the experiments, for answering the kids’ questions … [they are] building up a portfolio of experiments and materials and questions” (Sam, and indirectly Stan). These scientists are suggesting that the more experiences teachers have within their MyScience CoP, the more that their own pedagogical practices and science content knowledge will grow, and (Scott implied) they will be empowered through their MyScience participation to initiate investigating scientifically communities “themselves beyond MyScience”. The iterative nature of the school visits led the scientists to report that they felt that they had increased their own knowledge around communication and group management skills with primary students –which they and
teachers were learning through participation, which is a hallmark of a CoP. This corroborates findings by Howitt et al. (2009), Rennie (2012), and Bolstad and Bull (2013), who found that scientists’ perceptions of their interactions with school students helped them to become better science communicators.

The *MyScience* educational model is designed to provide a guiding framework for participants through “scaffolded learning experiences that promote independence and autonomy” (Forbes & McCloughan, 2010, p. 25; also see Chapter 2, Section 2.6). The “key advantage” that the *MyScience* structure provides is the ease with which professionals can become involved (Sam). Both Stan and Sam commended the way that the processes of *MyScience* reflected the “conceptual idea of science … doing an experiment, having an idea, testing it…” (Stan) “just like completing your PhD and then pursuing a science career” (Sam). The opportunity for students to enter their findings into state level science award schemes “impressed” Sam “very much”; that students involved in *MyScience* “could be so successful and get such a high level of validation for the work that they did”, he felt, “was hugely powerful and … should certainly continue”. Scientists also valued the structure of the *MyScience* program as it enabled students to engage with other (primary and other) science communities of practice (through the award scheme feedback mechanisms).

Elana thought that *MyScience* allowed students to have “a lot more say in what happens … there is broader scope for [their own] ideas” and “that’s one of the things that I liked about MyScience, [that there was] a little bit of the unknown”. This aspect of the *MyScience* educational model is in Element 3 where ‘primary students are supported to scientifically investigate their own questions’ (Forbes & McCloughan, 2010, p. 26). Evan, agreeing that a “bit of variety is good” as opposed to everyone doing the same investigation, noted that students were attracted by what other groups (in the class) were doing. This inherent interest in others investigating their own questions, it could be argued, are examples of student groups interacting as part of a social learning system where students are “engaging in and contributing to the practices of their communities” (Wenger, 1998a, p. 7).
Aspect (b): Barriers to learning ‘as participation’ through a community of practice

One inference/interpretation supports this aspect (see ‘evidence’ shown in Table 4.1). It is that, ‘The work demand on teachers was regarded as an issue’. The evidence supporting the inference/interpretation follows the inference/interpretation statement (in bold type).

The work demand on teachers was regarded as an issue.

The MyScience framework was not perceived by scientists to be a ‘bed of roses’ for all participants. Three scientists commented on (and therefore recognised the value of) the amount of work required by the teacher to remain

… on top of all of the different experiments … It’s a huge variety … very open ended … and the teacher has to … bring it all to a conclusion so that the kids actually have something to write up at the end (Sam).

Despite concerns that teachers may feel “swamped”, other scientists applauded teachers’ efforts as exemplifying an attribute of a ‘community’ (of practice), namely, ‘acknowledgement of others’ roles in investigating scientifically’, and is the essence of CoP attribute #2: Community. If, as Scott implied, teachers perceived their classroom as a CoP when the scientists were not there, then they might more willingly perform a multi-faceted role. Harris and Rooks posited that a “considerable challenge for teachers is to learn new ways of managing the classroom to position students for learning through inquiry” (2010, p. 228) proposing a pyramid model approach to enable ‘pervasive management’. The MyScience educational model achieves this goal, positioning teachers as facilitators, and is described in more detail in Chapter 5.

Wenger (2002) articulated what he perceived to be the best approach to cultivating the development of communities of practice. Many of his suggestions are, independently, what have been implemented when initiating MyScience communities of practice. Ten ‘critical success factors’ (which could therefore be viewed as affordances or barriers to the development of a successful community of practice) have been identified, five related to each of two areas: ‘community’ and ‘organisation’. The factors are listed in Table 4.2 with darkened cells identifying factors addressed through the MyScience program.
Table 4.2. Wenger’s (2002) ten CoP critical success factors mapped against *MyScience*

<table>
<thead>
<tr>
<th>COMMUNITY</th>
<th><em>MyScience</em> example</th>
<th>ORGANISATION</th>
<th><em>MyScience</em> example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domain that energizes a core group</td>
<td>Interest basis for school participation. Initially two <em>MyScience</em> teachers in a school. Success encourages others from school to join.</td>
<td>Strategic relevance of domain</td>
<td>Supporting the teaching of primary science – key priority area for national curriculum (ACARA, 2013c)</td>
</tr>
<tr>
<td>Skilful and reputable coordinator</td>
<td><em>MyScience</em> facilitator</td>
<td>Adequate resources</td>
<td>School responsibility</td>
</tr>
<tr>
<td>Involvement of experts</td>
<td>Mentors – part of <em>MyScience</em> program</td>
<td>Dance of formal and informal structures</td>
<td><em>MyScience</em> program and encouragement to create own ‘<em>MyScience</em>@ …’</td>
</tr>
<tr>
<td>Address details of practice</td>
<td><em>MyScience</em> program structure, mentor expertise</td>
<td>Visible management sponsorship, but without micro-management</td>
<td><em>MyScience</em> website and program – purpose statement</td>
</tr>
<tr>
<td>Right rhythm and mix of activities</td>
<td><em>MyScience</em> program</td>
<td>Consistent attitude</td>
<td><em>MyScience</em> program</td>
</tr>
</tbody>
</table>

**In summary**, scientists commended the iterative nature of *MyScience* for: developing teachers’ NOS knowledge and science teaching practices (‘building up a portfolio …’) leading to CoP development in the absence of the mentors; and for developing mentors’ own knowledge. The structure of the program was perceived to enable students’ tacit learning (through participation) about the nature of science (‘conceptual idea of science’); to foster student-directed learning (‘lot more say…’, ‘broader scope for…’); and to learn from observing other students’ activities in the CoP. This same program structure was also viewed, by some mentors, to be a barrier to the development of communities of practice (e.g., teachers possibly finding it a burden). With sensitive management by a “skilful and reputable coordinator” and with the provision of “adequate resources” (Wenger, 2002) and support from the school to teachers, this aspect of *MyScience* should hopefully be addressed.

The following presents two assertions related to secondary science teachers’ views of their *MyScience* mentoring experience. The smaller number of assertions (two) arising from the four secondary science teachers’ interviews compared with the five assertions from the nine scientists’ interviews are not easily explained. There was less qualitative data available from which to derive ‘evidence statements’, leading to ‘aspects’ and then ‘assertions’ but the depth and level of analysis was similar for both data sets, as were the interview questions (Table 3.4) asked of all participants.
4.3 Findings and discussion: perceptions of secondary science teachers as mentors

4.3.1 Secondary science teachers’ assertions: How they address the research question

Participating secondary science teachers’ perceptions of their experiences of MyScience and how these influenced their views about ‘science’, ‘science learning’ and ‘science teaching’ (the research question – Section 4.1.1) lead to assertions addressing the two latter aspects: ‘science learning’ in Assertion #7, and ‘science teaching’ in Assertion #6.

4.3.2 Overview of secondary science teachers’ views

Participation in MyScience changed secondary teachers’ views of science teaching and science learning in secondary school settings, and for some, resulted in them changing their pedagogy [#6]. Secondary science teacher mentors wished to develop primary-secondary links between the participating schools. They viewed their involvement as: providing primary students with NOS guidance and discussion; playing devil’s advocate; developing collaborative group skills; and building confidence in primary teachers. These mentors were profoundly surprised at the level of enthusiasm and capabilities of participating primary and Year 9 science students [#7]. Table 4.3 summarises the findings from the secondary science teacher interviews and identifies related CoP and NOS attributes from Table 3.8.
### Table 4.3. Summary of findings from secondary science teacher interviews

<table>
<thead>
<tr>
<th>Category</th>
<th>#</th>
<th>Description of Assertion/Aspect/Evidence*</th>
<th>NOS/CoP attributes from Table 3.8</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ASSERTION 6</strong></td>
<td></td>
<td>Participation in <em>MyScience</em> changed secondary teachers’ views and practices about how to approach the teaching of science in secondary school and also influenced colleague (non-<em>MyScience</em>) teachers’ practices.</td>
<td></td>
</tr>
<tr>
<td>Aspect</td>
<td>(a)</td>
<td>Influence on <em>MyScience</em> secondary teachers’ views and practices:</td>
<td></td>
</tr>
<tr>
<td>Evidence</td>
<td></td>
<td>- Teachers expressed a desire to change their own teaching practices.</td>
<td>NOS#1 CoP#1, #2</td>
</tr>
<tr>
<td>Evidence</td>
<td></td>
<td>- Teachers changed their pedagogy to meet the needs of incoming Year 7 <em>MyScience</em> old-timers.</td>
<td></td>
</tr>
<tr>
<td>Aspect</td>
<td>(b)</td>
<td>Influence on colleague (secondary) teachers’ pedagogical practices:</td>
<td></td>
</tr>
<tr>
<td>Evidence</td>
<td></td>
<td>- Other (colleague) teachers introduced open-ended investigations into their science lessons.</td>
<td>-</td>
</tr>
<tr>
<td><strong>ASSERTION 7</strong></td>
<td></td>
<td><em>MyScience</em> fostered primary-secondary links and secondary teachers’ views of their role were consistent with a CoP interpretive framework.</td>
<td></td>
</tr>
<tr>
<td>Aspect</td>
<td>(a)</td>
<td>Insights into the primary school context:</td>
<td></td>
</tr>
<tr>
<td>Evidence</td>
<td></td>
<td>- Secondary teachers’ motivations for becoming mentors included nurturing primary-secondary relationships.</td>
<td>NOS#1 CoP#1, #2, #3</td>
</tr>
<tr>
<td>Evidence</td>
<td></td>
<td>- Secondary teachers gained awareness of primary students’ capabilities.</td>
<td></td>
</tr>
<tr>
<td>Evidence</td>
<td></td>
<td>- Secondary teachers’ role included supporting primary students and their teachers.</td>
<td></td>
</tr>
<tr>
<td>Aspect</td>
<td>(b)</td>
<td>Insights into the secondary school context:</td>
<td></td>
</tr>
<tr>
<td>Evidence</td>
<td></td>
<td>- Secondary teachers gained awareness of Year 9 students’ capabilities.</td>
<td>-</td>
</tr>
</tbody>
</table>
4.3.2.1 Assertion #6 (#6): Participation in MyScience changed secondary teachers’ views and practices about how to approach the teaching of science in secondary school and also influenced colleague (non-MyScience) teachers’ practices.

Two aspects of how MyScience participation changed secondary science teachers’ approaches to the teaching of science in their own school are presented below. Aspect (a) details the influences on those teachers who were mentors, and aspect (b) relates to colleague teachers who were not involved in the program but interacted with these mentors back in their home CoP (the science faculty in their secondary school) and subsequently changed aspects of their science teaching. Each of these aspects provides evidence for assertion #6. See Section 3.5.1 for the relationship between evidence, aspects and assertions.

Aspect (a): Influence on MyScience secondary teachers’ views and practices

Two inferences/interpretations support this aspect (see ‘evidence’ shown in Table 4.3). They are that firstly, ‘Teachers expressed a desire to change their own teaching practices, and secondly, ‘Teachers changed their pedagogy to meet the needs of incoming Year 7 MyScience old-timers’. The evidence supporting each inference/interpretation follows the inference/interpretation statement (in bold type).

Teachers expressed a desire to change their own teaching practices.

Colin is an experienced science teacher whose typical approach to teaching science is a “‘lock step’ comfort zone way of doing business” which the Deputy Principal –Charles– commented that he had “been trying to sort of shake him [out of] for a while”. Charles hoped that MyScience participation would help to transition Colin’s pedagogy away from his preferred transmissive teaching style towards a more student-centred and engaging approach to science learning, an observation also noted by Watkins who commented that “secondary specialists often employ some of the more conservative approaches” (2010, p. 34).

Colin, who mostly taught the older secondary students, recounted experiencing great enjoyment during his MyScience school visits: he “loved … working with younger kids and learning with younger kids … [finding out] what they are capable of”. Back in his secondary school, Colin was invited to watch a Year 7 class being taught by one of the science teachers who was also a MyScience mentor. He regarded this experience as an
“opportunity” and thought that “it was excellent, [the students] enjoyed it … totally they were into it, they loved it” and commented “if I was teaching Year 7 I’d use the idea of MyScience, structured groups where you work them on a project …”. Here we can see that Colin’s views of what it means to be teaching science are changing (as was hoped for by Charles), triggered by the experience of ‘doing’ MyScience with primary students and then seeing it in action with secondary students. It may be that the temporal ‘spacing’ of the two experiences has allowed him to reflect and learn so that the inquiry-oriented practices of MyScience are becoming part of his own pedagogical beliefs and behaviour patterns (Levitt, 2001). The notion of teachers needing time to integrate new ideas and teaching practices into their repertoire was also commented on by Rennie (2010), and Opfer and Pedder (2010).

**Teachers changed their pedagogy to meet the needs of incoming Year 7 MyScience old-timers.**

Charles, Carol and Carmel recognised that incoming Year 7 students who had done MyScience had a different skill set from other Year 7 students. Charles felt that it was the school’s responsibility to differentiate the curriculum to meet the needs of MyScience old-timers: “because the children, that's the scary part, because when they hit us if they've been good at MyScience we’ve got to recognise that and value-add from a higher level than we normally would”. This insightful comment by Charles aligns with findings from the 2009 Wellcome Trust report where “contrasting styles of pedagogy” were identified as a key area of concern associated with the “dip in attitudes and attainment” across the primary-secondary transition (Watkins, 2010, p.33). Charles wished to mitigate MyScience students’ transition from primary to secondary science through ‘raising the bar’ of secondary science teaching practices at his school – influenced by the higher levels of science knowledge and skills of incoming MyScience students. He has gained this awareness through being a mentor. Watkins comment that “some of the most effective pedagogy can be found from primary non-specialists, whereas secondary specialists often employ some of the more conservative approaches” (2010, p. 34) fits Colin’s pedagogical approach, mentioned previously.

Carmel noted that incoming Year 7 students (who had done MyScience) already had “an understanding of what’s meant by an aim and a hypothesis and this and that … other schools, those kids don’t have that”. She commented that the ideas of the Year 6 students that she worked with were “amazing” and wanted Year 9 science students who were
doing their major research project to “go and see these Year 6s come up with ideas because the ideas that they come with … are amazing compared to some of the Year 9s”.

To accommodate the range in NOS understandings of incoming Year 7 students Carmel described how she firstly ascertained the students’ *MyScience* experience (‘spoke to them…’, ‘the majority…’) and changed the style of the first semester unit from a ‘recipe based investigation’ to a student-centred investigation similar to that done in *MyScience*:

The top Year 7 class, when I spoke to them at the start of the year, a number of them had done MyScience … [I]n our Semester One course we have a topic called ‘Investigation’ and up … until this year it ha[s] been … [a] recipe based investigation, so it really wasn’t … [an] investigation, it was … ‘here’s a prac that we can try’ kind of thing. But because a number of them had done MyScience, and because it is mandatory that you do a Stage Four major project with the kids I thought this year we’d try … so I [made] … a scaffold … for them to do … and the top Year 7 class hammered it. They loved it, no dramas. … I had another [mixed ability] Year 7 class… [and] they also got really into it but it was [a] longer process for them.

Here we can see that Carmel noted a difference in the way that her non-*MyScience* students participated (‘it was [a] longer process for them’), and that both student groups were interested and engaged (‘hammered it’, ‘loved it’, ‘got really into it’). Her personal experiences of observing secondary students’ increased engagement and science learning, complemented by her primary school *MyScience* experiences, are likely to have reinforced student-centred scientific inquiry as an effective approach to be included in her pedagogical repertoire, as has been noted by Levitt in primary school contexts: “Once teachers in [my] study observed their students learning, the teachers’ belief in the new approaches and commitment to them changed significantly” (2001, p. 20).

Carol thought that awareness of, and involvement in, primary students’ *MyScience* experiences by her science staff created the “motivation” to provide continuity between Year 5 and Year 9, commenting: “I do it with my Year 8s”.

**Aspect (b): Influence on colleague (secondary) teachers’ pedagogical practices**

One inference/interpretation supports this aspect (see ‘evidence’ shown in Table 4.3). It is that, ‘Other (colleague) teachers introduced open-ended investigations into their science lessons’. The evidence supporting the inference/interpretation follows the inference/interpretation statement (in bold type).
Other (colleague) teachers introduced open-ended investigations into their science lessons. Not only did participating science teachers as mentors change their teaching practices, but other colleague teachers (who had not been MyScience mentors) were observed to be trialling more student-centred activities as described by Carol – the Head Science teacher:

now teachers feel slightly motivated to even have little mini ones [student-centred investigations] within their classes because I noticed that [a colleague teacher] had done one on her own … she gave them a few topics and they ended up doing it as an in-class task.

The influence of the MyScience mentors as ‘tempered radicals’ (Carlone et al., 2010) within their home CoP may be at work here, where new knowledge about science learning and science teaching learned from participation in the MyScience CoP has been brought into the secondary school science CoP and is having “an incremental and eventual impact on the organisation’s taken for granted, daily ways of doing business” (p. 945). The mentors could also be viewed as ‘culture brokers’ between the MyScience CoP and the secondary school science CoP where, as ‘newcomers’, the colleague teachers learn new practices through interactions (observing teaching, conversations…) with the old-timers (science teacher mentors).

In summary, we have seen evidence of all four of the interviewed secondary science teachers – as well as a ripple effect to colleague teachers– changing aspects of their secondary teaching practices to accommodate student-centred teaching and learning with a focus on authentic scientific contexts and practices, a keystone of the MyScience educational model. This has come about because of their participation in the program. Colin is willing to use “the idea of MyScience” in his teaching, Carmel has altered the first semester unit for Year 7 students to meet the needs of incoming MyScience old-timers, and Carol uses the approach with her Year 8 students and has observed other faculty members doing likewise. This indicates that primary-secondary partnerships (where primary schools are doing MyScience) provide opportunities to foster both primary and secondary student engagement in science through a ‘re-imagining of the science curriculum’ (Tytler, 2007). Such partnerships also substantiate the influence of MyScience participation on, not only primary science teaching practices, but also on secondary science teaching practices.
4.3.2.2 Assertion #7 (#7): MyScience fostered primary-secondary links and secondary teachers’ views of their role were consistent with a CoP interpretive framework.

Two aspects of how MyScience participation cultivated primary-secondary links are presented below. Aspect (a) details secondary teacher mentors’ insights into the primary school context, and aspect (b) relates to secondary teacher mentors’ insights into the secondary school context. Each of these aspects provides evidence for Assertion #7. See Section 3.5.1 for the relationship between evidence, aspects and assertions.

Aspect (a): Insights into the primary school context

Three inferences/interpretations support this aspect (see ‘evidence’ shown in Table 4.3). They are that firstly, ‘Secondary teachers’ motivations for becoming mentors included nurturing primary-secondary relationships.’ Secondly, ‘Secondary teachers gained awareness of primary students’ capabilities.’ Furthermore, ‘Secondary teachers’ role included supporting primary students and their teachers.’ The evidence supporting each inference/interpretation follows the inference/interpretation statement (in bold type).

Secondary teachers’ motivations for becoming mentors included nurturing primary-secondary relationships.

When Carmel was asked what she had got out of doing MyScience (Interview Question #3, Table 3.4) she replied: “you form relationships with students and … teachers in feeder schools which means that you’re kind of providing that link between primary schools and high schools”. Carol saw value in the program as a foundation for the science teaching and science learning in the secondary years of schooling:

I would think that MyScience would be the future of teaching science at high school – giving primary school students the appreciation of that concept of science rather than primary school students walking into their Year 7 class and going what are we going to blow up?

The notion of ‘forming relationships’ with the primary students and teachers is a hallmark of a community of practice, particularly CoP attribute #2 – members who are collaboratively engaged in activities and discussions related to the domain (Wenger-Trayner, 2013).
Secondary teachers gained awareness of primary students’ capabilities.

*MyScience* participation afforded secondary science teachers with a window into the world of primary students. Charles found *MyScience* participation to be beneficial for his staff because

... they really don't know that much about primary, they make assumptions and then they go out and find that their assumptions are a tad erroneous and that they really need to lift their game and don't assume an empty slate when kids arrive in Year 7.

Carmel concurred with this view commenting “it kind of gives you a feel for … where to launch from”.

Colin, reflecting on his interactions with primary students said: “you build up a relationship, you understand their level of understanding”. He spoke of the importance of knowing “where that knowledge is coming from … understanding the other side” when students begin their secondary schooling. Colin relished the opportunity to work with a small group of students to develop their NOS capabilities:

It was excellent, it was fantastic ‘cause the kids, ‘cause you had five kids, three kids in front of you, you could focus your attention to three kids, and you could work with them. You can explain to them where they are going, where they need to fix this up, what do you think that might be better, how would that improve ...

These are all examples of Colin developing a positive relationship with his primary students (‘excellent’, ‘work with…’), learning about primary students’ capabilities (‘understanding the other side’) and helping them to improve their NOS understandings – and are representative of community of science practice attributes CoP#2, CoP#1 and CoP#3 respectively where: CoP#2 is community –’members who are collaboratively engaged in activities and discussion related to the domain’, CoP#1 is the domain –‘acknowledged shared interest area in which members collectively learn from each other’, and CoP#3 is practice –‘what members ‘do’ when they interact’ (Wenger-Trayner, 2013).

Findings by Jeans and Farnsworth (1993) corroborate Colin’s positive views of the benefits of working with primary students and is reflected in his affirming *MyScience* experiences and his willingness to change his secondary science teaching approach to include *MyScience* practices with Year 7 students (“if I was teaching Year 7 I’d use the idea of *MyScience*”) [#6(a)]. This notion –of teachers’ changed beliefs impacting on
classroom practices— is further developed in Chapter 5 related to primary teachers’ perceptions of *MyScience* participation.

**Secondary teachers’ role included supporting primary students and their teachers.**

**Student support:** Carol thought that her role as a mentor (and therefore what she would ‘do’ as a member of the CoP) to the primary students was to “play devil’s advocate … to almost create scenarios [such as asking] ‘Well what if that didn’t work?’ you know, so got them thinking rather than trying to ultimately get a text book sort of situation’.”

Charles had a similar view of his mentoring role which was to have “students come up with a good scientific investigation … to have [them] learn” with learning regarded as the hallmark of a ‘successful’ experiment even if didn’t work well. This view of learning could be interpreted as ‘participatory’ since it would occur within the *MyScience* CoP and the example that follows demonstrates the type of non-directive questioning used by Charles who used the

... whole cows moo softly\(^{12}\) approach – ‘What could we possibly measure here? What would you use to measure it?’ Okay that's something you want to measure. ‘Can we actually measure it though with what we've got?’ No probably not. ‘Well what else is there?’ Just to have them do a lot more brainstorming of what the possibilities are and then run with something that's doable with what's available.

Colin thought that the mentors’ role was to help primary students with their collaborative group skills: “to guide children … lead them … make them act as leaders in the group … designate the roles they have to do … help them with their ideas”.

**Teacher support:** Carmel thought that mentors provided scientific knowledge to primary teachers, which gave them “a lot of confidence … having someone there that you can kind of fall back on [when] your own scientific understanding is exhausted…” She went on:

I think that’s reassuring. So if they get to a situation and they sort of go ‘Oh I don’t really know where to go next’ then they’ve got someone there that they can go, ‘Well this person has got more experience and tap into that.’ … just having those extra hands and that extra understanding … that provides a lot of support to the teachers. Once they’ve seen [a] scientific investigation happen … then that in itself gives them the confidence to maybe try it

\(^{12}\) ‘Cows Moo Softly’ is an acronym for controlling variables in scientific fair tests: ‘Change one thing, Measure something, and keep everything else the Same’, developed by Hackling (2005).
again even without the mentors next year, or whatever, or at a different time during the year, you know to give that a go.

Carmel’s comments are similar to those voiced by another scientist mentor – Elana (see Assertion #2(b):

I think what we are doing is supporting teachers … not many primary school teachers… have a science background… [and] a lot… will stand back a bit … we were able to… reinforce her [a teacher and] say, ‘No, no, okay this is what we need’ … so then she can carry on and reinforce those things … because some outside people have reinforced the fact that this is what scientists do” (Elana).

Aspect (b): Insights into the secondary school context

One inference/interpretation supports this aspect (see ‘evidence’ shown in Table 4.3). It is that, ‘Secondary teachers gained awareness of Year 9 students’ capabilities’. The evidence supporting the inference/interpretation follows the inference/interpretation statement (in bold type).

Secondary teachers gained awareness of Year 9 students’ capabilities.

When asked what she had gained by being involved in MyScience (the same question asked earlier of Carmel) Carol’s response focused on participating Year 9 science students who had made considerable gains in their confidence levels in science classes. She described observing a couple of her “very shy students … undergo a level of metamorphosis” particularly identifying Caitlyn (one of the interviewed students in Chapter 6) as being apprehensive about volunteering ideas and information during class. After participating in MyScience Carol commented that Caitlyn’s “shoulders got pushed back a little bit … she put up her hand in the classroom, [and joined in the] conversation, so I think for her it’s really done a world of good”. Carol linked Caitlyn’s transformation to their relationship in school which concurrently provides an insight into the workings of their ‘home’ CoP: “I valued her contribution, or I saw value in her in the sense that I said to her I think you’d be a great mentor and whether she believe[d] it or not she took it on board”.

Carmel thought that her school relationships with Year 9 students were enhanced through the mentoring experience and valued the time that was spent engaging in ‘serious kind of science talk’:
… obviously you develop relationships with the students that we take from our school and that’s really good. … I guess they see themselves in a bit of a leadership position so it gives you an opportunity to really engage in serious science kind of talk with them about how they’re going to contribute.

She clearly regarded the ‘opportunity to really engage’ with her students as beneficial, indicating that this may not be common practice. A conducive factor could be the lower student to teacher ration during the mentor visits allowing for more intimate and in depth discussions.

In summary, the notion of mentors wishing to provide support to students (‘play devil’s advocate…’, ‘brainstorming of what the possibilities are…’) and teachers (‘extra hands and that extra understanding’, ‘just having seen that happen…’) is an example of CoP attribute #2: members who are collaboratively engaged in activities and discussion related to the domain. The examples showcase how these secondary teachers’ roles were an integral component of the interactions, which fostered primary-secondary linkages (‘you form relationships with (primary) students and teachers…’) and helped to inform them about the incoming Year 7 cohort’s capabilities (‘gives you a feel where to launch from’, ‘understanding the other side…’). Concurrently, the secondary science teachers witnessed significant changes (‘metamorphosis’) in some of their Year 9 students’ confidence, interest and engagement around science, and afforded opportunities to discuss science issues (‘really engage in serious science kind of talk…’) as the MySTics (see 4.1.2: MyScience trainees in the classroom) developed their science leadership skills. These secondary teachers’ have positive perceptions of the changes brought about by MyScience which augers well for the ongoing development of the MyScience CoP in the primary school and for the continuing evolution of science teaching practices in the secondary school and is a view supported by Jeans and Farnsworth’s findings (1993) – see earlier.

4.4 Findings and discussion: perceptions of secondary Year 9 science students as mentors

4.4.1 Secondary science students’ assertions: how they address the research question, and the significance of these mentors’ views

Participating Year 9 students’ perceptions of their experiences of MyScience and how these influenced their views about ‘science’, ‘science learning’ and ‘science teaching’ (see Section 4.1.1) lead to assertions addressing all three aspects: their own views of
‘science’ and ‘science learning’ in assertion #8; their influence on primary students’ ‘science learning’, and their views about science teaching in assertion #9. These student mentors are in a critical schooling stage of science education, with only one remaining year of compulsory science study. Their current views of science and science learning provide insights into ‘the students’ voice’, adding to the research knowledge base into why students lose or retain interest in science across their schooling years. This view is supported by Logan and Skamp (2008), who researched students’ views about science across the primary-secondary interface, and identified the “importance of listening to and heeding the students’ voice … in addressing the decline in students’ attitudes and interest in science” (p. 501).

4.4.2 Overview of secondary science students’ views

Year 9 science students perceived that MyScience participation improved their confidence and knowledge of science in secondary school. They consequently viewed science differently: their ability to think creatively and to work independently was enhanced and they experienced more enjoyment when doing science in secondary school. They perceived that they learned leadership skills and that their younger age helped primary students feel more comfortable, confident and connected with them than with their older teachers as mentors. They provided NOS knowledge and explanations to primary students, prompting discussion related to results and expressed surprise at the depth of primary students’ answers and ideas.

The following presents two assertions related to secondary students’ views of their MyScience mentoring experience. Assertion #8 details the influence of MyScience CoP practices on Year 9 science students’ NOS practices and confidence in their secondary school, while assertion #9 relates to Year 9 science students’ perceptions of their influence on primary students’ NOS understandings and learning.

Table 4.4 summarises the findings from the secondary science student interviews and identifies related CoP and NOS attributes from Table 3.8.
Table 4.4. Summary of findings from secondary science student interviews

<table>
<thead>
<tr>
<th>Category</th>
<th>#</th>
<th>Description of Assertion/Aspect/Evidence*</th>
<th>NOS/CoP attributes from Table 3.8</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASSERTION 8</td>
<td>8</td>
<td>Participation in <em>MyScience</em> changed Year 9 science students’ views about secondary school science and science learning.</td>
<td></td>
</tr>
<tr>
<td>Aspect</td>
<td>(a)</td>
<td>Changes in secondary NOS practices:</td>
<td></td>
</tr>
<tr>
<td>Evidence</td>
<td></td>
<td>▪ Increased enjoyment of, and improved ability to work independently, think creatively and persist in investigative science.</td>
<td>NOS#1, #5 CoP#1</td>
</tr>
<tr>
<td>Aspect</td>
<td>(b)</td>
<td>Changes in secondary NOS confidence:</td>
<td></td>
</tr>
<tr>
<td>Evidence</td>
<td></td>
<td>▪ Improved leadership skills and confidence in science through explaining science to others.</td>
<td>NOS#1 CoP#1</td>
</tr>
<tr>
<td>ASSERTION 9</td>
<td>9</td>
<td>Year 9 science students perceived that their interactions with primary students benefitted primary-secondary linkages and primary students’ NOS understandings and learning.</td>
<td></td>
</tr>
<tr>
<td>Aspect</td>
<td>(a)</td>
<td>Factors that enabled primary-Year 9 interactions:</td>
<td></td>
</tr>
<tr>
<td>Evidence</td>
<td></td>
<td>▪ The close age of Year 9 mentors to primary students enabled interactions and discussion.</td>
<td>CoP#2, #3 NOS#1</td>
</tr>
<tr>
<td>Aspect</td>
<td>(b)</td>
<td>Perceived NOS understandings and learning achieved by primary students through primary-Year 9 interactions:</td>
<td></td>
</tr>
<tr>
<td>Evidence</td>
<td></td>
<td>▪ Primary students improved their understanding of drawing graphs and interpreting data.</td>
<td>NOS#1, #2 CoP#2, #3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Primary students improved their understanding of the steps in the inquiry process.</td>
<td></td>
</tr>
</tbody>
</table>
4.4.2.1 Assertion #8 (#8): Participation in MyScience changed Year 9 science students’ views about secondary school science and science learning.

Two aspects of how MyScience participation influenced Year 9 students’ views of secondary science are presented below. Aspect (a) details changes in their NOS practices, and aspect (b) relates to changes in their NOS confidence. These changes, reported through the reflective responses to interview questions (Table 3.4), signify that learning has occurred. Each of these aspects provides evidence for Assertion #8. See Section 3.5.1 for the relationship between evidence, aspects and assertions.

Aspect (a): Changes in secondary NOS practices

One inference/interpretation supports this aspect (see ‘evidence’ shown in Table 4.4). It is that students reported, ‘Increased enjoyment of, and improved ability to work independently, think creatively and persist in investigative science’. The evidence supporting the inference/interpretation follows the inference/interpretation statement (in bold type).

Increased enjoyment of, and improved ability to work independently, think creatively and persist in investigative science.

Caitlyn –a student mentioned by Carol in the previous section who was ‘very shy’ and underwent a ‘transformation’ in her behaviour during science classes– described how her participation in MyScience changed her view of secondary science:

[Now], when we do experiments … [I] try to think of different ways to do it. … In a practical investigation … [I] think more out of the box and it helps me. [When teachers ask] ‘What do you think this is?’ … [I will now] … research at home, and stuff like that.

She perceived that she was thinking more creatively (‘out of the box’) to solve arising issues and questions and spent her own time researching areas about which she was uncertain – thus showing considerable interest and engagement in science. Caitlyn also felt that her mentoring experience had raised her confidence around doing experiments on her own:

I felt [sic] more confident now. I can do an experiment but [now] I was doing it by myself. Usually, I always need a friend … I always have to ask them, ‘How do you do this?’, but I knew how to do it.
Here, Caitlyn’s new skills—thinking creatively, independently researching and working on her own doing school experiments—have developed (been learned) because of her MyScience participation and are therefore an example of participatory learning, an attribute of a CoP.

For Cassandra, witnessing primary students’ high levels of enjoyment while doing their investigations changed her perception of science:

I didn’t really have much confidence in science before I really went there. Because the kids are cheerful and they really sink into it and [are] really happy to be doing it, it gave me a different view on it.

This ‘different view’ was also linked to the notion of tenacity. Cassandra commented that primary students “teach their mentors stuff as well as the mentors teaching them. … They can also teach their mentors to persevere ….” Here we have Year 9 mentors perceiving that they are developing different attitudes towards science because of their interactions with primary students and this learning is reciprocated through the help that they provide to the younger students. This collaborative learning dynamic is a hallmark of CoP attribute #1: acknowledged shared interest area in which members collectively learn from each other.

Aspect (b): Changes in secondary NOS confidence

One inference/interpretation supports this aspect (see ‘evidence’ shown in Table 4.4). It is that students reported ‘Improved leadership skills and confidence in science through explaining science to others’. The evidence supporting the inference/interpretation follows the inference/interpretation statement (in bold type).

Improved leadership skills and confidence in science through explaining science to others.

Three of the five interviewed Year 9 students perceived that MyScience participation had benefitted their own science capabilities in secondary school. Candice thought that she gained leadership skills: “leading the little kids and [learning] how to communicate with them and how to support them”. She added: “If I can explain it, that means I know what I am talking about and ah, yeah – it shows that I know”. Cassandra explained that she “got more confidence in teaching people and with science as well [she] got more confidence [and] wouldn't stuff experiments up and things like that”. Caitlyn recognised that participation not only helped the primary students but had also helped her confidence and
NOS understandings related to inquiry-oriented science learning (‘how they do it’) describing *MyScience* as a:

... good experience. It’s something good for the kids and you. It’s not just for them. It’s, like, for you, as well. It gives you a lot of confidence and it helps you with science yourself. ... It helps me with science because I’m more, definitely more confident and ... I get more answers of different experiments. Like, how they do it and I get the result as well ...”

Logan and Skamp (2008) raise the notion that students who participate in activities that value school science (in their case it was as participants in a research study about the primary-secondary transition, whereas in this case it is being a mentor that supports primary students to do investigative science) may come to “see more clearly the value of science as a result of clarifying their thoughts about the subject and therefore feeling more motivated towards it” (p. 517). Here, the Year 9 students’ science expertise is valued: they are in a leadership position (‘leading the little kids’, ‘teaching people’); they perceive that if they “can explain it ... it shows that [they] know [what is going on in a ‘science sense’]” and it is through these experiences that both Caitlyn and Cassandra reported that they felt more confident. Therefore, participating in *MyScience* may have raised their awareness of the value of secondary school science and their motivation and confidence in doing it. Findings by Zoller and Nahum (2012) corroborate the notion that explaining science ideas to others enhances students’ abilities to think in science. Candice, Caitlyn and Cassandra perceived that their science capabilities had improved because of their mentoring role in explaining science concepts to others.

**In summary**, these examples show that the mentoring experiences of the interviewed Year 9 MySTics in primary school settings have positively influenced their levels of enjoyment (‘really happy... gave me a different view on it’), confidence (‘helps me with science because I’m ... definitely more confident’), independence (‘I can do an experiment ... doing it by myself.’) and creativity (‘you think more ... out of the box and it helps me’) in secondary science. These traits are traditionally absent in the secondary years of science education and which, according to Lyons, could be remedied by “embrac[ing] approaches and curricula that engage and nurture the interests of today’s young people” (2006, p. 608). These findings indicate that such an ‘approach’ could be incorporating *MyScience* into secondary students’ science experiences.
4.4.2.2 Assertion #9 (#9): Year 9 science students perceived that their interactions with primary students benefitted primary-secondary linkages and primary students’ NOS understandings and learning.

Two aspects of how Year 9 students’ perceived that their MyScience participation influenced others are presented below. Aspect (a) details factors that were viewed to enable primary-Year 9 interactions, and aspect (b) relates to primary students’ NOS understandings and learning as a consequence of interactions with MySTics. Each of these aspects provides evidence for Assertion #9. See Section 3.5.1 for the relationship between evidence, aspects and assertions.

Aspect (a): Factors that enabled primary-Year 9 interaction

Two inferences/interpretations support this aspect (see ‘evidence’ shown in Table 4.4). They are that firstly, ‘The close age of Year 9 mentors to primary students enabled interactions and discussion’, and secondly, ‘Year 9 students valued primary-secondary links’. The evidence supporting each inference/interpretation follows the inference/interpretation statement (in bold type).

The close age of Year 9 mentors to primary students enabled interactions and discussion.

Four of the five interviewed Year 9 students commented directly, and the other inferred, that the small age gap between them and their primary student groups offered distinctive benefits to the younger students. Catherine felt that she had a “a big role in MyScience with the students because [she was] helping them make their own decisions and that’s important”. She commented that: “it was good to be able to help them and see their different ideas and their different opinions”. She observed differences between primary students’ interactions with MySTics compared with science teachers as mentors, perceiving that Year 9 students provided a more relaxed or ‘safe’ environment with more opportunities for primary students to voice their opinions and ideas – similar to findings by Darby (2005). Catherine observed:

I think it’s important to have [Year 9 students as mentors] because we’re not as young as them [as the primary students] but we’re not old … so I think they can like sort of feel more comfortable with us… because we have knowledge but we’re not like teachers, like where we’re really strict on it. [Primary students] were a lot more laid back with us than
they were with the teachers. [Primary students] would sit up straight and be very, you know, formal about how they ask the teachers questions, but they were kind of loose about their ideas [with us] and it just kind of came out… The teachers were kind of thrusting their ideas onto them. So they [primary students] didn’t really have a chance to speak, whereas with us they were just kind of going for it.

Here, Catherine identified several examples of positive CoP interactions (‘not as young… but we’re not old’, ‘more laid back’, ‘loose about their ideas’, ‘just kind of going for it’) between primary students and Year 9 mentors (CoP#2) and also recognised that they have worthwhile ‘knowledge’ to impart or share (NOS#1). The observation of secondary science teacher mentors ‘thrusting their ideas’ onto primary students was not mentioned during the secondary teacher interviews (see Section 4.3) or during the primary student interviews (see Chapter 6) so is not easy to triangulate. It may be that Catherine’s perception of her science teachers typically using transmissive teaching approaches in secondary science classes (cf. Lyons, 2006) has been transferred to the primary school setting and is clouding her judgement of teachers’ interactions with primary students.

Caitlyn commented that: primary students “talk to me normally” because “we’re kids like them … we’re not as young but still, they realise that we’re just kids, so we’re pretty much the same”. Carla thought that primary students connected with them more than the teachers; while Cassandra felt that their presence gave the younger students confidence. These are three more examples of CoP interactions where members are collaboratively engaged in the domain (CoP#2). Candice felt that the presence of mentors gave primary students an opportunity to get information and alternative explanations (related to their science investigations) from people other than their teacher, indicating that it’s good for the students to have mentors because it’s not only their teachers that are helping out. So they get knowledge from different other people and different perspectives and stuff. … the teachers might give them [knowledge] in a simpler [sic] way and then we might make it even more simpler for them (Candice).

Here, Candice appears to have the view that Year 9 mentors are better at explaining (simplifying) ideas to the primary students (than the primary teachers), possibly due to their closer age proximity. Obliquely, these examples (encompassing all of the Year 9 mentors) could be perceived as a criticism of the secondary (and primary) teachers’ practices – and therefore of their science teaching practices – in both primary and secondary contexts.
Chapter Four

**Year 9 students valued primary-secondary links.**

Carla was in the unusual position of having been a member of the first Year 6 class to experience *MyScience* when she attended School C in 2006, and was now a MySTic helping primary students back at her old school. She described the following anecdote about recognising Charles (her mentor in Year 6), who was the Deputy Principal at her Year 7 orientation:

> I remember in Year 6 thinking he was quite a cool guy. He made all these jokes and everything and then when I was at the orientation coming into Year 7 he was the Deputy Principal up the front. I was like – he was a mentor thing. Because my brothers and I, we all did it, ’cause I’m a triplet … and yeah we were like, ‘Is that the guy?’ And then we’re going, ‘Oh yeah look at him.’

Here, it appears that Carla appreciated having had Charles as a mentor when she was in Year 6 (‘thinking he was quite a cool guy’, ‘made all these jokes …’) and then to recognise a familiar face at the Year 7 orientation may have eased her primary-secondary transition.

Catherine enjoyed being part of *MyScience*, working with primary students and contributing to their development. She commented that: “helping younger people is really fun. Like to feel like you’re doing something too, giving back to them”. She posited: “If I was, say I did it in primary and then to teach them, [that would] be a pretty awesome feeling”. Here, Catherine seems to be wishing that she had also had Carla’s opportunity – experiencing *MyScience* as a primary student and also as a Year 9 mentor – perhaps as a way of having continuity between the two schools, but she also wants to help primary students with their science learning. Like Catherine, Caitlyn also expressed enjoyment at being involved with primary students doing science: it gave her the opportunity to “go to the same level as the kids and do an experiment that [was] fun for [her] and them”.

These examples indicate that linkages between the primary and secondary school are considered to be important by Year 9 participants (‘he was quite a cool guy…’, ‘feel like you’re doing something…’, ‘knowledge from different other people’), and signify that these younger mentors are a valuable resource for developing sustainable *MyScience* CoPs.
Chapter Four

Aspect (b): Perceived NOS understandings and learning achieved by primary students through primary-Year 9 interactions

Two inferences/interpretations support this aspect (see ‘evidence’ shown in Table 4.4). They are that firstly, ‘Primary students improved their understanding of drawing graphs and interpreting data’, and secondly, ‘Primary students improved their understanding of the steps in the inquiry process’. The evidence supporting each inference/interpretation follows the inference/interpretation statement (in bold type).

**Primary students improved their understanding of drawing graphs and interpreting data.**

All of the Year 9 mentors recounted NOS examples of their interactions with primary students. Caitlyn commented that her primary students “didn’t really know how to do a graph or a table … so I had to try to teach them” as did Carla who “drew the graphs up and recorded the results for them”. These types of science skills –referred to as the “tools of the trade” by Feasey (2012, p. 62)– are clearly regarded as significant by the MySTics, since they have been specifically identified. These mentors’ actions (drawing graphs and tables, recording results) would have been completed with the primary students, thereby affording the mentors with a teaching and learning opportunity, and the students with a learning opportunity, all of which exemplify CoP attributes related to collaboration –CoP#2, and what members ‘do when they interact’ –CoP#3. Students would likely have developed understandings around the notion of “what (the tables and graphs) are used (for) and when and how to use them” –increasing what Feasey calls students’ “concepts of evidence” (2012, p. 62-63). Feasey comments that these skills “need to be taught” (2012, p. 67), and here we have evidence that is precisely what the Year 9 students have done.

Carla described another example related to developing primary students’ ‘thinking and working scientifically skills’. She guided her primary students to more closely interrogate their data in an experiment to do with the effect of creating static charge by rubbing a balloon. Changes to the strength of the charge were measured by an increase in the number of small pieces of paper that were attracted to the balloon. Carla, pointing to the results, described how she asked the students “[Do] you guys notice anything that’s going up with this [the time spent rubbing]?” adding that “… [then] they noticed [that the number of paper pieces increased as well]”. This anecdote illustrates that Carla seized an important ‘teaching moment’ for her student group which was possible because of her own NOS understandings and would likely have contributed to developing her students’ NOS thinking and working scientifically skills – NOS#1.
Primary students improved their understanding of the steps in the inquiry process.

Cassandra thought that it was important to teach primary students “how to break down the aim and the method and draw diagrams and graphs and stuff like that” (aspects of the NOS), because they “might panic if they do something wrong, and the mentors kind of helped them to realise that it’s not that bad if they do stuff up they can just try again”. This notion of ‘perseverance’ relates to the tentative nature of science (NOS#2) –when unexpected results or events occur in the process of ‘doing science’– and was also raised by the scientist mentor Spencer, in the context of pursuing a good data set (see Assertion #1(c)), reinforcing that this characteristic has value when doing inquiry-oriented science.

Cassandra’s comment about mentors ‘helping (primary students) to realise’ is an indicator of CoP#2: members who are collaboratively engaged in activities and discussion related to the domain, and CoP#3: what members ‘do’ when they interact.

Candice described her relationship with the primary students as: “we’re like a recipe for them and they’re the ones cooking”, indicating that she sees her role as guiding the primary students as they do their scientific investigations – similar to the ‘helping role’ described by Cassandra.

In summary, Year 9 MySTics perceived that, due to their closer age to the primary students, their interactions with the younger students created a more relaxed atmosphere (‘more comfortable’, ‘more laid back’) where primary students spoke more easily about what they were thinking (‘loose about their ideas’, ‘just kind of came out’, ‘talk to me normally’). Year 9 students provided alternative sources for explaining ideas to the primary students and perceived that they were able to ‘make (NOS knowledge) even more simpler’ than the adult primary and secondary teachers. Primary students were perceived to be more connected with Year 9 mentors than with secondary science teacher mentors, and that the MySTics’ presence gave primary students confidence. Year 9 students valued the opportunity and experienced enjoyment mentoring primary students, recounting examples of interactions where they taught or explained NOS skills.
4.5 Concluding remarks and pedagogical implications

The underlying aim of the mentor study was to determine fresh insights into improving primary science practice by researching mentors’ perceptions of their participation in MyScience communities of science practice, where participants share in the discursive practices that embody how science works (Scott et al., 2007), and how their involvement influenced their views about science, science learning and science teaching. A keystone of the MyScience educational model is involving people with science expertise –Element 4: Scientists mentoring students where, the “scientist mentors [are] people who … can be scientists from research and industrial organisations; university and pre-service secondary science teachers; science teachers from local secondary schools (at times with Year 9/10 students filling an apprentice role) or parents and other school community members” (Forbes & McCloughan, 2010, p. 26). Therefore, gaining understanding of the experiences and views of as many types of mentors as possible is important for helping to identify the conditions under which effective community-linked projects may become embedded in metropolitan school science programs (Rennie, 2007; Tytler, 2007).

4.5.1 Responses to the MyScience experience

The responses of scientists, secondary science teachers and Year 9 students to their mentoring experiences were overwhelmingly positive (with the exception of Eric, #3(b)) and therefore augur well for the development of sustainable MyScience communities of practice. Mentors’ motivations for involvement in the program appear to be strongly associated with characteristics of each group’s home CoP.

Overall, professional scientists’ wished to positively influence primary students’ views about science as a human endeavour [#1]. Astronomers wanted to develop young students’ capabilities in ‘scientific intuition’, aspects of scientific literacy such as evaluating scientific evidence, to seed an interest in, and a love of science, and to give students ‘agency’ [#4(a)]. Engineers also wanted to develop an interest in science and to seed future career aspirations in primary students, but appeared to have a stronger emphasis (than the astronomers) on linking and showing the relevance between ‘school science’ and ‘real world science (Tytler, 2007) [#4(b)]. These mentors adapted and used the practices of their home CoP in their interactions with primary students and teachers.

Secondary science teachers’ motivations for involvement related to developing primary-secondary links between the participating schools. Similar to the scientists, they wanted to provide primary students with NOS guidance and discussion, and primary teachers with
‘extra hands’ and modeling NOS practices to improve teachers’ confidence [#7]. They adopted MyScience CoP student-responsive practices in their primary school interactions, which changed their views of science teaching and learning in secondary school settings [#6].

Year 9 students wanted to work with and help primary students. For some, there was an element of nostalgia related to visiting their old primary school, or of ‘giving back’ to the primary school community through their involvement [#9(a)]. MyScience experiences appeared to significantly contribute to these students becoming more engaged, interested and confident around their secondary science education.

4.5.2 The value of using a CoP framework for interpreting data

Groups of people who work together –sharing a concern or passion and learning how to do it better as they interact regularly– are, by definition, in a community of practice (Wenger-Trayner, 2013). Using a CoP lens to interpret data has been used by Borg (2009), and Koliba and Gajda (2009). In this study, the approach helped to answer the research question by uncovering participants’ views of science, science learning and science teaching; their interactions with others; and perceptions of their own, and others’ roles while working and thinking scientifically, and therefore provided insights into participants’ views of their sense of belonging within their MyScience CoP. Since a strong sense of belonging fosters the development of the community’s practice, which in turn engenders learning, it makes sense to identify key factors that may advance or hinder the development of sustainable CoPs. This has been successfully achieved in this study using a CoP framework to interpret data.

4.5.3 Views about science

Being in a community of practice around investigating scientifically gave scientists an opportunity to showcase ‘real world science’, and their passion and views about working in that world, to primary students and primary teachers [#1(a), (b)]. A desire to increase community scientific literacy by ‘intervention’ in the early schooling years was a key reason for some astronomers’ involvement as mentors [#4(c)]. This strategy was affirmed through these mentors reporting that students had learned about the nature of science through interactions with other CoP participants [#5].

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13 Secondary science teachers did not refer to ‘science’ per se in their interview responses.
Year 9 students’ perceptions about secondary science changed as a result of their MyScience participation: they perceived that they enjoyed science more; were more confident; more persistent; and were more able to work independently and to think creatively. These new insights were gained through interactions with the primary students, observing how the younger students enjoyed science, persisted, and had ‘different ideas and different opinions’ [#8, #9].

4.5.4 Views about science learning

Scientists, secondary science teachers and Year 9 students all commented on science learning occurring because of participation in a MyScience CoP. Scientists observed primary students learning about the nature of science, science as a human endeavor and ‘developing scientific intuition’ during school visits and perceived that this was due to mentor-student interactions [#1]. Similarly, Year 9 students thought that they helped primary students learn foundational science skills related to drawing tables and graphs, recording and interpreting data [#9(b)]. Primary students’ capabilities and enthusiasm (related to science learning) were recognised and commended by scientists [#2(a)], secondary science teachers [#7] and Year 9 science students [#9], serving to reinforce the benefits of their involvement.

Secondary teachers commented that some Year 9 mentors went through a ‘metamorphosis’ in their science confidence, interest and engagement in secondary science classes and that there were useful opportunities to ‘really engage in serious kind of science talk’. This signals a further noteworthy benefit for nurturing primary-secondary school partnerships to develop MyScience CoPs.

4.5.5 Views about science teaching

Scientists reported that their own skills in how to best support students had improved through participation in MyScience CoPs [#3(a)]. During school visits, scientists [#1(c)] and secondary science teachers [#7(a)] used non-directive, open questioning to promote thinking, discussion, problem solving and collaborative interactions around science and had the opportunity to more deeply engage with and understand the primary context. For the secondary science teacher mentors this was a transformational experience, resulting in them adopting these new teaching strategies in a number of ways back in their home CoP through: accommodating the needs of incoming Year 7 MyScience old-timers; demonstrating the

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14 Science as a Human Endeavor (SHE) does embrace the nature of science (NOS), but has been separated here for the purposes of emphasis.
techniques to colleague teachers; trialling a student-centred approach with Year 8 students; and even having colleagues who were not mentors changing their teaching approach (with secondary science classes) to include ‘mini student-centred’ investigations [#6(a), (b)].

Year 9 students felt that their style of interactions with primary students fostered a more informal environment (than that provided by their secondary science teachers) where the younger students more readily voiced their opinions and ideas.

4.5.6 Implications for primary participants of having different ‘types’ of mentors

This study has provided insights into the variety of strengths and expertise brought into MyScience CoPs by the different types of mentors. Almost all mentors saw themselves as integral members of their CoP recognizing that they have a synergistic relationship with classroom teachers and students and that all play a vital role in the CoP. The principal and parents were viewed as important but not central to the functioning of the CoP.

Professional scientists and engineers provided high levels of expertise around NOS knowledge, science as a human endeavor, and linkages between the worlds of ‘school science’ and ‘real world science’ to both primary students and their teachers. This highly desirable set of practices was achieved through their lived experiences of ‘doing’ science in their daily work. They encouraged collaboration and discussion amongst primary students and skillfully used questioning to promote thinking – as did the secondary science teacher mentors.

Secondary science teacher mentors provided NOS knowledge and advice to primary students and also benefitted by gaining insights into: the primary schooling context; new strategies for the teaching and learning of science (teacher as a facilitator, not as a director); and the high levels of science expertise achieved by MyScience students. This prompted them to change their teaching approach to accommodate and build on the higher levels of science expertise of incoming Year 7 students, thus facilitating a smoother transition for students across the primary-secondary interface. Year 9 mentors provided NOS advice and were close in age to the primary students. MyScience involvement positively changed their attitudes towards secondary science education.

4.5.7 Pedagogical implications for primary science education

Findings from this study indicate that scientists and engineers were eager and willing to provide support to primary schools and that a program such as MyScience provides both a
structure and a purpose that is able to seed the development of communities of practice. Similarly, secondary schools were willing to support teachers and students in feeder primary schools, making primary-secondary school partnerships a sustainable way to develop *MyScience* communities of practice.

Responding to this study’s research question about mentors’ perceptions has provided insights into understanding how a CoP around ‘investigating scientifically’ operated in an urban primary school setting and how a successful CoP can affect mentors’ beliefs and reported practices about science, teaching science and ‘learning as participation’. These findings will now be augmented by considering the views of primary teachers (Chapter 5), and then primary students (Chapter 6).
Chapter 5

Primary teachers’ perceptions of their participation in MyScience

5.1 Introduction and chapter structure

As described earlier (Chapters 1 & 3) the main research study was concerned with looking at participation in MyScience as a ‘community of practice’ (CoP) where participants from different communities come together to work collaboratively on the common venture of ‘investigating scientifically’. Specifically, the study was concerned with how participation in MyScience affected participants’ views of science, science learning and science teaching to better understand the complexities of the teaching and learning interface and how participants’ views of their own sense of belonging and/or participating in the MyScience CoP changed as they moved from being newcomers – on the periphery of the CoP – to experienced members of the community and thus at the centre of their CoP. The study also fulfils an articulated need for research on the conditions under which schools, universities and businesses can work together sustainably as outlined in Chapter 2.

This Chapter (5), and the two either side as ‘bookends’ (Chapters 4 & 6), present interpreted findings of the lived experiences of the interviewed participants as follows:

- Chapter 4: mentors (professional astronomers and engineers, secondary school science teachers and Year 9 science students),
- Chapter 5: primary teachers, and
- Chapter 6: primary students.

Chapter 7 presents a synthesis of the findings from each of these three key stakeholders with a proposed ‘community of science practice’ model for the sustainable implementation of MyScience.

Chapter 5 presents the researcher’s interpretations of teachers’ perceptions of their MyScience participation. Participants were interviewed and the data analysed according to the procedures described in Chapter 3. All primary teacher participants were asked the same interview questions as those of the mentors and primary students and are presented in Table 3.4. ‘Community of practice’ (CoP) and ‘nature of science’ (NOS) lenses were used to analyse and interpret teachers’ perceptions from School A (n=2), School B (n=4), and School C (n=2) – the same schools from which participants in
Chapters 4 and 6 were sourced. Relevant literature pertaining to the notion of using attributes associated with ‘communities of practice’ and the ‘nature of science’ as analytic lenses is detailed in Chapters 2 and 3.

5.1.1 The research question related to primary teachers

The specific research question that foreshadowed the findings reported in this Chapter was:

What are stakeholders’ (here, primary teachers in Schools A, B and C) perceptions of their involvement in MyScience, and how does being in a ‘community of practice’ around ‘investigating scientifically’ influence their views about science, science learning and science teaching?

5.1.2 The context for the primary teacher study

Demographic information for each of the three participating schools at the time of the study and how this related to MyScience participation is detailed in Table 4.1, Chapter 4, Section 4.2.3. For purposes of comparison and contrast (Bogdan & Biklen, 2007) primary teachers were sampled from the same three schools (Schools A, B and C) as the mentors in Chapter 4.

The experiences and views of the primary teachers who were participants in MyScience were those in whose classrooms the scientists and engineers were mentors (see Chapter 4, Section 4.2), that is, in Schools A and B, and also included two teachers from the third school –School C– where the mentors were pre-service secondary science teachers, secondary science teachers, and secondary science students (see Chapter 4, Sections 4.3 and 4.4).

Teachers’ perceptions about science, science learning and science teaching directly influence their classroom decisions and actions when teaching science (Levitt, 2001). Their perceptions are affected by, among other variables, context, where context can be interpreted in a variety of ways (Lumpe et al., 2000). Of particular relevance to the present study is that teachers’ actions and perceptions can interact with each other and a change in one can result in changes in the other (Carlone et al., 2010; Levitt, 2001). This chapter reports teachers’ perceptions about science, science learning and science teaching within the innovative context of MyScience that has the potential for transformative change. Very few studies were located that reported primary teachers’ perceptions of the interaction of scientists (and other mentors) with themselves and
their students in ongoing classroom investigations apart from Bolstad and Bull (2013; Howitt et al. (2009) and Rennie (2012). From the teachers’ perspective Bolstad and Bull (2013) reported few tangible outcomes for teacher learning in school-science community linked initiatives but overall there was a perception that school-science community initiatives were beneficial for “connecting school learning to real-world contexts, extending gifted and talented students; and providing students with insights into science careers” (2013, p. 20). Howitt et al. (2009) presented three case studies of scientist-teacher partnerships from the Scientists in Schools program two of which were based in primary schools through mostly online interactions. The authors reported that teachers benefitted

… by increased knowledge and understanding of real-world, contemporary science; increased opportunities for professional learning through communication with scientist and other teachers; increased access to resources; increased awareness of the types and variety of careers available in the sciences; and increased motivation (2009, p. 38).

Rennie’s evaluation of the Scientists in Schools program found that teachers “perceived significant benefits for themselves” which included opportunities to communicate and work with scientists, and to increase student engagement in science (2012, p. 79). Primary science teachers valued the increased profile of science that participation in the program brought to their schools, and felt more confident when teaching science and in their knowledge of contemporary science.

This chapter reports the first detailed investigation of primary teachers’ views about extended (over several weeks, and often over several years) face to face contact with scientists and other mentors with science expertise. This is significant when the important connections between context, teachers’ perceptions and practice are considered. Furthermore, the findings in this study contribute to calls for research into the conditions that support the effective embedding of community-linked projects into school science programs (Rennie, 2007; Tytler, 2007) that have been found to improve science practice in Australian regional schools (Tytler, 2007; cf. Howitt et al., 2009; Tytler et al., 2008). It is probably the first study to provide insights into such programs in metropolitan schools.

Of the teachers interviewed in this study four from School B had experienced MyScience from one to three times and had taught students in Years 3, 4 and 6. In School C MyScience had begun in the two Opportunity Classes (OC) in 2006. The two interviewed teachers both taught the OC classes (Years 5 and 6) and had experienced
MyScience three or four times. These teacher participants were therefore typically old-timers (Lave & Wenger, 1991). School A teachers were first-timers.

As described in Chapter 3, section 3.3.2 the interviewed primary teachers were selected using two purposive sampling techniques: ‘snowball sampling’ and ‘maximum variation sampling’ (Patton, 1990). In each school, the key MyScience teacher (who was the school contact person for the program) was invited to participate in the research study. The school principal recommended additional MyScience teachers with a range of professional development experience, opinions (about their MyScience participation) and gender. Pseudonyms have been used for all teacher names and were allocated so that the first letter of each teacher’s name correlated with their school (e.g., Angela is from School A, Brian is from School B). Table 5.1 provides the background for the interviewed teachers from the three schools and the ‘relevant mentor names’ to facilitate cross-referencing to the findings in Chapter 4. As shown, all except two teachers had extensive teaching experience, and there was only one male (Brian). All interviewed teachers were generalist primary classroom teachers who, at the start of their MyScience participation, had limited science background knowledge.

Table 5.1. Details of teachers (and relevant associated mentors) interviewed from Schools A, B and C

<table>
<thead>
<tr>
<th>School</th>
<th>Teacher name</th>
<th>Schooling year taught</th>
<th># times in MyScience</th>
<th>Classroom experience (years)</th>
<th>Relevant mentor names</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Angela</td>
<td>5/6</td>
<td>1</td>
<td>20+</td>
<td>Sam</td>
</tr>
<tr>
<td></td>
<td>Amy</td>
<td>3/4</td>
<td>1</td>
<td>20+</td>
<td>Sasha Scott</td>
</tr>
<tr>
<td>B</td>
<td>Beth</td>
<td>6</td>
<td>3</td>
<td>20+</td>
<td>Elana</td>
</tr>
<tr>
<td></td>
<td>Brian</td>
<td>6</td>
<td>1</td>
<td>15+</td>
<td>Evan</td>
</tr>
<tr>
<td></td>
<td>Bridget</td>
<td>4</td>
<td>2</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bettina</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Cathy</td>
<td>5/6</td>
<td>4</td>
<td>20+</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chris</td>
<td>5/6</td>
<td>3</td>
<td>20+</td>
<td></td>
</tr>
</tbody>
</table>

# = ‘number’
5.2 Findings and Discussion: primary teachers

A number of findings emerged from participants’ interviews and these are expressed as two plausible assertions with supporting evidence.\textsuperscript{15}

In line with Anfara et al.’s (2002) suggestions to present evidence of “methodological rigour and analytical defensibility [in] qualitative research” (2002, p. 28) the primary teacher findings are presented as follows:

1. an ‘overview of findings’;
2. a ‘tabulated summary of assertions, aspects, evidence including relevant NOS and CoP attributes’;
3. each assertion, its aspects and detailed supporting evidence; and
4. a summary of each assertion.

Thus, an overview of the primary teachers’ views is presented in Section 5.2.1 and Table 5.2. The definition and hierarchy of ‘assertion, aspect and evidence’ in the table and associated findings relate to the data analysis procedure (see Chapter 3) where: ‘evidence statements’ are derived from themes arising from the coding, ‘aspects’ are statements derived from the collection of evidence statements and ‘assertions’ are statements derived from the collection of aspects. ‘In text’ references to assertions are denoted by, for example, [#1] forAssertion #1.

These reported ‘assertions’ and ‘aspects’ are the researcher’s interpretations and inferences, from, in part, analysis of participants’ responses to interview questions about their involvement in MyScience (see the research question in Section 5.1.1). To further aid the reader with cross-referencing to Table 3.8 (CoP and NOS attributes) and to highlight significant CoP and NOS connections, right hand margin notes have been inserted to correlate with relevant sections of text (identified by dotted underlines – as indicated). At times, significant aspects of CoPs and NOS that merit additional noting e.g., ‘collaboration’ have also been added as margin notes. The first example in the text in this chapter is as follows and has been indented to enhance its visibility:

\textsuperscript{15} These findings have been reported in: Forbes, A. & Skamp, K. (2013). "Because we weren't actually teaching them, we thought they weren't learning": Primary teacher perspectives from the MyScience initiative. Research in Science Education. doi: 10.1007/s11165-013-9367-9
Chris also felt *MyScience* gave science “more prominence which I think is really important ...” while Cathy saw it as “a way of focusing [her] energies” on the skills of investigating scientifically, which she had previously neglected.

### 5.2.1 Overview of primary teachers’ views from each of the three schools

In general, when asked to compare their *MyScience* experiences with their normal school science experiences, teachers described the key differences as being related to inherent features of the *MyScience* program and that these features profoundly impacted their views of science and science learning (Assertion #1 [#1]). The main influences on the views reported by teachers related to:

- the types of classroom activities they experienced while doing *MyScience* such as: the explicit teaching of ‘scientific methods’; students’ active involvement in hands-on collaborative ventures with their peers; interactions between teachers, students and mentors; and the wide variety of concurrently occurring scientific investigations;
- the amount of student choice and independence;
- the complexity and stimulation afforded by *MyScience*; and
- the presence and expertise of the mentors.

The *MyScience* initiative is designed to address all of these areas (see Chapter 2, Section 2.6 for an overview of the *MyScience Educational Model*) but what is significant is that teachers independently reported these perceptions with no prompting during interviews.

These teachers also have particular views of their own role –and these implicitly and explicitly represent their views of science teaching– as well as views of other CoP members’ roles (Assertion #2 [#2]).

Each of these assertions, which together relate directly to the research question, is now presented and discussed with supporting evidence and pedagogical implications from this study and associated literature. Occasional reference in this chapter is made to relevant findings derived from the perceptions of scientists (Chapter 4) and primary students (Chapter 6) since they were co-participants at the time of this study. As outlined earlier, a more detailed synthesis of findings is presented in Chapter 7.

Table 5.2 summarizes the findings from the primary teacher interviews and identifies related CoP and NOS attributes from Table 3.8.
Table 5.2. Summary of findings from primary teacher interviews

<table>
<thead>
<tr>
<th>Category</th>
<th>#</th>
<th>Description of Assertion/Aspect/Evidence*</th>
<th>NOS/CoP attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ASSERTION 1</strong></td>
<td></td>
<td>Participation in <em>MyScience</em> changed teachers’ views of what it meant to be ‘doing science’ in the primary classroom; these views exemplified CoP and NOS attributes that underpin, in part, the <em>MyScience</em> initiative.</td>
<td></td>
</tr>
<tr>
<td>Aspect</td>
<td>(a)</td>
<td><em>MyScience</em> legitimized the place of science in the primary curriculum:</td>
<td></td>
</tr>
<tr>
<td>Evidence*</td>
<td></td>
<td>- <em>MyScience</em> provided an opportunity to focus on science and resulted in teachers creating resources to support CoP participants.</td>
<td>NOS#1, #3, #5, #6 CoP#1, #2, #4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- <em>MyScience</em> provided an opportunity to integrate literacy, numeracy and information technology (IT) (but this required forward planning).</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- <em>MyScience</em> provided an engaging, exciting and interesting way to teach investigative science for both teachers and students that differed markedly to normal school science.</td>
<td></td>
</tr>
<tr>
<td>Aspect</td>
<td>(b)</td>
<td>The types of <em>MyScience</em> activities influenced teachers’ views of their own and others’ roles while doing science, and their own and others’ views of learning in and about science:</td>
<td></td>
</tr>
<tr>
<td>Evidence</td>
<td>(i)</td>
<td>Effect on student roles and learning:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Through <em>MyScience</em> students had an increased sense of accountability, and learning was more student-directed and collaborative.</td>
<td>NOS#1, #5, #6 CoP#1, #2, #3, #4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Students learned about the nature of science and science as a way of knowing.</td>
<td></td>
</tr>
<tr>
<td>Evidence</td>
<td>(ii)</td>
<td>Effect on teachers due to their role changing from ‘director’ to ‘facilitator’:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Teachers experienced a transformation in their own understanding of student achievement and how students learn.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Teachers reported feelings of disempowerment when not in a director role.</td>
<td></td>
</tr>
</tbody>
</table>

| **ASSERTION 2** | | Teachers’ perceptions of participants’ roles, including their own, were consistent with a CoP interpretive framework and provide further insights into teachers’ views about the nature of science, and learning and teaching science. | |
| Aspect | (a) | Teachers’ views of students: | |
| Evidence | | - Students should demonstrate characteristics such as active participation, reliability, responsibility, creativity, care and perseverance. | NOS#1, #5, #6 CoP#1, #2, #3 |
| Aspect | (b) | Teacher-student relationships: Teachers’ views of their own roles in assisting student learning: | |
| Evidence | | - Teachers provided varied support for students in investigative contexts. | CoP#2, #3, #4 |
| | | - Teachers prepared students for investigations during mentor visits. | |
| | | - Teachers provided support to students during and after mentor visits. | |
| | | - Teachers acted as a mediator or border crosser between students and mentors. | |
| | | - Teachers maintained a physically and emotionally safe and open learning environment in the classroom. | |
| | | - Teachers fostered interest and enthusiasm about science. | |
| | | - (Newcomer) teachers learned from old-timer students. | |
| | | - The impact of students disregarding teachers’ science expertise. | |
| Aspect | (c) | Teachers’ views of the teacher-mentor relationship: | |
| Evidence | | - Teachers regarded the presence of ‘good’ mentors as a critical component of the program. | NOS#1, #3 CoP#1, #2, #3 |
| | | - Teachers learned about the nature of science from mentors. | |
| | | - Mentors gave teachers ‘breathing space’. | |
| | | - The negative impact of mentors assuming that teachers have low levels of ‘nature of science’ knowledge. | |
| Aspect | (d) | Teachers’ views of the mentor-student relationship: | |
| Evidence | | - Mentors provided a link between the worlds of ‘in’ and ‘out’ of school science. | CoP#1, #2 |
| | | - Mentors provided students with passion, knowledge and information about science and ‘doing science’. | |
| | | - Mentors provided students with more attention. | |
| Aspect | (e) | Teachers’ views of the Principal and parents: | |
| Evidence | | - Principal was viewed as a gatekeeper and advocate for the program. | NOS#1 CoP#1, #2 |
| | | - Parents provided resources, and showed interest in students’ investigations. | |

* Evidence statements are summative examples of participant perceptions (derived from interview transcripts) that may be interpreted as support for aspects underpinning each assertion.
5.2.2.1 Assertion #1 [#1]: Participation in MyScience changed teachers’ views of what it meant to be ‘doing science’ in the primary classroom: these views exemplified CoP and NOS attributes that underpin, in part, the MyScience initiative.

Teachers’ views of ‘doing science’ changed in two major ways. Firstly, there was evidence that strongly suggested these MyScience teachers now considered the initiative had legitimized the place of science in the primary curriculum (referred to as ‘Aspect (a)’ below). Secondly, the types of MyScience activities influenced teachers’ views of their own and others’ roles while doing science, and their own and others’ views of learning in, and about, science (referred to as ‘Aspect (b)’ below). In each instance these teachers’ interview responses, and other data, provided numerous examples of classroom events that exemplified the presence of CoP and NOS attributes (Table 3.8). This could be interpreted as teachers articulating these features of MyScience without necessarily appreciating their CoP and NOS significance. Each of these aspects provides evidence for Assertion #1. See Section 3.5.1 for the relationship between evidence, aspects and assertions.

Aspect (a): MyScience legitimized the place of science in the primary curriculum

These teachers indicated that the place of science in their curriculum was legitimized in several ways by the MyScience educational model (which replaced an existing curriculum planning framework) with teachers devoting additional time to science as well as preparing resources to support the MyScience structure. The MyScience initiative made science (rather than other subjects) the focus for the integration of other curriculum areas all of which supported the development of science inquiry skills. Furthermore, as MyScience made investigative science far more appealing (than ‘normal’ classroom science) to teachers and students, it was seen as having additional value in the primary curriculum.

Three inferences/interpretations support this aspect (see ‘evidence’ shown in Table 5.2). They are that firstly, ‘MyScience provided an opportunity to focus on science and resulted in teachers creating resources to support CoP participants. Secondly, ‘MyScience provided an opportunity to integrate literacy, numeracy and information technology (IT) (but this required forward planning)’. Furthermore, ‘MyScience provided an engaging, exciting and interesting way to teach investigative science for both teachers and students
that differed markedly to normal school science’. The evidence supporting each inference/interpretation follows the inference/interpretation statement (in bold type).

*MyScience provided an opportunity to focus on science and resulted in teachers creating resources to support CoP participants.*

Within the crowded primary curriculum, *MyScience* gave participating primary teachers an opportunity—a reason—to be able to focus on science in their classrooms and to legitimize its place in the suite of subjects they are required to teach. Amy commented that their curriculum was “COGs\(^{16}\) driven” and *MyScience* “gave me opportunities to focus on science” whereas “a lot of the COGs …, maybe they don’t”. *MyScience* afforded her with a way to “umbrella” her other curriculum responsibilities under the “*MyScience* banner”. Chris also felt *MyScience* gave science “more prominence which I think is really important…” while Cathy saw it as “a way of focusing [her] energies” on the skills of investigating scientifically, which she had previously neglected.

Chris described how “the language [of science]” became “a real focus”, with students “using the language and exploring the concepts behind the language” and with everybody having “their [scaffolding] posters up …” (for some examples see Figure 5.1). Cathy now recognised “the importance of the children coming up with the investigation” (rather than the teacher) thus “open[ing] up a different aspect” for her. These new inclusions suggest an awareness of NOS#1 (Science is inquiry based): that it has particular practices including ways of stating and describing events and thoughts; selecting and using words with specific scientific meanings; and working through the steps of a fair test scientific investigation. Teacher-generated resources, such as posters, assisted these processes (see Figure 5.1).

\(^{16}\) COGS is an acronym for ‘Connected Outcome Groups’, a teaching program containing a variety of units of work that is often used by public school teachers. COGS units typically have a limited focus on science concepts. See, for example: [http://www.curriculumsupport.education.nsw.gov.au/timetoteach/cogs/index.htm](http://www.curriculumsupport.education.nsw.gov.au/timetoteach/cogs/index.htm) (accessed January 19, 2014).
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Figure 5.1. Teacher-generated classroom posters at School C (by Cathy)

There were strong indicators of the presence of a community of science practice in all three schools. Similarly to Chris and Cathy (School C), Beth and her colleagues (School B) developed a student-scaffold, which was highly valued by Elana, an engineer mentor (see Chapter 4) who successfully used it with her students. Angela (School A) also developed a number of documents to support her teachers during mentor visits. These teacher-developed resources are an example of reification (similar to the mentor recruitment poster –Figure 4.1– developed by ABC in Chapter 4) and indicate that the producers have a significant sense of belonging to their MyScience CoP. Cathy’s reflection on her new science knowledge and understandings about including more student-directed investigations (see above, ‘different aspect’) indicated she was seeing herself as engaged in ‘activities related to the domain’ of ‘investigating scientifically’.

MyScience provided an opportunity to integrate literacy, numeracy and information technology (IT) (but this required forward planning).

MyScience was perceived by several teachers as a way to incorporate literacy, numeracy and IT skills and occurred when students: recorded their developing ideas in log books; discussed their ideas with others; took measurements, and recorded and presented their data (“graphing and measurement” [Amy], creating pie graphs [Brian]); and shared their findings using Excel and PowerPoint applications. Science became the focus area for the development of practices and skills in other subjects, but also advanced the development
of ‘specific methods labeled scientific’. All the interviewed teachers agreed that these practices and skills required advanced planning and explicit, timely instruction for students (as recommended by Feasey, 2012) and were ‘factored in’ for the following year’s program. Here, the added value placed on science within the curriculum is obvious. Furthermore, as shown in the following examples, there is evidence of teachers learning how to do MyScience better as they interact regularly – a hallmark of members of a CoP (CoP#1, CoP#2) (see Wenger-Trayner, 2013).

MyScience provided an engaging, exciting and interesting way to teach investigative science for both teachers and students that differed markedly to normal school science.

All interviewed teachers expressed this perception: “There really is no comparison [with normal school science]. MyScience, by far and away, is a stronger product … on that whole inquiry method of learning” (Brian, emphasis added). It “… is more interesting… for me but also for the kids … they wanted to keep doing it after it finished…” (Bridget), and is

… so different to anything they have done before … coming from K-2 … where everything is quite directed, all of a sudden they were given an independent activity which was just theirs and they were investigating something different to what their friend was in the next group and so it was all about them and they were looking for answers to their own questions (Bettina).

Angela concurred with Bettina’s view adding that she observed her students using higher order thinking skills such as “analyze, how can we do this … comparing what they’ve done to [before] … [and when] they’ve got their results, they have to then be able to work out why there might be data that didn’t [fit]”; she added “… all of that's really intriguing. It's beyond what normal classroom stuff goes into” (emphasis added).

Collaboration and creativity were clearly present within these consensual views about MyScience inquiry-oriented science processes. At least three teachers described how their students engaged in ‘meaningful learning’ by applying acquired knowledge and skills in new contexts – they were remembering and building on their previous experiences consistent with the NOS attribute of science being developmental. In Amy’s classroom, students applied scientific investigation skills in a study of the Murray-Darling river system while Beth noticed students were “more logical” and used planning when
challenged to “build the strongest tower” using available classroom materials. Bridget described a time when

… because [students] had so much fun doing their own experiments for MyScience, we actually used the idea of them creating and making stuff for two different homework projects. And they loved it. It was the only time that they’ve all brought in their homework.

… They had to … investigate and design a log cabin … (emphasis added).

Relatedly, Year 3 students’ abilities to transfer NOS skills and knowledge to new contexts were also noted by Akerson et al. (2013) when high achievers were explicitly taught about the NOS.

Evidence of MyScience students’ personal interest and deeper engagement with the content of science (as represented in MyScience), rather than simply a situational interest (Palmer, 2008), is present in the above responses, especially where students were given ownership of their learning (see Bridget-italicized comments). Observations of students applying their problem-solving skills to new situations and contexts (such as those reported by Beth and Bridget) have also been reported by Zoller and Nahum (2012), and Harris and Rooks (2010). Beth noticed deeper interest and engagement with some “quite discipline-poor boys” who were normally disengaged at school. She felt this was because they had experienced MyScience a number of times and it had “really changed their [approach], made them do some research …”; these boys now had the expectation that they would participate in MyScience the following year and they were “start[ing] to plan what they are going to do” for future investigations.

Aspect (b): The types of MyScience activities influenced teachers’ views of their own and others’ roles while doing science, and their own and others’ views of learning in and about science

Initially, teachers’ views of the effect of MyScience activities on student roles and learning (see (i)) will be discussed, followed by teachers’ views of MyScience activities on teacher roles and learning (see (ii)).

(i) MyScience activities: Effect on student roles and learning

Four inferences/interpretations support this aspect, which is subdivided into two components (see ‘evidence’ related to aspect 1(b) shown in Table 5.2). The first component’s (student roles and learning) two evidence statements are ‘Through
MyScience students had an increased sense of accountability, and learning was more student-directed and collaborative’ and ‘Students learned about the nature of science and science as a way of knowing’. The evidence supporting each inference/interpretation follows the unnumbered inference/interpretation statement (in bold type).

Through MyScience students had an increased sense of accountability, and learning was more student-directed and collaborative.

Student roles

MyScience developed and increased students’ sense of accountability as they had to complete regular logbook entries (Angela); work collaboratively with others and ‘pull their weight’ (Amy and Brian); and report their findings to others in the Science Fair (Bridget):

[In normal science lessons] it would all be basic, like, this is … talk about it, everyone do the thing and … I may do one or two experiments … [In MyScience] they were more engaged but they … knew to a certain extent they were responsible for what they had to do and so if they didn’t do it when it came to the, like our Science Fair, they’d have nothing to show (Bridget).

Improved student learning

MyScience improved student-directed, collaborative learning. Compared with normal classroom science practices these MyScience students were “doing their own experiments and not … the teacher’s experiment … they learned to follow their own curiosity …” (Angela; Bridget and Bettina made similar comments). Even more explicitly Angela added: it is the “students directing their own learning and it’s collaborative … (they learn) so much from each other in … ways to solve problems … create an experiment” and develop “a knowledge base”, while Chris noticed continuing improvement in students’ ability to work in groups: they became “this little unit” who remembered to take their measurements “day after day … talking that (science) language”. Significantly, Chris commented that primary students are usually perceived as not being able to “do that kind of thing” – a finding also noticed by Metz (1995). These examples are evidence of CoP#1: Domain (‘own experiments’, ‘directing own learning’), CoP#2: Community (‘collaborative’, ‘learned so much from each other…’), CoP#3: Practice (‘this little unit’),
NOS#1: Science is inquiry based (‘follow own curiosity’, ‘report findings’), and NOS#6: Science is collaborative (‘work collaboratively’, ‘pull their weight’).

Angela “liked” all these changes and was “excited” by them – providing an insight into why teachers found their involvement in MyScience so rewarding. Observing changed student roles and improved student learning due to enhanced engagement, student ownership and positive collaboration was also reported by Primary Connections teachers who, having observed “student interest and improved learning outcomes” enjoyed teaching science more (Skamp, 2012a, p.192). It also further corroborates these teachers’ new appreciation of the valued place of science in the primary curriculum (Assertion #1(a)).

**Students learned about the nature of science and science as a way of knowing.**

Several teachers referred to students practising a range of inquiry-oriented science discursive practices and they clearly connected this with students’ participation in MyScience. Students: “are good at now looking at (their investigation) and working out what a hypothesis is and giving me reasons as to why they think that, rather than just saying ‘I think this will happen’” (Beth); had learned about the importance of carefully taking and recording measurements and that “you can’t just say you know, ‘Oh it’s about that’… you shouldn’t estimate – it has to be factual and accurate and … you can’t embellish anything you know like you can in story writing …” (Amy; emphasis added); displayed a developed ability to identify the variables involved in investigations; surprised their teacher “at the number of different variables that they could actually identify” (Cathy); and had

... learnt the whole scientific process, ... having to record data carefully ... change one variable only and keep the others the same ... record data and find a means to communicate that. Having to think outside the square and work out why their data may not have gone the way they would have ... anticipated ... (Angela, emphases added).

This is evidence of teachers perceiving that some of these students are also distinguishing science as a way of knowing compared to other subjects and that it requires creativity (NOS#5) – a notion that is “at the heart of science” (Feasey, 2012, p. 90) and that can be developed in students through encouraging them to seek ways of answering questions to

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17 Primary Connections is an Australian primary science initiative: see http://primaryconnections.org.au (accessed January 17, 2014).
real life problems that are not found through examples in science textbooks. These findings also corroborate Kelly (2008) and Lederman’s (1992) assertions that students’ development of NOS understandings was enhanced when they participated in the discursive practices of science.

Of particular note was a ‘fourth timer’ student who had a deeper understanding of what needed to be done to execute investigations than her less experienced group members:

… she was really the driving force as far as, ‘Right. Checklist. We’ve got to do this, we’ve got to do that.’ … ‘Have you done this? It has to be set up in a certain way. Everything has to be labelled’ (Cathy).

Here, Cathy is describing evidence of the behaviour of her students while doing MyScience (and is therefore a description of the CoP practices – CoP#3) where old-timers and newcomers have quite different levels of expertise associated with the domain (CoP#1) and the former are introducing the latter into these practices (Lave & Wenger, 1991).

These examples of teachers’ awareness of their own and their students’ understanding that science is inquiry based (NOS#1) correlate with participating scientists’ views that indicated they witnessed students’ growing awareness of, and ability to apply, these NOS attributes while they were investigating scientifically, and they believed this happened because of interactions within the CoP (see Sam’s recount of a classroom observation, Chapter 4, Section 4.2.2a, Assertion #1(b)).

(ii) MyScience activities: Effect on teachers due to their role changing from ‘director’ to ‘facilitator’

Teachers experienced a transformation in their own understanding of student achievement and how students learn.

All teachers recognised that their role in a MyScience classroom was different to how they would normally manage the teaching and learning of science – their classrooms were irrevocably changed. A common refrain was along the lines of ‘Once you’ve tried MyScience you’ll never teach science the same way again’ as described by participating MyScience teachers in the introductory video Perspectives on the benefits of MyScience (MyScience Professional Learning Toolkit, 2009)). As teachers iteratively participated in MyScience many experienced a transformation in their own understanding of what
students could achieve through the embedded approaches in the program. Angela eloquently described the powerful influence the teachers’ role can have on student learning:

… [the change was] for me personally, just letting go of trying to do something en masse and doing something together and having replicated [hands-on] experiments going [on] in several different areas of the room. … It has been hands on in the past but it's been so [teacher] directed and also assessment driven… [an instance was when] they had to cleanse some water. I had collected samples of water from rivers … and I was very proud of myself that I'd actually… done that part, but then the rest of it was just so meaningless … it was almost like a cooking class. You know they just watched each other, there wasn’t enough discovery, and they just copied each other…

Whereas this [MyScience] is letting go of that kind of control and letting the kids actually go with their thoughts and their own research and their own questions and queries. And … to have so many different experiments going in the one room, it was … inconceivable almost. And what was so nice is that they were all related… parts of a jigsaw puzzle. For me to do that was a huge step and not have more control over what was going [on]. Actually, I was a bit nervous … (emphases added).

Angela had recognised that her students’ hands were on but their heads were (more than likely) out (Skamp, 2007). She learned that stepping back and giving control to the students while they worked on different, yet related, investigations led to meaningful (heads-on) learning (see ‘inconceivable’, ‘parts of a jigsaw puzzle’, ‘all related’). Evan, an engineer mentor, had made a similar observation to Angela: ‘students were attracted by what other groups (in the class) were doing’ (Chapter 4, Section 4.2.2.5, Aspect #5(a)). Despite witnessing first hand the profound effect of student directed learning, this “was a huge step” for Angela, presenting her with a challenging dichotomy: student versus teacher control of learning experiences. Angela’s reflection about her role and the amount of support to provide to students is similar to findings from Harris and Rooks about “how much guidance or independence to give students” (2010, p. 232).

Angela’s description was not unique. Others had similar ‘light bulb’ moments about ‘meaningful [MyScience] student learning’, such as Cathy who appreciated that her previous “practical science” activities were “really only scratching the surface”. Beth and a colleague thought that their children were “just playing… [and] getting nothing” during the “open-ended” investigating time and were concerned (“this is a nightmare”) that their
students were not learning “but then when we went to the Science Fair and we saw these children explaining, we thought ‘Gee they have learnt a lot’”. These experienced teachers had a “huge” realization when listening to their children at the Science Fair. They said their students

... had learnt a lot [and if we] had stopped [the MyScience activities] before the Science Fair, we would have said that [MyScience] was just a waste of time [because] we thought they wouldn’t have learnt anything. Because we weren’t actually teaching them, we thought they weren’t learning (Beth, emphases added).

Beth’s perception of how students learn has been changed (see emphases); her students were learning science through interactions with each other –through ‘participation’– a finding also found with mentors (see Chapter 4, Section 4.2.2.5, Assertion #5). These findings show that even highly experienced teachers found it surprising that students could learn in situations where they were not ‘being taught’; they underestimated the capabilities of younger learners (Metz, 1998). It also highlights how critical it is for teachers to personally experience changes in their students’ engagement and learning in science before they are able to effectively examine and change their own beliefs and practices about inquiry-based practices (See Section 2.5.2, Guskey, 1986; Levitt, 2001):

Once teachers in [my] study observed their students learning, the teachers’ belief in the new approaches and commitment to them changed significantly. With changes in classroom practice, teachers’ beliefs continually evolved. Teachers need time to reflect on and learn from their experience (Levitt, 2001, p.19).

**Teachers reported feelings of disempowerment when not in a director role.**

Other teachers’ experiences were not as transformative and this may be, as Levitt (2001) argues, due to long held beliefs about the teacher’s role. Amy wanted to know where her students “were headed” and what they were “looking for” and felt disempowered if, firstly, she was not in ‘control’ of these aspects, and secondly, if students followed their own interests, then she may lack the scientific background associated with their investigations and be unable to “guide them” because of her limited experience. Brian also felt that “teachers need … a bit more ownership … of [the] … investigations” to avoid students “going off on a whim … some students’ topics were sort of really ‘out there’ and I thought … what use is there to know about… is it faster to read a text message than normal writing?” These experienced teachers were clearly uncomfortable
with the amount of choice that students were given in *MyScience*. Control—or lack of it—was a major issue for teachers. Beth, as part of a discussion related to teachers’ uptake of *MyScience*, commented on Brian’s (and hence some others’) approach to implementing the initiative:

… the biggest thing [for some teachers] is the lack of control … because they are used to having a very structured style of teaching and … Brian will probably tell you, he said to me, … ‘It’s like having 12 reading groups going in your class at the same time.’ He feels that he has to be with each one of them. He doesn’t seem to be able to give them [i.e., students] that power to just think [so] that they are going to go off and do something (Beth).

The contrast here is between teachers who want to maintain a higher level of control over their students’ investigations (i.e., a guided investigation approach) and those who are willing to encourage more open investigations (Hackling, 2005). The former is indicative of a teaching style where the teacher selects what, how and when learning will occur; it is symptomatic of teachers who prefer to use hands on activities that “work”, that are “manageable”, and where the teacher can “maintain class control” (Appleton & Kindt, 2002, p. 49). Although these authors findings referred to inexperienced teachers they clearly also apply to experienced teachers as witnessed by the evidence from this study. Brian and Amy’s preferred teaching styles would likely hamper effective implementation of *MyScience* since they would be less willing—or able— to take on the role of a collaborative participant in the CoP (CoP#2).

As described in Chapter 2, Section 2.5.2, Levitt categorized teachers’ beliefs and practices as “traditional, transitional and transformational” (2001, p. 8). Teachers with traditional beliefs aligned the least with science education reform programs; transitional believers showed evidence of beginning to align with reform measures but still showed and practiced some traditional beliefs and/or practices; and teachers with transformational beliefs most closely aligned with science education reform and their espoused beliefs most closely aligned with their classroom practices. Within the context of *MyScience* implementation these interviewed teachers’ responses and observations by the researcher in the field appear to place Angela, Beth Cathy and Chris in Levitt’s (2001) ‘transformational’ group, Bettina and Bridget in the ‘transitional’ group, and Brian and Amy in the ‘traditional’ group. Angela, Beth, Cathy and Chris’s willingness to adopt and share *MyScience* practices within their schools was a key factor in the development of each school’s CoP; all three schools have successfully and sustainably embedded...
MyScience into their school science program. These transformational teachers not only encouraged other teachers to try MyScience by providing support and guidance through personal interactions (e.g., “passing on knowledge to other teachers” (Chris)) but developed support materials (described earlier see Aspect #1(a)). This correlates with CoP participants viewing themselves as old-timers who pass on the practices of the CoP to newcomers (‘other teachers’) (Lave & Wenger, 1991). These highly experienced (see Table 5.1), but transformed, teachers have learned ‘new tricks’ and changed their pedagogical practices. They have changed their views of what it means to teach and learn in science. “Teachers’ beliefs are influenced by their context” (Skamp, 2012a, p.15) and here it would appear that ‘immersion’ in MyScience has changed some teachers’ beliefs and transformed their science education pedagogy. If classroom teachers explicitly build and model attributes of the NOS into their teaching practice, for instance during classroom discussions, then the types of interactions experienced during mentor-student interactions are reinforced and students may be more likely to view their teachers as having science expertise as suggested by Abd-El-Khalick and Lederman (2004), Brown (1997) and Metz (2008).

In summary, Assertion #1 states that participating teachers perceived that MyScience sanctioned the place of science in the primary curriculum, and provided opportunities to integrate literacy, numeracy and IT skills. As teachers became more involved and confident in their membership of their classroom MyScience CoP they created resources to support their students and colleagues into the practices of investigative science. Teachers reported that the teaching and learning of science through MyScience afforded teachers and students with a more engaging, interesting and exciting experience than the traditional science lessons that were normally presented.

Teachers perceived that MyScience activities engendered an increased sense of accountability in students, and that student learning was more student-directed and collaborative. Teachers realized that student learning about the nature of science and science as a way of knowing occurred through participation (the same view as some scientist mentors in Chapter 4). This awareness transformed many participants’ views of student achievement and learning in science, validating the MyScience approach, and challenging their previous (traditional, teacher-directed) views of investigative science practices.
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*MyScience* situates teachers in the role of a facilitator (rather than that of a director) – a position that many teacher participants found to be challenging. Most teachers adapted to this new role, paving the way for the development of communities of science practice in their classrooms where participants collaboratively engaged in activities and discussion related to the domain of investigating scientifically (Wenger-Trayner, 2013).

5.2.2.2 Assertion #2 [#2]: Teachers’ perceptions of participants’ roles, including their own, were consistent with a community of practice interpretive framework and provided further insights into teachers’ views about the nature of science, and learning and teaching science.

The *MyScience* framework provides a scaffold to support teachers in their role as learning facilitators of investigative science in their classrooms. Not all teachers, however, felt comfortable acting as a facilitator in more ‘open’ investigative situations (see Assertion #1(b)). In the following, teachers’ perceptions of stakeholders’ interactions are presented since they may shed light on these teachers’ science pedagogical views and provide insights into how best to support primary science teachers as they facilitate student-responsive open-ended science investigations. Aspects (a), (b) and (c) address teachers’ perceptions of their own, student and mentor roles; their relationships with these members of the CoP are further detailed in Aspects (b) and (c); mentor-student relationships constitute Aspect (d); and the principal and parents as peripheral CoP members are presented in Aspect (e). Each of these aspects provides evidence for Assertion #2. See Section 3.5.1 for the relationship between evidence, aspects and assertions.

**Aspect (a): Teachers’ views of students**

One inference/interpretation supports this aspect (see ‘evidence’ shown in Table 5.2). It is that, ‘Students should demonstrate characteristics such as active participation, reliability, responsibility, creativity, care and perseverance’. The evidence supporting the inference/interpretation follows the inference/interpretation statement (in bold type).

*Students should demonstrate characteristics such as active participation, reliability, responsibility, creativity, care and perseverance.*

Angela thought that students should actively participate when doing *MyScience* which included being “open to their colleagues’ or their peers’ ideas to take on board questions” CoP#1
and to be willingly guided by teachers and mentors (Bettina). Also, students should be responsible for coming up with a feasible idea or question to investigate as well as bringing in equipment or designing and making what they needed to use (Bridget, Beth and Bettina). Amy felt students needed to “pull their weight” in their group while Angela thought students had a wider responsibility to “report back to other groups and have something to say about those groups and then to present at the [Science] Fair” – a task Angela said they did well. These roles, which these teachers encouraged, align with several CoP attributes: CoP#1 – students having a shared interest in investigating scientifically and being willing to learn from others’ ideas and input; CoP#2 – students collaboratively engaging in activities and discussions related to investigating scientifically– and CoP#3 – what members ‘do’ when they interact. The collaborative aspect of the nature of science is evident in Angela’s comment (NOS#6 – ‘report back…’) and this expectation would have fostered the discursive practices of science within her classroom. See Chapter 3, Table 3.8 for details of CoP and NOS attributes.

Amy expanded on the above: students “have … to be creative, they have to think of a problem … that they really want to solve, they have to be reliable, responsible and … careful” with Bridget adding that students need to be “on task or realizing that if they’re not on task it’s only going to affect their project later on” (italics highlight NOS and CoP attributes).

Of the other teachers, Chris described the students’ role as being willing to learn, to have a go, and to be well organized; these were the characteristics of “the most successful groups … in the finals (of the STANSW\textsuperscript{18} Young Scientist Awards)”. She also contrasted groups that were “resourceful… organized (and played) an equal role within the group and (were) willing to research” with others that did not fulfill these roles (e.g., did not bring in promised resources). Cathy observed a lack of responsibility with some students, but not with old-timers. She was a strong advocate for the development of collaborative skills and planned to encourage this by creating a group assessment sheet “where [students] say, ‘I did this and … this is what I contributed to the group’”. In conjunction with collaboration, Cathy believed an “initial [student] role” was to “just have an interest and want to participate in the process”. She thought this

\textsuperscript{18} STANSW is the acronym for the Science Teachers’ Association of NSW

www.stansw.asn.au
depended “a lot on what I do” but added “I think … this [also] depends on the type of kid too” – whether they are “able to manage their time and work cooperatively as part of a group and … share the roles and the responsibilities”. Associated with all of these roles Cathy referred to perseverance: being able “to carry it [an investigation] through until the end … and maybe an ability to … see their goal and understand the steps they’ve got to take to get to the goal”.

It is worth noting that, from a science inquiry perspective, these teachers’ views of students’ roles align with all of Harlen’s (2009, p.40) learner roles: students are expected to collect evidence, use science inquiry skills, learn actively (mentally and physically), report and discuss evidence, reason with others about how different ideas fit the evidence, and reflect on what and how they have learned.

Aspect (b): Teacher-student relationships: Teachers’ views of their own roles in assisting student learning

In the following, interviewed teachers describe six roles they fulfilled in assisting students’ science learning, and also imply two more unusual relationships between themselves and their students. These findings supplement Assertion #1 (‘Changed teachers’ views of what it means to be ‘doing science’”).

Identified teacher roles referred to assisting students with making decisions about: scientific investigations in a ‘safe’ environment, and with student-mentor interactions.

Eight inferences/interpretations support aspect (b) (see ‘evidence’ shown in Table 5.2) and include the following: ‘Teachers provided varied support for students in investigative contexts’, ‘Teachers prepared students for investigations during mentor visits’, ‘Teachers provided support to students during and after mentor visits’, ‘Teachers acted as a mediator or border crosser between students and mentors’, ‘Teachers maintained a physically and emotionally safe and open learning environment in the classroom’, ‘Teachers fostered interest and enthusiasm about science’, ‘(Newcomer) teachers learned from old-timer students’ and ‘The impact of students disregarding teachers’ science expertise’. The evidence supporting the inference/interpretation follows the inference/interpretation statement (in bold type).
Teachers provided varied support for students in investigative contexts.

In more open investigative contexts students are assisted in making their own decisions about what problems to investigate, how to plan and carry out their investigations, and how to interpret, report on and evaluate their results. The most challenging (“scariest” and “frustrating”) phase of this process for Cathy and Chris was supporting their students in the generation of testable questions (“getting the kids to actually choose their own area of investigation”). This is a complex teaching strategy for many primary teachers requiring them to learn new pedagogical practices that may be outside their comfort zone (Opfer & Pedder, 2011; Warford, 2011). Cathy assisted students in making investigative decisions by developing a checklist “to try and alleviate the problem of the kids [saying], ‘Oh, I don’t need to do that’ and skipping over a step and just getting to the really interesting bit of conducting the investigation …” The checklist maintained student focus while ensuring that all steps in the investigation were followed. Chris summarised the dilemma succinctly: “[it’s a] funny mix between letting them go and do their investigations but also managing”.

Other teachers made more general comments about the support they offered students as they engaged in investigative science. “Pos[ing] questions” came “quite naturally” to Angela, and along with Cathy and Chris, she felt it was important for teachers to “shut their mouth” – presumably as a way for less teacher intervention to occur and hence allow students to make decisions. Bridget, Bettina and Beth also implied they were ‘facilitating’ not ‘directing’. These views contrasted with Brian and Amy’s more teacher controlled environment (see Assertion #1(b)).

Teachers prepared students for investigations during mentor visits.

Beth prepared students for mentor visits through “scaffolding … teaching them how to do an investigation … cycle”, for example, “what is a fair test? … What is a hypothesis? What are we coming up with?” Explicit teaching of how to conduct fair test investigations is part of the MyScience educational model (see Chapter 2; also see Feasey, 2012). Beth clearly understood her role in the MyScience CoP, here emphasizing some of the discursive attributes of the NOS and her role in the ‘Community’ (CoP#2) and its Practices (CoP#3).
Teachers provided support to students during and after mentor visits.

During mentor visits Bettina described how she “floated around and made sure everyone was okay” while Beth “[was] helping with equipment, just sort of listening in [to] ideas …”. These views are consistent with communities of practice where members need to interact with each other and see each other as co-participants (Wenger, 1998a).

Teachers act as a mediator or border crosser between students and mentors.

Bridget and Angela acted as ‘border crossers’ (Aikenhead, 1996) or mediators enabling interactions between students and mentors within the CoP. Bridget ensured that the mentors were “aware of what the kids are doing as well as [their different] capabilities” while Angela occasionally translated mentors’ questions for students. This independently corroborates (and triangulates with) observations made by scientist and engineer mentors –Sasha and Elana respectively– where, within a CoP, all stakeholders benefit when teachers use their “children guiding experience” and mentors use their “specific information” (see Chapter 4, Section 4.2.2.2, Assertion 2#(b),).

A mediating teacher anecdote related to a returning mentor whose previous MyScience experience had not been particularly fulfilling was described by Beth: The mentor, on one visit, had “spent all that time [working with the students]” but by the next visit the students “had completely changed what they decided”. Consequently Beth and the other teachers told the students “Once you have made up your mind that is what you are going to do”.

Teachers maintained a physically and emotionally safe and open learning environment in the classroom.

For transformative learning to occur (here, students taking responsibility for their own investigative decision-making) students need to feel that they are in a ‘safe’ environment where their ideas are accepted and their teacher relates to them in a supportive, encouraging and attentive way (Darby, 2005). Most of the above instances either directly or indirectly indicated that creating a ‘safe’ environment in this sense was uppermost in these teachers’ minds; for example, the facilitative actions of Chris and Cathy, and, more specifically, Angela, when she expressed concern for the emotional safety of her students while trying to ensure that her classroom was an “open one”: “I sometimes think … I … should protect them from the failure” but realized that “the
failure's the learning”. It could be assumed she did this in a way that understood where her students ‘were coming from’. Two teachers also expressed concern about maintaining a physically safe environment for their students. There was anxiety about students performing different experiments some of which “were outside” (Amy), while Angela agreed that safety was “a major issue” commenting that she would “be a little more alert to that next year”. These teachers’ attention to safety is likely to have stemmed from a much earlier incident at their school where a student was burned with hot water during a science lesson (Personal communication from Angela, November 2010). An awareness of Feasey’s developmental scheme describing “student progression in the choice and use of science equipment from preschool to Year 6” including a “safety and care” category (cited in Skamp, 2012a, p.389) may alleviate these teachers’ safety concerns when implementing open-ended scientific investigations.

**Teachers fostered interest and enthusiasm about science.**

It is implied in many of the previous comments that these teachers wanted to foster a classroom environment where students have interest in, and enthusiasm about, learning science, doing science and learning about science. This desire or belief is a key precursor for teachers to begin the process of changing their classroom practices (Lederman, 1992). An indication of teachers’ desire to achieve these goals was exemplified by Cathy, who realised the importance of making sure that her “background knowledge is up to scratch” and showed evidence of forward planning for MyScience when she said, “I’ve already started looking at next year’s units and going ‘Ooh, this one lends itself to a theme’…”

**More unusual roles for teachers: (Newcomer) teachers learned from old-timer students.**

Teachers were not always alone in the facilitative role. Chris described how old-timer students (i.e., who had experienced MyScience three or four times) helped newcomer teachers: these “kids almost help the teacher … the children know the process very well”. She also observed that old-timer students “seem to hop into the process pretty easily…” Here there is evidence of a functioning CoP where participants’ knowledge of how the CoP ‘works’ is used to support the integration of newcomers (CoP#1 – Domain and CoP#3 – Practice) and that these CoP relationships exhibit reciprocity (Wenger, 1998b). Findings by Wallace and Loughran (2012) and Logan and Skamp (2008)
provide evidence for, and the value of, teachers learning from students, and the example described by Chris demonstrates the benefits of such a relationship in a MyScience CoP.

**More unusual roles for teachers: The impact of students disregarding teachers’ science expertise.**

There were two recollections where teachers’ perceptions of the student-teacher relationship were temporarily strained. Both were in contexts where students had opportunities to make their own investigating decisions. In one instance Chris said a group of students would not accept Cathy’s advice about using salt instead of sugar when they wanted to grow crystals. Cathy recalled the group:

… wanted … to do something with crystal growing and I had the feeling that they’d just been on the Internet and they’d seen, this is how you grow crystals and that’s all they wanted to do. They didn’t want to do the actual investigation. They just wanted to do … a trick sort of thing … because the instructions on the Internet said sugar, they wanted to do sugar and I was saying, ‘Well, from my experience, I’ve done this before and I’ve found that … a salt solution works much better than a sugar solution’. No, no, no, no, no, they didn’t want to listen to that at all and in the end, all they ended up with was mould (emphasis added).

It is interesting that these two teachers commented earlier that generating investigable questions was challenging. Cathy recognised that her students were not investigating but failed to suggest that they plan an investigation, for example, to ‘test’ which of two substances produced the best crystals. Similarly, her students, unlike the old-timer above, had not taken ‘on board’ MyScience’s investigation ethos as a mindset approach to decision-making.

A related situation occurred when students were investigating sound transmission in ‘string telephones’, “something about the length of the string and the volume of the sound” and they had decided that they would measure the volume through “a microphone … attached to a computer [with] the Audacity Program”. The students’ choice of materials was polystyrene cups and wool despite Cathy suggesting that “You need to look into the properties of those two materials, and sound waves and what happens, I think they might absorb the sound waves. … My suggestion would be tin cans and fishing line”. Here, rather than the Internet, the same advice from a (Head Science Teacher) mentor was accepted by the students. As with the ‘crystal growing’ context, students were accepting a perceived ‘authority’ to make a decision rather than their teacher. In both instances, as
Angela said above, the task for teachers (and mentors) is to discern strategies that facilitate student decision-making rather than provide information (here, ‘they might absorb the sound waves’), provided there is time for that to occur, which seems to have been the case in this situation. Again Cathy, Chris and the mentor could have suggested a ‘which X does Y best’ strategy as a way forward. Cathy interpreted the students’ immediate acceptance of the Head Teacher’s advice (rather than hers) as “it was almost like, ‘What do you know? You’re not actually a science teacher, you’re just … but this guy’s a science teacher. He must know what he’s talking about’”.

This perception of their teachers by some School C students correlated with findings from School A and B where some students perceived that their teachers did not have the same depth of science knowledge as the mentors (see Chapter 6, Section 6.2.2.2, Assertion #2(c)). If this dynamic persisted it may be a barrier to developing a sustainable CoP in the teachers’ classrooms. Mentors and teachers need to model and explicitly discuss with students what it means to be part of a CoP focusing on ‘investigating scientifically’ where (like the old-timer student) students question and ‘test’ their decisions rather than ‘accept’ what/who they perceive as an authority – a view supported by many researchers (Brickhouse, 1990; Cunningham, 1998; Lederman, 1992; Kelly, 2008). In other words CoP members cooperatively engage with each other about issues in their domain rather than contradict (here students), or unwittingly provide information (here, the teacher and mentor).

Aspect (c): Teachers’ views of the teacher-mentor relationships

This relationship impacted on teachers’ willingness to do MyScience. Many teachers found mentors to be invaluable as they, firstly, provided NOS knowledge, which students and teachers learned through participation, and secondly, provided classroom assistance during intensive hands-on periods. A ‘cautionary tale’ was raised by an old-timer teacher (Chris) related to her perceptions of her level of NOS understandings (and therefore that mentors were no longer required) and provides a salient reminder of the vigilance required to maintain sustainable communities of practice.

Four inferences/interpretations support Aspect (c) (see ‘evidence’ shown in Table 5.2) and include the following: ‘Teachers regarded the presence of ‘good’ mentors as a critical component of the program’, ‘Teachers learned about the nature of science from mentors’, ‘Mentors gave teachers ‘breathing space’, and ‘The negative impact of mentors assuming
that teachers’ have low levels of ‘nature of science’ knowledge’. The evidence supporting the inference/interpretation follows the inference/interpretation statement (in bold type).

**Teachers regarded the presence of ‘good’ mentors as a critical component of the program.**

There was consensus amongst interviewed teachers that ‘good’ mentors with science expertise and who were skilled communicators were essential for the program, yet one teacher indicated that she could sustain a CoP after the mentors departed, while another, after experiencing *MyScience* over several years, felt that mentors were no longer required. In some instances teachers perceived mentor qualities as problematic in advancing *MyScience*’s goals.

For some teachers the mentors were key CoP participants and were virtually indispensable; for example: “Without [mentors] … it [MyScience] would be very hard” (Beth), it “wouldn’t work” (Angela, a first-timer); or “… I wouldn’t do it (Bridget)”. Perhaps Angela spoke for others, like another first-timer, Amy (who felt mentors “could certainly guide [students] because they knew more about science than I do”), when she implied teachers’ limited science knowledge would constrain students’ investigations.

You really need [the mentors] because, that specialist interest or area of expertise was what enriched the program and gave it depth and allowed the children to focus on their area of interest … a generalist [primary] teacher … would find that quite difficult unless they had done some more science after high school. … I would hate to see the program without [mentors] because I think that was of very high appeal to the children and for me… (Amy)

It is worth remembering that primary teachers with ‘intermediate’ science knowledge facilitated inquiry oriented science more effectively than those with too little or too much science knowledge (Dobey & Schafer, 1984). Although it is acknowledged that some primary teachers lack confidence in their science knowledge and skills (e.g., see Morgan, 2012), some (of the teachers in the present study) may be underestimating their efficacy in teaching investigative science, in light of how they described their facilitative roles (e.g., see Assertion #1(a)], Angela and Beth). By way of contrast, Chris (an old-timer) now felt she could implement *MyScience* without mentors: “I think it’s nice for [the students] to have somebody to come in there to talk to, but I don’t think we need it”. It is problematic as to how to interpret this response. From years of *MyScience* experience, Chris may have developed her facilitative strategies (e.g., generating testable questions,
although this was still a challenge –see earlier) but, because she indicated mentors were concurrently still providing NOS advice, her view may deny students’ access to mentors and detract from their science learning.

As mentioned earlier, mentor quality influenced teachers’ perception of *MyScience*: Teachers “who really liked it were the people who had the quality mentors” while those “who didn’t like it, their mentors weren’t [as good]” (Beth), although other teachers’ views were not always this definitive. Mentors varied in their abilities to relate and communicate with young learners (Amy, Bettina, Cathy, Chris) and in their knowledge of “the criteria that we were working towards” (Cathy, Brian). Cathy wondered whether her primary students listened carefully to the Year 9/10 students (some of whom “were good”), which may link to primary students’ perceptions of who they regarded as having ‘science knowledge’ (see ‘students’ disregard of …’ Assertion 2(b)). Brian’s evaluation may be underpinned by other factors as follows:

Brian appeared to encounter more issues with mentors than other teachers. His students had “many prongs to their investigation” which seemed to lead Brian to conclude his mentors were not “thoroughly on top of their role … the teaching of that whole scientific method”. He expanded: “They weren’t narrowing it down so that it was definitely testable, and measurable as a scientific test”. This potentially alludes to a misunderstanding: Brian appeared to think that a fair test investigation could not be legitimately conducted with two independent variables (e.g., investigating the influence of light and soil type on plant growth). Since Brian’s mentors were pre-service secondary science teachers (‘mentors from university…’) and his students were all *MyScience* old-timers (‘done *MyScience* before…’), then mentors and students were likely to have knowledge and experience of conducting controlled scientific investigations with his students being ‘ready’ for a more complex experimental design. Interestingly, Cathy also referred to mentors who encouraged her students to set up multiple fair test investigations within the one trial: “it was just … too many things to think about” and so, after the mentors had left, she told the students “Yeah, well, that’s really good, but, you know, you’ve got these two [variables] … let’s just focus on the one”. In Cathy’s case (contrasting with that of Brian), she understood the mentors’ objectives but wanted to simplify the experimental design for the students.

These views highlight the critical role that different participants (here mentors and teachers’ and students’ perceptions of them) play in a *MyScience* community of science.
practice. It is important that participants’ perceive that CoP members are ‘pulling their weight’; if they are not, as was the case with the mentor Eric (Chapter 4, Section 4.2.2.3, Assertion #3(b)) who had a poor experience of mentoring due to his perception of teachers not being “enthralled by the program” and students being unprepared for mentor visits, then participants will be dissatisfied with their experience and the CoP may flounder. Participant dissatisfaction in School B (teachers and mentors) was resolved through each organisation conducting, and then responding to findings from an internal audit of stakeholders’ views of their MyScience involvement.

**Teachers learned about the nature of science from mentors.**

In either conversation with, or (mainly) through listening to, mentor-student interactions, teachers increased their repertoire of NOS practices: “… they were asking kids questions that I probably wouldn’t have thought” (Beth). Examples from three teachers’ recollections of events that led to increased insights were about: data sets and replication; experimental design, objectivity and measurements; and applying ideas from other sources. Of interest is that mentors, despite Cathy’s concerns, did not “dumb things down, because they knew the kids were … not high school kids”, rather they used “technical terms” and encouraged them to use the meta-language of science.

Angela had her ‘eyes opened’ to the importance of a good “data set”, including the need for repetition to improve the integrity of the data set. Sam, a scientist, “struck a chord” with her, when he said:

> It’s the quantity … accuracy … and quality of what you collect … [that] makes your result valid … I’d never really thought how crucial that was … I’ve started using that now as a real focus … it’s really important to get that because … that’s your information isn’t it?

In another instance, Angela overheard a mentor (a plant entomologist) saying “something about repeating the experiment …” And my ears pricked up and I thought, what? [laughs] But then when he said something about four times, I thought oh great! [chuckles]”.

Angela’s responses have been retained to emphasise her reactions, which suggest she is questioning whether such a process would be practical in her classroom. She did continue though, reflectively commenting: “We can do that because we’ve done it once now, we can improve on it and collect [more] data”, but in some other instances (“their shallots and soil”) she believed her “kids … just couldn’t get their act together”. Here, Angela
seems to be acknowledging that the mentor’s advice is a good idea but for ‘resource intense’ investigations this could be problematic in primary school settings.

Cathy observed mentors (university researchers) providing NOS advice focusing “on the importance of the background research” and the need to take objective measurements. She recalled a mentor questioning a student group who were “growing mould on cheese,” about what they were trying to find out. After much probing the students said they were “going to see which one has the most mould”. The mentor, then, according to Cathy, persistently asked students how, eventually adding “What are you going to measure?” This teacher felt the mentors “were really good at … pushing them [the kids] to take measurements”, and not just to ‘take measurements’, but to be “more objective” about what they were investigating; hence rather than the students simply saying “Oh, yeah. It looks like there’s more” the mentors would extend them, for example, asking “…are you actually going to measure the width of the patch of mould, or are you going to scrape it off and measure the mass?” Cathy expressed this as “getting them [the kids] to … really focus on the practical”. The mentors challenged the students – “really getting them to question everything” (as in what to ‘measure’); their questioning, at times, exemplified effective scaffolding.

One NOS attribute is that science is ‘developmental’ –that conceptual understanding builds from previous, sometimes simpler, abstractions. Beth appeared to recognise this when students were shown “different things that I wouldn’t have thought of”. She described how, when making catapults, one mentor “immediately had them down on the floor …. [using] different lengths of rulers … having a look at principles and things”. Here we see Beth recognising the mentor’s deep understanding of underpinning ‘big ideas’ (‘principles and things’) and values this input.

Here we have evidence of teachers (Angela, Beth and Cathy) observing and recognizing that mentors used a variety of discursive science practices that they then modeled themselves. As an example, after mentor visits, Bettina “would go around and help each group out and definitely … would … follow on from what I remembered they [the mentors] had been doing before and … tried to take their approach a little bit more”. This is evidence that teachers perceived their classroom to be a CoP when the mentors were not there, an observation also made independently by Scott – one of the professional astronomers at School A (Chapter 4, Section 4.2.2.5, Assertion #5a).
Mentors gave teachers ‘breathing space’.

Cathy acknowledged the collaborative nature of the partnership between the mentors and teacher: “it was … a cooperative thing with the mentors and the class teacher”. Bettina, an “early career teacher”, was particularly grateful for mentor assistance when students were conducting their investigations:

I have always found science a bit daunting in the sense that I do want to do a lot of investigation, but it’s hard to manage it when it’s just me and trying to coordinate it … [the presence of the mentors] gave [students] a really good opportunity to do that hands on stuff that they wouldn’t be able to do if it was just me trying to teach them in their little groups or just me demonstrating in front of the class. But that comes from my own experience as well, not feeling comfortable sending them off with their own experiment … The mentors did the practical, which is the bit that I felt I didn’t feel comfortable to supervise if they were all doing it outside or whatever.

Here, management of multiple groups experimenting and supervising of safety issues –a common concern of primary teachers (cf. Harris & Rooks, 2010; Skamp, 2012b)– were assisted by the mentors’ presence, hence meeting Bettina’s desire to have her students engaged in inquiry-oriented science. These examples show members collaboratively engaged in activities and discussion related to the domain of investigating scientifically (i.e., CoP#2: Community).

The negative impact of mentors assuming that teachers have low levels of ‘nature of science’ knowledge.

First-timer primary teachers acknowledged that their “generalist” training (Angela) made it difficult to guide students because they “didn’t have enough background” (Amy). Cathy, an old-timer, had a different mind-set. She described a time when mentors expressed surprise at the depth of her science knowledge while simultaneously acknowledging her readiness to admit to a lack of science knowledge where relevant:

I’m quite willing to say, ‘Oh, well, I don’t know about that’ and there were a couple of times where I deferred to them and said, … ‘Am I right in saying this?’ … But they seemed quite surprised that … after a couple of sessions … I was talking about things at a particular level with the class, ’cause they were saying … ‘Oh, you know, you’ve got it right’ sort of thing. As if they were expecting me to not to know much, which was interesting (Cathy).
This example—some mentors presuming that teachers lack science background—and the earlier example of students ignoring teacher advice about growing crystals showcase Cathy’s sense of disbelief and frustration (‘what do you know, you’re not a science teacher…’, ‘that stands out’, ‘as if they were expecting me not to know much’) at the lack of acknowledgement of her growing science knowledge and expertise. This potentially signals an issue with the presence of mentors when teachers perceive their NOS understanding has developed with extensive MyScience participation (also cf. another old-timer, Chris’ related views, described earlier in Assertion #2b: ‘unusual roles for teachers’). In such situations, the participation of mentors, while beneficial to the students, may compete with teachers’ needs for recognition and acknowledgement of their new learning, and may affect the functionality of the CoP (CoP#2: Community) signaling the need for a change in ‘what members ‘do’ when they interact’ (CoP#3: Practice). Mentors acknowledging different NOS understandings amongst primary school teachers, especially with old-timers, could address this situation.

**Aspect (d): Teachers’ views of the mentor-student relationship**

This relationship provided students with a link to out-of-school science enhancing the authenticity of students’ school science learning (Hume & Coll., 2010). It also led to bonding between many mentors and various student groups probably due to students recognizing the passion the mentors had about science as well as the more individual attention that was possible.

Three inferences/interpretations support this aspect (see ‘evidence’ shown in Table 5.2). They are that firstly, ‘Mentors provided a link between the worlds of ‘in’ and ‘out’ of school science’. Secondly, ‘Mentors provided students with passion, knowledge and information about science and ‘doing science.’ Furthermore, ‘Mentors provided students with more attention’. The evidence supporting each inference/interpretation follows the inference/interpretation statement (in bold type).

**Mentors provided a link between the worlds of ‘in’ and ‘out’ of school science.**

Teachers appreciated the involvement of real scientists and engineers as it provided both themselves and their students with a rare opportunity to link the worlds of ‘out-of-school’ and ‘in-school’ science. Mentors shared with the children “little scientific stories or information (e.g., “black hole[s]”)” which “the kids really, really liked” and thought “was fascinating”; and Angela said the “introductory talking about themselves as scientists was
really good”. When asked what mentors provided by coming into the school Angela continued

Oh … the real world application and excitement because they are scientists. It’s … a professional that they don’t normally get to meet. They meet bakers and they might meet … people that come to their homes, computer technicians … but to meet a scientist. I mean you only see them on TV or in those Science programs. To actually meet one, like for me that was exciting. And as I say, check it out, stares at the stars and he gets paid for that (emphasis in original).

Other teachers made similar comments stressing the importance of mentors simply coming in and “saying, ‘I’m an engineer or I am a scientist,’ just suddenly gives them [the students] this figure that the children really listen to and admire” (Beth; also Amy). Angela added

… that is something that is of so much value –to enrich and expose children to people outside the school community. Especially experts in their field ‘cause it also opens their mind up as to, wow this is a possibility, this is a career.

These teachers’ views were independently confirmed in student interviews (Chapter 6). They also provide evidence of primary teachers’ positive views of having school-community links in an urban setting, mirroring the findings of Tytler et al. (2008) in rural settings, and add to Howitt et al.’s. findings that teacher-scientist interactions benefitted teachers by providing teachers with

… increased knowledge and understanding of real-world, contemporary science; increased opportunities for professional learning through communication with scientists and other teachers; increased access to resources; increased awareness of the types and variety of careers available in the science; and increased motivation (2009, p. 38).

Similarly, Bolstad and Bull (2013) reported that teachers’ involvement in school-science community initiatives helped them to learn about students’ capabilities and their own NOS understandings; while Rennie (2012) reported that interactions with scientists in the SiS project produced “measurable increases in … in teachers’ confidence in teaching science and being confident of their science knowledge” (p. 79).
Mentors provided students with passion, knowledge and information about science and ‘doing science’.

Students were exposed to many opportunities to learn about the NOS (e.g., see earlier, Aspects #2(a) and (b)). Furthermore, mentors provided “that specialist interest or area of expertise [and this] enriched the program and gave it depth and allowed the children to focus on their area of interest” (Angela). According to Bettina (and also Bridget) mentors “could push the kids in the right direction ... they were asking kids questions that I probably wouldn’t have thought of and got them thinking,...” – indicating that teachers have learned a new way of asking questions through listening to mentor-student interactions. Bridget also thought her students were more responsive to their mentors than to her and attributed this to mentors’ passion (“love of science”) and novelty (“people that they don’t see day in and day out’) that captured students’ attention.

An interesting example of the mentors’ interest with their student groups (and an indication of their ‘passion’ and desire to share ideas) was their continuing interaction with students via an online Wiki (between the face-to-face visits), asking questions such as:

Well, that’s really good, but how about you try this?’ and ‘Why don’t you try this?’ and ‘Why do you think that you might be having a problem here? Let’s try, let’s have a look at this and next time we come we’ll talk (Cathy).

Mentors provided students with more attention.

Smaller student groups were possible with mentors (ratio of 1 mentor: 6 students) providing students with “more one-on-one time”. It was also regarded as beneficial for the students to interact with other people apart from their teachers (Cathy). Bridget made a similar observation adding that her students were more ‘on task’ when mentors were present (also see Bridget’s above comments) which was attributed to students having “someone more responsible for them” than what she could manage by herself. This seems to infer that students’ increased engagement was related to a sense of belonging or being bonded to their mentors.

Aspect (e): Teachers’ views of the Principal and parents

Two inferences/interpretations support this aspect (see ‘evidence’ shown in Table 5.2). They are that firstly, the ‘Principal was viewed as a gatekeeper and advocate for the
program’, and secondly, ‘Parents provided resources, and showed interest in students’ investigations’. The evidence supporting each inference/interpretation follows the inference/interpretation statement (in bold type).

**Principal was viewed as a gatekeeper and advocate for the program**

Teachers viewed the Principal as the school gatekeeper who needed to be open to allowing programs such as MyScience into the school (Angela and Chris), and correlates with the views of professional scientists and engineers (Chapter 4, Section 4.2.2.3, Assertion #3c). Student safety was a foremost concern for Angela with the Principal viewed as the ‘permission giver’ for such activities to take place.

Teachers from School B thought that the Principal’s role was about “promoting (MyScience) and trying to get more staff to do it” (Bridget), to oversee program implementation, and to liaise with mentors (Bettina). The researcher observed that the School B Principal was much more involved with MyScience than the Principal from School A. Principal B visited classrooms when children were working on their investigations, welcomed and interacted with mentors and was deeply engaged in conversations with students at the school Science Fair. Principal A allowed MyScience to be implemented in her school but only came to the Science Fair when expressly invited to attend and otherwise showed little evidence of engagement in the program (Personal communication from Angela and Amy, November 2010). These observed differences—in the level of involvement of the two principals—was evident through School B growing and developing MyScience in more classes than in School A: by the end of the third year of involvement, School B had eight classes and School A had three. It could be argued that Principal B’s greater level of involvement in the school’s MyScience CoP (compared with that of Principal A), enabled classroom CoPs to develop more widely in School B.

**Parents provided resources, and showed interest in students’ investigations.**

Interviewed teachers perceived that there was considerable parental support and interest in MyScience in all three schools. Several parents at School A volunteered as mentors (attending information and orientation sessions prior to the school visits), while others contributed by attending the Science Fair. Angela thought that some parents may have even given students “some extra … knowledge” to continue with their work at home, implying that parents were also contributing to students’ NOS development and understandings. This observation was independently corroborated through student interview responses describing
parental advice and support at home (see Chapter 6 for details). Angela (and similarly Bettina) attributed parents’ interest in MyScience to students’ interest in what they were doing at school:

…the kids go home and they share. The parents were very interested. They came into that Fair because there was a parent session. They were very curious and there was a lot of really good feedback from parents. I think that falls under the duty of a parent to show some interest in their child’s learning, but it was initiated because the kids were so interested that they did share.

Five other teachers (Beth, Bridget, Amy, Chris and Cathy) described instances of considerable involvement by parents and other relatives in making equipment available, for example, as resources for student investigations such as a rocket that was then tested at school and a metal ramp for testing cars (Beth & Bridget).

These examples demonstrate that teachers recognised and valued parental involvement in their MyScience CoP providing evidence for attribute CoP#1: parents were acknowledged by teachers to be supportive of and showed interest in childrens’ investigations (attended the Science Fair, provided ‘extra knowledge’ at home); and CoP#2: some parents served as mentors and so were ‘collaboratively engaged (with students and teachers) in activities and discussion related to the domain’.

In summary, Assertions #2 states that teachers’ perceptions of participants’ roles when doing MyScience included that students should actively be involved and engaged when doing MyScience, that they should be a good ‘team player’ remembering to bring in resources, and to follow through with any responsibilities. Old-timer students were noted as being more experienced in these areas and were observed taking on a leadership role in groups with newcomer students. Occasionally, old-timer students inducted newcomer teachers into the practices of MyScience. Teachers also wished for students to demonstrate behaviours aligned with NOS attributes such as collaboration, creativity, care and perseverance [#2a].

Teachers’ views of the teacher-student relationship related to perceptions of their own role in assisting student learning in and about science. Teachers wished to provide and maintain a physically and emotionally safe learning environment for students. They generated checklists and scaffolds to support students and to prepare them for mentor visits. They asked students questions to facilitate rather than to direct student learning. During mentor visits teachers continued to provide support to students and served as a mediator between
the students and mentors. Teachers felt that they fostered interest and enthusiasm in students about science and were unimpressed when other stakeholders (students and/or mentors) did not value their science knowledge, which, they perceived, had developed and deepened through participation in *MyScience* over several years [#2b].

Teachers’ views of the teacher-mentor relationship were almost unanimously positive. Mentors who were skilled, knowledgeable and good communicators were highly valued, particularly for their science expertise, their ‘novelty’ appeal, their ability to use the discursive practices of science and the extra ‘pair of hands and eyes’ that they provided for student supervision and individual attention. Although newcomer teachers recognised that they did not have deep science background knowledge, over time they did develop and gain NOS understandings (through *MyScience* participation) and wished for this increased expertise to be acknowledged by other stakeholders (students and mentors) [#2c].

Teachers’ views of the mentor-student relationship were that mentors provided an authentic link between the worlds of ‘in-school’ and ‘out-of-school’ science during the face-to-face school visits. Mentors were also perceived to provide students with passion, knowledge and information about science and ‘doing science’ in the way that they questioned and discussed ideas with students, and the types of words that they used. Teachers perceived that students learned about the NOS through participating in such interactions [#2d].

The Principal in all three schools had a gatekeeper role, allowing the program to be implemented. In School B, the principal had more extensive interactions with stakeholders during mentor visits and at the Science Fair than in Schools A and C and this appeared to translate into greater participation across more classes. Teachers thought that parents played a key role in all three schools providing resources, knowledge (at home) and interest (at home and attending the Science Fair) which should auger well for these students’ future interest in their secondary science education (Lyons, 2006).

### 5.3 Concluding Remarks and Pedagogical Implications

Transforming, or even tweaking, how science is taught in primary schools is fraught with challenges. A significant hurdle is to ensure that science is being taught at all and, to then hope to reform or refine teachers’ pedagogy, adds another layer of complexity. Traditional school science education practices (teacher as director, learning of de-contextualised conceptual knowledge through acquisition, practical exercises to demonstrate known
phenomena) continue to enjoy an extraordinary level of ‘resilience’ and popularity in primary and secondary school curricula (Tytler, 2007, p. 3). Concurrently, and in all likelihood as a consequence of these teaching approaches, many Western students have little or no interest or engagement in science (cf. Lyons, 2006; Fensham, 2008; Tytler, 2007). Skamp (2012a) cites a number of factors from the research literature that have been found to impact primary teachers’ willingness to adopt new practices including: the duration of engagement with professional development associated with the reform; institutional and individual teacher characteristics; context (physical environment, human interactions, school policies); and teacher beliefs (about science, science learning and science teaching). Faced with these challenges it behoves the science education community to research the impact of initiatives, such as MyScience, that address these issues and that broaden teachers’ perceptions of what it means to teach and learn about science in ways that engage students and enhance their understanding of the NOS.

This study addressed four aspects of teachers’ perceptions, namely, those related to their involvement in MyScience and how this involvement influenced their views about science, science learning and science teaching. These last three aspects correlate with Skamp’s (2012a) ‘teacher beliefs’ factors which influence uptake of new science teaching practices. Each of these four aspects is presented below, followed by suggested pedagogical implications.

5.3.1 Responses to the MyScience experience

Most teachers significantly changed their perceptions and attitudes about what it means to ‘do’ science in primary classrooms [#1]. Moreover, these teachers changed how they taught science. They adopted a more –if not total– student-responsive integrated approach to ‘learning science through participation in a CoP’, underpinned by students’ questions, interests and experiences. This developed students’ critical thinking skills, fostered their collaboration and motivation, and anchored learning in meaningful contexts. As teachers became more involved with, and regarded themselves as old-timers in their CoP, they took on leadership roles to induct newcomer teachers, and created resources to support colleague teachers, students and mentors, which in turn engendered a sense of belonging in these participants [#1(a)]. This indicates that not only did teachers adopt new practices but also they developed (learned) new strategies themselves – an example akin to Levitt’s (2001, p. 19) proposition that ‘teachers’ beliefs continually evolve’ and evidence that these teachers valued and accepted the premises of the reform (MyScience). They did this because of their
experiences as a member of a CoP. Old-timer teachers, however, became disenfranchised when mentors and students undervalued their increased NOS expertise (gained through their CoP membership), to the extent that they were willing to forgo mentors as CoP participants. This correlates with Wenger-Trayner’s (2013) CoP attributes—the domain, the community and the practice— that need to develop simultaneously for a CoP to emerge and develop, and highlights that teacher perceptions of their role in the CoP include contributing their own NOS knowledge and skills.

5.3.2 Views about science, science learning and science teaching

Interactions with mentors—particularly professional scientists and engineers—imbued CoP participants with real life examples of ‘science as a human endeavour’ as well as opportunities for participative learning through the discursive practices of science [#2(c)]. Thus teachers and their students learned new NOS understandings through interactions with mentors. The triggering effect of the mentors’ visits provided teachers with the knowledge and confidence to continue to develop their CoP during the mentors’ absence. Again, it was participation in a CoP that changed teachers’ views of what it means to teach science.

Learning to do science as a member of a CoP widened teachers’ perceptions of their role as a facilitator and how students learn in and about science [#2(a)]. This came about through teachers stepping away from their traditional role, which then afforded students with alternative learning opportunities. These circumstances were so different to those normally experienced by teachers that their initial reaction was that students weren’t learning because they weren’t ‘being taught’! Teachers reported high levels of student engagement, excitement and interest in doing science and these, combined with evidence of student learning, contributed to their willingness to remain involved with the program and to further support and develop their CoP [#1(b)]. This correlates with Levitt’s (2001) and Guskey’s (1986) findings related to staff development and the process of teacher change: teachers need to actually experience student learning and engagement to fully embrace new teaching approaches.

Thus, using, in part, ‘community of practice’ and ‘nature of science’ lenses to analyse participating primary teachers’ perceptions of their involvement in the MyScience program, most interviewed teachers held views that were consistent with the hallmarks of successful communities of practice according to Wenger (2002). Teachers viewed themselves as essential members of their CoP with students and mentors playing vital roles. The principal
and parents were viewed as important but not central to the functioning of the CoP [#2(e)]. Teachers viewed their role as providing support to students before, during and after mentor visits; fostering students’ interest and enthusiasm in science; acting as a mediator between students and mentors and providing a safe and open classroom learning environment [#2(b)]. Students were expected to actively collaborate with, and consider, others’ ideas, to be responsible, creative and to be willing to learn [#2(a)] – attributes which align with Harlen’s (2009) ‘learner roles’ in an inquiry-oriented science context.

5.3.3 Pedagogical implications

MyScience situates most teachers in a profoundly different role from that which they are used to. For most participating teachers this experience transformed their views about their own and their students’ capabilities around the ‘doing of science’ and learning in and about science in primary school settings. The pedagogical implications for primary science are that most teachers who fully engage with MyScience never teach science in the same way again – they adopt a more student-centred approach which leads to deep student engagement and learning in science. Angela, in the following, identifies how, as a consequence of her own and her students’ membership within a CoP and increased awareness of NOS attributes, more critical thinking across many facets of the primary curriculum came about:

The MyScience program has made a huge impact on my teaching and the students’ learning. The process of inquiry is relevant in many fields, not science alone. Students have also become far more critical of thought processes, in particular with methods of data collection, the importance of variables and the various interpretations that can be made across key learning areas, such as media reports, valid points and counterpoints for debating and mathematical problem solving. MyScience has opened my eyes and given depth to my understanding of how children learn best. MyScience is engaging and allows children to question and follow their curiosity. It is ‘real world stuff’ and the young student ‘scientists’ get to meet and talk with real scientists. My colleagues and I have experienced what it is like to ‘let go of the reins of control’ of comparatively teacher directed lessons and learnt that the MyScience process of child-centred approaches can provide our students with real learning experiences – with what education is all about. (Email communication received September 13, 2012)

An unsolicited email communication from Angela in January 2014 sent to participating mentors to thank them for their time, energy and passion included the following, indicating the profound impact on students of participating in MyScience:
It may interest you to know that in their reflections last December, the graduating Y6 students of 2013 ranked *MyScience* in their top experiences of all their years in primary school. *MyScience* rated as a most valued and enjoyable experience, along with the Y5 four day 'camp' to Myuna Bay and the three day Y6 excursion to Canberra and the Snowy Mountains!

The time you volunteered made a huge impact on the young 'scientists'. (This opinion has been reflected in the previous years of the *MyScience* program at our school. Having experts in the room was considered by the students to be an 'experience out of the ordinary' and they really saw great value in working closely with 'scientists'.) Furthermore, your contribution, as a *MyScience* Mentor has been most appreciated by the teachers and the students' parents. (Email received January 12, 2014)

The email also indicates that, in the three years since data was first collected for this research project (in 2010 when Angela was a first-timer *MyScience* teacher), that *MyScience* CoPs have become integral to School A’s curriculum, following the developmental pathway described in Figure 7.8 in Chapter 7.

Responding to this study’s research question about teachers’ perceptions has provided insights into understanding how communities of practice around ‘investigating scientifically’ operated in urban primary school settings. Participating teachers experienced a different way of teaching and learning in and about science in primary school settings and for many this led to a transformation in their pedagogical practices. *MyScience* provides a medium where learning to do science through participation in a community of science practice enhances students’ and teachers’ NOS learning. Findings from the teacher study (this Chapter) and the mentor study (Chapter 4) will now be added to views of the third (and last) key stakeholder group from each of the three schools (A, B and C): primary students in Chapter 6.
Chapter 6

Primary students’ perceptions of their participation in *MyScience*

6.1 Introduction and chapter structure

As described earlier in Chapters 1 & 3, the main research study was concerned with looking at participation in *MyScience* as a ‘community of practice’ (CoP) where participants from different communities came together to work collaboratively on the common venture of ‘investigating scientifically’. Specifically, the study was concerned with how participation in *MyScience* affected participants’ views of science, science learning and science teaching to better understand the complexities of the teaching and learning interface and how participants’ views of their own sense of belonging and/or participating in the *MyScience* CoP changed as they moved from being newcomers – on the periphery of the CoP – to experienced members of the community and thus at the centre of their CoP. The study also fulfilled an articulated need for research on the conditions under which schools, universities and businesses can work together sustainably as outlined in Chapter 2.

This Chapter (6) and the two that precede it (Chapters 4 & 5) present interpreted findings of the lived experiences of the interviewed participants as follows:

- Chapter 4: mentors (professional astronomers and engineers, secondary school science teachers and Year 9 science students),
- Chapter 5: primary teachers, and
- Chapter 6: primary students.

Chapter 7 presents a synthesis of the findings from each of these three groups of key stakeholders with a proposed ‘community of science practice’ model for the sustainable implementation of *MyScience*.

Chapter 6 presents the researcher’s interpretations of primary students’ perceptions of their *MyScience* participation. Participants were interviewed and the data analysed according to the procedures described in Chapter 3. All primary student participants were asked the same interview questions as those of the mentors and primary teachers and are presented in Table 3.4. ‘Community of practice’ (CoP) and ‘nature of science’ (NOS) lenses were used, in part, to analyse and interpret primary students’ perceptions of their involvement in
Chapter Six

*MyScience* from the same three schools in Chapters 4 and 5: School A (n=9), School B (n=8) and School C (n=10). Relevant literature pertaining to the notion of using attributes associated with ‘communities of practice’ and the ‘nature of science’ as analytic lenses is detailed in Chapters 2 and 3.

6.1.1 The research question related to primary students

The specific research question that foreshadowed the findings reported in this chapter was:

> What are stakeholders’ (here, primary students in Schools A, B and C) perceptions of their involvement in *MyScience* and how does being in a ‘community of practice’ around ‘investigating scientifically’ influence their views about science, science learning and science teaching?

6.1.2 The context for the primary student study

Demographic information for each of the three participating schools at the time of the study and how this related to *MyScience* participation is detailed in Chapter 3, Tables 3.1 and 3.2, pages 76 and 77 respectively.

Within each class, students formed friendship groups in pairs or threes. Themes were used as a focus for each class brainstorm to derive areas of students’ personal interest. At the time of the study students in Schools A and B had a theme of ‘energy’ and in School C the theme was ‘growth and change’. Each student group selected their preferred area from the class brainstorm (e.g., sound energy, heat energy, movement energy … in the case of the ‘energy’ theme) and then generated questions that they were interested in investigating scientifically. Concurrently, students experienced explicit teaching (with their classroom teacher) around the notion of scientific inquiry with a focus on fair testing using Mark Hackling’s ‘Cows Moo Softly’ scaffold (2005, p. 18). Adults with science expertise typically visited the classroom at this point in time for the first of three one hour visits where they met their two groups of two to three students. These adults were known as, and referred to as, mentors by the primary teachers and students. The mentors advised their allocated students about the testability of their question(s) and offered guidance and support to the students as they began to design and implement their investigations. Students had ownership of the investigation area, the questions that they were interested in answering, and planning and implementing decisions that they made following discussions with their mentor and teacher. Examples of investigations related to the different themes
that students chose to investigate (based around an energy theme) included: ‘Which types of string allow sound to pass the easiest?’, ‘What conditions allow an object to slide the furthest on ice?’, ‘Which liquids close an electric circuit?’; and based around a growth and change theme ‘What is the best environment for growing radishes’, ‘Which substance dissolves the fastest in water?’, ‘Does the fat content in ice creams affect the melting process?’. Students were interviewed about their MyScience experiences a few months after they had completed their school Science Fair presentations (in November 2010) –the final element of the MyScience educational model (see Chapter 2, Figure 2.1).

For purposes of contrast (Bogdan & Biklen, 2007) primary students were sampled from the same three schools used in the studies of mentors (Chapter 4) and teachers (Chapter 5), i.e., Schools A, B and C. For this study, primary students were selected from each school using aspects of two purposive sampling techniques: ‘snowball sampling’ and ‘maximum variation sampling’ (Patton, 1990). The MyScience School Coordinator in each school was asked to identify a gender balance of Year 5 and Year 6 participants with a range of views of their MyScience participation. Eight to ten participants were selected from each school, which was within Creswell’s (2007) recommended range of 5-25 individuals who have experienced the phenomenon. Pseudonyms are used for all student names and have been allocated so that the first letter of each student’s name correlates with their school e.g., Amelia is from School A, Blake is from School B. Where possible, findings from mentors who worked alongside these students (see Chapter 4) have been included to enhance understanding of how participants engage in and contribute to the practices of their particular community of science practice. The scientists’ pseudonyms are: Sam, Sasha, Scott and Spencer, and the engineers’ pseudonyms are: Elana, Emily and Ezra. Table 6.1 details demographic information of the interviewed primary students from the three schools and the ‘relevant mentor names’ to facilitate cross-referencing to the findings in Chapter 4. As shown, all students were in years 5 or 6 and had experienced MyScience a varying number of times: all School A students and three School C students (Carla, Cassius and Connor) were first-timers, all School B students had previously participated in the program at least once, and in both Schools B and C there were several experienced old-timer students who were on their third (Blake, Bella), fourth (Ben, Carmen, Chad), and fifth (Candy) occasions of doing MyScience.

In order to supplement and to gain deeper insights into interviewed students’ perceptions of their MyScience participation, all students in the School A Year 5/6 class (n=26) from
which the interviewees were drawn, were invited (in November, 2010) to participate in an activity (the ’20 word activity’) where they recorded the first twenty words (in order) that they associated with their *MyScience* experience. Twenty-six students chose to participate. All of their words were entered into a spreadsheet and then analysed for the relationship between their mean rank and the frequency with which the word was cited. These findings are presented in Section 6.2.2.
Table 6.1. Demographic information of interviewed primary students

<table>
<thead>
<tr>
<th>School</th>
<th>Student name</th>
<th>Gender</th>
<th>Schooling year</th>
<th># times in MyScience</th>
<th>Mentors*</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Amelia</td>
<td>F</td>
<td>5</td>
<td>1</td>
<td>Sam</td>
</tr>
<tr>
<td></td>
<td>Adam</td>
<td>M</td>
<td>5</td>
<td>1</td>
<td>Sasha</td>
</tr>
<tr>
<td></td>
<td>Alex</td>
<td>M</td>
<td>5</td>
<td>4</td>
<td>Scott</td>
</tr>
<tr>
<td></td>
<td>Amanda</td>
<td>F</td>
<td>6</td>
<td>1</td>
<td>Spencer</td>
</tr>
<tr>
<td></td>
<td>Anne</td>
<td>F</td>
<td>6</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>April</td>
<td>F</td>
<td>6</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ava</td>
<td>F</td>
<td>6</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Alan</td>
<td>M</td>
<td>6</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Andrew</td>
<td>M</td>
<td>6</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Blake</td>
<td>M</td>
<td>5</td>
<td>3</td>
<td>Elana</td>
</tr>
<tr>
<td></td>
<td>Bob</td>
<td>M</td>
<td>5</td>
<td>2</td>
<td>Emily</td>
</tr>
<tr>
<td></td>
<td>Brad</td>
<td>M</td>
<td>5</td>
<td>2</td>
<td>Ezra</td>
</tr>
<tr>
<td></td>
<td>Brett</td>
<td>M</td>
<td>5</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Becky</td>
<td>F</td>
<td>6</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bella</td>
<td>F</td>
<td>6</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ben</td>
<td>M</td>
<td>6</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bill</td>
<td>M</td>
<td>6</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Carla</td>
<td>F</td>
<td>5</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cassius</td>
<td>M</td>
<td>5</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Connor</td>
<td>M</td>
<td>5</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Candy</td>
<td>F</td>
<td>6</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Carmen</td>
<td>F</td>
<td>6</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Callum</td>
<td>M</td>
<td>6</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cameron</td>
<td>M</td>
<td>6</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chad</td>
<td>M</td>
<td>6</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cid</td>
<td>M</td>
<td>6</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Clint</td>
<td>M</td>
<td>6</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

# = ‘number’

* = scientist and engineer mentors identified as having worked with the interviewed students
6.2 Findings and Discussion: primary students

A number of findings emerged from participants’ interviews and these are expressed as two plausible assertions with supporting evidence.

In line with Anfara et al.’s suggestions to present evidence of “methodological rigour and analytical defensibility [in] qualitative research” (2002, p. 28) the primary student findings are presented as follows:

1. an ‘overview of findings’;
2. a ‘tabulated summary of assertions, aspects and evidence including relevant NOS and CoP attributes’;
3. each assertion, its aspects and detailed supporting evidence; and
4. a summary of each assertion.

Thus, the primary students’ teachers’ views are presented in Section 6.2.1 and Table 6.2. The definition and hierarchy of ‘assertion, aspect and evidence’ in the table and associated findings relate to the data analysis procedure (see Chapter 3, Section 3.5.1) where: ‘evidence statements’ are derived from themes arising from the coding, ‘aspects’ are statements derived from the collection of evidence statements and ‘assertions’ are statements derived from the collection of aspects. ‘In text’ references to assertions are denoted by, for example, [#1] for Assertion #1.

These reported ‘assertions’ and ‘aspects’ are the researcher’s interpretations and inferences, from, in part, analysis of participants’ responses to interview questions about their involvement in MyScience (see research question in Section 6.1.1).

To further aid the reader with cross-referencing to Table 3.8 (CoP and NOS attributes) and to highlight significant CoP and NOS connections, right hand margin notes have been inserted to correlate with relevant sections of text (identified by dotted underlines – as indicated). The first example in the text in this chapter is as follows and has been indented to enhance its visibility:

When asked ‘What have you got out of doing MyScience?’ (Question 3, Table 3.4) Alex described learning about a variety of aspects of science ranging from content knowledge around energy, to scientific terms, to details of the scientific process including fair testing and making sense of collected data:

NOS#1
In addition, margin comments (as explained in Section 3.5.2) such as ‘scientific intuition’ are inserted to highlight relevant correlations between these participants’ views (primary students in Chapter 5) and those of other participants’ (mentors’ views in Chapter 4 and teachers’ views in Chapter 6). These correlations will be expanded in Chapter 7, and are inserted to signify their location to the reader. The first example in the text is as follows:

In response to the question: “So do you think you have to be smart to do science?” Bella replied: “Well you don’t have to exactly be smart but you have to have a lot of knowledge about these kind of things”.

6.2.1 Overview of primary students’ views from each of the three schools

In general, when asked to compare their MyScience experiences with their normal school science experiences, students described the key differences as being related to inherent features of the MyScience program and that these features profoundly impacted their views of science and science learning (Assertion 1 [#1]). The main influences reported by students related to:

- the types of classroom activities they experienced while doing MyScience such as: the explicit use of ‘scientific methods’, their active involvement in hands-on collaborative ventures with their peers, interactions with their teachers and mentors, and the wide variety of concurrently occurring scientific investigations;
- the amount of student choice and independence;
- the complexity and stimulation afforded by MyScience.

The MyScience initiative is designed to address all of these areas (see Chapter 2, Section 2.6 for an overview of the MyScience Educational Model) but what is significant is that students reported these perceptions with no prompting during interviews.

These students also have particular views of their own and other CoP members’ roles (Assertion 2 [#2]).

Each of these assertions, which together relate directly to the research question, is now presented and discussed with supporting evidence and pedagogical implications from this study and associated literature. Occasional reference in this chapter is made to
relevant findings derived from the perceptions of mentors (Chapter 4) and primary teachers (Chapter 5) since they were co-participants at the time of this study. As outlined earlier, a more detailed synthesis of findings is presented in Chapter 7.
Table 6.2. Summary of findings from primary student interviews

<table>
<thead>
<tr>
<th>Category</th>
<th>#</th>
<th>Description of Assertion/Aspect/Evidence*</th>
<th>NOS/CoP attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASSERTION 1</td>
<td></td>
<td>Participation in <em>MyScience</em> changed students’ views of what it meant to be ‘doing science’ in the primary classroom: these views exemplified CoP and NOS attributes that underpin, in part, the <em>MyScience</em> initiative.</td>
<td></td>
</tr>
<tr>
<td>Aspect</td>
<td>Evidence*</td>
<td>Students learned about the nature of science and experienced science as a human endeavour:</td>
<td>NOS#1, #2, #3, #6 CoP#2</td>
</tr>
<tr>
<td>(a)</td>
<td>Interviewed students perceived that, through <em>MyScience</em> participation they had been exposed to aspects of the NOS including that science is inquiry based, tentative, developmental and collaborative.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aspect</td>
<td>Evidence</td>
<td>Students linked their learning to the use of scientific methods and having fun:</td>
<td>NOS#1</td>
</tr>
<tr>
<td>(b)</td>
<td>Active physical and mental involvement in hands-on investigations was viewed as a critical factor for effective science learning.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aspect</td>
<td>Evidence</td>
<td>Collaboration with other group members had a number of benefits:</td>
<td>NOS#1, #5, #6 CoP#1, #2, #3</td>
</tr>
<tr>
<td>(c)</td>
<td>Students perceived that working with others: reduced workload, enabled awareness of others’ strengths, provided access to a wider variety of ideas, improved social skills and provided a way to make friends.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aspect</td>
<td>Evidence</td>
<td>Participation afforded students with a sense of membership in a CoP:</td>
<td>NOS#1, #6 CoP#1, #2, #3</td>
</tr>
<tr>
<td>(d)</td>
<td>Observing and participating in a wide variety of concurrently occurring activities imbued a sense of belonging to a community of science practice.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aspect</td>
<td>Evidence</td>
<td>Student choice was highly valued and was perceived to enable learning:</td>
<td>NOS#1, #5</td>
</tr>
<tr>
<td>(e)</td>
<td>Student-directed learning was perceived to foster independence, and to provide opportunities to think creatively and to learn from mistakes.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aspect</td>
<td>Evidence</td>
<td><em>MyScience</em> was more stimulating and complicated than normal school work and this enabled learning:</td>
<td>NOS#1, #5</td>
</tr>
<tr>
<td>(f)</td>
<td>Students perceived that they had to think more when doing <em>MyScience</em> and that they were able to achieve what was perceived to be ‘impossible’.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASSERTION 2</td>
<td></td>
<td>Students’ perceptions of participants’ roles, including their own, were consistent with a CoP interpretive framework and provide further insights into teachers’ views about the nature of science, and learning and teaching science.</td>
<td></td>
</tr>
<tr>
<td>Aspect</td>
<td>Evidence</td>
<td>Students’ views of students:</td>
<td>NOS#1, #3 CoP#1, #2, #3</td>
</tr>
<tr>
<td>(a)</td>
<td>Students perceptions of their role when doing <em>MyScience</em> included: to learn while conducting scientific investigations, to collaborate with their peers, and to take responsibility for planning implementing, recording and reporting their investigation.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aspect</td>
<td>Evidence</td>
<td>Students’ views of mentors:</td>
<td>NOS#1, #3, #5, #6 CoP#2, CoP#3</td>
</tr>
<tr>
<td>(b)</td>
<td>Students appreciated the involvement of real scientists as mentors, had high regard for mentors’ scientific knowledge and advice, and recognized mentors’ ability to link ‘in-school’ to ‘out-of-school’ science.</td>
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<tr>
<td>Aspect</td>
<td>Evidence</td>
<td>Students’ views of teachers:</td>
<td>NOS#1 CoP#1, #2, #3, #4</td>
</tr>
<tr>
<td>(c)</td>
<td>During <em>MyScience</em>, students generally perceived that their teachers provided science procedural guidance and support (that was less scientific than the mentors) and were focussed on the safety and supervision of students. At times, the teacher was viewed as a learner during mentor visits.</td>
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<tr>
<td>Aspect</td>
<td>Evidence</td>
<td>Students’ views of the Principal and parents:</td>
<td>NOS#6 CoP#1, #2</td>
</tr>
<tr>
<td>(d)</td>
<td>Students’ views of the role of the principal and parents included: allowing <em>MyScience</em> into the school, showing interest in student investigations, sourcing equipment, being a discussion sounding board at home, and applauding students’ efforts.</td>
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* Evidence statements are summative examples of participant perceptions (derived from interview transcripts) that may be interpreted as support for aspects underpinning each assertion.
6.2.2.1 Assertion #1 [#1]: Participation in MyScience changed students’ views of what it means to be doing science and enabled them to identify factors that influenced their learning.

Students’ views of ‘doing science’ changed in six major ways. Firstly, there was evidence that strongly suggested these students considered that participation enabled them to learn about the NOS (referred to as ‘Aspect (a)’ below). Secondly, students linked their learning to the use of scientific methods and to having fun (‘Aspect (b)’ below). Thirdly, collaboration with other group members was perceived to have a number of benefits (‘Aspect (c)’ below). Fourthly, participation in MyScience afforded a sense of belonging to a community of science practice (‘Aspect (d)’ below). Fifthly, student choice was highly valued and perceived to enable learning (‘Aspect (e)’ below). Sixthly, students viewed the complexity and stimulation of MyScience as learning affordances (‘Aspect (f)’ below). In each instance these students’ interview responses, and other data, provided numerous examples of classroom events that exemplified CoP and NOS attributes (listed in Chapter 3, Table 3.8). see Section 3.5.1 for the relationship between ‘evidence’, ‘aspects’, and ‘assertions’.

Aspect (a): Students learned about the nature of science and experienced science as a human endeavor

One inference/interpretation supports this aspect (see ‘evidence’ shown in Table 6.2). It is that, ‘Interviewed students perceived that, through MyScience participation they had been exposed to aspects of the NOS including that science is inquiry based, tentative, developmental and collaborative’. The evidence supporting the inference/interpretation follows the inference/interpretation statement (in bold type).

Interviewed students perceived that, through MyScience participation they had been exposed to aspects of the NOS including that science is inquiry based, tentative, developmental and collaborative.

When asked ‘What have you got out of doing MyScience?’ (Question 3, Table 3.4) Alex described learning about a variety of aspects of science ranging from content knowledge around energy, to scientific terms, to details of the scientific process including fair testing and making sense of collected data:
Well, we learnt a lot about energy and lots of different terms in science, and we also learnt, the scientific process, like hypothesizing and finding results, and we learnt lots of things from our results. … I learnt a lot about air pressure, and I learnt how we can only change one thing, like cows moo softly, and, yeah, like I said, we learnt the scientific process, and we learnt how to experiment on lots of different things. Also, we learnt how to, set out our data in graphs and really neatly, and then work out patterns and, and working out the conclusion and stuff.

Amelia identified that she had gained knowledge about “the process of the science [sic] … how to actually set it up properly, and do the experiments, and think it all through … how you set all the results up”, as did April: I learnt “more about the procedure of doing an experiment, you know, writing [up] the scientific investigation and learning what to do in what order and [to] make sure it’s a fair test”. Cassius made similar comments: “we learnt that you have to be very exact to carry out something accurately”, and Carmen:

I got scientific knowledge [so] that I know how to produce an experiment, and I know how to, work out how to plan it, and how to do my log, and how to present it in a way that people would be interested.

All of these responses are evidence of students’ understanding of NOS#1: Science is inquiry based.

Another student –Anne– (also in response to Question 3) described her learning resulting from an investigation into the colour of lighting that best supported the growth of shallots as follows:

I now know [more about] photosynthesis … basically how … green light cannot go through a green plant. [We found that] the best [type of light] was actually the green, surprisingly. It was actually the same for both of them … First we thought of theories why it could have been like that … contradicting the photosynthesis … [but] nobody’s done the [sic] plant in particular.

In this anecdote she shows some understanding of how plants use light energy to grow (photosynthesis), but her comments also indicate awareness of the need for replication in the inquiry process (‘both of them’), the tentative nature of science (‘surprisingly’), that science is collaborative (‘we’) and that science is developmental –building on others’ findings (‘theories … nobody’s done the plant in particular’).
This is evidence of NOS#1: Science is inquiry based; NOS#2: Science is tentative; NOS#3: Science is developmental (builds on the findings of others) and NOS# 6: Science is collaborative (we thought of theories ...) all of which are aspects of ‘Science as a Human Endeavour’ (ACARA, 2013b). The notion of ‘we’ refers to students (and mentors) working and thinking together to solve issues associated with the investigation and is therefore an example of CoP#2: members who are collaboratively engaged in activities and discussion related to the domain.

Bella (as with Anne’s earlier comment: ‘first we thought of theories …’) touched on the ‘traditional notion’ of the developmental nature of science with a comment related to sourcing additional information: “When we went into the library we looked at information about beans and what beans are good”. She also made an interesting reflection that harked back to mentors’ comments about developing scientific intuition in students (see Chapter 4, Assertions #1(b), #2(a) and #4(a)). In response to the question: “So do you think you have to be smart to do science?” Bella replied: “Well you don’t have to exactly be smart but you have to have a lot of knowledge about these kind of things”. Here, Bella seems to be saying that to successfully ‘do science’ she needs a wide range of knowledge and understandings related to the ‘doing’ of science: she needs to have scientific intuition – the ability to think intuitively within scientific contexts.

Chad, a fourth timer participant, described how his own NOS expertise had developed through serial participation in MyScience:

As I went further in age, the experiments became more complex … when I was in Year 3 we did something really basic, [but now] … I’ve learned more about how we can test it and the different subjects that we can go into.

This notion of students applying knowledge into new contexts was also independently raised by teachers in Chapter 5 (Section 5.2.2.1, Assertion #1(a)). Here, Chad’s personal observations indicate awareness of increasing sophistication of how to do (fair) testing (‘became more complex’, ‘in Year 3 we did something really basic’).

Ben experienced MyScience four times –the most of all interviewed students at School B– and appeared to have a wider perspective of science compared with other
Chapter Six

interviewed students, demonstrated through the linking of his *MyScience* school-based activities to real world issues. He explained: “One of the most interesting things I found out [through doing *MyScience* in Year 3 was] that a roller coaster or something, it could break down easily [sic] on a cold day than a normal type day”.

Ben’s Year 6 recollection of this event from his first year of participation (in Year 3) is evidence of the profound effect that this realisation had on the development of his scientific knowledge and understandings. In another comment, pondering a future topic for investigation in high school, he said:

I was thinking that next year, if I do *MyScience*, because I heard there’s a rumour that graffiti is removed by deodorant, so I was going to see which deodorant removes it, removed graffiti better, what type of graffiti is removed the easiest, and on what materials. Because, there’s like a lot of people graffiti there in the holidays, so it would be useful for them.

What is interesting here is that Ben is concerned with and relates his science skills and knowledge to real life issues. When asked: “What does it mean to be doing *MyScience*?” – he again linked the doing of experiments with the notion of helping society: “To be doing MyScience [means] to be doing experiments to find out something that is worth finding out for the human society” (Ben). Three of the five engineer mentors who were interviewed from Ben’s school (Ezra, Emily and Elana) commented that they wanted to help students ‘understand the link and increase the relevance between ‘school science’ and ‘real world science’ (see Chapter 4). It appears that at least with Ben their wish has been partially fulfilled.

Many students described learning science content knowledge or information related to their investigation area and that this information was largely sourced from the mentors. The following are examples of comments made by students relating to specific science knowledge provided by their mentors: “learning more about flies and what they like eating” (Andrew), “I learned a lot about air pressure” (Alex); “I learnt … that … even if it’s [plastic bottle] streamlined, if it doesn’t have a big air capacity it can’t really blast that far” (Adam); “I’ve learned a lot of interesting stuff about water, electricity … what types of liquid conduct electricity” (Ava); “we’d learn more about the rocket every day” (Brad), “I’ve learnt a lot about how, when I did the catapult I learnt how gravity pulls it down, and about air resistance and about how objects float down, like the piece of paper I was talking about” (Blake); “[doing
MyScience] gives you a lot of knowledge about your, the human body and the subject that you’re learning about” (Bella).

In summary, these examples demonstrate students’ awareness of their increased knowledge of scientific methods, phenomena and principles achieved through application of scientific methods while interacting with others in MyScience – through their participation in MyScience. Students’ recognition of their own learning through participation aligns with the findings of mentors’ and teachers’ perceptions of students also learning through this mode (reported in Chapters 4 and 5 respectively).

The awareness of the significance of ‘interactions with others’ is also a keystone for students realising that people –humans– are the reason that there is such a thing called ‘science’. The ‘doing’ of science is necessarily a human enterprise and underpins the notion of Science as a Human Endeavour (SHE). While science is a vast body of knowledge it also has its own “practices, conventions and modes of expression” that embody how science works (Scott et al., 2007, p.41). The composite collection of the practices of science (nature of science attributes #1 - #6, Table 3.8) are what people use or do when they are thinking and working scientifically and provide a way to identify the presence and/or awareness (by participants) of aspects of SHE. In this section, evidence has been presented showing students’ awareness of, and increased knowledge about, aspects of the nature of science related to science being inquiry based (NOS #1), tentative (NOS #2), developmental (NOS #3) and collaborative (NOS #6) which also indicates that they have experienced science as a human endeavour.

Aspect (b): Students linked their learning to the use of scientific methods and having fun

One inference/interpretation supports this aspect (see ‘evidence’ shown in Table 6.2). It is that, ‘Active physical and mental involvement in hands-on investigations was viewed as a critical factor for effective science learning’. The evidence supporting the inference/interpretation follows the inference/interpretation statement (in bold type).
Active physical and mental involvement in hands-on investigations was viewed as a critical factor for effective science learning.

When asked ‘What does it mean to be doing MyScience?’ students frequently commented on their active (mental) involvement (referred to as ‘heads-on’ by Skamp, 2007) in doing hands-on experiments leading to better understanding: ‘it’s learning and experimenting and pretending to be scientists, and it’s really fun because you learn new things, and you know how things work by experimenting, and yeah, it was fun’ (Alex); “doing something hands-on [makes you] understand it more” (April); and … getting involved [helps you] to understand it, ‘cause if you don’t understand it you’re not really doing it … you need to understand the, kind of logics behind [the] experiment, and you also need to get your hands in [to the] project (Adam).

Cassius described his excitement when doing his investigation:

In normal school science we just learn stuff, we don’t do much [sic] experiments. But in MyScience we actually got to conduct an experiment and the thrill of … we predicted that the vinegar would melt the ice cube fastest, and we were all ecstatic that [we were correct].

Here, students are linking enjoyment (‘fun’, ‘thrill’, ‘ecstatic’), learning how things work, and the process of investigating scientifically (‘experimenting’, ‘conduct an experiment’) with the notion of ‘being a scientist’. Some have also appeared to realize the significance of hands-on activities needing to be minds-on (e.g., Adam’s reference to ‘logics’). These students are exhibiting positive views about science, which was a goal for participating scientist and engineer mentors (see Chapter 4, Assertion #4).

When comparing MyScience with normal school science Adam and Anne commented that they did do hands-on activities in their normal school science but that these activities were not minds-on –they lacked the use of scientific practices– a notion also raised by their teacher Angela, in Section 5.2.2.1, Assertion #1(b), p. 180:

MyScience gets you more involved and it’s better than just doing normal science … I remember when I did science experiments at my old school, they didn’t have MyScience, and it was really hectic and everything and we didn’t really have a procedure. We just
did what we had to and I think I can remember that quite a lot of factors did change and [so] it wasn’t a fair test. (Adam)

When we did the normal science, even with the bean growing, we didn’t do any graphing or anything, just water it, done. We didn’t do anything, no graphing. So this one [growing plants in MyScience] we actually did graphing and we got to find the averages and record the results and everything. So we actually got to know about, you actually feel like you’re actually doing some science. (Anne)

Anne also described normal school science as boring:

I know when we were in Year 3 and Year 2, we didn’t really get to actually do the experiment; we just read about the experiment for example and … just read the procedure and it was really boring; it wasn’t fun. This [MyScience] you actually get to do it and you get to bring the equipment in and test it, the results and graph it …

while Cassius contrasted the ‘recipe approach’ of normal school science with that of MyScience: “we just listed what would happen and what’s already known” compared with “we’ve got to do what we don’t know and test it out” indicating a clear understanding of the purpose of investigating scientifically.

Becky concurred with the views of Adam and Anne, but went a step further linking the ‘doing of science’ with fun, which then aided remembering:

Becky: …with normal science, well mostly we just have to write stuff out and kind of just like keep it in your mind but with MyScience it’s much easier to learn because you actually get to do things, instead of just sitting around writing stuff out.

Interviewer: So how does doing things help you learn more?

Becky: Because if you’re having fun, you’re more likely to remember it.

These vignettes and the earlier examples show that students remember participating in hands-on activities in their ‘normal science classes’ but that through MyScience they have come to recognize that these experiences were not scientific (‘didn’t have a procedure … a lot of factors changed … no data collection …’) or interesting (‘it was really boring’). The resulting disinterest, disengagement and lack of learning when students merely follow recipe style investigations (hands-on but not minds-on) has also been described by Goodrum et al. (2001) in their review of The status and quality of teaching and learning science in Australian schools. Through MyScience,
students have learned that scientific inquiry has a procedure where variables are controlled (Adam), that measurements need to be taken, recorded and reported (Anne), that science can be interesting and it is through using scientific methods (experimenting) that they are able to learn how the world works. There was also recognition by Anne that MyScience provided her with an authentic science experience (‘you actually feel like you’re actually doing some science’). This is evidence that students have come to realize NOS#1: Science is inquiry based and represents partial achievement of one of the main reasons why scientists became MyScience mentors – for students to gain ‘scientific intuition’.

When asked what he had got out of doing MyScience Ben was the only School B student who specifically mentioned science inquiry skills: “Well, I have learned how to do experiments a lot better” and went on to explain that this meant that he had learned: “... how to make it an equal test, how to make a fair test, how, which ones would be worth the human society knowing about, and how to display and record results”. Becky indirectly alluded to her inquiry skills having improved and that this had helped her to learn more science when she commented: “It’s [MyScience] really fun and you learn a lot about science from it because you get to learn to do experiments better”.

Overall, School B students appeared to place less emphasis on their use of, and the significance of, scientific inquiry skills than School A students. This difference between the two student cohorts could be due to a number of factors. One possibility for the higher number of School A students’ comments about their use of scientific methods is the type of guidance provided by the mentors (astronomers at School A and engineers at School B), each with their own community of science practices and their own motivations for involvement as mentors. As reported in Chapter 4, School A mentors wished: to develop students’ scientific intuition: ‘to seed an interest in, and a love of, science in students’ (see Chapter 4, Assertion #4); to have science viewed as being ‘inquiry based’; and to give students ‘agency’ to be able to ‘independently ask and answer questions’. School B mentors also wanted students to develop an interest in science but their focus appeared to be aimed at helping students ‘to understand the link and increase the relevance between ‘school science‘ and ‘real world science’. It could be argued that multiple interactions between students and mentors—who have particular ways of thinking, discussing and using science, and who have different motivations for their involvement as mentors—
results in students who then reflect their mentors’ views. Thus School A students, who were mentored by practicing scientists (astronomers) may have encountered more emphasis on the use of scientific methods and so commented more frequently on these aspects of their MyScience experience.

Another possibility for the difference between the two student cohorts could be related to the number of times that they have experienced MyScience. As stated earlier, School A students were all first-timers while School B students were old-timers. MyScience has a focus on scientific inquiry so for School A students who were new to the program, their recollected experiences may be more likely to be in this area. School B students had experienced MyScience several times so exposure to, and the more frequent use of scientific inquiry processes, dialogue and discussion may have rendered these activities to be a less memorable topic for discussion during the interviews. Furthermore, School B students’ recollections of their MyScience experiences tended to focus on aspects such as content knowledge associated with their topic area. Further research is needed to identify the effects of the mentors’ background and repeated experiences of MyScience on students’ reported responses.

**Aspect (c): Collaboration with other group members had a number of benefits**

One inference/interpretation supports this aspect (see ‘evidence’ shown in Table 6.2). It is that, ‘Students perceived that working with others reduced workload and enabled awareness of others’ strengths, provided access to a wider variety of ideas, improved social skills and provided a way to make friends’. The evidence supporting the inference/interpretation follows the inference/interpretation statement (in bold type).

*Students perceived that working with others reduced workload and enabled awareness of others’ strengths, provided access to a wider variety of ideas, improved social skills and provided a way to make friends.*

MyScience was described as a collaborative enterprise by Alan: “[MyScience is] working together in a group to find out how something works”, and Adam: “[it was] much better than working by yourself … working with other people can actually make the job easier”. Amanda described how she and her partner “developed [more of] a friendship” as they worked together and they each learned about their respective strengths:
My friend was good at presenting … and writing everything … she was better than I thought, she was really good. I think she thought I was good at research because I just kept on searching up on the internet and I just looked at loads of sites and found loads of information that were good (Amanda).

Bill and Carla made similar comments to those of Amanda:

[Through MyScience] I’ve gotten friends, better friends … we’re going to understand each other more and what we think of science. … When we were doing the graphs and stuff … my friend was good at doing graphs and stuff and then I was good at doing something else – so we know what we are good at (Bill).

[Working] with my friends in a group I learnt that Ciara is sort of shy and she’s really into plants and stuff and science … I thought she would’ve not liked science at all. Chelsea who also was in my group, she is usually into soccer and all that sporty stuff but I found out that she also likes science as well. And Cleo, I thought she would be interested in science the whole time, so nothing really [new] with Cleo… (Carla).

Bill’s comments show that he feels that his social relationships have improved as he has come to a better understanding of his own and his colleagues’ science views and strengths. Carla has gained information about her friends also having an interest in science and this mutual interest could lead to the subject gaining higher status amongst her peer group as suggested by Logan and Skamp (2008). Both Bill and Carla’s comments indicate participants who are collaboratively engaged in activities and discussion related to science, and each groups’ investigation, and is therefore evidence of CoP#2 (members who are collaboratively engaged in activities and discussion related to the domain).

Group work provided access to a wider variety of ideas, improved social skills and provided a way to make friends. Four of the eight interviewed School B students alluded to the potential for group work to precipitate a wider variety of ideas than could be achieved individually and that these ideas could be combined. Blake stated this succinctly as “more people means more ideas” – recognizing that science is collaborative (CoP#6), and that CoP members learn from each other (CoP#1). Bella described a sense of safety and a willingness to share and learn from others’ ideas:

If you’re working with a group then you also get to talk to them a lot and express your ideas … It was really good [working in a group] because when we had troubles …
other people in our group [helped us], they gave us new ideas that we wouldn’t have thought of.

Carla also commented on the increased opportunities for learning from others when working in a group: “In MyScience you’re actually working in a group … you can learn more from each other”, while Blake included the notion of creativity – combining ideas to develop solutions (NOS#5) – “We have an idea and then we can join … two people have an idea, then we combine them together … to make a big success”. Bill went on to describe a group interaction that resulted in his group accepting and using his idea to more carefully record their data:

… at first we were just going to take a … with the protractor, we were just going to estimate. But I came up with the idea of taking a picture, and actually reading properly, zooming in and actually reading it perfectly …

Bill’s comment indicates an awareness of the need to accurately record measurements – that ‘estimating’ is not sufficient, that science is rigorous (NOS#1) – and his creative solution exemplifies NOS#5. Coincidentally (and independently) an emphasis on measurement was a strong theme in both Sam (a scientist mentor) and Elana’s (an engineer mentor) interview responses (Chapter 4), and Bill’s comments indicate his awareness of this aspect of the NOS. Carla’s comment about ‘learning more from each other’ when working in a group (as opposed to working independently) is a clear statement that she sees herself as a member of her CoP (CoP#1, #2).

Several students commented that their own social skills had improved through group interactions and is evidence of CoP#3 – what members ‘do’ when they interact: “when you have a partner it helps you with your social [skills]” (Bella), “I’ve learnt more about working together [in groups]” (Brad) and “[doing MyScience] has actually helped with my group skills too because I’m very independent … ‘cause everybody gets to commit to something and we all join in” (Becky). Blake felt that MyScience provided a way to make friends and that this lead to science being collaborative (NOS#6): “[MyScience is] a way [for] how kids can become friends … we do a lot of science experiments, and we just work together as a team”. Working with friends transformed Blake’s view of learning in science as described in the following anecdote:
Interviewer: How has MyScience changed for you since you've been doing it?

Blake: Well, first, I hated science … in Year 2. When I was in Year 3 I was put in a group where I had no friends in it … so I just worked by myself and then I started to change. In Year 4 I worked with Ben and I started to change that feeling because [I realized] it's fun, because I'm learning a lot of stuff and it's good. We get to choose our own experiments. And now here in Year 5 I'm loving it.

Bella’s view concurred with Blake’s: “ … if you worked with someone you didn’t really like it wouldn’t be that much fun”. Brett said that working with friends was “better because we all cooperate”. Group size was a concern for Becky since (in her experience) large groups (more than three) tended to argue more “cause everyone wants to have a go at something”.

These examples show that working with others was mostly perceived to: enhance learning in science (Alan); reduce workload (Adam); be more enjoyable (Bella, Blake); be more creative (Blake, Bella, Bill); and afforded the development of social skills and understanding of others’ strengths (Amanda, Bella, Brad, Becky, Bill, Carla). The beneficial effects of social interactions within primary science classrooms have been reported by several researchers and therefore corroborate these findings. Murphy et al. (2012) found that students enjoyed working with their friends in science (as reported by Blake, Bella and Brett). Smith et al. found that social interactions widened Year 6 students’ exposure to a “range of ideas students … which often led them to develop more complex views” (2000, p. 402). This notion is supported by comments from: Blake (‘more people means more ideas’, ‘combine them together … to make a big success’); Bella (‘new ideas that we wouldn’t have thought of’); and Carla (‘you can learn more from each other’).

Analysis of students’ interview responses appeared to indicate that School B students made relatively more comments about the benefits of working in a group (collaboratively) than School A and School C students. Of the 16 comments cited as evidence in this aspect of Assertion #1 (#1(c)), eleven comments (69%) were from School B students, three comments (19%) were from School A students, and two comments (13%) were from School C students. These comparative numbers are significant since all students were asked the same interview questions and therefore participants’ responses will necessarily be linked to their own particular MyScience experiences. An explanation for this observation may be related to School B’s long-
standing, historical relationship with a single source of mentors – company ABC – rather than the varied source of mentors for School C – pre-service and in-service secondary science teachers, and secondary science students – resulting in a deeper sense of belonging to the MyScience CoP by School B mentors compared with School A and School C mentors. This, in turn, may have influenced School B students’ sense of belonging and identity as a productive and valued member of their CoP. Another contributing factor may be that, at the time of the interviews, MyScience was embedded in School B’s curriculum as a critical aspect of the science program. This ‘two-pronged’ effect may have influenced School B students’ views related to collaboration and group work, compared with students from the other schools.

Aspect (d): Participation afforded students with a sense of membership in a CoP

One inference/interpretation supports this aspect (see ‘evidence’ shown in Table 6.2). It is that, ‘Observing and participating in a wide variety of concurrently occurring activities imbued a sense of belonging to a community of science practice’. The evidence supporting the inference/interpretation follows the inference/interpretation statement (in bold type).

Observing and participating in a wide variety of concurrently occurring activities imbued a sense of belonging to a community of science practice.

The variety of classroom activities going on at the same time was commented on by several students indicating their awareness of what others were doing and of the potential learning opportunities due to the relatedness of the investigations. Amelia said “… it’s interesting, because there’s all these activities going on at once, except they all turn out really good, and it all works out … they were all about energy sources”. Amanda’s comment alluded to a sense of satisfaction of belonging to a community of science practice: “there’s other people doing it in the classroom too and it’s, it’s just, I don’t know how to say it, it’s just cool because, everyone’s doing some experiments”. Ben also made a comment affirming that he viewed himself as part of a community of science practice, and that part of his role was to be a ‘guinea pig’ for other groups in their data collection:
If we are doing the experiment, our role is to find results. If we are not then our role is to help other people, and if they have a test to do [using students as their data], then do their test for them.

When asked if there were differences between doing normal school science and doing MyScience Clint commented:

…[In MyScience] not everybody’s doing the same thing. So people do different things and you learn from each other and you use it in your own experiment and you share it…. If you just do one topic … one section of a topic, you don’t really learn … you only learn that much. But if other groups do different stuff, you learn everything, ’cause you share it.

Here, Clint expressed a clear view that more learning occurred when different investigations were occurring simultaneously, and when group members shared their findings with others. This goes to the essence of the nature of a community of practice: “groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly” (Wenger-Trayner, 2013, paragraph 1).

Carla was in the same school class as Clint. She was a member of a group investigating the effect of watering broad bean seeds with salt water, sugar water and normal water. When asked at the end of her interview if there was anything that hadn’t been covered (by the interview questions) she replied:

Carla: Well there is one thing that we haven’t covered, which is what the other groups are doing. One of the groups also used seeds but they did what environment, they had the shade, the sun and darkness and they used radishes.

Interviewer: Okay. And what happened?

Carla: Well they left one in the storeroom, they left one outside and they left one under the verandah sort of thing and they figured that it’s better to grow radishes in the dark.

Here, it is evident that Carla observed and learned information about other groups’ investigations because of their close proximity –and she felt this was important enough to mention as part of her interview. She clearly felt part of her CoP, and that she had an identity as a member of her CoP and she learned through her participation in her CoP.
Cassius described activities at the School Science Fair in a similar way –that they afforded an opportunity for him (and other students) to see and learn about different group’s work and ideas:

The science fair was nice. We got to see everyone’s investigation. We also saw what other people thought because on their poster they had the hypothesis and why they think [sic] that. So we learnt how other people think, how logical they are …

Cassius’s reference to other groups’ hypotheses, “and why they think [sic] that”, indicates a high level of NOS awareness and that scientific discussions would have been happening during the Science Fair. This type of discussion and the sharing of ideas and information are hallmarks of a CoP (CoP#2).

These comments provide evidence of students directly recognizing and appreciating that they are part of a larger collective –part of a community of science practice– where everyone is working scientifically on related topics. This ‘hoped for’ perception –that students and teachers see themselves as members of a community of science practice– was raised by mentors in Chapter 4, and from these students’ comments, appears to have been realized and is evidence of NOS#1: Science is inquiry based; NOS#6: Science is collaborative; CoP#1: Acknowledged shared interest area in which members collectively learn from each other; CoP#2: Members who are collaboratively engaged in activities and discussion related to the domain, and CoP#3: What members ‘do’ when they interact.

Aspect (e): Student choice was highly valued and was perceived to enable learning

One inference/interpretation supports this aspect (see ‘evidence’ shown in Table 6.2). It is that, ‘Student-directed learning was perceived to foster independence, and to provide opportunities to think creatively and to learn from mistakes’. The evidence supporting the inference/interpretation follows the inference/interpretation statement (in bold type).

Student-directed learning was perceived to foster independence, and to provide opportunities to think creatively and to learn from mistakes.

Students recognized that when doing MyScience they had choice in their area of investigation: “we had different groups with different ideas, and we could choose
what we were doing” (Amelia), and that this was due to differences in the role of the teacher:

In the normal science we don’t get to choose what to do, the teachers just give it, the things to us and we just have to follow the instructions and we do it as a whole class instead of in different groups (Amanda).

Amanda continued “… and I don’t think it’s [normal science] as creative because you don’t make it up yourselves and the teachers help you a lot instead of you doing it by yourself”. Normal science was viewed as being teacher directed: “the teacher just told us everything and we just had to write it down” and that this was “not really learning as such” (Amanda). When asked what it meant to be doing MyScience Anne stated:

I think … you show you’re creative because there’s no set question that we’re given. You just get to do whatever you want and whatever you’re interested in, and whatever knowledge you had and whatever you’re going to gain, you can use that to do something creative (Anne).

Chad valued having choice when doing MyScience and, like Anne and Amanda, had a negative view of too much teacher direction or involvement:

In MyScience it’s more hands on. You get to do the work for yourself and see what happens, and experimenting with things, rather than just knowing, getting the information from a textbook or a teacher. … It makes you feel like you are doing an experiment on your own. You are not getting other people just giving you other information.

When asked about learning and the amount of scaffolding in the classroom, Amanda identified the importance of making errors to be able to learn more effectively:

Interviewer: So do you think you learn better if you kind of have to bumble your way through it a bit, and you’re not told all the steps?
Amanda: Yes, because you can learn from your mistakes.

When asked what science entails, Amanda linked creativity, investigating scientifically (‘test stuff’), repetition (‘do it again’) and making mistakes:
Interviewer: Do you think there’s another part of science apart from just knowing information?
Amanda: Yeah. Creativity. You have to try and test stuff out and do mistakes and just do it again and [do] creative stuff about stuff…
Interviewer: So you think that’s all part of science too?
Amanda: Yeah.

This adds weight to Amanda’s previous comment that passively writing down what the teacher tells you is ‘not really learning [science] as such’.

Several School C students also mentioned the value of making mistakes and that this enhanced their learning. Callum commented: “in some other stuff [subjects], mistakes … sort of distorts [sic] the whole thing. But in MyScience … it just adds to the information”. Connor had a similar view stating: “sometimes you find that your theory and your statements are correct … you get [them] right and you get happy. And if you don’t get it right, you learn something new”. Here, the notion of a theory underpinning his scientific ideas indicates Connor’s awareness of this aspect of the NOS –similar to the earlier comment by Anne in #1(a).

When asked how MyScience had changed for him (over time) Bill identified that having choice about the investigation resulted in ‘good’ experiments and that this was a significant factor in gaining experience and enjoying science more: “We’ve gotten more experience, and we enjoy science more, because we actually get to do good experiments, and we get a lot of choice in it”. He also commented that MyScience prompted him to think and encouraged student choice because of the wide range of possible scientific investigations. Interestingly the notion of student choice was linked to a baby selecting what they want to eat:

Because they give you one topic [the class theme], they don’t make you, they don’t tell you to do one exact thing, so it makes you think of what you want to do, rather than the teacher… It’s kind of like [when] a baby gets a choice of what food they eat, because then they get to pick what they like to do, what they like to eat … rather than someone just giving them the same food all day (Bill, emphasis added).

Perhaps there is a link here (in Bill’s mind) between optimal physical health (choice of food rather then ‘the same food all day’) and optimal mental/educational health.
(student choice versus being told to ‘do one exact thing’). Another School B student–Blake– linked his growing affection towards science with being able to choose experiments: “… it's fun, because I'm learning a lot of stuff and it's good. We get to choose our own experiments”.

These comments from Amelia, Amanda, Anne, Bill, Blake, Chad, Callum and Connor come as a consequence of their participation in MyScience and identify their learning in science as being linked with: student choice (‘we could choose’, ‘do whatever you want’, ‘whatever you are interested in’, ‘do the work for yourself’, ‘in normal science we just have to follow the instructions (emphasis added)’); independence (‘[in normal science] we do it as a whole class instead of in different groups’, ‘doing an experiment on your own’); and thinking creatively (‘you show you’re creative because there’s no set question’, ‘make it up yourselves’). These students prefer to choose and conduct their own choice of scientific investigation and in doing so they feel more creative (NOS #5), and that they are learning science more effectively due to the associated ownership and autonomy. This corroborates research findings by Hanrahan (1998), Logan and Skamp (2008), Olivera (2009), Osborne et al. (2003), and Tytler and Osborne (2012), all of who have reported the significance of students’ autonomy for science engagement and learning.

**Aspect (f): MyScience was more stimulating and complicated than normal school work and this enabled learning**

One inference/interpretation supports this aspect (see ‘evidence’ shown in Table 6.2). It is that, ‘Students perceived that they had to think more when doing MyScience and that they were able to achieve what was perceived to be ‘impossible’. The evidence supporting the inference/interpretation follows the inference/interpretation statement (in bold type).

**Students perceived that they had to think more when doing MyScience and that they were able to achieve what was perceived to be ‘impossible’**.

When comparing MyScience with normal school science Alan stated: “MyScience sort of stimulates your brain to do more … you are encouraged to do more, but [there are] exciting experiments, so you want to do more”. Alex commented that he found school work to be “pretty easy, but [in] MyScience, I learned a lot more stuff that I
didn’t really understand. So the work I learned there was more complicated than school work, so yeah, I enjoyed it more”. It could be argued that the higher cognitive demand (‘more complicated’) of *MyScience* contributes to students’ engagement (‘exciting experiments’, ‘enjoyed it more’) and learning (‘stimulates your brain’, ‘learned a lot more stuff’). The notion of *MyScience* going or extending “beyond what normal classroom stuff goes into” was independently raised by several teachers in Chapter 5, but particularly Angela in Assertion #1(a) who observed her students using higher order thinking skills. The development in students of ‘higher order cognitive skills’ has been argued to be a “major driving force” required for the reform of science education (Zoller & Nahum, 2012, p.209).

Brett was in a group known as the ‘NASA boys’ because their investigation was to do with rockets. The following anecdote demonstrates the heights to which students were able to rise through their *MyScience* participation, and that they achieved what they thought was impossible:

Interviewer: Overall, what do you think you learned by being in *MyScience*, by doing *MyScience*?
Brett: I learned more things, I learned stuff that I thought were [sic] like impossible.
Interviewer: So, what do you mean?
Brett: Like, I thought we would never be able to make the rocket.

Several students referred to *MyScience* participation as causing them to have to think more than when they were doing normal science activities. Bella commented: “[In MyScience] you have to kind of think of things out of the box”. This comment could be linked with the notion of creativity (as in the previous aspect #1(e)). Bill and Ben (not the flowerpot men!) concurred with Bella as follows: “If we are doing a science experiment in the classroom, we get instructions on what to do. But if we do *MyScience*, we have to think of the instructions, we can’t just read them” (Bill); “Because they give you one topic [the class theme], they don’t make you, they don’t tell you to do one exact thing, so it makes you think of what you want to do …” (Ben). It appears that these students perceived that, through *MyScience*, they were stimulated, that they wanted to do more, that they achieved what they thought was impossible, that they had to think more, that they had to think laterally, that they were challenged and yet they also
experienced enjoyment – all of which indicate a high level of engagement while learning.

**In summary,** Assertion #1 states that students perceived that through *MyScience* participation they increased their knowledge of scientific methods, phenomena and principles. They also showed awareness of some of the more intangible (for primary students) aspects of the nature of science such as its tentativeness, that new science knowledge is developmental, that science is a human undertaking, and that findings may be used to solve real life issues. These perceptions and students’ interactions with mentors, teachers and their peers indicate a growing awareness of ‘science as a human endeavour’.

Students reported that collaborative, active (minds-on) involvement in hands-on investigations in *MyScience* deepened their understanding, engagement and interest in science and enabled them to link their learning about how things work to the use of scientific methods. Concurrently, students attributed ‘having fun’ as a key factor that enabled their learning.

Many comments were made by students from all three schools about the benefits of collaboration with peers including that it was seen as a way: to reduce workload; to learn about others’ strengths; to access a wide variety of ideas; to improve social skills and to make friends. Observing and participating in a variety of concurrently occurring activities was also perceived by students to contribute to their sense of belonging to their CoP.

School B students appeared to make more comments about collaboration than students from the other two schools, which may be influenced by the long-term involvement of company ABC, and the attendant sense of belonging to the *MyScience* community of practice as an integral part of School B’s curriculum.

Students linked their learning in *MyScience* with choice and creativity as a consequence of being allowed to follow their own interests. Furthermore, this was perceived to foster independence and to provide an opportunity to learn from any mistakes. When comparing normal school science with *MyScience*, students perceived that the latter was more stimulating, complex and enjoyable, that it caused them to think more, and that
these attributes enabled their learning in science. *MyScience* was considered by students to be a highly engaging learning environment.

Through *MyScience* participation students developed their NOS understandings related to: science being inquiry based (NOS#1), tentative (NOS#2), developmental (NOS#3), creative (NOS#5) and collaborative (NOS#6). They also described interactions and activities consistent with CoP attributes related to the domain of investigating scientifically (CoP#1), interactions with other (CoP#2), and inherent CoP practices (CoP#3). Referring to the research question it is clear that students’ perceptions of their involvement as a member of a *MyScience* community of science practice have profoundly changed their views of what it means to be doing science. Students now perceive that particular factors enable their learning in science and include: science is a collaborative human endeavour involving interactions with others (peers, teacher and mentor); science uses methods to understand how things work; and learning in and about science through *MyScience* is an enjoyable, interesting, exciting and creative adventure. With these positive associations and attitudes in place, these students are more likely to retain a “positive commitment towards science that is enduring” (Osborne et al., 2003, p. 1072).

6.2.2.2 **Assertion #2 [#2]: Students’ perceptions of participants’ roles, including their own, were consistent with a community of practice interpretive framework and provide further insights into students’ views about the nature of science, and learning and teaching science.**

In the following, students’ perceptions of stakeholders’ roles and interactions provide insights into (and are evidence of) the organization and functioning of *MyScience* communities of science practice and, at times, provide information about students’ views of science, science learning and science teaching. Aspect (a) details students’ views of their own role and that of their peers; Aspect (b) relates to students’ views of the role of mentors; Aspect (c) describes students’ perceptions of the role of their teachers; and Aspect (d) presents students’ views of the Principal and parents. Each of these aspects provides evidence for Assertion #2. See Section 3.5.1 for the relationship between ‘evidence’, ‘aspects’, and ‘assertions’.


Aspect (a): Students’ views of students

There are three parts to this aspect (see ‘evidence’ shown in Table 6.2), which are presented in the following section. They are that firstly, students perceived that their role in MyScience included learning while conducting investigations. Secondly, students perceived that their role was to collaborate with their peers. Finally, students perceived that part of their role in MyScience was to take responsibility for planning, implementing, recording and reporting their investigation. The evidence supporting each part follows the initial statement, which is in bold italics.

Students perceived that their role when doing MyScience included learning while conducting scientific investigations.

Alex and Ava, when asked how they viewed their role in MyScience (Question 8, Table 3.4), described that it was: “to learn new things, to experience new things, and to experiment … to try out stuff that we’ve never actually done at school before” (Alex), and “to learn as much as we can and conduct the experiment well and get good results” (Ava). Carla agreed with this view of the student’s role but thought that any learning should include interpretation and application of knowledge to new contexts which aligns with NOS#3, that science is developmental:

I think the student’s role is to interpret what they’ve learnt and try and expand it and learn more about it. Say you’re doing smell or something like that. … you take it in and then you expand on it and you can learn whether children can smell better than adults, which is what one of the groups did.

Collaboration with their peers was specifically identified as a role for students when doing MyScience by April:

[The student’s role is] to work with [their] partner and to also think more deeply about things before [they do their] experiment. So think, plan it thoroughly, and then do [their] experiment instead of just going straight into it and working out that there’s a lot of problems.

and Amanda: “you have to work together as a team and we have to talk together and discuss stuff”. The notion of collaboratively solving problems by working as part of a team differs from the earlier more egocentric activities detailed in Aspect #1(c) – reduced workload, awareness of others’ strengths, access to a wider variety of ideas, improved
social skills, way to make friends— and indicates a mature view of what it means to be ‘collaboratively engaged in activities and discussion related to the domain’ (Wenger-Trayner, 2013) (CoP#2). The notion of planning what to do to prevent or circumvent potential issues (‘think, plan it thoroughly…’) indicates a growing awareness of NOS#1.

Anne recognized that her preferred working style was as a group member: “I feel more comfortable to work [sic] with somebody and I’m more a person who’s not that independent. Other people could be independent but I know I’m better at group working [sic]”. Through MyScience participation, Adam changed his views about working with others: “… before I was actually quite a, kind of solo kind of person. I always did projects and stuff by myself…” and he seemed to attribute this to group tension: “I liked working [with] people, but sometimes we had different ideas so we contradicted a lot”. He found that with MyScience there was more of a team effort, possibly due to the expectation (within the program) that students work in groups where they are also responsible for their decisions:

This time was really different. We actually worked together to bring the equipment to school. My friend Arnie brang [sic] a pump and he also climbed the ladder to attach the bottles. I brang two of the bottles and my [other] friend … brang a bottle. Although he didn’t bring as much he still helped a lot (Adam).

Blake described MyScience as having turned (his) science (experience) “upside down and made it fun”, and attributed this to working with others to combine ideas to “make something big” and inspiring others through sharing his findings: “A kid came up to me and said, ‘Your rocket was so good, I’m making it at home’

Ben thought that students had more than one role. He described how his role changed depending on what was happening so that if he were doing the experiment his role was to find results and if not then his role was to help others with their own data collection (also see Assertion #1(d)).

Becky, Bill and Brett commented that their role was to do the investigation to the best of their ability and to have fun, while Bella, Brad, Connor, Blake and Cid focused on the collaborative nature of their groups’ decision-making processes so that everyone’s ideas were considered. These latter five students’ comments are presented below and provide valuable insights into the sophisticated approach with which these primary
school students participated as inclusive functioning members of their community of science practice making the effort to consider other group member’s views.

[My role is] to work with my group and give them ideas and say which is better [for instance] — ‘Hey if you do this then maybe it would be better’ (Bella).

We made the decisions as a team. We tested the different [ideas] … if half of us said ‘We have to do this’ and the others said … [then] we tested and we looked at which one worked the best (Brad).

[Working in a group] was quite fun and we could see each other’s views of stuff, … One of my teammates said oil could dissolve [substances such as salt] … I said it wouldn’t dissolve, and the other one of our teammates said if it’s heated it will dissolve. And we found out that it didn’t dissolve… (Connor)

Our job is to work with each other, because some groups, they were a group and then they split apart. So our job is to keep together, listen to everyone’s ideas, [and] don’t have put-downs (Blake).

Bob, he didn’t want to listen to our stuff and then we told him about this other thing that we want, and then he just got back up and [said] ‘Okay, we’ll do that.’ So … because his head was thinking, ‘I don’t want to do this idea,’ but then when we mixed his [idea] with ours he went, ‘That should work’ (Blake).

If someone wanted to experiment how a caterpillar grows into a butterfly … and then someone else wanted to experiment how long a person’s lifespan is, they could [both] experiment how long a caterpillar’s lifespan is… (Cid).

Students perceived that part of their role in MyScience was to take responsibility for planning, implementing, recording and reporting their investigation.

Responding to the question about the students’ role, Amelia and Anne described that it was their responsibility “to be organised and make sure … that everything is going on as planned” (Amelia), “to get the equipment … write the whole procedure out … actually carry out the experiment, record the results, measure exact soil, exact water, get the shallots, get everything basically…” (Anne). Amelia’s comment indicates that there is a plan underpinning her investigation (‘be organized…’), while Anne demonstrates a deep understanding of fair testing and therefore of NOS#1 (‘exact soil, exact water’, ‘carry out … record the results’). Amanda answered the same question
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(‘What do you think the role of the students is in MyScience?’) by including the notion of student choice (‘personal interest’) that featured so prominently in Assertion #1(e) and therefore emphasizing its value and significance in students’ perceptions: “[the student’s role is] to make up a topic or an experiment according to the [sic] personal interest and to test it out and to see what happens”. Bella also commented on the responsibility that she felt as part of her role in MyScience reflecting the expectation that students are held accountable for their decisions: “Well you have to have the responsibility of managing the whole experiment –like this year taking the plants out and in again”. Several teachers (Angela, Bridget, Bettina, Chris in Chapter 5) independently commented on the development of students’ ability to ‘follow their own curiosity’, to ‘work together to take their measurements’, and to ‘direct their own learning’. These findings reflect those of Rogoff (2004) whose research on students participating in schools based on a ‘community-of-learners model’ also found that students developed a strong sense of responsibility for their actions: “In communities of learners, students appear to learn how to coordinate with, support, and lead others, to become responsible and organized in their management of their own learning” (2004, p. 225).

In summary, these examples show that students recognized and were able to articulate their own and other students’ roles in MyScience which were generally concerned with the collaborative process of investigating scientifically (‘actually carry out the experiment’) and more specifically involved working with others to: consider everyone’s ideas (‘we tested and we looked at which one worked best’, ‘listen to everyone’s ideas …’, ‘we mixed his idea with ours’, ‘made the decisions as a team’, ‘see each other’s views of stuff’); plan (‘think more deeply…’); discuss (‘talk together…’); source equipment in a timely manner (‘we actually worked together to bring the equipment to school…’); carefully measure controlled variables (‘exact soil, exact water…’); take responsibility (‘managing the whole experiment’); and to record results and report findings. The selected quotes provide evidence of CoP#1: Domain – Acknowledged shared interest area in which members collectively learn from each other, CoP#2: Community –members who are collaboratively engaged in activities and discussion related to the domain, and CoP#3: Practice –what members ‘do’ when they interact, as well as NOS#1: science is inquiry based (see Table 3.8). These attributes are key elements of what it means to do MyScience and arise from implementation of the
MyScience educational model (see Chapter 2). Students’ perceptions of their MyScience involvement appear to confirm that the intended and actual outcomes have been realized—that students view themselves as contributing and valued members of the collaborative enterprise of MyScience.

Aspect (b): Students’ views of mentors

There are three parts to this aspect (see ‘evidence’ shown in table 6.2), which are presented in the following section. They are that firstly, students appreciated the involvement of real scientists as mentors. Secondly, students had high regard for mentors’ scientific knowledge and advice. Finally, students recognized mentors’ ability to link ‘in-school’ to ‘out-of-school’ science. The evidence supporting each part follows the initial statement, which is in bold italics.

Students appreciated the involvement of real scientists as mentors.

Students at School A were fully aware of and appreciated that they had a number of professional scientists as mentors as shown by the following comments from Alan, Amelia and Anne. Note the interesting observation by Amelia that she sees these mentors as belonging to their own community of science practice and that this is valued: “they were real scientists which know their stuff … they understand the procedure and scientific process” (Alan), “they actually, they belong to somewhere, and they can teach you about what they do, and you know they are mentors, they are real scientists…” (Amelia), “I think we feel kind of proud to be with a real scientist” (Anne). Bella (from School B, who had professional engineers as mentors) concurred, commenting: “When you’re having a mentor it’s very exciting because you know that someone professional is helping you along the way”.

Students had high regard for mentors’ scientific knowledge and advice.

Mentors were recognized (by students) for providing scientific procedural advice underpinned by a comprehensive foundation of science content knowledge as shown in the following examples: “[our mentor] told us that, because we used a little cup to measure it [salt crystals], he said that, we need to measure it in mass, not volume” (Ava). This anecdote related to two different samples of salt being brought in by different group members. Both were sodium chloride crystals but one sample had larger crystals.
than the other meaning that the same volume of salt from each source would actually result in different masses being used, and thus introduce an additional variable.

April described procedural advice provided by her mentor (Spencer) as follows:

Interviewer: What do the mentors do?
April: Well, they guided us. He [Spencer] helped us with our experiment because what happened was during the time we occurred [sic] a problem and he explained to us why that would have happened.
Interviewer: Okay. So what was that?
April: Our ice had got a big lump on it towards the outside, so that when we were sliding along the ice that would change the experiment because there’s a lump. So we had to just avoid that lump and work on flat space. But he said it was … probably because we [froze] it for a long time so it start[ed] to harden on the outside and expand …

Here, Spencer provided science information (about the ice expanding as it froze) as well strategic –and creative– advice about how to solve the problem of having a lump of ice on the tray as objects were slid over the surface. April realized that the uneven surface introduced an unplanned variable and in discussion with Spencer her group was able to solve the issue without having to refreeze the whole ice slab, and also came to understand the reason for the lopsided freezing.

Alex recounted a similar scenario where his mentor provided advice about how to report the group’s findings of an investigation into ‘balloon rockets on a string’, but that he also “knew a lot about friction and those [sic] stuff, and those terms and he taught us a lot about things”:

He gave us a bit of information about our conclusion, and how the things actually work … He told us how we can change some stuff in our experimenting process. Our [investigation] was mostly about friction and air pressure, so … he said we could put oil onto the straw so there was less friction (Alex).

Similarly, Cid commented that when they were doing a trial of an experiment investigating how much water different materials absorbed their mentor suggested another approach to gain more accurate measurements: “[instead of] measuring the water we should measure the materials and subtract that. She suggested the different way to do it so we changed the procedure”.
Mentors who were professional scientists were regarded as science experts whose science advice was perceived to be more accurate and believable than that of their teachers. Adam commented that “the mentors specialised in science, so they’ll have more knowledge … but the teachers can only provide you with a certain amount of knowledge”, adding that:

They’re real scientists, they help you with things that you might not know [so] rather than jumping onto a computer for hours, you have active information…. And the mentors know what to tell you … [and] know what not to [tell you]… (Adam).

Alex’s perspective was that: “a teacher isn’t really that scientific. The mentors give more scientific ideas and tips, and that stuff”, while Amanda commented “I think that the mentors do have more science knowledge but I still listen to the teacher”. Anne thought that “the tips that the mentor gives you are more to do with science, and the tips that [my teacher] would give us were more about how to not get it wrong”. These mentors seem to be regarded as science experts because they work in a scientific field (‘specialized in science so they’ll have more knowledge’, ‘real scientists’) but the teacher still played a significant role which will be discussed in more detail in the next section. These students’ views provide triangulated data for teacher Cathy’s comments in Chapter 5 (Section 5.2.1.2, Assertion #2(b)) where she perceived that students disregarded her science expertise.

Overall, School B students (who had engineers as mentors) and School C students (who had secondary school science teachers and students as mentors) appeared to present fewer comments on the comparative merits of the scientific advice provided by their mentors and teachers than School A students who had astronomers as their mentors. Becky thought that her teacher would be able to help her but that it would take too long:

She [classroom teacher] probably would be able to help us [in a similar way to the mentors] but it would take much longer because there are so many groups. So she would have to go around all the groups, discuss things with them, and if a couple of groups still don’t understand it would take much longer (Becky).

Cid also raised this point indicating that he “understood more from the mentor” because “in class [time], because it’s for the whole class, they [the teacher] might not have time to explain everything”.

CoP#2
Here, mentors seem to be viewed as an extra pair of hands—or ears—providing attention and advice, which would otherwise be lacking. This correlates with teachers’ views of the role of mentors as presented in Chapter 5, Section 5.2.1.2, Assertion #2(c) & (d).

Many students recognized and appreciated—as did the teachers—that their mentors had high levels of science expertise: “they know a lot more about science than we do, and how to, they help a lot with how to set up your experiment, and how to help it work” (Ben), but students still felt that they retained ownership of their ideas with the mentors making suggestions for improvements: “we had an idea, and then the mentor made it better” (Bill); “we couldn’t figure out what to do, then he just taught us, and do [sic] hints, then we figured it out” (Brad). Connor made an insightful comment when he described how his mentor “really helped us, saying that we shouldn’t find the experiment first, we should find the question first”. This was in response to his group having “a list of experiments” that they were interested in doing—a common approach in primary school science classrooms. Connor’s mentor effectively steered the group towards the notion of having a question to investigate, rather than a recipe to follow, clearly involving these students in scientific discussions and ideas that were remembered and recalled during the interview.

Other examples of the ways in which mentors helped students are as follows: Mentors provided advice about formulating a question: “… they told us how to [form] a question. He gave us examples about it, of the question, like how far does the rocket go?” (Bob); mentors helped to combine different ideas “and put it [sic] all in one [question]” (Callum); and mentors provided direction about what to measure, how to measure and the need to record data—“they taught us how to measure it, and that we had to write down in our book” (Brad), and, “well this year our mentor she brought us the beans and what to do every week, [how] to measure it and write it down in a little book” (Bella). Bella also described how her mentor provided advice about experimental design suggesting the addition of an innovative element—cotton wool instead of soil:

   We thought that we should just put soil but she said that if we put cotton wool it would be something else … Everyone knows that you [are] supposed to put plants in soil but if you did cotton wool it would be more exciting.

This comment hints at a sense of camaraderie between the students and their mentor where they appear to be creating an experiment that will stand apart from others in the
class and that may also yield unexpected results. It also infers that science is developmental –NOS#3– (‘everyone knows that…’) and that the unknown answer to the question may be approached using scientific methods.

Chad described how his mentor “helped us [by] knowing what to do next … guiding us through the first processes, just knowing how to make the fair testing, and helping us with that”. He also commented that “this year we didn’t really know how to test the [sic] corrosion” and described a number of ideas that were discussed with their mentor including:

... just to do it with observation, but we couldn’t even do that, so he said to do it, like a rating ... We were going to [weigh the materials] but ... when we first tried ... with steel wool ... we couldn’t really weigh it, because it was light (Chad).

Another School C student –Carmen– also described the following interesting anecdote:

We had lots of cups with the same amount of different liquids like juice, water, white vinegar and then we put a cheeseo in each one at the same time –we got our friends to help– and then we counted. We timed 45 minutes and at the end of that we used a syringe to see how much water was left and then we had to minus it from the original amount. And it was interesting but it took a while for us to do. We had a few attempts that didn’t work out, because we didn’t do enough time, and there wasn’t enough, a significant change of levels of water.

Here we have evidence that Chad and Carmen have been participating in collaborative scientific discussions related to the optimal approach for measuring changes in their dependent variable (amount of corrosion, amount of water remaining in the cup) within the constraints of primary school settings where it is rare to have sensitive measuring instruments (‘we couldn’t really weigh it, because it was light’, ‘there wasn’t … a significant change …’). This ongoing dilemma is a key aspect of the nature of science – what measurements to make and how to make them, with solutions often requiring a significant amount of creativity. The notion of perseverance is apparent in Carmen’s description (‘it took a while for us to do’, ‘we had a few attempts’) – an attribute that (teacher) Cathy wished for her students to exhibit (Chapter 5, Section 5.2.1.2, Assertion #2(a)).
Bella commented that one of the reasons that mentors came to the school “was because they wanted to show us what science is really about and because they’re kind of professionals at it. They helped us along the way”. This comment reflects Bella’s recognition of science being a human endeavour, that mentors are acting as border crossers between the worlds of ‘in-school’ and ‘out-of-school’ science (‘show us what science is really ‘about’) – see next section, and that mentors were positively motivated to provide support (‘they wanted to …’) – an important attribute for developing a sense of belonging to a community of science practice.

**Students recognized mentors’ ability to link ‘in-school’ to ‘out-of-school’ science.**

Students described mentors as being able to answer just about anything that was asked of them: “when we asked him any sort of question, he could kind of reply and answer our question really well” (Alex). Mentors provided initial motivation: “[they] gave you ideas and they gave you a kick-start” (Andrew), and they also acted as border crossers (Aikenhead, 1996) between students’ science experiments ‘in-school’ and ‘out-of-school’ examples, thereby assisting students to see how ‘school science’ relates to ‘scientific processes’ in the ‘real world’ (Murphy et al., 2011):

We had this idea where we could get objects and drop them from the same height into the sand, and see the dent that would be made. And then Scott told us that it was kind of similar to the meteors bashing into the moon, that they had to measure the dents and the size … (Ava).

Here, border crossing by the mentors has been described in two ways by students (which is similar to the multiple definitions in Chapter 4, Section 4.2): for Bella, the mentors’ presence in school provides a link between the world of ‘what science is really about’ and school, and for Ava the link is metaphorical (sand dents and moon dents).

Students reported finding out about the nature of the work that scientists do: “we got to know more about careers in science” (April); “we had some time to talk about his job, and he told us about how he looked at stars, and … he went to Chile once, and he got paid a lot just to look at stars” (Amelia) – a comment also made independently by her teacher, Angela (Chapter 5, Section 5.2.2.2, Assertion #2, Aspect (d)). This is evidence that students perceived that they were exposed to aspects of science as a human endeavour through sustained face to face interactions with their mentors – as was hoped for by mentors (see Chapter 4, Section 4.2.2.1, Assertions #1(a), #1(c)).
**In summary,** these examples show that primary students recognised and valued having professional scientists as mentors (‘actually belong to somewhere’, ‘proud’, ‘exciting’). Mentors appeared to provide School A students with what was considered to be more credible and wide ranging scientific expertise and guidance than that from their class teacher (‘mentors give more scientific ideas and tips’), and although all students valued mentors’ expertise and advice they retained ownership of their investigation. Mentors were perceived by students to provide a human face to the world of science (‘they wanted to show us what science is really about’) while also making explicit links between ‘in school’ and ‘out of school’ science (‘similar to the meteors bashing into the moon … measure the dents and size’). Students recognized that mentors engaged them in scientific discussion around creative ways to solve arising issues (‘just had to avoid that lump’, ‘put oil onto the straw’, ‘we should find a question first’, ‘we couldn’t really weigh it’) and were an additional source of science information when normally the whole class only had the teacher to consult.

All of these factors indicate the positive impact of having scientists as mentors, and are similar to some of those found by Rennie in her evaluation of the *SiS* project notably: “bringing the practice of real world science to students … enabling scientists to act as mentors and role models for students, and inspiring and motivating … students in the teaching and learning of science” (2012, p. 79). Similarly, Howitt et al., also with reference to the *SiS* project, reported that students benefitted from interactions with scientists through “increased knowledge and understanding of real-world, contemporary science; opportunities to experience real science with real scientists; and an increased awareness of the type and variety of careers available in the sciences” (2009, p. 38).

Findings from this study provide evidence of CoP#2: Community – members who are collaboratively engaged in activities and discussion related to the domain, and CoP#3: Practice – what members ‘do’ when they interact. Support provided by mentors focused on NOS#1: Science is inquiry based, NOS#3: Science is developmental, NOS#5: Science is creative, and NOS#6: Science is collaborative.

**Aspect (c): Students’ views of teachers**

There are two parts to this aspect (see ‘evidence’ shown in table 6.2), which are presented in the following section. They are that firstly, students generally perceived that their teachers provided science procedural guidance and support (that was less scientific than
the mentors) and were focused on the safety and supervision of students. Secondly, at times, the teacher was viewed as a learner during mentor visits. The evidence supporting each part follows the initial statement, which is in **bold italics**.

**During MyScience, students generally perceived that their teachers provided science procedural guidance and support (that was less scientific than the mentors) and were focused on the safety and supervision of students.**

Students from all three schools expressed a range of views about the role of the teacher when doing *MyScience*, all of which were positive. Alex commented:

> ... she helped us. She helped us prepare, she helped us start, and she did lots of organizing for us. ... she helped us get equipment, and, for example, she helped us drill holes ... she did all of it. She also gave us a lot of opportunity, because she let us do some of the hard stuff, so she gave us lots of new experiences. And then she gave us a good start and she gave us many tips and discussions.

Here, the teacher’s role is viewed as being supportive (through helping with organization and equipment) but not overly directive since Alex perceived that he was given “opportunities” and “new experiences” and allowed to “do some of the hard stuff”.

Clint had a similar view to that of Alex, commenting that “the role of the classroom teacher is just to supervise and encourage and sort of help” adding that they were not told what to do: “We had to figure it out. And she was like, ‘Maybe you could do this or maybe you could do that’. She gave us options and we, as a group, decided which one to do”. This is evidence of students recognizing the facilitative role of the teacher and students making learning decisions.

Amelia recalled “having reminders [put] up for us to remember to take our equipment to school” and that the teacher was “keeping an eye on everyone and making sure they weren’t doing anything silly”. Bill remembered his teacher “keeping us encouraged, and also telling, also helping us, a bit like the mentors do, also helping us, and saying, ‘Oh this is good, you can add this’...” while Brad, Blake and Callum commented that their teacher helped students to source equipment.

Cameron thought that his teacher was the source of information for strategies to approach their investigation and noted the usefulness of the teacher-generated posters around the room (see Chapter 5, Figure 5.1):
She’s the one who tells us what we should do it \( [sic] \), how we should do it, all [the] strategies
of doing it. She has all the posters on the boards, of how we are going to prove the
hypotheses and all that \( [sic] \) solutions (Cameron).

Another School C student –Connor– commented that the teacher’s role was “to guide us
on the way if our mentor isn’t here” indicating that in the absence of mentors, the
community of science practice was able to continue. This outcome was hoped for by
participating mentors (Chapter 4, Assertion #2(b)) and highlights the critical role of the
teacher in the CoP.

Becky remarked that the role of her teacher was to act as a border crosser, introducing
“the mentors to our groups”. This correlates with –mentors– Sasha and Elana’s
perceptions of the role of the teacher where mentors are the newcomers and the teacher
and students are oldtimers in the MyScience community of practice (see Chapter 4,
Section 4.2.2.2, Assertion #2(b)).

April was the only School A student who directly commented that her teacher and the
mentors had similar roles:

April: I think she was just guiding us, like the mentors too, and helping us with our
experiments and helping us get around problems that occurred.
Interviewer: So can you, so when she was guiding you, you said like the mentors.
April: Yeah.
Interviewer: Did she give you the same sort of guidance or was it different?
April: Pretty much the same I think but because she had the same answer as our mentor did
for our problem about the expanding ice.

April’s view may be due to the correlation between her teacher and mentor presenting her
with similar explanations for why the ice tray had a large lump in it (an example
described in the previous section: Assertion #2(b) –students’ views of the role of the
mentors). Subsequently, April qualified her view about the amount of science knowledge
that she attributed to her teacher and mentors: “The mentors probably go into more of a
science, more technical [explanation] –they’re sure of what they know. The teachers do
too but the mentors, probably they knew more because they’ve worked in a science field”.
The comment “they’re sure of what they know” and attributing this to working “in a
science field” as reasons for the mentors providing more scientific advice was also
alluded to by both Alan and Anne. When asked about the role of his teacher in MyScience
Alan explained that it was “to organise groups and to further on [sic] our knowledge” and explained that a difference between the teacher and mentors was that the teacher “just suggest[s] ideas that might work … whereas a mentor sort of knows …” The attribution of ‘just’ and ‘might’ to the teacher and ‘knows’ to the mentor indicates that Alan has a higher regard for mentors’ scientific advice.

Anne had a similar view to Alan’s –that their teacher (Angela) had less science expertise than the mentors– but Anne accorded her teacher with ‘pot mastery’ because she was familiar with the teacher’s interest in “plants and stuff”:

Anne: [Our teacher] was the one who told us about the drainage pot because I think she’s into lots of plants and stuff.

Interviewer: Okay.

Anne: So she told us that and she’s giving us a bit, a few side tips.

Interviewer: Okay. So she kind of was a bit like a mentor then? … So what do you think about … the tips that she gives you compared to the tips that the mentors give you? How would you, are they different?

Anne: Well, I think the tips that the mentors give you are more to do with science and the tips that [our teacher] would give us were more about how not to get it wrong.

Anne referred to her teacher’s advice as “side tips” that are concerned with “how not to get it [the procedure] wrong” and contrasted this with the mentor’s advice, which was described as being “more to do with science”. Adam also commented on the notion of the teacher preventing something going ‘wrong’:

Interviewer: When it’s actually happening, MyScience, what do you see the classroom teacher as doing? They’re going around and giving you some ideas?

Adam: Yeah. She walks around and tells us what might go a bit wrong –if we’re changing more than one factor so…

Interviewer: Okay, so she’d help you with making it a fair test?

Adam: Yep.

Here it is clear that the advice being given by the teacher relates to the nature of science (‘changing more than one factor’) and that this aspect of the NOS has been recognized by Adam.
Candy described an example of her teacher being a great help and that “she also knew … a fair bit about chemistry”. She explained that:

Before we started MyScience, we started doing some science … a very basic science experiment. And it was testing which iceblock would melt quicker but in different things. So we wrapped [the iceblock] up in bubble wrap and foil and then afterwards we found out that bubble wrap kept it frozen for longer. And then she [the teacher] started explaining to us that foil … because the heat reflects on it, and then sometime later, it’ll just start seeping into the foil. So she helped us (Candy).

The key point reflected in this anecdote is that the teacher was perceived to have ‘chemistry knowledge’ and that because of this knowledge ‘she helped us’. The correctness of the explanation (‘because the heat reflects on it, and then sometime later, it’ll just start seeping into the foil…’) is questionable but this is a second hand version of what was said by the teacher. It is possible that Candy was given incorrect information about foil being a ‘heat reflector’ and that the iceblock was ‘seeping into the foil’ rather than the foil being a heat conductor and the iceblock melting in which case her view of the teacher as being helpful may not be warranted.

As described in the previous assertion (#2(b)), School B students identified that their mentors had high levels of science expertise: “they know a lot more about science than we do” (Ben) but they did not compare this with their teachers’ level of science expertise in the interviews for this study to the same extent that School A students seemed to do. Ben perceived that his teacher monitored students’ behaviour and was an experimental procedure advisor: “[my teacher] always makes sure that we behave, makes sure that the experiments, that we are doing the experiments right, and if we are doing something wrong then she’ll correct us, so we can get it right”. Bella shed some light on why behaviour management was needed: “[our teacher] manages everyone because when the mentors come we get a little excited”.

These examples seem to indicate that students view their teacher in two main roles in MyScience: the first is related to the notion of being a safety and organizational supervisor (Alex, Amelia, Brad, Blake, Connor), and the second is related to being in an advisory role where the type of information and advice offered is not considered to be as scientific as that of the mentors (April, Alan, Anne and Adam) – even though it is clear that the teacher is offering science advice in the situation described by Adam (‘changing more
than one factor’). This may be because Adam (and others) perceives that their teacher lacks science expertise so their advice is not regarded as being ‘scientific’. It is also possible that students may view scientific procedural advice differently (possibly with lower status) from scientific information and explanations of phenomena – an area in which the mentors are likely to have a wider breadth of background knowledge compared to their teachers.

Other roles for teachers included: providing scientific advice that was valued (Candy); brokering mentor-student relationships (Becky); and supporting and continuing with CoP practices when mentors were absent (Connor). In all of these examples, there is evidence of students and teachers working together on the collaborative enterprise of investigating scientifically (NOS#1) with evidence of CoP#2: Community and CoP#3: Practice. Considerable research has found that student engagement in science lessons was strongly linked to their views of their teacher (Darby, 2005; Logan & Skamp, 2008; Tytler & Osborne, 2012). Students’ views of their teachers in this study are overwhelmingly positive, which augurs well for their development of positive attitudes towards school science.

At times, the teacher was viewed as a learner during mentor visits.

Amanda was asked about the role of the classroom teacher in MyScience and described the following scenario:

Interviewer: What about the classroom teacher: what do you think she does, or he, if you had a he?
Amanda: Well she sort of just goes around and ... with the mentors she just sort of went around and looked at the groups and how they were going and what they were talking about. And actually she learnt a lot too.
Interviewer: How do you know that?
Amanda: Because sometimes she’d just sort of join in the conversation [saying] ‘Oh, right. Oh, of course’.

Amanda’s observation is significant in several ways: Amanda was tuned in to what was going on around her, she recognized her teacher’s choice of words when she joined in the conversation as being indicative of learning something new, and she viewed her teacher as a co-learner This is evidence of CoP#1: Domain – acknowledged shared interest area in
which members collectively learn from each other. A community of science practice is operating in the classroom and participants are learning from each other through their participation.

Aspect (d): Students’ views of the Principal and parents

There are two parts to this aspect (see ‘evidence’ shown in table 6.2), which are presented in the following section. They are that firstly, students perceived that the Principal was a gatekeeper for allowing MyScience into the school and that s/he showed interest in their investigations. Secondly, parents were perceived as an important resource for sourcing equipment, discussing ideas at home and applauding students’ efforts. The evidence supporting each part follows the initial statement, which is in bold italics.

The role of the Principal included allowing MyScience into the school and showing interest in student investigations.

Six of the nine School A students had the perception that their school principal (Principal A) had nothing or little to do with the organization and implementation of MyScience. Adam and Ava described the principal’s role as a gatekeeper, deciding whether MyScience was suitable to allow into the school: “If the principal didn’t choose MyScience, we wouldn’t have as much fun and… we wouldn’t be doing [it] probably…” (Adam), and “[the principal] can see if it’s good or not for the kids to do” (Ava).

Four of the eight interviewed School B students thought that their principal (Principal B) did play a role with organizing and implementing MyScience. This quite different perspective (from School A students) may be due to the higher level of interest that the School B principal had for the program and that she frequently visited classrooms while students, teachers and mentors were working on their investigations —recorded through observations made by the researcher when in the field— and as shown by Blake and Brett’s comments: “We showed her our experiment. She said it was really good” (Blake), and “She came around, even she tried the rocket” (Brett).

Three of the ten interviewed School C students (Carla, Cassius and Cameron) described their principal’s (Principal C) role as being involved with organization and permission for classes to do MyScience: “he might organize what [sic] classes are doing it and what [sic] classes aren’t” (Carla); “without the principal’s approval of MyScience I think we wouldn’t be able to do all these experiments” (Cassius); and “I think he’s the one who
actually lets this school do the MyScience activity [sic]” (Cameron). One student –Chad– commented that the Principal “had a look at the experiments we did” and four students thought that the Principal’s role was to submit MyScience projects to the Science Teachers’ Association of NSW Young Scientist Awards (see Chapter 2, Section 2.6).

Students from all three schools appreciated any interest shown in their investigations by their principal, but this only appeared to have been a common occurrence at School B.

*The role of the parents included sourcing equipment, being a discussion sounding board at home, and applauding students’ efforts.*

At School A, some of the mentors were parents with a science background so students considered that the role of parents included being a mentor. The role of parents was mostly described as helping to source equipment needed for the investigations: “they helped me get the materials and stuff” (Amanda), but parents were also a discussion sounding board for students as explained by Amelia: “they kind of discussed it with me, they taught me, they asked me questions”, and Anne: “every time I would go home and tell my mum and … she used to give me a couple of tips about ‘You shouldn’t put too much water –just little ones [tips] that she would know’. Ava’s parents seemed to be more involved than most: “they helped me research a lot … they taught me how to wire the electrodes to work in the … energy drink and they taught me a lot of stuff about salinity …” Parents also had a role as an audience at the Science Fair. If they were unable to attend then in the case of highly interested parents such as Ava’s: “I’ve taken the poster home and shown them”.

Several School B students described instances where they had discussed ideas with their parents at home. Bill described how “… my dad especially helped me saying, ‘This might look better, or this could work.’ Because we were first using a fan, and then my dad told me you could use a hair dryer and make it more powerful”. Bella recounted: “When I tell them about what we did in MyScience they say, ‘Oh this is interesting, maybe you should also try this as well and maybe that would bring [sic] the experiment a little more interesting?’” Parental interest was also reflected in Brad’s comment: “I told [my parents] how at the Science Fair we had lots of people watching it, and my mum was proud of me”. So, even though his parents were unable to attend, Brad still felt validated –and valued– by his parents’ interest in what he was doing at school. Blake’s parents were particularly proud of his achievements. Previously, Blake had not been allowed to publish his work
online but his parents gave him permission to do so when he persuaded them that this was something he wanted to do:

I wasn’t allowed to have photos once and then I told them [my parents] about MyScience. [that it] is really good and I could be a good scientist if I’m good. So they let me have photos and they let me put it online, because me [sic] and Marco had our last year’s experiment online (Blake).

Blake’s group was awarded a certificate (from the Young Scientist Awards – see Chapter 2) for their efforts and he described how “My dad’s really proud of me because I’ve got a certificate last year for high achievement. So every time someone comes over he says, ‘Go get your certificate’”. This validation of students’ interest and achievements in science by parents has a significant effect on students’ later interests in science (Lyons, 2006), so these students are fortunate to have this type of support in their early years of schooling.

School C had been involved with MyScience since its inception in 2006 (one year longer than School B), and many students – as in School B – had had the opportunity to participate in their younger schooling years. School C students were expected to source any materials needed for their investigation from home. Perhaps this is the reason for several students (Clint, Chad, Carmen, Callum, Cameron, and Cassius) citing their parents’ role as an equipment source first and foremost. Clint, Chad, and Cassius commented that their parents were interested in what they were doing, while others went into more detail describing conversations that they had at home such as Carmen who was investigating stain removers:

Well, at first, it looked like the lemon juice was going to win … But when it dried, the bicarbonate of soda got rid of it faster. So I talked to my parents about it and they told me that after a while –I’m not sure exactly what they said but– after a while, lemon juice isn’t that … it’s not active anymore (Carmen).

and Connor, who indicated that other group members’ parents had been offering ideas as well:

I told my mum what we’re doing and then she said, ‘That’s quite interesting.’ We were doing oil and water and then she said, ‘Why don’t you add vinegar?’ And then my other friend, well, her father told her to try vinegar, as well. So we tried vinegar and the other person in our group said it was okay (Connor).
Overall, the parents’ guidance role was considered to be less significant than that of the mentors and teacher, and seemed to focus on advice related to science content knowledge and understandings rather than science processes (‘you shouldn’t put too much water’, ‘wire the electrodes’, ‘make it more powerful’, ‘try vinegar’) and is evidence of CoP#1: Acknowledged shared interest area in which members collectively learn from each other.

Parental interest was perceived to be important (‘my mum was proud of me’) as was the interest of the Principal and seemed to be more evident in the comments from School B and School C students. This may be because at the time of the interviews, Schools B and C had been running MyScience for three and four years respectively, while School A was in their first year, and so students’ comments about parents and the Principal could be reflecting a deeper sense of awareness of the roles of participants in the CoP due to the longer time frame of involvement. Similarly, the parents and Principal at Schools B and C would have been aware of and more involved with the CoP for a longer period of time and therefore more likely to have a vested interest in students’ activities. A contributing factor for students’ differing perceptions of the Principal’s role in each school may have been because Principal A was much less involved with, and made few, if any, classroom visits throughout the program (Personal communication to researcher from Angela and Amy, November 2010) compared with the School B Principal –as was noted in Chapter 5, Section 5.2.2.2, Assertion #2, Aspect (e). The physical absence of Principal A may have influenced School A students’ views of her role in MyScience, as it did for School A teachers.

In summary, the parents and principal were perceived to be part of their school’s MyScience community of practice to varying degrees, and is evidence of CoP#2: Members who are collaboratively engaged in activities and discussion related to the domain. Furthermore, parents provided advice and ideas in discussions at home that contributed to students’ science learning and understandings and are evidence of NOS#6: science is collaborative and CoP#1: acknowledged shared interest area in which members collectively learn from each other.

In summary, Assertion #2 states that, when they are doing MyScience, students clearly see themselves as part of a community of science practice. Key stakeholders (the CoP members) include themselves, their peers, their teacher, their mentors and minor stakeholders include the school principal and students’ parents. Each is viewed as having
different yet significant roles as they collaboratively engage in activities and discussion related to the domain of ‘investigating scientifically’

Students perceived that their role was to take responsibility for and to learn while conducting scientific investigations in collaboration with their peers. Mentors provided guidance and support that was generally perceived to be more scientific than that provided by teachers and they also provided real (by their presence), as well as contextualized examples of links between the worlds of ‘in-school’ and ‘out-of-school’ science. The teacher was perceived to provide a wide range of support to students, mostly around organizational issues and monitoring behaviour with a view to safety, and was viewed as a co-learner during mentor visits. Principals were viewed as a gatekeeper by students (allowing MyScience into the school) and their involvement was noticed more when they were visibly present and showing interest in students’ investigations in classrooms. Parents were viewed as equipment sources and as discussion sounding boards at home. Parental interest in MyScience was highly valued by students.

Through MyScience participation, students developed understandings about the NOS being inquiry based (NOS #1) and collaborative (NOS #6) and recognized that they were part of a community of science practice where stakeholders were collaboratively engaged in activities and discussion related to investigating scientifically (Cop #1, #2 and #3).

These findings, as well as those from Assertion #1, provide evidence of students’ perceptions of their involvement in MyScience and therefore answer the first part of the research question: ‘What are stakeholders’ (here, primary students in School A and School B) perceptions of their involvement in MyScience…’. The second part of the research question: ‘… and how does being in a ‘community of practice’ around ‘investigating scientifically’ influence their views about science, science learning and science teaching?’ has been partially answered through reported findings from Assertion #1 and is supplemented by the findings from Assertion #2.

6.2.2 Findings from the ‘20 word activity’

As described earlier –in Section 6.1.2: ‘The context for the primary student study’– to supplement and to gain deeper insights into interviewed students’ perceptions of their MyScience participation, all students in the School A Year 5/6 class (n=26) from which the interviewees were drawn, were invited to participate in an activity where they
recorded the first twenty words (in order) that they associated with their *MyScience* experience. This activity was only trialled with the one class to identify its ease of use as a supplementary source of information for the study. All words were entered into a spreadsheet and then analysed for the relationship between their mean rank and the frequency with which the word was cited. A graph showing the results of this relationship is presented in Figure 6.1.
Figure 6.1. Relationship between the mean rank and frequency of the first 20 words associated with MyScience from students (n=26) in a Year 5/6 class in School A.
It can be seen that the two higher frequency quadrants (those on the right) contain 45% of the total number of words cited but the total number of separate words numbers only twelve. This data represents a snapshot across the class (twenty-six students in total including the nine interviewed students), and provides insights into the nature of students’ views about MyScience which are presented below.

The five most common words –19% of the total– with the highest ranking (top right hand quadrant) are (in order): experiments/s, energy, scientific, educational and fun. The next seven most common words –26% of the total– have a slightly lower frequency and lower ranking than the previous set (bottom right hand quadrant) and are (in order): hypothesis, mentors, results, equipment, method, aim, conclusion. Both of these ‘sets’ of words are listed in Table 6.3.

| SET 1: SET 2: |
| HIGHER FREQUENCY, HIGHER FREQUENCY, |
| HIGHER RANK LOWER RANK |
| experiment/s hypothesis |
| energy mentors |
| scientific results |
| educational equipment |
| fun method |
| educational aim |
| fun conclusion |

Comparing the two sets of words: Set 1 words appear to have broader connotations referring to aspects of scientific process (experiments), concepts (energy) and affect (fun), while Set 2 words are mainly associated with scientific inquiry (hypothesis, results, equipment, method, aim, conclusion) and the importance of mentors. As a data set, this information provides summary information of these students’ views of MyScience that correlate with findings from students one on one face-to-face interviews. The data were quick and easy to obtain, process and analyse, suggesting that this approach may be a feasible solution for obtaining information about (other) participants’ views of their MyScience experiences.
6.3 Concluding remarks and pedagogical implications

Western secondary students’ disenchantment with school science is well documented (cf. Fensham, 2008; Goodrum et al., 2001; Lyons, 2006; Tytler, 2007;), but when primary students’ perspectives –the students’ voice– of their transition into the secondary years were investigated using, in part, qualitative interviews (as in this study) it was found that students’ interest in science was maintained (Logan & Skamp, 2008, p.502). These researchers also identified the need for research into students’ views of effective teaching to further identify factors affecting students’ interest. It would appear therefore, that researching students’ perceptions of their school science experiences has value for not only the potential to retain student interest in science, but to also garner useful information with which to remediate school science experiences to be more appealing, engaging and of interest to students.

This study centred on four aspects of students’ perceptions: their involvement in MyScience, and how this involvement influenced their views about science, science learning and science teaching. Each of these four aspects is presented below, followed by suggested pedagogical implications.

6.3.1 Responses to the MyScience experience

All of the interviewed primary students’ views about what it means to be ‘doing science’ have changed because of their involvement in a ‘community of science practice’ [#1]. An integrated range of factors were identified as being likely to have influenced students’ views, some of which were nominated directly by students while others were inferred from data interpretations by the researcher.

Students saw themselves as integral members of their CoP recognizing the significance of their own role as well as the roles of their peers, their teachers, their mentors, their parents and their principal [#2]. The teacher and mentors were both highly valued with the mentors accorded a higher level of science expertise [#2(b), (c)]. The roles of the parents and the school principal were acknowledged but not regarded as significant to the functioning of the CoP, and old-timer students (Schools B and C) appeared to perceive that their parents and principal contributed more to MyScience than first-timer students (School A) [#2(c)]. One student’s recollection of their teacher as a science learner during
the mentor visits indicated a sophisticated level of awareness and observation of members in her CoP [#2(c)] – and how the teacher, as well as herself and colleague students, learned through participation.

6.3.2 Views about science and science learning

Students’ self-identified that the types of classroom activities experienced while doing MyScience changed their views of what it means to be doing science. Their views changed from regarding science as being boring, purposeless, teacher directed, non-collaborative, uncreative and unchallenging, to science being interesting, enjoyable, purposeful, student-directed, collaborative, creative and challenging, and as a means to work out how the world works [#1(a)].

Students acknowledged that they gained scientific intuition and were exposed to aspects of science as a human endeavor through sustained face-to-face interactions with their mentors [#1(a)]. Students identified the explicit use of scientific methods [#1(b)], their active involvement in hands-on collaborative ventures with their peers [#1(c)], the wide variety of concurrently occurring scientific investigations [#1(d)], the high degree of student choice and independence [#1(e)], and the complexity and stimulation of MyScience [#1(f)] as significant factors influencing their views about science and what it means to learn in science. Students had high regard for the involvement of real scientists as mentors, relishing links made between ‘in-school’ and ‘out-of-school’ science [#2(b)].

6.3.3 Views about science teaching

Students’ views of the role of their teacher when doing science were changed by the realisation that the optimal science learning environment was one in which they had choice, independence, and the opportunity to think creatively and to learn from their mistakes [#1(e)]. Students recognized the role of the teacher as a border crosser between themselves and their mentors [#2(c)].

6.3.4 Pedagogical implications

The aim of this component of the research study was to hear the primary students’ voice as a member of a community of science practice, and to identify aspects of the MyScience program that may improve science practice in primary classrooms. The MyScience educational model afforded participating primary students with the opportunity to
experience a different way of being taught, and a different way to learn in and about science in primary school settings. For all interviewed students this led to a positive transformation in their views of what it meant to be doing science. *MyScience* was found to provide a medium where learning to do science through participation in a community of science practice enhanced students’ and teachers’ understandings of the nature of science. Findings from the student study (this Chapter), the mentor study (Chapter 4) and the teacher study (Chapter 5) will now be synthesized and presented in Chapter 7.
Chapter Seven

Chapter 7
Final Discussion and Conclusions

7.1 Introduction and chapter structure

As described in Chapters 1 & 3, the main component of this research study investigated participation in MyScience as a ‘community of practice’ (CoP) where participants from different communities came together to work collaboratively on the common venture of ‘investigating scientifically’. Specifically, the study was concerned with how participation in MyScience affected participants’ views of science, science learning, and science teaching to better understand the complexities of the teaching and learning interface, and how participants’ views of their own sense of belonging and/or participating in the MyScience CoP changed as they moved from being newcomers –on the periphery of the CoP– to experienced members of the community and thus at the centre of their CoP. The study also fulfilled an articulated need for research on the conditions under which schools, universities, and businesses can sustainably work together as outlined in Chapter 2.

This concluding chapter draws together the interpreted findings of the lived experiences of the interviewed participants from Chapter 4 (mentors), Chapter 5 (primary teachers), and Chapter 6 (primary students) within the context of the main research question of the larger study. Arising threads (themes) that bind stakeholders in positive or negative relationships within their communities of science practice are presented in Section 7.2. Section 7.3 reports other ways to interpret CoP functionality that have arisen out of the data. Implications of the findings for the seeding and development of sustainable CoPs are presented in Section 7.4. Suggestions for future research are explained in Section 7.5, and a conclusion and final reflection are presented in Section 7.6.

The main findings presented in the thesis to date are summarized in the following section (7.1.2) and provide answers to the research question (7.1.1). As described in Chapter 3, participants’ responses to the interview questions served as the primary source of data used to answer the questions guiding this study. Data analysis for this study was carried out in four stages: coding and distribution of data; deriving assertions from the data mainly through NOS and CoP lenses (Chapters 4, 5 and 6); responding to the research questions (Chapters, 4, 5, 6 and 7); and identifying emerging inferences from the data (Chapter 7) that may provide further insights into how communities of science practice may be implemented and developed in primary school settings.
Emerging inferences were classified into eight key factors which repeatedly arose in the data and were found to be related to stakeholders’ views of: (a) the *MyScience* framework and (b) *MyScience* participation. The factors are presented in Table 7.1 with colour coding that is also used in later discussions and figures in this chapter: blue for ‘Framework Factors’ and green for ‘Participation Factors’. Table 7.1 has been duplicated on a loose-leaf laminated page accompanying the thesis (which also includes a copy of Table 3.8) to aid the reader with cross-referencing these key factors to the text on the following pages.

Table 7.1. Key factors arising from stakeholders’ views of the *MyScience* framework and CoP participation

<table>
<thead>
<tr>
<th>Stakeholders’ views of …</th>
<th>Framework factors</th>
<th>Participation factors</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>MyScience</em> model [1]</td>
<td>Reason(s) for participating [1]</td>
<td></td>
</tr>
</tbody>
</table>

‘Framework Factors’ include those features that are inherently part of the *MyScience* educational model described in Chapter 2, Section 2.6. ‘Participation Factors’ relate to stakeholders’ views of their involvement and experiences in a *MyScience* CoP. These two ‘sets’ of factors appeared to significantly impact the development of *MyScience* CoPs as explained in Section 7.1.2.

To aid the reader with the line of reasoning and to provide an audit trail that clarifies the generation of the ‘factors’ in Table 7.1 which led to the derivation of the relationship themes in Section 7.2, right-hand margin notes have been inserted to correlate with relevant sections of text (identified by dotted underlines as indicated). Colour coding was applied, where relevant, to aid understanding, as were bracketed numbers from Table 7.1 e.g., [1], to identify where the various margin notes ‘fit’ within the ‘Framework’ or ‘Participation’ factors. To preserve margin space, mentors are identified as ‘M’, teachers as ‘T’ and students as ‘Ss’. See Section 7.1.2 for an explanation of the meaning of [M#5(a)]. The first example in this chapter was sourced from summary sections within Chapter 4:
Mentors, related to scientist mentors’ positive perceptions of MyScience involvement. It has been indented in reduced font size to enhance its visibility:

Scientist mentors commended the structure and the iterative nature of MyScience for: providing a way for “professionals” (Sam) to become involved; developing teachers’ NOS knowledge and science teaching practices leading to CoP development in the absence of mentors; developing mentors’ own knowledge around communication and group management skills with primary students; and fostering student-directed learning. Primary students were perceived to learn about the NOS through interactions with others and from observing nearby groups’ activities in the classroom [M#5(a)].

Using this example and Table 7.1, the margin note – iterative participation [4] – signals that ‘iterative participation’ is classified within ‘framework factor’ [4]: iterative cycle, and that this was a key influence in teachers’ and mentors’ learning. Similarly, the margin note – Ss-M-T relationship [2] – is within the ‘participation factor’ [2]: participant relationships and interactions, and that this was key for students’ learning. This ‘technique’ provides a method for summarizing and synthesizing the major findings from Chapters 4, 5 and 6 so that a ‘big picture’ may be clarified.

In summary, the findings from Chapters 4, 5, and 6 gave rise to thirteen assertions (with thirty-eight aspects, see Table 3.11). Analysis of the these assertions related to the main research question identified eight key factors: ‘Framework factors’ and ‘Participation factors’ detailed in Table 7.1. These factors provided a framework within which all participants’ views could be synthesized, leading to the development of a ‘big picture’ relational framework for participants in MyScience CoPs.

7.1.1 The main research question

As outlined in Chapter 3, and reported for key stakeholder groups in Chapters 4, 5, and 6, the larger research study had an overarching aim to answer the following question:

What are stakeholders’ perceptions of their involvement in MyScience, and how does being in a ‘community of practice’ around ‘investigating scientifically’ influence their views about science, science learning and science teaching?
7.1.2 Summary overview of findings for key stakeholders (mentors, primary teachers and primary students) related to the research question

In the following, relevant assertions from earlier chapters in this thesis related to the main research question are brought together. To aid the reader with cross-referencing, each assertion is identified with [M] for mentors, [T] for primary teachers, and [Ss] for primary students, followed by the corresponding assertion and aspect. For instance, [M#1(a)] refers to mentor Assertion #1, Aspect (a) which is worded as follows: ‘Scientists believed that their sustained, face-to-face interactions exposed primary students to a range of aspects of science as a human endeavor (SHE), particularly astronomers and engineers, their human face and their work’.

The different parts of the research question are presented sequentially as follows:

- 7.1.2.1: Stakeholders’ perceptions of their involvement in MyScience
- 7.1.2.2: Stakeholders’ views of science
- 7.1.2.3: Stakeholders’ views of science learning
- 7.1.2.4: Stakeholders’ views of science teaching
- 7.1.2.5: Summary of stakeholders’ views
Five explanatory Figures (7.2, 7.3, 7.4, 7.5 and 7.6) have been generated that link: the *italicised* aspect of the research question –see Section 7.1.1; details of stakeholders’ views from Chapters 4, 5, and 6; and the ‘framework’ and ‘participation’ factors in Table 7.1 as shown below for Figure 7.2.

**Figure 7.1. Diagram indicating the origin of information in Figures 7.2, 7.3, 7.4, 7.5 and 7.6**

Aspect of research question

![Diagram](image)

- Stakeholders’ views from Chapters 4, 5, and 6 related to the identified aspect of the research question
- ‘Framework’ and ‘participation’ factors from Table 7.1
- Stakeholders’ views from Chapters 4, 5, and 6
- ‘Framework’ and ‘participation’ factors from Table 7.1
- ‘Framework’ and ‘participation’ factors from Table 7.1
- ‘Framework’ and ‘participation’ factors from Table 7.1
7.1.2.1 Stakeholders’ perceptions of their involvement in MyScience

Participants’ perceptions of their involvement in MyScience were overwhelmingly positive and are described in the first part of this section: ‘Positive perceptions’. Engineer mentor Eric, astronomer mentors Sam and Stan, and primary teachers Brian, Amy and Cathy expressed concerns around different aspects of their participation and are described below in the second part of this section: ‘Negative perceptions’.

Positive perceptions of MyScience involvement and how they link to ‘framework’ and ‘participation’ factors.

Scientist mentors commended the structure and the iterative nature of MyScience for: providing a way for “professionals” (Sam) to become involved; developing teachers’ NOS knowledge and science teaching practices leading to CoP development in the absence of mentors; developing mentors’ own knowledge around communication and group management skills with primary students; and fostering student-directed learning. Primary students were perceived to learn about the NOS through interactions with others and from observing nearby groups’ activities in the classroom [M#5(a)].

Primary teachers perceived that MyScience legitimised the place of science in the primary curriculum and gave participating primary teachers an opportunity to focus on science as well as to integrate literacy, numeracy and information technology. It provided a more engaging, exciting and interesting way to teach investigative science compared with normal school science and fundamentally transformed teachers’ views of the nature of ‘doing science’ in the primary classroom. The types of MyScience activities were found to have significantly influenced teachers’ perceptions of their own and students’ roles and their own and students’ learning when doing science [T#1].

All of the interviewed primary students’ views about what it meant to be ‘doing science’ changed because of their involvement in MyScience [Ss#1]. Aspects of the MyScience framework that contributed to students’ altered perceptions independently reflected some of those described by mentors and included: iterative participation in concurrent related scientific investigations, with active physical and mental involvement in hands-on investigations.

Stakeholders’ positive perceptions of MyScience participation derived from the findings in Chapters 4, 5, and 6 are summarized in Figure 7.2, providing additional details to support the three preceding summary paragraphs.
Figure 7.2. Summary of stakeholders’ positive perceptions of *MyScience involvement* (part of the research question) from Chapters 4, 5, and 6, with colour coding that relates to Table 7.1

M = mentors, T = Primary teachers,
Ss = Primary students, NOS = Nature of Science

**M views** (from Chapter 4)
- CoP continues in M absence [1]
- Way for M to be involved [1]
- T develop NOS knowledge and pedagogy
- M develop communication and group management skills of Ss
- Ss exposed to NOS through interactions with others and observing peers [2]
- Ss directed learning [1]

**T views** (from Chapter 5)
- Legitimize science in primary curriculum [1]
- Focus on science, integrate literacy, numeracy and IT [1]
- T develop NOS knowledge and pedagogy
- More engaging, exciting and interesting way to teach investigative science compared with normal school science [1]
- Transformed T views of the nature of ‘doing science’ particularly their own and students’ roles, and their own and students’ learning when doing science

**Ss views** (from Chapter 6)
- Transformed Ss views of the nature of ‘doing science’ due to:
  - Iterative participation [4] in concurrent related scientific investigations, active physical and mental involvement in hands-on investigations [2]
Negative perceptions of MyScience involvement and how they link to ‘framework’ and ‘participation’ factors.

Three mentors (one engineer mentor and two scientist mentors) and three primary teachers voiced concerns about different aspects of their MyScience experience. These were all related to participant relationships and included: other CoP members’ actions during participation (Eric, Sam and Stan); and participant roles and expertise such as –others’ responsibilities (Sam); changing their role (Brian and Amy); and non-recognition of perceived increase in science expertise (Cathy). These perceptions are described in the following.

Mentor Eric was unimpressed by primary teachers’ perceived lack of interest and availability during his mentor school visits, and primary students’ lack of science knowledge and preparation for these visits [M#3(b)]. Mentors Sam and Stan were perturbed about primary students’ asking personal or unexpected questions [M#3(a)]. Both of these are significant issues for CoP functionality: If mentors perceive or experience that their science expertise and time commitment are undervalued or unappreciated, or that interactions with others are uncomfortable, then their participation, interactivity, identity and sense of belonging within the CoP will be compromised.

Sam expressed unease about teachers’ increased levels of work related to organizing and supervising a wide variety of activities in the classroom [M#5(b)], but this sentiment was not reflected in teachers’ views. Cathy was unsettled by her students’ disregard for her science advice (when the same advice was accepted from mentors) and this feeling was exacerbated when mentors expressed surprise at the depth of Cathy’s science knowledge [T#2(b)]. Other teachers reported feelings of disempowerment when not in a director role –which was their default relationship with students– and found this to be challenging but surmountable [T#1(b)]. Essentially, these teachers and mentors were concerned with how they themselves were being affected within the CoP as a result of others’ actions and behaviour, with the exception of Sam’s concern about teachers being overworked.

Stakeholders’ negative perceptions of MyScience participation derived from the findings in Chapters 4 and 5 are summarized in Figure 7.3, and provide additional details to support the three preceding paragraphs.
Figure 7.3. Summary of stakeholders’ negative perceptions of *MyScience involvement* (part of the research question) from Chapters 4 and 5, with colour coding that relates to Table 7.1

M = mentors, T = Primary teachers, Ss = Primary students,

[S] = concern for self, [O] = concern for others.

**M concerns** (from Chapter 4)
Scientists and engineers:
- **T** disinterested during visits [S] [2]
- **Ss** unprepared for visits [S] [3]
- **T** have too much work to do [O] [3]
- **Ss** questions to **M** [S] [2]

**T concerns** (from Chapter 5)
- Sense of disempowerment in facilitator role [S] [2]
- Lack of acknowledgement by **Ss** and **M** of science expertise [S] [3]
- Role change in classroom [S] [3]
Chapter Seven

7.1.2.2: Stakeholders’ views about science

The main research question had three aspects of views related to science education: stakeholders’ views about science, science learning, and science teaching. ‘Views about science’ in this study included everything that was not related to learning or teaching, and so, at times may appear to have a loose connection with ‘science’ per se. For example, in Figure 7.4, a key reason for secondary science teacher mentors’ involvement in the program was to ‘nurture primary-secondary relationships’. At a glance this appears to have no connection with science, but in the text (below, where there is more room for details) it is clear that the relationship is related to ‘science’.

Scientist and engineer mentors believed that their sustained face-to-face interactions exposed primary students to a range of aspects of science as a human endeavor [M#1]. They were keen to develop primary students’ scientific intuition and scientific literacy; to seed an interest in and a love of science; to seed future career aspirations; and to support students to understand links between ‘in-school’ and ‘out-of-school’ science [M#4].

A foremost reason for secondary science teacher mentors wanting to participate as mentors was to nurture primary-secondary relationships around science [M#7(a)].

Secondary science student mentors reported changes in their own views of secondary science because of interactions with enthusiastic and interested primary students. Their changed views included increased personal enjoyment of, and improved ability to work independently, think creatively and persist in investigative science. They also reported feeling an improvement in their own leadership skills, and confidence in science, through explaining science concepts to others [M#8].

Primary teachers felt that MyScience legitimized the place of science in the primary curriculum and simultaneously elevated it to become the focus for integration and the development of teacher-generated resources. It provided an engaging, exciting and interesting way to teach investigative science for both teachers and students that differed markedly to school science [T#1]. Teachers thought that students should demonstrate characteristics such as active participation, reliability, responsibility, creativity, care and perseverance when doing science [T#2(a)].
Teachers perceived that mentors provided students with passion, knowledge and information about science and ‘doing science’ [T#2(d)]. Most participating teachers’ views of science were transformed through their MyScience participation including: deeper understanding of the elements of the scientific inquiry process around fair testing, replication, data collection and reporting; wider appreciation of attributes of the nature of science; and awareness of the connections between the worlds of ‘in-school’ and ‘out-of-school’ science [T#2(c), (d)]. Teachers felt that they fostered an interest and enthusiasm about science in students [T#2(b)].

All participating primary students’ perceptions of science were transformed by their MyScience involvement. Collaboration, student ownership and active (physical and mental) involvement resulted in high levels of student engagement, interest, excitement, and confidence around science. Students’ sense of belonging to a community of science practice was enhanced through observing and participating in a wide variety of concurrently occurring activities. Students’ views of science changed similarly to that of their teachers: from regarding it as being boring, purposeless, teacher directed, non-collaborative, uncreative and unchallenging to science being interesting, enjoyable, purposeful, student-directed, collaborative, creative and challenging, and as a means to work out how the world works [Ss#1]. Students gained awareness of the links between ‘in-school’ and ‘out-of-school’ science through their interactions with mentors [Ss#2(b)].

Stakeholders’ views about science derived from the findings of Chapters 4, 5, and 6 are summarized in Figure 7.4 and provide additional details to support the preceding 7 paragraphs.
Figure 7.4. Summary of stakeholders’ views about science (part of the research question) from Chapters 4, 5, and 6, with colour coding that relates to Table 7.1

M = mentors, T = Primary teachers, Ss = Primary students,
SHE = Science as a Human Endeavor, NOS = Nature of Science

**M views** (from Chapter 4)
Scientists and engineers:
- Sustained face-to-face interactions exposed Ss to SHE [2]
- Eager to develop Ss scientific intuition and scientific literacy [1]
- Eager to seed an interest in and a love of science and future career aspirations [1]
- Eager to support Ss to understand links between ‘in-school’ and ‘out-of-school’ science [1]

Secondary science teachers:
- Eager to nurture primary-secondary relationships [1]

Secondary science students (Year 9):
- Personal increased enjoyment of science [1] due to interactions with primary students [2]
- Personal improved ability to work independently, think creatively and persist in investigative science [1]
- Personal improved leadership skills and confidence in science [1] and increased sense of feeling valued [3]

**T views** (from Chapter 5)
- Significance of the role of the MyScience framework as depicted in Fig 7.1 [1-4]
- T developed deeper understanding of the elements of the scientific inquiry process, NOS, connections between in/out-of-school science [2]
- M & T fostered interest and enthusiasm about science in Ss [2]

**Ss views** (from Chapter 6)
- High levels of engagement, interest, excitement, and confidence around science due to program activities: collaboration, ownership, purposeful, student-directed, collaborative, creative, and challenging, and as a means to work out how the world works [1]
- Awareness of the links between ‘in-school’ and ‘out-of-school’ science through interactions with M [2]
7.1.2.3: Stakeholders’ views about science learning

**Scientist and engineer mentors** perceived that *MyScience* enabled primary students’ learning about the nature of science, fostered student-directed learning and facilitated students’ science learning through observing other students’ activities in the CoP. Teachers were perceived to build a base of science resources through serial participation [M#5].

**Secondary science teacher mentors** gained awareness of primary and Year 9 students’ science capabilities [M#7].

**Secondary science student mentors** perceived that their close age to primary students enabled interactions and discussion, which led to primary students’ improved understanding of the steps in the scientific inquiry process, drawing graphs and interpreting data [M#9].

**Primary teachers** perceived that *MyScience* activities engendered an increased sense of accountability in students, and that student learning was more student-directed and collaborative. Teachers realized that students learning about the nature of science and science as a way of knowing occurred *through participation* – a view that was also held by some scientist mentors (see Chapter 4). This awareness transformed many primary teachers’ views of student achievement and learning in science, validating the *MyScience* approach, and challenging their previous (traditional, teacher-directed) views of investigative science practices.

Students’ high levels of engagement, excitement and interest in doing science combined with evidence of student learning, were key factors leading to teachers’ willingness to participate in *MyScience*. Through their immersion in *MyScience*, teachers realised that students could learn in situations where they were not ‘being taught’ [T#1]. Students were observed by teachers to be learning about the NOS from interactions with mentors, and teachers, in turn, learned about the NOS mainly through listening to these mentor-student interactions. Newcomer teachers learned about *MyScience* from old-timer students [T#2(b)].

**Primary students** perceived that, through *MyScience* participation, they learned about the nature of science, experienced science as a human endeavor, gained science content knowledge and awareness of links between ‘in-school’ and ‘out-of-school’ science. The
impact was so profound that, in one instance, a student (Ben) spoke of his plans for a future topic for investigation in high school that showcased his ability to apply his science skills and knowledge to real life issues [Ss#1(a)].

Having fun, collaboration with others –particularly those in their friendship group– and active physical and mental involvement in hands-on investigations, were identified by students as key factors for effective science learning [Ss#1(b), (c)]. Student choice was highly valued and perceived to enable learning – particularly related to the ‘opportunity’ to ‘make mistakes’ [Ss#1(e)].

Students reported that part of their role in MyScience was to learn while conducting scientific investigations [Ss#2(a)]. They identified mentors as a key source of information and advice, with professional scientists’ advice perceived to be more accurate and believable than that of their teachers [Ss#2(b)]. Teachers were perceived to provide science procedural guidance and support to students, and on one occasion was viewed as a learner during mentor visits [Ss#2(c)].

There was acknowledgement, by students, that they developed scientific intuition and were exposed to aspects of science as a human endeavor through sustained face-to-face interactions with their mentors [Ss#1(a)]. Students identified the explicit use of scientific methods [Ss#1(b)], active involvement in hands-on collaborative ventures with their peers [Ss#1(c)], the wide variety of concurrently occurring scientific investigations [Ss#1(d)], the high degree of student choice and independence [Ss#1(e)], and the complexity and stimulation of MyScience [Ss#1(f)] as significant factors influencing their views about science and what it means to learn in science. Students had high regard for the involvement of real scientists as mentors, relishing links made between ‘in-school’ and ‘out-of-school’ science [Ss#2(b)].

Stakeholders’ views about science learning derived from the findings of Chapters 4, 5, and 6 are summarized in Figure 7.5 and provide additional details to support the preceding 9 paragraphs.
Figure 7.5. Stakeholders’ views about science learning (part of the research question) from Chapters 4, 5, and 6, with colour coding that relates to Table 7.1

M = mentors, T = Primary teachers, Ss = Primary students,
SHE = Science as a Human Endeavor, NOS = Nature of Science

<table>
<thead>
<tr>
<th>Views about science learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>MyScience CoP</td>
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**M views**
(from Chapter 4)

- **Scientists and engineers:**
  - *MyScience* framework enabled Ss learning about NOS, fostered student-directed learning, facilitated learning from peers [1, 2]
  - T built resource ‘bank’ through serial participation [4]

**Secondary science teachers:**

- Gained awareness of primary and Year 9 Ss capabilities [2]

**Secondary science students (Year 9):**

- Provided support to primary Ss around process of investigating scientifically and reporting data [2]

**T views**
(from Chapter 5)

- *MyScience* framework enabled Ss accountability, ownership and collaboration [1, 2]
- Ss learned about NOS through participation in MyScience
- Ss learned from interactions with M [2]
- T learned new insights into Ss science learning due to immersion in MyScience model [1]

**Ss views**
(from Chapter 6)

- Ss learned from M about NOS, as well as experiencing SHE, gaining content knowledge and understanding links between ‘in’ and ‘out-of-school’ science [3] [2]
- Effective science learning was identified as having fun, collaboration with others, and active physical and mental involvement in hands-on investigations [2]
- Student choice enabled learning and was highly valued [2]
- Ss learned from observing peers in CoP [2]
- M science information and advice valued over that of T [3]
- T viewed as procedural guide and support [3]
7.1.2.4: Stakeholders’ views about science teaching

Scientist and engineer mentors perceived that they were a resource for primary students [M#2(a)]. They recognised that they used personal experiences to, for instance, highlight the tentativeness of science to students and encouraged scientific discussion, collaboration and creativity amongst students through probing questions [M#1(c)]. Mentors perceived and acknowledged that they were in a partnership with teachers –each playing different and critical roles– and that teachers developed and continued communities of science practice in their classrooms in the absence of the mentors [M#2(b)]. They appreciated teachers’ enthusiasm and interest and teacher-generated student scaffolds [M#3(b)].

Secondary science teacher mentors expressed a desire to, and in some instances changed their own teaching practices\(^{19}\) to meet the needs of incoming Year 7 MyScience old-timers following their participation in MyScience. Colleague teachers were observed to introduce open-ended investigations into their science lessons [M#6 (a), (b)].

Secondary science student mentors perceived that they were in a teaching role when interacting with primary students and that their close age was a factor enabling them to simplify explanations for the primary students [M#9(a)].

Primary teachers, similarly to the secondary teachers, reported that they changed how they taught science by adopting new practices and developing new strategies. They learned new pedagogical skills where their role changed to that of a facilitator –rather than that of a director– and students made choices about what they would investigate. Teachers felt that they prepared students for investigations during mentor visits and provided support to students both during and after mentor visits [T#2]. This is at odds with mentor Eric’s observations described earlier [M#3(b)].

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\(^{19}\) Note that these teachers changed their role/expertise in their own secondary school and therefore, a margin note of ‘T role/expertise [3]’ is not warranted as it does not apply to a MyScience CoP.
Students’ views of the role of their teacher when doing science were changed by the realisation that the optimal science learning environment was one in which they had choice, independence, and the opportunity to think creatively and to learn from their mistakes [Ss#1(e)]. Students recognised the role of the teacher as a border crosser between themselves and their mentors. The teacher was perceived to provide a wide range of support to students, mostly around organizational issues, and monitoring behaviour with a view to safety, and was viewed as a co-learner during mentor visits [Ss#2(c)]. Mentors were identified as the key source of science advice and information [Ss#2(b) & (c)].

Stakeholders’ views about science teaching derived from the findings of Chapters 4, 5, and 6 are summarized in Figure 7.6 and provide additional details to support the preceding 5 paragraphs.
Figure 7.6. Stakeholders’ views about science teaching (part of the research question) from Chapters 4, 5, and 6, with colour coding that relates to Table 7.1

M = mentors, T = Primary teachers, Ss = Primary students
7.1.2.5: Summary of stakeholders’ views

In this section, associations between ‘framework factors’ (coloured blue), and ‘participation factors’ (coloured green) from Table 7.1, and how they influence ‘participants’ views’ (coloured lilac) are discussed, and presented diagrammatically in Figure 7.7. Given the ongoing cyclic nature of MyScience participation, influential factors are situated within a circle. The peripheral arrows are designed to indicate the recursive nature of the factors influencing participants’ views of their involvement in MyScience, and their direction has significance as follows: For first timers, ‘framework factors’ are likely to be more influential for continued membership and engagement in the CoP since ‘participation factors’ take time to develop. For second and third timers ‘participation factors’ are likely to be more influential for ongoing involvement in the CoP.

Essentially, this section provides a summative response to the main research question:

What are stakeholders’ perceptions of their involvement in MyScience and how does being in a ‘community of practice’ around ‘investigating scientifically’ influence their views about science, science learning and science teaching?

Views about MyScience involvement

It is significant that, with the exception of Sam’s concern about teachers being overloaded, all of the reported issues related to MyScience involvement centred on individuals’ feelings of being valued within their CoP. This, according to Wenger (2006), directly affects participants’ sense of belonging to, and therefore the development and sustainability of, the CoP. The MyScience framework – particularly iterative participation and the types of embedded activities – were identified by participants as fundamental factors for positive perceptions of their involvement. The relationship between ‘framework factors’ (blue), ‘participation factors’ (green) and participants’ views about their involvement in MyScience (lilac) are represented in Figure 7.7 (a).

Views about science

Stakeholders’ views about science were influenced by relationships and interactions with other participants within their CoP with a key element being the diversity of expertise and roles that members contributed during the interactions. An additional factor related to the reasons that mentors described for their willingness to become involved in the program. The relationship between ‘framework factors’ (blue), ‘participation factors’ (green) and participants’ views about science (lilac) are represented in Figure 7.7 (b).
Views about science learning

Science learning was viewed as having come about through participation in the CoP –as a consequence– of having been in a CoP. Stakeholders realized that this was a legitimate way of learning about science. The MyScience educational model—activities and interactions with other stakeholders over a sustained length of time situated within school classrooms—provided the scaffolding for this style of learning to occur. The relationship between ‘framework factors’ (blue), ‘participation factors’ (green) and participants’ views about science learning (lilac) are represented in Figure 7.7 (c).

Views about science teaching

Participating primary and secondary teachers changed their science teaching approaches as a consequence of their MyScience experiences. Three factors appeared to be influential in modifying primary teachers’ reported teaching approaches and hence their classroom behaviour: sequenced activities that immersed them in a facilitator role, stakeholders having defined roles, and the way participants interacted and developed relationships. Mentors and primary teachers viewed their relationship as a partnership, and both mentors and primary students perceived that the key source of science advice and information was mentors. This allowed primary teachers to partially ‘step away’ or to ‘pass on the responsibility’ for knowing and delivering science knowledge to their students and afforded them with an opportunity to ‘teach’ in a different mode.

Secondary science student mentors perceived that they were in a teaching role when interacting with primary students. Primary students’ recognised that their teachers provided them with a range of support that was less scientific than that provided by mentors. The relationship between ‘framework factors’ (blue), ‘participation factors’ (green) and participants’ views about science (lilac) are represented in Figure 7.7 (d).
Figure 7.7 summarises the relationship between different aspects of the research question (stakeholders’ views about: MyScience involvement, science, science learning and science teaching), MyScience ‘framework factors’ (the MyScience model, participant roles and expertise, iterative participation, and activities), and ‘participation factors’ (participant relationships and interactions, reasons for participating, feeling valued, and sense of belonging). Interestingly, a handful of factors appear to be influential in all aspects of the research question and include: the ‘framework factors’ of participant roles and expertise, and activities; and the ‘participation factor’ of participant relationships and interactions – signalling the importance of people and how they interrelate. This is discussed in more detail in the following Section 7.2. Some factors are noticeable by their absence: ‘views about
science’ is the only category to not include iterative participation; ‘views about science learning’ is the only category to not include feeling valued; and ‘views about science’ teaching is the only category to not include the MyScience model. These patterns are worth noting and may provide a fruitful area for further research.

In summary, it is evident that, within MyScience communities of science practice, stakeholders’ views of their involvement, science, science learning and science teaching have been influenced by particular factors associated with: the MyScience educational model –participants having different roles and responsibilities; working scientifically activities that provide students with ownership and choice and that are collaborative, hands-on and concurrent; and a series of steps that guide participants through their first couple of MyScience experiences– and by factors related to interactions with others –reasons for participating, relationships, feeling valued, sense of belonging. Together, these factors resulted in the development of communities of science practice that enabled primary teachers and primary students to learn about science with support embedded in the CoP construct. The relationship between factors related to the development of MyScience CoPs is presented in the following section.
7.2 The threads that bind: stakeholder relationships in *MyScience* CoPs

Research findings from the previous section indicate that ‘framework factors’ and ‘participation factors’ recursively interact in the development of *MyScience* CoPs as represented in Figure 7.8.

![Diagram showing the interaction between framework and participation factors in the development of MyScience CoPs.](image)

**Figure 7.8. Factors which impact the development of *MyScience* communities of science practice**

If these factors are then viewed holistically within the iterative development of *MyScience* CoPs, and the notion of newcomers initially participating on the periphery of the CoP is included, then a situation such as that in Figure 7.9 typically comes to pass. ‘Framework factors’ provide a set of guiding principles within which ‘participation factors’ lead to learning. The development of a CoP is spiral in nature rather than cyclic due to newcomer stakeholders’ increased experience and learning over time. The research findings described in Chapters 4, 5, and 6 indicate that in the **first year** of *MyScience* implementation, participants are all ‘newcomers’ in the CoP and are on the periphery of what it may become. In the **second year** of implementation participants with previous experience (second-timers) move towards the centre of the CoP and provide support to first-timers into the practices of
the CoP. By the third year of implementation, third-timers are now ‘old-timers’ who have considerable history and knowledge of the workings of the CoP and they, along with the second-timers are able to independently train and support newcomers into the CoP. Thus the CoP becomes self-sustaining as a ‘knowledge community’ develops (Lindkvist, 2005). Participants learn about the nature of science through participation in situated contexts, where they see, hear, discuss and sense how science is practiced. This notion was particularly evident in Chapter 5 with: Cathy’s description of a ‘fourth timer’ student supporting newcomer students; Chris’s description of old-timer students supporting newcomer teachers; and Beth and Angela supporting newcomer teachers and mentors with student scaffolds and other documents. In Chapter 6, this awareness was noticeable through many students’ comments in Assertion #1, particularly fourth-timers Chad and Ben who recognised their personal increasing science expertise over time because of MyScience participation (Chad), and made decisions about what to investigate linked to real-world issues (Ben).

In Figure 7.9, torso numbers and dotted lines connect participant symbols, demonstrating how participants follow a trajectory towards the centre of their CoP over time.
Figure 7.9. The stages of development in a typical primary school *MyScience* CoP
Research findings (see Chapters 4, 5, and 6) demonstrate that affirmation of stakeholder relationships was critical for the successful development of MyScience CoPs. Although the primary reason for participants coming together was concerned with the ‘doing of science’, stakeholders’ positive perceptions of one another significantly influenced their views of participation, science, science learning and science teaching (see Section 7.1) – an observation also made by Gee who stated: “Members of the community of practice bond to each other primarily through a common endeavor and only secondarily through affective ties which are, in turn, leveraged to further the common endeavor” (2000, p. 518).

Negative perceptions related to two types of stakeholder relationships within CoPs: ‘concern for self’ and ‘concern for others’ (see Section 7.1.2.1, Figures 7.2 & 7.3). These were evident in only two of the stakeholder groups – scientist mentors and primary teachers. ‘Concern for self’ included teachers who felt disempowered when not in a director role, and who felt ‘slighted’ when their perceived science expertise was disregarded; and included mentors who were concerned about student questions, and who felt that the preparedness of teachers and students for mentor visits was deficient. ‘Concern for others’ related to mentors worrying that teachers had too much work. All of these issues – both positive and negative – are pressure points for the successful functioning of a CoP, and if not addressed could destabilize CoP development and sustainability. Suggestions for a way forward are outlined in Section 7.4: Implications of the findings for practice.

7.3 Other considerations for interpreting CoP functionality

Accidentally – or coincidentally – many characteristics of the MyScience educational model appear to facilitate the development of communities of science practice, and have been noted in the research literature. They include the potential influences of the following constructs: the ‘Zone of Proximal Development’, ‘dissonance’, and ‘immersion’. These notions are discussed in the following.

7.3.1 Zone of Proximal Development

MyScience situates teachers in the role of a facilitator (rather than that of a director) – a position that many primary teacher participants found to be challenging. Changing teachers’ practice into a less directorial and more student-centred role in the classroom involves a shift in teachers’ way of thinking about science as well as changes in how they approach the teaching and learning of science. As described in Chapter 5, Assertion #1, teachers’
prior views of science changed to include science as: having an elevated status in the primary curriculum; providing a focus for integration; and creating an environment where learning in science was engaging, exciting and interesting.

*MyScience* participation for most transitional and transformational teachers (as described in Chapter 5) could be viewed as being *within* their Zone of Proximal Development (ZPD) (Vygotsky, 1978 as cited in Polman, 2010) i.e., *between* what teachers can do and already know, and what teachers do not yet do or already know. The notion of ZPD could therefore account, in part, for how a CoP ‘works’ and reciprocally, a functioning CoP could be viewed as affording participants with a learning environment commensurate with their particular ZPD. In such settings, CoP members could choose to ‘take on’ as much as they are ready for at a particular time –to remain on the periphery of their CoP, for example– and to develop a deeper interest and commitment to the domain over time, through iterative participation.

### 7.3.2 Dissonance

When teachers experience dissonance or cognitive conflict their teaching approaches and thinking are challenged and there is an opportunity for “creativity and change” to occur (Opfer & Pedder, 2011, p. 388). However, as noted in Chapter 2, “if the dissonance among beliefs, practices, knowledge, and experience is too large, teachers may dismiss new ideas as inappropriate to their situations” (Opfer & Pedder, 2011, p. 389). This notion is similar to that of ZPD where teachers’ discomfort could be viewed as a catalyst enabling them to internalize and adapt to the new demands of, for instance, being a facilitator.

### 7.3.3 Immersion

Opfer and Pedder’s recent review of teacher professional development literature asserts that “teachers learn most effectively when activity is school based and integrated into (their) daily work … and when the pedagogy of professional development is active and requires teachers to learn in ways that reflect how they should teach pupils” (2011, p. 385). *MyScience* provides a context that immerses teachers, with support, in such settings. Support is sustained and embedded through: the steps of the program; through the involvement of participants with differentiated roles, responsibilities and expertise; and through the public reporting of students’ findings. Together, these elements interact to provide an environment where primary teachers are supported in their science learning and align with Opfer and Pedder’s view that teacher learning should be “conceptualized as a
complex system rather than as an event” (2011, p.377), where the “systems and subsystems associated with teacher learning are interdependent and reciprocally influential” (2011, p. 379). Furthermore, Bolstad and Bull (2013), in their review of school-science community initiatives, commented on the importance of immersion and “repeated engagements over time” (p. xii, emphasis in original), which gave students more opportunities to develop relationships with science-community partners. The notion of the importance of relationships is reflected in the findings of this study as ‘participation factors’.

The notions of ZPD, dissonance and immersion appear to play a role in how CoPs function and so need to be taken into account when applying these research findings.

7.4 Implications of the findings for practice

The implications of the research findings for future initiatives to seed and develop MyScience CoPs are discussed in the following and include: addressing issues raised by stakeholders related to roles and responsibilities; accommodating the needs of both ‘traditional’ and ‘transformational’ teachers to facilitate their participation in CoPs; encouraging teachers to persist with their CoP involvement since ‘learning through participation’ takes time; and helping members turn their tacit knowledge into explicit knowledge.

7.4.1 Addressing issues related to stakeholder roles and responsibilities

As a consequence of the findings reported in Sections 7.1, 7.2 and 7.3, and to address ZPD and dissonance issues raised by participants, teacher and mentor training sessions –which are part of the MyScience Educational Model (see Chapter 2)– have been modified. Mentor concerns (raised by Eric, Sam and Stan) are now introduced and discussed in the initial teacher orientation and learning sessions and teachers are advised: to adequately prepare students for mentor school visits; to warmly welcome mentors; to remain actively involved during mentor school visits; and to forewarn students about appropriate ways to interact and speak with mentors. Teachers are also briefed about their roles as a facilitator and provided with strategies for interacting with others when their science expertise is not being recognised. In mentor orientation sessions, participants are now advised that old-timer teachers are likely to have significant science content knowledge through MyScience participation and that this needs to be recognised.
7.4.2 Accommodating the range of needs of traditional and transformational teachers

Based on the perceptions of Brian and Amy –who were identified as using traditional teaching approaches (Chapter 5) and appeared to have the most difficulties (significant ZPD and dissonance issues) adapting to the demands of the role of a facilitator– it may be prescient to include the option of adjusting the MyScience educational model to accommodate their preferred mode of teaching. By limiting student choice around open-ended science investigations, the classroom environment would be less challenging to manage, resulting in less dissonance for these teachers and therefore providing them with a ‘gentler pathway’ into membership within the CoP. For instance, the class theme could be narrowed from ‘energy’ to ‘heat energy’ or from ‘the environment’ to ‘plants’. Transformational teachers on the other hand (e.g., Cathy and Chris) appear to have been insufficiently challenged by their more recent MyScience experiences (where they appear to perceive that they do not need mentors –that they know all of the science knowledge that is required- and so require a different set of modifications to sustain their sense of belonging and identity within the CoP. These teachers could be encouraged to be more reflexive and to identify personal growth points around the teaching and learning of science and how these may be addressed.

7.4.3 Encouraging teachers to persist with the CoP learning approach

A key finding to have emerged from the research (detailed in Chapter 5) was that teachers’ views about students’ science learning were transformed through MyScience participation when teachers directly experienced evidence of students’ learning. Guskey reported that “for the vast majority of teachers, becoming a better teacher means enhancing student learning outcomes” (2002, p. 382), and that this was best achieved through teachers receiving professional development, teachers changing their classroom practice, teachers observing changes in student learning outcomes, and then teachers changing their beliefs and attitudes (2002). This view was also supported by Levitt (2001) –that significant change to teachers’ attitudes and beliefs occurs after they have evidence of student learning, that seeing is believing, and that this happened for many teachers in this study at the end of the process when students reported their findings at their annual Science Fair. Carlone et al. discussed the notion of teachers perceiving themselves in the process of ‘becoming’ –“becoming science people, teachers and reformers” (2010, p. 955), and that teachers similarly “talked about how students grew in their confidence and identity as learners from their experiences in science” (p. 953). It is therefore important that teachers
are encouraged to persist with their CoP involvement even when they may feel that the ‘learning through participation’ process is not working. These processes take time, and when sustained, may lead to science education reform.

7.4.4 Turning tacit knowledge into explicit knowledge

The research findings indicate that MyScience participants develop NOS understandings, which have mostly been interpreted by the researcher from the answers to interview questions. There were few responses from, for instance, primary teachers and primary students that could unequivocally be taken as evidence of a deep understanding of what it means ‘to do science’. Therefore, a future focus area would be to help members turn their tacit knowledge of the nature of science into explicit knowledge of the nature of science as suggested by Gee (2000) and Feasey (2012). Lederman (1992), and Tan and Barton’s (2007) findings related to the interconnectedness of teachers’ classroom practices, students’ conceptions of the nature of science and students’ science identity formation also signal this as an area of interest for future research, as do the findings from a number of other researchers discussed in Chapter 2 such as: Girod and Twyman (2009); Harris and Rooks (2011); Murphy et al., (2011); and Olson (2008).

7.5 Suggestions for future research

This research study has provided valuable insights into how communities of science practice function in primary school settings in metropolitan areas. Sourcing and placing mentors with science expertise into participating classrooms is a time consuming exercise since there is a limited pool of available professional scientists. It makes sense to use local mentors as much as possible – from local universities and secondary schools. Therefore, researching the involvement of pre-service secondary science teachers, pre-service primary teachers, and higher numbers of secondary science students and secondary science teachers as mentors is a foremost concern. Longitudinal studies on the views of old-timer primary students as they move into secondary school settings would provide useful information about students’ science interest, knowledge, skills and thinking. Finally, there is the notion of researching the impact of participation on mentors sourced from undergraduate and postgraduate science and engineering degrees and to ascertain if this precipitates a career change to school teaching in the much-needed disciplines of science and mathematics.
Koliba and Godja (2009) recommended researching the structures and practices that facilitate, sustain or strain CoP functionality such as: communication modes, the quality of dialogue and the quality of knowledge created and used within CoPs. They called for future CoP research to focus on factors related to CoP development such as: “the effects of participation in CoPs, conditions that advance or impede CoP development, administrative actions that foster or hinder CoP development, and how relationships between CoPs are formed” (2009, p.112). This research study has identified some such factors –related to MyScience ‘participation’ and the MyScience ‘framework’– which now need to be articulated for participants to use. An interesting development and research context could relate to nurturing CoPs around other disciplines using the MyScience Educational Model as the framework. Thus, the notion of teachers as facilitators, students having ownership and choice over their learning and in-school visits by mentors with specific discipline expertise could be developed in mathematics, English, art, music, history, geography, or a combination thereof. This would build teacher capacity, enhance student engagement and learning outcomes, and lift the performance of schools using a community based approach to professional learning. Discipline experts could be sourced from Professional Teacher Associations.

7.6 Conclusion and final reflection

This interpretive research study explored the ‘lived experiences’ of mentors’, teachers’ and students’ involvement in MyScience. The program indicates benefits across the educational continuum: for primary teachers and their students; mentors sourced from local secondary schools (secondary science teachers and Year 9+ students); undergraduate and postgraduate science and engineering students; pre-service secondary science teachers; and science and engineering researchers.

MyScience has evolved as an urban school-community initiative with research findings suggesting likely ‘conditions’ for success and has produced evidence of participants’ transformed understandings about the nature of science, science teaching and science learning. The school-community model underpinning MyScience provides an indication of how the initiative could be embedded in the science curriculum of both primary and secondary schools resulting in enhanced engagement, interest and learning in science.
Although this study has the limitations discussed in Section 3.8, it is hoped that the findings will be transferable to other school and community localities where they may enhance primary science practices.

Harris and Rooks’ call for “models of how teachers can successfully manage the complexity of inquiry instruction in a range of settings” (2010, p. 238) is realised through the MyScience Educational Model, which provides a conceptual participatory framework that systemizes practical experiences for participants. When the diverse range of participants –teachers, students and mentors– come together to work on the joint enterprise of working scientifically, a community of practice (CoP) usually develops. MyScience CoPs present participants with ‘learning spaces’ into which they may choose to step and engage with or participate in experiences with others. Initially, newcomers may choose to ‘watch and wait’, remaining on the periphery of the CoP. With recurrent experiences, participants usually become more involved in the practices of the CoP, learning through participation. To begin with, participants may experience feelings of dissonance and instability, which over time, develop into a sense of belonging, identity and agency within the realm of working scientifically –participants are transformed through their own actions and those of others. Learning takes effort and work. It is not easy to re-structure what are deemed to be ‘tried-and-true’ teaching and learning practices, but in the case of primary (and secondary) science education, a new approach is evidently needed. MyScience appears to be a ‘package’ with significant potential for effective science education, and offers a way for school communities to embed authentic science practices within their curricula.
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References


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APPENDICES

APPENDIX A
Research Diary extracts demonstrating researcher observations, discussions and insights during the research study

APPENDIX B
Steps for exporting NVivo data

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Information Sheets and Consent Forms

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APPENDIX D
Extract from Cathy’s interview indicating how (her) was used in the example in Section 3.5.2 and 3.5.3 to replace ‘my’ in line 238.
Extract from Carmel’s interview indicating the source of data used to create the quote cited in Section 3.5.3.

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APPENDIX A

Research Diary extracts demonstrating researcher observations, discussions and insights during the study.
APPENDIX B

Steps for exporting NVivo data: Step 1/7 - Expand all tree nodes

Once the data had been deductively analysed in the NVivo structural framework using the Interview Questions, and CoP and NOS attributes as organizing categories, a number of named nodes (N) were displayed which aligned with the number of sources (S) and the number of references (R) contained within the tree node. (See Figure 1). Tree nodes contain nodes that are organized into a hierarchical structure with a parent node containing multiple child nodes. Tree nodes were used to explore the relationships of concepts in participants’ interviews, which were associated with the Interview Questions and CoP/NOS attributes.

Figure 1. Screen shot of NVivo software template containing nodes (N), sources (S) and references (R)

The last three tree node ‘labels’ in Figure 1 above – near the ‘N’ arrowhead are: ‘NOS_science content’, ‘NOS_science processes’, ‘work as a scientist’… These labels were created by the researcher to identify interpreted meanings within sections of interview transcripts. They have been identified here to provide a thread that links the steps involved with exporting the analysed data from NVivo. At this stage, all of the nodes were ‘condensed’ and needed to be ‘expanded’. The method for doing this is shown in Figure 1 as follows: #1 = select the ‘view’ tab, #2 = scroll down to ‘expand/collapse’, #3 = select ‘expand all tree nodes’.
Steps for exporting NVivo data: Step 2/7 - Export list

Once expanded, the tree nodes (TN) appeared as shown in Figure 2.

Figure 2. Screen shot of NVivo software template containing expanded tree nodes

The tree nodes and their accompanying source and reference were then exported into a more manageable format such as Excel or Word. The procedure for doing this is shown in Figure 2 as follows: #1 = select the ‘Project’ tab; #2 = scroll down and select ‘Export List’.
Steps for exporting NVivo data: Step 3/7 - Tree nodes in Excel

Once exported into an Excel spreadsheet, the condensed tree nodes (TN) appeared as shown in Figure 3.

Figure 3. Screen shot of Excel workbook containing exported condensed tree nodes

The last three tree node ‘labels’ in Figure 3 near the ‘TN’ arrowhead are the same as those in Figure 1: ‘NOS_science content’, ‘NOS_science processes’, ‘work as a scientist’. They are readable in the magnified red rectangle and demonstrate the integrity of the extraction process.
Steps for exporting NVivo data: Step 4/7 - Expand rows to show nodes

Each tree node was then expanded by selecting the ‘+’ symbols associated with it. Clicking the ‘+’ symbol reveals the ‘child nodes’ and changes the symbol to ‘-’. See Figure 4 for details.

Figure 4. Screen shot of Excel workbook showing the first tree node ‘AAO links’ in an expanded form
Steps for exporting NVivo data: Step 5/7 - Bold column titles

In order to enhance visibility of key organisers for the exported data, the column titles were formatted in ‘bold’ as shown below in Figure 5.

Figure 5. Screen shot of Excel workbook showing how to select bold font for column titles

The procedure for doing this is shown in Figure 5 as follows: #1 = highlight column titles; #2 = select ‘B’ in ‘Formatting Palette’.
Steps for exporting NVivo data: Step 6/7 - Clear ‘Tree Node’ labels

In order to reduce unnecessary text in the data set for future analysis the content of ‘redundant cells’ was cleared as shown in Figure 6.

Figure 6. Screen shot of Excel workbook showing how to ‘clear tree node labels’

The procedure for doing this is shown in Figure 6 as follows: #1 = select content in columns to be ‘cleared’; #2 = select ‘Edit’, scroll down to ‘Clear’ and the then across to ‘Contents’.
Appendices

Steps for exporting NVivo data: Step 7/7 - Retrieve identified quotes/text from NVivo

Interview quotes and sections of transcripts were retrieved from NVivo and copied verbatim into the exported Excel spreadsheet as shown in Figure 7.

Figure 7. Screen shot of Excel workbook showing inserted text and quotes related to the node ‘work as a scientist’
INFORMATION SHEET TO PRIMARY STUDENTS

TITLE OF PROJECT: MyScience - communities of practice around the teaching and learning of primary science
NAME OF RESEARCHER: Anne Forbes

Dear MyScience student,

You are invited to participate in a research project. This letter provides you with some information to help you decide whether you are willing to help with this research.

The purpose of this research is to find out from you how you have found the experience of being part of MyScience at your school.

You have been chosen by your teacher as a useful person for me to interview. If you agree to be interviewed I will arrange for you to talk to me for about 30 minutes during school hours. The interview will be audio taped. If you feel more comfortable doing so, you are welcome to invite a friend to sit with you during the interview.

What you say in the interview will provide valuable information about your experience of the MyScience program. It will help us to understand how different people have found MyScience and whether there have been any challenges and/or lessons learned that might be useful for similar programs.

It is for you to decide if you want to talk to me and before you decide whether to help me you might like to talk about this project with your parents or with a friend. If you do agree to talk to me then we can stop when you want to, or have a break. I keep tapes and notes of the interviews in a safe, lockable place. When I talk about the research and write reports I change the people’s names so that no one knows who said what. You can choose a name for me to use if you wish. I will send you a copy of the short report we write if you would like to see it.

If you have any questions regarding this project please contact me as follows:

Anne Forbes, 9701 4330, anne.forbes@acu.edu.au

If you agree to participate in this project, you should sign both copies of the consent form, keep one copy for your records and return the other copy to your class teacher. Your parents/caregiver will also be receiving an Information Sheet and Consent Form that needs to be completed and returned as well.
CONSENT FORM FOR PARTICIPANTS

Copy for researcher

TITLE OF PROJECT: MyScience - communities of practice around the teaching and learning of primary science

NAME OF RESEARCHER: Anne Forbes

(Contact details of the researcher and the supervisor are contained in the Information Sheet about this research)

NOTE: This consent form will be kept by the Southern Cross University researcher for their records.

I have been provided with an Information Sheet about the above research project. Yes □ No □

I know the name and contact details of the researcher and I understand I can contact them at any time with questions about the research project. Yes □ No □

I have read the Information Sheet and understand that I will be interviewed. Yes □ No □

I understand that it is my choice to take part in the interview. Yes □ No □

I understand that I can choose to stop the interview at any time. Yes □ No □

I understand that my real name will not be used in the report. Yes □ No □

I agree to be part of this research project. Yes □ No □

I understand that I am to return this consent form to the researcher and that I am to keep the other copy for myself. Yes □ No □

I understand that if I would like to receive the short report then I can provide my email or mail address below. Yes □ No □

Participant name: ........................................................................................................................................

Participant signature: ........................................................................................................................................

Date: ..........................................................................................................................................................

Contact Telephone # (optional): ....................................................................................................................

Email address (optional): ............................................................................................................................

Mail address (optional):
CONSENT FORM FOR PARTICIPANTS

Copy for participant

TITLE OF PROJECT: MyScience - communities of practice around the teaching and learning of primary science

NAME OF RESEARCHER: Anne Forbes

(Contact details of the researcher and the supervisor are contained in the Information Sheet about this research)

NOTE: This consent form will be kept by the Southern Cross University researcher for their records.

I have been provided with an Information Sheet about the above research project.  Yes ☐ No ☐

I know the name and contact details of the researcher and I understand I can contact them at any time with questions about the research project.  Yes ☐ No ☐

I have read the Information Sheet and understand that I will be interviewed.  Yes ☐ No ☐

I understand that it is my choice to take part in the interview.  Yes ☐ No ☐

I understand that I can choose to stop the interview at any time.  Yes ☐ No ☐

I understand that my real name will not be used in the report.  Yes ☐ No ☐

I agree to be part of this research project.  Yes ☐ No ☐

I understand that I am to return the other consent form to the researcher and that I am to keep this copy for myself.  Yes ☐ No ☐

I understand that if I would like to receive the short report then I can provide my email or mail address below.  Yes ☐ No ☐

Participant name: ..................................................................................................................

Participant signature: ..........................................................................................................

Date: .....................................................................................................................................

Contact Telephone # (optional): ..........................................................................................

Email address (optional): ......................................................................................................

Mail address (optional):
INFORMATION SHEET TO SCIENTIST MENTORS (SECONDARY STUDENTS)

TITLE OF PROJECT: MyScience - communities of practice around the teaching and learning of primary science

NAME OF RESEARCHER: Anne Forbes

Dear MyScience MySTic,

You are invited to participate in a research project. This letter is designed to provide you with some information to help you decide whether you are willing to contribute to this research.

The purpose of this research is to find out from you how you have found the experience of being part of MyScience as a mentor to primary students.

You have been selected by your science teacher as a useful person for me to interview with another five to ten MySTics from your school. If you agree to be interviewed I will arrange for you to talk to me for about 45 minutes during school hours. If you would feel more comfortable doing so, you are welcome to bring along a non-speaking friend to accompany you during the interview.

Through your participation, you will be providing valuable information about your experience of the MyScience program. The research will provide a better understanding of how this type of program has been experienced by the different groups of people and whether there have been any challenges and/or lessons learned that might be useful for similar programs.

The findings will form part of a doctoral thesis which the researcher – Anne Forbes – will also write up in an academic journal.

Participation is voluntary and you can withdraw at any time without giving a reason, including after the interview has begun. Should you decide to participate in an individual interview then other students and teachers at your school may be aware of that participation. However, any information that might identify you will be changed or deleted in the research notes, and in any published findings, the identification of you and your school will be through pseudonyms (alternative names).

If you have any questions regarding this project please contact the researcher as follows:

Anne Forbes, 9701 4330, anne.forbes@acu.edu.au

If you agree to participate in this project, you should complete both copies of the consent form, keep one copy for your records and return the other copy to the researcher. Your parents/caregiver will also be receiving an Information Letter and Consent Form that needs to be completed and returned as well.

……………………………………
Researcher
Anne Forbes
Australian Catholic University
25A Barker Road
Strathfield
NSW 2135
CONSENT FORM FOR PARTICIPANTS

Copy for researcher

TITLE OF PROJECT: MyScience - communities of practice around the teaching and learning of primary science

NAME OF RESEARCHER: Anne Forbes

(Contact details of the researcher and the supervisor are contained in the Information Sheet about this research)

NOTE: This consent form will be kept by the Southern Cross University researcher for their records.

I have been provided with an Information Sheet about the above research project. Yes ☐ No ☐

I know the name and contact details of the researcher and I understand I can contact them at any time with questions about the research project. Yes ☐ No ☐

I have read the Information Sheet and understand that I will be interviewed. Yes ☐ No ☐

I understand that it is my choice to take part in the interview. Yes ☐ No ☐

I understand that I can choose to stop the interview at any time. Yes ☐ No ☐

I understand that my real name will not be used in the report. Yes ☐ No ☐

I agree to be part of this research project. Yes ☐ No ☐

I understand that I am to return this consent form to the researcher and that I am to keep the other copy for myself. Yes ☐ No ☐

I understand that if I would like to receive the short report then I can provide my email or mail address below. Yes ☐ No ☐

Participant name: ........................................................................................................................................

Participant signature: .................................................................................................................................

Date: ...........................................................................................................................................................

Contact Telephone # (optional): .....................................................................................................................

Email address (optional): ............................................................................................................................

Mail address (optional): ...............................................................................................................................
CONSENT FORM FOR PARTICIPANTS

Copy for participant

TITLE OF PROJECT: MyScience - communities of practice around the teaching and learning of primary science

NAME OF RESEARCHER: Anne Forbes

(Contact details of the researcher and the supervisor are contained in the Information Sheet about this research)

NOTE: This consent form will be kept by the Southern Cross University researcher for their records.

I have been provided with an Information Sheet about the above research project. Yes ☐ No ☐

I know the name and contact details of the researcher and I understand I can contact them at any time with questions about the research project. Yes ☐ No ☐

I have read the Information Sheet and understand that I will be interviewed. Yes ☐ No ☐

I understand that it is my choice to take part in the interview. Yes ☐ No ☐

I understand that I can choose to stop the interview at any time. Yes ☐ No ☐

I understand that my real name will not be used in the report. Yes ☐ No ☐

I agree to be part of this research project. Yes ☐ No ☐

I understand that I am to return the other consent form to the researcher and that I am to keep this copy for myself. Yes ☐ No ☐

I understand that if I would like to receive the short report then I can provide my email or mail address below. Yes ☐ No ☐

Participant name: ____________________________________________________________

Participant signature: ________________________________________________________

Date: ________________________________

Contact Telephone # (optional): _____________________________

Email address (optional): ________________________________

Mail address (optional): ____________________________________________
INFORMATION SHEET TO PARENT/CAREGIVER

TITLE OF PROJECT: MyScience - communities of practice around the teaching and learning of primary science

NAME SUPERVISOR: Associate Professor Keith Skamp
NAME OF RESEARCHER: Anne Forbes
NAME OF PROGRAM IN WHICH ENROLLED: PhD (Southern Cross University)

Dear Parent/Caregiver,

Your daughter/son/ward is invited to participate in a research project. This letter is designed to provide you with some information to help you decide whether you are willing to give your consent for their participation to contribute to this research.

The purpose of this research is to look at participation in MyScience as a ‘community of practice’ where participants from different communities come together to work collaboratively on a common venture. Your daughter/son/ward has been participating in the MyScience program through their school.

I will be asking selected people involved in the program to talk to me individually (younger students may bring a non-speaking friend) to report their lived experiences of involvement in MyScience. Audio taped interviews will be conducted at the school during operating hours in consultation with the class/subject teacher and are likely to be 30 - 45 minutes duration.

To maximize the range of reported participant experiences, teacher selection has been through the recommendation of the Principal, and student selection through the recommendation of the selected teachers. Two to five teachers are being interviewed from your daughter/son/ward’s school, and five to ten students within each of those teacher’s classes.

Participation in the research study by your daughter/son/ward will provide valuable information about participants’ experiences in the MyScience program. The research will provide a better understanding of how this type of program has been experienced by the different participating groups of participants and whether there have been any challenges and/or lessons learned that might be applicable for other such programs. The findings will form part of a doctoral thesis which the student researcher – Anne Forbes – will also write up in an academic journal.

Participation is voluntary and your daughter/son/ward can withdraw at any time without giving a reason, including after the interview has begun. Should your daughter/son/ward decide to participate in individual interviews then other staff and students at the school may be aware of that participation. However, any information that might identify any individual will be changed or deleted in the research notes, and in any published findings, schools and individuals will be identified through pseudonyms.

Any questions regarding this research can be directed to the supervisor or the researcher by contacting them as follows:

Associate Professor Keith Skamp, keith.skamp@scu.edu.au
The published doctoral thesis will be available through the library at Southern Cross University. On request, a summary of the findings will be available for you to read.

This study has been approved by the Human Research Ethics Committee at Southern Cross University – approval number ECN-09-112 and also the NSW Department of Education and Training – approval number SERAP 2009125.

Complaints about the ethical conduct of this research should be addressed in writing to the following:

Ethics Complaints Officer
HREC
Southern Cross University
PO Box 157
Lismore, NSW, 2480
Email: sue.kelly@scu.edu.au

All complaints are investigated fully and according to due process under the National Statement on Ethical Conduct in Human Research and this University. Any complaint you make will be treated in confidence and you will be informed of the outcome.

If you agree to give permission for your daughter/son/ward to participate in this project, you should sign both copies of the consent form, retain one copy for your records and return the other copy to the class/subject teacher at your daughter/son/ward’s school.

Anne Forbes
Australian Catholic University
25A Barker Road
Strathfield
NSW 2135
CONSENT FORM FOR PARRENT/CAREGIVER

Copy for participant

TITLE OF PROJECT:  MyScience - communities of practice around the teaching and learning of primary science

NAME OF RESEARCHER:   Anne Forbes
NAME OF SUPERVISOR:   Associate Professor Keith Skamp

(Contact details of the researcher and the supervisor are contained in the Information Sheet about this research)

NOTE: This consent form will be kept by the Southern Cross University researcher for their records.

I have been provided with an Information Sheet about the above research project. Yes ☐ No ☐

The name and contact details of the researchers are contained therein and I understand I can contact them at any time regarding my participation in this research. Yes ☐ No ☐

I have read the information contained therein and understand the contents of this information. Yes ☐ No ☐

I understand that my participation is voluntary and there is no risk attached to my participation in this research. Yes ☐ No ☐

I understand that I can withdraw from this research at any time. Yes ☐ No ☐

I understand that my privacy and confidentiality will be protected. Yes ☐ No ☐

I therefore agree to participate in this research project. Yes ☐ No ☐

I understand that if I would like to receive any results of this research, I can give details of my email and/or mail address below and material will be forwarded to me in due course. Yes ☐ No ☐

Parent/caregiver name: ____________________________________________________________

Parent/caregiver signature: _______________________________________________________

Student name: ________________________________

Date: ______________________________________

Contact Telephone # (optional): ________________________________

Email address (optional): _________________________________________________

Mail address (optional): _________________________________________________
CONSENT FORM FOR PARENT/CAREGIVER

Copy for researcher

TITLE OF PROJECT: MyScience - communities of practice around the teaching and learning of primary science

NAME OF RESEARCHER: Anne Forbes

NAME OF SUPERVISOR: Associate Professor Keith Skamp

(Contact details of the researcher and the supervisor are contained in the Information Sheet about this research)

NOTE: This consent form will be kept by the Southern Cross University researcher for their records.

I have been provided with an Information Sheet about the above research project. Yes ☐ No ☐

The name and contact details of the researchers are contained therein and I understand I can contact them at any time regarding my participation in this research. Yes ☐ No ☐

I have read the information contained therein and understand the contents of this information. Yes ☐ No ☐

I understand that my participation is voluntary and there is no risk attached to my participation in this research. Yes ☐ No ☐

I understand that I can withdraw from this research at any time. Yes ☐ No ☐

I understand that my privacy and confidentiality will be protected. Yes ☐ No ☐

I therefore agree to participate in this research project. Yes ☐ No ☐

I understand that if I would like to receive any results of this research, I can give details of my email and/or mail address below and material will be forwarded to me in due course. Yes ☐ No ☐

Parent/caregiver name: __________________________________________________________

Parent/caregiver signature: _____________________________________________________

Student name: _________________________________________________________________

Date:  ________________________________________________________________

Contact Telephone # (optional): ________________________________________________

Email address (optional): ______________________________________________________

Mail address (optional): ________________________________________________________
INFORMATION SHEET TO TEACHERS

TITLE OF PROJECT: MyScience - communities of practice around the teaching and learning of primary science

NAME SUPERVISOR: Associate Professor Keith Skamp

NAME OF RESEARCHER: Anne Forbes

NAME OF PROGRAM IN WHICH ENROLLED: PhD (Southern Cross University)

Dear MyScience teacher,

You and five to ten students in your class are invited to participate in a research project. This letter is designed to provide you with some information to help you decide whether you are willing to contribute to this research.

The purpose of this research is to look at participation in MyScience as a ‘community of practice’ where participants from different communities come together to work collaboratively on a common venture. I will be asking selected people involved in the program to talk to me individually (younger students may bring a non-speaking friend) to report their lived experiences of involvement in MyScience. Audio taped interviews will be conducted at your school at a time that is convenient and will take about one hour. Student interviews are likely to be 30 - 45 minutes duration.

To maximize the range of reported participant experiences, teacher selection has been through the recommendation of your Principal, and student selection through the recommendation of the selected teachers. Two to five teachers are required from your school, and five to ten students within each of those teacher’s classes.

Through your participation and that of the students that you identify at your school, you will be providing valuable information about participants’ experiences in the MyScience program. The research will provide a better understanding of how this type of program has been experienced by the different participating ‘communities of practice’ and whether there have been any challenges and/or lessons learned that might be applicable for other such programs. The findings will form part of a doctoral thesis which the student researcher – Anne Forbes – will also write up in an academic journal.

Participation is voluntary and you, and/or your students can withdraw at any time without giving a reason, including after the interview has begun. Should you, and selected students decide to participate in individual interviews then other staff and students may be aware of that participation. However, any information that might identify any individual will be changed or deleted in the research notes, and in any published findings, schools and individuals will be identified through pseudonyms.

Any questions regarding this research can be directed to the supervisor or the researcher by contacting them as follows:

Associate Professor Keith Skamp, keith.skamp@scu.edu.au
The published doctoral thesis will be available through the library at Southern Cross University. On request, a summary of the findings will be available for you to read.

This study has been approved by the Human Research Ethics Committee at Southern Cross University – approval number ECN-09-112 and also the NSW Department of Education and Training – approval number SERAP 2009125.

Complaints about the ethical conduct of this research should be addressed in writing to the following:

Ethics Complaints Officer
HREC
Southern Cross University
PO Box 157
Lismore, NSW, 2480
Email: sue.kelly@scu.edu.au

All complaints are investigated fully and according to due process under the National Statement on Ethical Conduct in Human Research and this University. Any complaint you make will be treated in confidence and you will be informed of the outcome.

If you agree to participate in this project, you should sign both copies of the consent form, retain one copy for your records and return the other copy to the student researcher.

………………………………………
Researcher
Anne Forbes
Australian Catholic University
25A Barker Road
Strathfield
NSW 2135
CONSENT FORM FOR PARTICIPANTS

Copy for researcher

TITLE OF PROJECT: MyScience - communities of practice around the teaching and learning of primary science

NAME OF RESEARCHER: Anne Forbes

NAME OF SUPERVISOR: Associate Professor Keith Skamp

(Contact details of the researcher and the supervisor are contained in the Information Sheet about this research)

NOTE: This consent form will be kept by the Southern Cross University researcher for their records.

I have been provided with an Information Sheet about the above research project. Yes ☐ No ☐

The name and contact details of the researchers are contained therein and I understand I can contact them at any time regarding my participation in this research. Yes ☐ No ☐

I have read the information contained therein and understand the contents of this information. Yes ☐ No ☐

I understand that my participation is voluntary and there is no risk attached to my participation in this research. Yes ☐ No ☐

I understand that I can withdraw from this research at any time. Yes ☐ No ☐

I understand that my privacy and confidentiality will be protected. Yes ☐ No ☐

I therefore agree to participate in this research project. Yes ☐ No ☐

I understand that I am to return this consent form to the researcher and that I am to keep the other copy for myself. Yes ☐ No ☐

I understand that if I would like to receive any results of this research, I can give details of my email and/or mail address below and material will be forwarded to me in due course. Yes ☐ No ☐

Participant name: ________________________________________________________________

Participant signature: _____________________________________________________________

Date: ___________________________________________________________________________

Contact Telephone # (optional): ____________________________________________________

Email address (optional): __________________________________________________________

Mail address (optional):
CONSENT FORM FOR PARTICIPANTS

Copy for participant

TITLE OF PROJECT: MyScience - communities of practice around the teaching and learning of primary science

NAME OF RESEARCHER: Anne Forbes

NAME OF SUPERVISOR: Associate Professor Keith Skamp

(Contact details of the researcher and the supervisor are contained in the Information Sheet about this research)

NOTE: This consent form will be kept by the Southern Cross University researcher for their records.

I have been provided with an Information Sheet about the above research project. Yes ☐ No ☐

The name and contact details of the researchers are contained therein and I understand I can contact them at any time regarding my participation in this research. Yes ☐ No ☐

I have read the information contained therein and understand the contents of this information. Yes ☐ No ☐

I understand that my participation is voluntary and there is no risk attached to my participation in this research. Yes ☐ No ☐

I understand that I can withdraw from this research at any time. Yes ☐ No ☐

I understand that my privacy and confidentiality will be protected. Yes ☐ No ☐

I therefore agree to participate in this research project. Yes ☐ No ☐

I understand that I am to return the other consent form to the researcher and that I am to keep this copy for myself. Yes ☐ No ☐

I understand that if I would like to receive any results of this research, I can give details of my email and/or mail address below and material will be forwarded to me in due course. Yes ☐ No ☐

Participant name: ..........................................................................................................................

Participant signature: .....................................................................................................................

Date: ............................................................................................................................................

Contact Telephone # (optional): ....................................................................................................

Email address (optional): ...............................................................................................................

Mail address (optional):
INFORMATION SHEET TO SCIENTIST MENTORS

TITLE OF PROJECT: MyScience - communities of practice around the teaching and learning of primary science

NAME SUPERVISOR: Associate Professor Keith Skamp

NAME OF RESEARCHER: Anne Forbes

NAME OF PROGRAM IN WHICH ENROLLED: PhD (Southern Cross University)

Dear Scientist Mentor,

You are invited to participate in a research project. This letter is designed to provide you with some information to help you decide whether you are willing to contribute to this research.

The purpose of this research is to look at participation in MyScience as a ‘community of practice’ where participants from different communities come together to work collaboratively on a common venture.

I will be asking selected people involved in the program to talk to me individually (younger students may bring a non-speaking friend) to report their lived experiences of involvement in MyScience. Audio taped interviews will be conducted at your school at a time that is convenient and will take about one hour. Student interviews are likely to be 45 minutes duration.

To maximize the range of reported participant experiences, teacher selection has been through the recommendation of the Principal, and student selection will be through the recommendation of the selected teachers. Two to five teachers are required from your school, and five to ten students.

Through your participation and that of selected teachers and students at your school you will be providing valuable information about participants’ experiences in the MyScience program. The research will provide a better understanding of how this type of program has been experienced by the different participating ‘communities of practice’ and whether there have been any challenges and/or lessons learned that might be applicable for other such programs. The findings will form part of a doctoral thesis which the student researcher – Anne Forbes – will also write up in an academic journal.

Participation is voluntary and you, and/or the students can withdraw at any time without giving a reason, including after the interview has begun. Should you, and selected students decide to participate in individual interviews then other staff and students may be aware of that participation. However, any information that might identify any individual will be changed or deleted in the research notes, and in any published findings, schools and individuals will be identified through pseudonyms.

Any questions regarding this research can be directed to the supervisor or the researcher by contacting them as follows:

Associate Professor Keith Skamp, keith.skamp@scu.edu.au
Anne Forbes, 9701 4330, anne.forbes@acu.edu.au
The published doctoral thesis will be available through the library at Southern Cross University. On request, a summary of the findings will be available for you to read.

This study has been approved by the Human Research Ethics Committee at Southern Cross University and also the NSW Department of Education and Training.

This study has been approved by the Human Research Ethics Committee at Southern Cross University – approval number **ECN-09-112** and also the NSW Department of Education and Training – approval number **SERAP 2009125**.

Complaints about the ethical conduct of this research should be addressed in writing to the following:

Ethics Complaints Officer
HREC
Southern Cross University
PO Box 157
Lismore, NSW, 2480
Email: sue.kelly@scu.edu.au

All complaints are investigated fully and according to due process under the National Statement on Ethical Conduct in Human Research and this University. Any complaint you make will be treated in confidence and you will be informed of the outcome.

If you agree to participate in this project, you should sign both copies of the consent form, retain one copy for your records and return the other copy to the researcher.

……………………………………
Researcher

Anne Forbes
Australian Catholic University
25A Barker Road
Strathfield
NSW 2135
CONSENT FORM FOR PARTICIPANTS

Copy for researcher

TITLE OF PROJECT: MyScience - communities of practice around the teaching and learning of primary science

NAME OF RESEARCHER: Anne Forbes

NAME OF SUPERVISOR: Associate Professor Keith Skamp

(Contact details of the researcher and the supervisor are contained in the Information Sheet about this research)

NOTE: This consent form will be kept by the Southern Cross University researcher for their records.

I have been provided with an Information Sheet about the above research project. Yes ☐ No ☐

The name and contact details of the researchers are contained therein and I understand I can contact them at any time regarding my participation in this research. Yes ☐ No ☐

I have read the information contained therein and understand the contents of this information. Yes ☐ No ☐

I understand that my participation is voluntary and there is no risk attached to my participation in this research. Yes ☐ No ☐

I understand that I can withdraw from this research at any time. Yes ☐ No ☐

I understand that my privacy and confidentiality will be protected. Yes ☐ No ☐

I therefore agree to participate in this research project. Yes ☐ No ☐

I understand that I am to return this consent form to the researcher and that I am to keep the other copy for myself. Yes ☐ No ☐

I understand that if I would like to receive any results of this research, I can give details of my email and/or mail address below and material will be forwarded to me in due course. Yes ☐ No ☐

Participant name: __________________________________________________________

Participant signature: _______________________________________________________

Date: ___________________________________________________________________

Contact Telephone # (optional): ___________________________________________________________________

Email address (optional): ___________________________________________________________________

Mail address (optional): _______________________________________________________

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CONSENT FORM FOR PARTICIPANTS

Copy for participant

TITLE OF PROJECT: MyScience - communities of practice around the teaching and learning of primary science

NAME OF RESEARCHER: Anne Forbes

NAME OF SUPERVISOR: Associate Professor Keith Skamp

(Contact details of the researcher and the supervisor are contained in the Information Sheet about this research)

NOTE: This consent form will be kept by the Southern Cross University researcher for their records.

I have been provided with an Information Sheet about the above research project. Yes ☐ No ☐

The name and contact details of the researchers are contained therein and I understand I can contact them at any time regarding my participation in this research. Yes ☐ No ☐

I have read the information contained therein and understand the contents of this information. Yes ☐ No ☐

I understand that my participation is voluntary and there is no risk attached to my participation in this research. Yes ☐ No ☐

I understand that I can withdraw from this research at any time. Yes ☐ No ☐

I understand that my privacy and confidentiality will be protected. Yes ☐ No ☐

I therefore agree to participate in this research project. Yes ☐ No ☐

I understand that I am to return the other consent form to the researcher and that I am to keep this copy for myself. Yes ☐ No ☐

I understand that if I would like to receive any results of this research, I can give details of my email and/or mail address below and material will be forwarded to me in due course. Yes ☐ No ☐

Participant name: ...................................................................................................................

Participant signature: .............................................................................................................

Date: .....................................................................................................................................

Contact Telephone # (optional): ............................................................................................

Email address (optional): .......................................................................................................
INFORMATION SHEET TO SCIENTIST MENTOR COORDINATORS

TITLE OF PROJECT: MyScience - communities of practice around the teaching and learning of primary science

NAME SUPERVISOR: Associate Professor Keith Skamp
NAME OF RESEARCHER: Anne Forbes
NAME OF PROGRAM IN WHICH ENROLLED: PhD (Southern Cross University)

Dear MyScience Mentor Coordinator,

You and selected staff who have been mentors in the MyScience program at your institution are invited to participate in a research project. This letter is designed to provide you with some information to help you decide whether you are willing to contribute to this research.

The purpose of this research is to look at participation in MyScience as a ‘community of practice’ where participants from different communities come together to work collaboratively on a common venture.

I will be asking selected people involved in the program to talk to me individually to report their lived experiences of involvement in MyScience. Audio taped interviews will be conducted at your workplace or at another chosen location, at a time that is convenient and will take about one hour.

To maximize the range of reported participant experiences, Scientist Mentor selection will be through your recommendation. Five to ten mentors are required from each participating institution.

Through your participation, and that of selected Scientist Mentors you will be providing valuable information about participants’ experiences in the MyScience program. The research will provide a better understanding of how this type of program has been experienced by the different participating ‘communities of practice’ and whether there have been any challenges and/or lessons learned that might be applicable for other such programs. The findings will form part of a doctoral thesis which the student researcher – Anne Forbes – will also write up in an academic journal.

Participation is voluntary and you and any other selected mentors can withdraw at any time without giving a reason, including after the interview has begun. Should you decide to participate in individual interviews then other members of your institution may be aware of that participation. However, any information that might identify any individual will be changed or deleted in the research notes, and in any published findings, institutions and individuals will be identified through pseudonyms.

Any questions regarding this research can be directed to the supervisor or the researcher by contacting them as follows:

Associate Professor Keith Skamp, keith.skamp@scu.edu.au
Anne Forbes, 9701 4330, anne.forbes@acu.edu.au
The published doctoral thesis will be available through the library at Southern Cross University. On request, a summary of the findings will be available for you to read.

This study has been approved by the Human Research Ethics Committee at Southern Cross University – approval number ECN-09-112 and also the NSW Department of Education and Training – approval number SERAP 2009125.

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Ethics Complaints Officer
HREC
Southern Cross University
PO Box 157
Lismore, NSW, 2480
Email: sue.kelly@scu.edu.au

All complaints are investigated fully and according to due process under the National Statement on Ethical Conduct in Human Research and this University. Any complaint you make will be treated in confidence and you will be informed of the outcome.

If you agree to participate in this project, you should sign both copies of the consent form, retain one copy for your records and return the other copy to the researcher.

……………………………………
Researcher

Anne Forbes
Australian Catholic University
25A Barker Road
Strathfield
NSW 2135
**CONSENT FORM FOR PARTICIPANTS**

*Copy for researcher*

<table>
<thead>
<tr>
<th>TITLE OF PROJECT:</th>
<th>MyScience - communities of practice around the teaching and learning of primary science</th>
</tr>
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<tbody>
<tr>
<td>NAME OF RESEARCHER:</td>
<td>Anne Forbes</td>
</tr>
<tr>
<td>NAME OF SUPERVISOR:</td>
<td>Associate Professor Keith Skamp</td>
</tr>
</tbody>
</table>

(Contact details of the researcher and the supervisor are contained in the Information Sheet about this research)

**NOTE:** This consent form will be kept by the Southern Cross University researcher for their records.

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
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<tbody>
<tr>
<td>I have been provided with an Information Sheet about the above research project.</td>
<td>☐</td>
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<td>The name and contact details of the researchers are contained therein and I understand I can contact them at any time regarding my participation in this research.</td>
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<td>☑</td>
<td>☐</td>
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</tbody>
</table>

Participant name: ...........................................................................................................

Participant signature: .......................................................................................................

Date: .................................................................................................................................

Contact Telephone # (optional): ..........................................................

Email address (optional): ...............................................................................................

Mail address (optional):
CONSENT FORM FOR PARTICIPANTS

Copy for participant

TITLE OF PROJECT: MyScience - communities of practice around the teaching and learning of primary science

NAME OF RESEARCHER: Anne Forbes

NAME OF SUPERVISOR: Associate Professor Keith Skamp

(Note: The contact details of the researcher and the supervisor are contained in the Information Sheet about this research)

NOTE: This consent form will be kept by the Southern Cross University researcher for their records.

I have been provided with an Information Sheet about the above research project. Yes ☐ No ☐

The name and contact details of the researchers are contained therein and I understand I can contact them at any time regarding my participation in this research. Yes ☐ No ☐

I have read the information contained therein and understand the contents of this information. Yes ☐ No ☐

I understand that my participation is voluntary and there is no risk attached to my participation in this research. Yes ☐ No ☐

I understand that I can withdraw from this research at any time. Yes ☐ No ☐

I understand that my privacy and confidentiality will be protected. Yes ☐ No ☐

I therefore agree to participate in this research project. Yes ☐ No ☐

I understand that I am to return the other consent form to the researcher and that I am to keep this copy for myself. Yes ☐ No ☐

I understand that if I would like to receive any results of this research, I can give details of my email and/or mail address below and material will be forwarded to me in due course. Yes ☐ No ☐

Participant name: ..............................................................................................................................................

Participant signature: ................................................................................................................................................

Date: ................................................................................................................................................................................

Contact Telephone # (optional): ............................................................................................................................

Email address (optional): ........................................................................................................................................

Mail address (optional):
INFORMATION SHEET TO SCIENTIST MENTORS

TITLE OF PROJECT:  
MyScience - communities of practice around the teaching and learning of primary science

NAME SUPERVISOR:  
Associate Professor Keith Skamp

NAME OF RESEARCHER:  
Anne Forbes

NAME OF PROGRAM IN WHICH ENROLLED:  
PhD (Southern Cross University)

Dear MyScience Mentor,

You are invited to participate in a research project. This letter is designed to provide you with some information to help you decide whether you are willing to contribute to this research.

The purpose of this research is to look at participation in MyScience as a ‘community of practice’ where participants from different communities come together to work collaboratively on a common venture.

I will be asking selected people involved in the program to talk to me individually to report their lived experiences of involvement in MyScience. An audio taped interview will be conducted with you at your workplace or another location of your choosing, at a time that is convenient and will take about one hour.

To maximize the range of reported participant experiences, Scientist Mentor selection has been through identification by the MyScience Mentor Coordinator of your institution. Five to ten mentors are required from each participating institution.

Through your participation, you will be providing valuable information about your experience of the MyScience program. The research will provide a better understanding of how this type of program has been experienced by the different participating ‘communities of practice’ and whether there have been any challenges and/or lessons learned that might be applicable for other such programs. The findings will form part of a doctoral thesis which the student researcher – Anne Forbes – will also write up in an academic journal.

Participation is voluntary and you can withdraw at any time without giving a reason, including after the interview has begun. Should you decide to participate in individual interviews then other members of your institution may be aware of that participation. However, any information that might identify any individual will be changed or deleted in the research notes, and in any published findings, institutions and individuals will be identified through pseudonyms.

Any questions regarding this research can be directed to the supervisor or the researcher by contacting them as follows:

Associate Professor Keith Skamp, keith.skamp@scu.edu.au
Anne Forbes, 9701 4330, anne.forbes@acu.edu.au

The published doctoral thesis will be available through the library at Southern Cross University. On request, a summary of the findings will be available for you to read.
This study has been approved by the Human Research Ethics Committee at Southern Cross University – approval number ECN-09-112 and also the NSW Department of Education and Training – approval number SERAP 2009125.

Complaints about the ethical conduct of this research should be addressed in writing to the following:

Ethics Complaints Officer
HREC
Southern Cross University
PO Box 157
Lismore, NSW, 2480
Email: sue.kelly@scu.edu.au

All complaints are investigated fully and according to due process under the National Statement on Ethical Conduct in Human Research and this University. Any complaint you make will be treated in confidence and you will be informed of the outcome.

If you agree to participate in this project, you should sign both copies of the consent form, retain one copy for your records and return the other copy to the researcher.

………………………………………
Researcher

Anne Forbes
Australian Catholic University
25A Barker Road
Strathfield
NSW 2135
CONSENT FORM FOR PARTICIPANTS

Copy for researcher

TITLE OF PROJECT: MyScience - communities of practice around the teaching and learning of primary science

NAME OF RESEARCHER: Anne Forbes

NAME OF SUPERVISOR: Associate Professor Keith Skamp

(Contact details of the researcher and the supervisor are contained in the Information Sheet about this research)

NOTE: This consent form will be kept by the Southern Cross University researcher for their records.

I have been provided with an Information Sheet about the above research project. Yes ☐ No ☐

The name and contact details of the researchers are contained therein and I understand I can contact them at any time regarding my participation in this research. Yes ☐ No ☐

I have read the information contained therein and understand the contents of this information. Yes ☐ No ☐

I understand that my participation is voluntary and there is no risk attached to my participation in this research. Yes ☐ No ☐

I understand that I can withdraw from this research at any time. Yes ☐ No ☐

I understand that my privacy and confidentiality will be protected. Yes ☐ No ☐

I therefore agree to participate in this research project. Yes ☐ No ☐

I understand that I am to return this consent form to the researcher and that I am to keep the other copy for myself. Yes ☐ No ☐

I understand that if I would like to receive any results of this research, I can give details of my email and/or mail address below and material will be forwarded to me in due course. Yes ☐ No ☐

Participant name: ________________________________________________________________

Participant signature: ____________________________________________________________

Date: __________________________________________________________________________

Contact Telephone # (optional): __________________________________________________

Email address (optional): __________________________________________________________

Mail address (optional):
CONSENT FORM FOR PARTICIPANTS
Copy for participant

TITLE OF PROJECT: MyScience - communities of practice around the teaching and learning of primary science

NAME OF RESEARCHER: Anne Forbes
NAME OF SUPERVISOR: Associate Professor Keith Skamp

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Participant signature: .......................................................................................................... Date: ...........................................................................................................................
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INFORMATION SHEET TO SCIENTIST MENTORS

TITLE OF PROJECT: MyScience - communities of practice around the teaching and learning of primary science

NAME SUPERVISOR: Associate Professor Keith Skamp

NAME OF RESEARCHER: Anne Forbes

NAME OF PROGRAM IN WHICH ENROLLED: PhD (Southern Cross University)

Dear Scientist Mentor,

You are invited to participate in a research project. This letter is designed to provide you with some information to help you decide whether you are willing to contribute to this research.

The purpose of this research is to look at participation in MyScience as a ‘community of practice’ where participants from different communities come together to work collaboratively on a common venture. I will be asking selected people involved in the program to talk to me individually (younger students may bring a non-speaking friend) to report their lived experiences of involvement in MyScience. Audio taped interviews will be conducted at your school at a time that is convenient and will take about one hour. Student interviews are likely to be 45 minutes duration.

To maximize the range of reported participant experiences, teacher selection has been through the recommendation of the Principal, and student selection will be through the recommendation of the selected teachers. Two to five teachers are required from your school, and five to ten students.

Through your participation and that of selected teachers and students at your school you will be providing valuable information about participants’ experiences in the MyScience program. The research will provide a better understanding of how this type of program has been experienced by the different participating ‘communities of practice’ and whether there have been any challenges and/or lessons learned that might be applicable for other such programs. The findings will form part of a doctoral thesis which the student researcher – Anne Forbes – will also write up in an academic journal.

Participation is voluntary and you, and/or the students can withdraw at any time without giving a reason, including after the interview has begun. Should you, and selected students decide to participate in individual interviews then other staff and students may be aware of that participation. However, any information that might identify any individual will be changed or deleted in the research notes, and in any published findings, schools and individuals will be identified through pseudonyms.

Any questions regarding this research can be directed to the supervisor or the researcher by contacting them as follows:

Associate Professor Keith Skamp, keith.skamp@scu.edu.au
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Researcher

Anne Forbes  
Australian Catholic University  
25A Barker Road  
Strathfield  
NSW 2135
CONSENT FORM FOR PARTICIPANTS

Copy for researcher

TITLE OF PROJECT: MyScience - communities of practice around the teaching and learning of primary science

NAME OF RESEARCHER: Anne Forbes
NAME OF SUPERVISOR: Associate Professor Keith Skamp

(Contact details of the researcher and the supervisor are contained in the Information Sheet about this research)

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Participant signature: ........................................................................................................................................

Date: .........................................................................................................................................................

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TITLE OF PROJECT: MyScience - communities of practice around the teaching and learning of primary science

NAME OF RESEARCHER: Anne Forbes

NAME OF SUPERVISOR: Associate Professor Keith Skamp

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Mail address (optional):
Appendices

APPENDIX D

Extract from Cathy’s interview indicating how (her) was used in the example in Section 3.5.2 and 3.5.3 to replace ‘my’ in line 238.

I: Yeah. okay. Cool. So what have you got out of doing MyScience?

R: Oh, okay. Ooh, I have to think back to before MyScience to answer that question.

I: Yeah, sort of like …

R: Oh, lots of things. As I said before, it’s the professional learning and just, again, the way of dealing with the science subjects. I’ve always been a very hands on person anyway. I’m not the sort of person …

I: [0:05:18.1]

R: And you said you like graphic, like, art more.

I: Yes, yeah.

R: So it was a real, new topic area?

I: It was – yeah. It was just a way of sort of focusing my energies into something that I hadn’t put that much focus into before. I’d always taught it and covered the syllabus and everything and in a reasonably practical way, but never focusing particularly on that, just that skills side of the Investigation process.

I: Okay.

R: I’d always, you know, just at looked at, you know, this is what I’ve got to cover and I’ll think of ways of getting the kids to investigate it, whereas it’s now made me think of the importance of the children coming up with the investigation.

I: Okay.

R: So it’s just opened up a different aspect for me.

I: So you learned more about investigating, so is there anything else you’ve got out of doing it?
Extract from Carmel’s interview indicating the source of data used to create the quote cited in Section 3.5.3.

I: Do you find that there’s many who haven’t done any?

P: Heaps, heaps haven’t done any still. Um, well at least identified that they’ve done some. Um, so like I took um – how many groups did I have, two or three? Um, two groups I think it was of Year 6 orientation last Friday or last Thursday and of those kids there was only a handful that had done um, that had done some science and I think that only two of them had done My Science. Um, so there’s still a huge number that don’t. So I think in terms of like you mixed classes, when you still feel like you’re starting a square one, um, but like 7R that I, which is the top that, which is the top Year 7 class…

I: Yeah.

P: Um, like I took them this year and we did like a major, like a major project type thing, group project similar to My Science at the start of the year.

I: So had you don’t that before? Or like how…

P: No this was the first year that I attempted…

I: So why did you decide, so what I’m trying to get out of here is, has your experience and involvement in My Science and seeing what you can do in primary setting, is that shifting or making you try different things in high school?

P: Um, not particularly I don’t think. Um, I, I think yeah the top Year 7 class, when I spoke to them at the start of the year a number of them had done My Science, so um, like the majority of them had done My Science. So whether that’s why they’re in the top science class or whether that just happens to correspond, who knows.

I: That’s interesting.

P: But a lot of them had done it and so when we – and we have in our semester one course we have a topic called Investigation and up until this year it had been a largely um, yeah, that sort of recipe based investigation. So it really wasn’t investigation, it was like, kind of like here’s grasp that we can try kind of thing. Um, but because a number of them had done My Science um, and because it is mandatory that you do a stage four major project with the kids, um, I thought this year we’d try it. Um, we did try it, so I did up like basically a scaffold of thing for them to do.

I: So how did that go, this year?

P: So 7R, so the top Year 7 class hammered it. They loved it, no dramas. I had another Year 7 class…
I: Did you have a theme or did you just let them do it on anything?

P: No I just let them do it on anything.

I: Yep.

P: Um, because like, because like it’s right at the start of Year 7 and they’re so excited and there’s — and you know, they arrive and there’s so much equipment in the lab and so I really wanted it to just be um, you know an opportunity to kind of almost become more acquainted with the lab, the things in it, all of those, so lots of them of course were like “Haz, I want to use a Bunsen burner,” you know and so um, so I wanted them to be able to have an opportunity to use that if that was the sort of angle that they wanted to take. So no I didn’t, I didn’t have a theme or anything like that. Um...

I: So you were talking about, yeah do the Year 7 project, yeah.

P: Oh yeah, so the um, the only other...

I: That sounds really interesting.

P: Yeah, it was good. The other Year 7 class, which was like a mixed ability um, kind of class um, they also got really into it but it was longer process for them. Um, so you know, the whole — yeah developing that sort of...

I: They hadn’t actually, they didn’t have, know the steps.

P: They didn’t have the formation format.

I: So in terms of, so okay if you look at those two Year 7 classes, the one who had done it could get going quicker and get started if you like ‘cause they’d already...

P: Yeah.

I: ...knew the steps but what was the depth, like understanding or drilling down you know for the data set and things like that?

P: Um, I guess the top Year 7, like the top class, I mean it’s difficult to say what the...

I: ‘Cause they’re brighter kids anyway.

P: ...They’re brighter anyway and so it’s hard to know whether — I think My Science certainly had an impact. The fact that um, you know that we were revising things rather than learning things for the first time, the fact that they could do like, peer -