Repositioning the Experience of Teachers Within the Subject Department in the Context of Social Change: A Study of the Integration of New Technologies in the Practice of Science Teachers in Three Schools

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Abstract

This research is concerned with the agency and community of science teachers. The research question asked, ‘What are the problems and prospects that shape the professional learning in the school subject department, and how can this influence individual teachers’ practice in the context of change?’ The focus was on the historical social action of science teachers in the integration of new technologies in their everyday practice in the first 10 years of the introduction of new technologies in schools.

In this study, I took the view that teachers’ workplace learning is a characteristic of the individual, their work environment, and their working relationships. Therefore, I began to explore science teachers’ experience of learning to work with new technologies as members of their primary workplace site, science departments, situated in a school context. I used the work of Wenger, McDermott, and Snyder (2002) on communities of practice and Edwards’ (2010) theory of relational agency, in concert with Harvey’s (2002) interpretation of Bhaskar’s (1998) transformational model of social activity, to create an analytical frame to interpret the data collected during fieldwork.

To investigate the social context of the three science departments and how each might impact the learning of the individual science teacher within them, I chose the naturalistic approach of ethnographic collective case study. Using this approach enabled the collection of detailed data about the science teacher and their respective departments. I employed a multiple methods approach to data collection using one-to-one interviews, field observations, field notes, and document analysis. The data collected from each school is presented in the form of interpretive case narratives, with an interpretation of how each department fits the analytical framework.
The three interpretive frameworks, when used in conjunction with the respective case narratives in this study, can readily be employed as case-based teaching resources in teacher education or as objects of comparison for those responsible for managing change in the secondary school. It is anticipated that through discourse generated by these case studies, teachers will identify the problems and prospects existent in subject departments that are likely to shape the professional learning associated with the introduction of a major policy innovation, such as the integration of new technologies.
Declaration

This is to certify that

(1) the thesis comprises only my original work towards the Doctor of Education,

(2) due acknowledgement has been made in the text to all other material used,

(3) the thesis is fewer than 100,000 words in length, exclusive of tables, maps, bibliographies, and appendices.
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<th>Description</th>
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<tbody>
<tr>
<td>ASEP</td>
<td>Australian Science Education Project</td>
</tr>
<tr>
<td>CRT</td>
<td>casual relief teaching</td>
</tr>
<tr>
<td>ICDL</td>
<td>International Computer Drivers Licence</td>
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<tr>
<td>ICT</td>
<td>information and communications technology</td>
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<tr>
<td>IT</td>
<td>information technology</td>
</tr>
<tr>
<td>JSSP</td>
<td>Junior Secondary Science Project</td>
</tr>
<tr>
<td>LoTE</td>
<td>language other than English</td>
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<tr>
<td>MCEETYA</td>
<td>Ministerial Council for Education, Employment, Training and Youth Affairs</td>
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<tr>
<td>MSN</td>
<td>MicroSoft Network</td>
</tr>
<tr>
<td>PC</td>
<td>personal computer</td>
</tr>
<tr>
<td>PD</td>
<td>professional development</td>
</tr>
<tr>
<td>RSGC</td>
<td>Redlands Secondary Girls College</td>
</tr>
<tr>
<td>SAMR</td>
<td>substitution, augmentation, modification, and redefinition</td>
</tr>
<tr>
<td>TMSA</td>
<td>transformational model of social activity</td>
</tr>
<tr>
<td>TPCK</td>
<td>teaching pedagogy and content knowledge</td>
</tr>
<tr>
<td>UK</td>
<td>United Kingdom</td>
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<tr>
<td>US</td>
<td>United States</td>
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<tr>
<td>VCE</td>
<td>Victorian certificate of education</td>
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<tr>
<td>VP</td>
<td>vice principal</td>
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<tr>
<td>WWW</td>
<td>World Wide Web</td>
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Chapter 1: Down the Rabbit Hole

‘Curiouser and curiouser!’ cried Alice. (Carroll, 1865)

1.1 Introduction

Just as Alice’s journey into Wonderland began with her curiosity to follow the White Rabbit, so my journey into the world of educational research began with my curiosity about the apparent failure among many of my colleagues in schools to grasp, accept, or even realise the profound educational significance of integrating the use of new information technologies into their professional identities as science teachers, while others fully embraced the challenges posed to their practice.

In this opening chapter, I set the scene for my research and outline the structure of my thesis. In situating the study, I draw on relevant policy and literature to explain the context of the study and its relevance to current trends in the integration of new technologies. I position myself in the study as a science teacher and teacher–educator, state my research questions, and outline my study design.

1.2 The Shape of Things to Come

In 1993, Scaife and Wellington spoke of their expectations and hopes for the integration of information and communications technology (ICT) in the science curriculum and the impact that this integration would have on the teaching and learning of science.

If we let it, the computer can increase the effective academic learning time students spend learning the necessary and traditional content goals of the science curriculum. But more than that, the computer can indeed help us transform the emphasis in the present curriculum—learning facts, vocabulary, terms and sometimes misconceptions or thin conceptions—into an existing and relevant curriculum, that emphasizes concrete, real world problem solving that has a technological and societal context. (p. 9)
They predicted that ICT would change the nature of science teaching from one that is content driven to one that is process driven, with teachers moving from the role of leaders and experts to fellow learners and facilitators. This implies that the classroom culture would move from competitive, individualistic learning to a more authentic, collaborative learning, encouraging group work and the negotiation of tasks.

A decade later, Musker (2004) presented us with a vision that illustrated how a high level of resources could potentially transform a science lesson. Musker’s fictitious lesson began with the teacher brainstorming a scientific concept with students on an interactive whiteboard to bridge the students’ everyday experiential conversation to the disciplinary discourse of science, a necessity later argued for by Correia Jesuino (2008). In Musker’s vision, the ideas generated would be sent via an infrared link to a shared access computer folder. The students would access this folder, discuss and research the ideas using the World Wide Web (WWW), and develop plans to investigate the concept experimentally. An actual experiment would be carried out, with data being gathered using data loggers (sensory probes), digital photography, and video. Finally, the students would use spreadsheets to process their results and generate graphs, accessing information from CD ROMs on their school Intranet system and the WWW, and to compare their results with previous students’ results, which would help to develop their conclusions. The final product was to be a video, a Microsoft Word document, or a Microsoft PowerPoint presentation to be emailed to the teacher for electronic marking.

A decade later, this scenario remains an elusive dream to enact in many secondary school science departments across the world. While several elements of Musker’s, and indeed Scaife and Wellington’s, vision are being observed in many secondary school science departments, it is widely reported that Musker’s imagined integration of ICT in science pedagogy is rarely realised or indeed attempted (Bingimlas, 2009; Campbell &
Bohn, 2008; Ertmer & Ottenbreit-Leftwich, 2013; Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012; Jones, 2004; Korte & Hüsing, 2006; Law, 2008; Ng & Gunstone, 2003; Orlando, 2014; Selwyn, 2009; Selwyn, 2013; Yu, 2013).

1.3 Personal Motivation for the Study

The motivation for this study evolved from my personal journey in ICT professional development (PD). As the science coordinator in a secondary school in the United Kingdom (UK) in 1998, I participated in a government-sponsored initiative to promote ICT use in the science curriculum. Before participating in this PD initiative, I would have described my personal use of computers as ‘basic’. I was able to use Microsoft Word in a limited capacity to produce class materials and Microsoft Excel to keep a record of student attendance. However, beyond this administrative use, I saw little potential for computers in my secondary modern classroom in London, especially as I only had one stand-alone personal computer (PC). I was, of course, aware of the availability of software programs for science and had seen these advertised in educational media and promoted at conferences. I had noticed that the majority of these packages boasted of easy test generation, or offered drill-and-skill activities, to aid student revision. There were programs like data logging that automated data gathering in the class laboratory, but I found these alienating. I had memories of using such data-gathering devices at the beginning of my teaching career in the early 1990s, with little success, a great deal of class time wasting, and some personal embarrassment. I was interested in simulation and modelling software, but there were more pressing items on which to spend our very limited departmental budget, such as modernising the laboratories, replacing equipment, and purchasing class texts.

During the PD program in London that focused my interest in 2000, I cannot remember a single Pentecostal vision of the value and potential of ICT use in science

teaching. However, I was aware of the large-scale government investment in making computers accessible in schools and the associated rhetoric of changing broader economic necessity. I now attribute my personal progress and the successes experienced by the other members of the science department to two social influences: (1) a relatively small, established, and collegial group of teachers and (2) the implementation of an ICT PD program that met our individual needs and limited resources. During our PD program, we often encountered problems, and people did become frustrated and despondent about their own ability to learn the new skills required to integrate ICT into the science curriculum. However, by working together through tensions between our habits of interpretation and belief, and in openly sharing our successes and failures, ICT slowly, over the next two years, became an everyday part of our teaching discussions and practices. In hindsight, in the early days we were not innovative in our use of ICT tools, but as our familiarity and confidence grew, some of us were inspired to try more ambitious ICT activities with our students. Collaborative staffroom conversations about personal successes and problems were significant to the social constitutive process of our learning. Over the two-year period, as well as learning from each other, we learnt from the feedback that our students gave us. While this feedback was typically informal, it served to give a strong indication of which particular activities worked well and were worth pursuing, and which activities needed development or abandoning.

In 2001, I was approached to be an online tutor of the PD program, supporting teachers participating in other schools. As an online tutor, I gained insight into the social organisation and operations of science departments around the UK. The program assumed all teachers in all schools would use the same PD package, but not all the schools and the teachers in them were responding in the same way or having the same success. At the end of the two-year government-sponsored funding period, two of the
schools I was coaching were far from the completion envisaged by the program administrators. Faced with reflecting on my own and others’ naïve confidence, I became interested initially in the differences in uptake between schools and realised that I needed a deeper understanding of the issues and problems involved for individual teachers and schools in changing behaviour in what initially seemed a simple process of learning to use an evolving suite of powerful new teaching resources.

Following my relocation to Australia in 2002, and while teaching science as a casual relief (emergency) teacher in a number of Melbourne secondary schools, I observed, like Alice, similar exotic behaviour in this information technology wonderland of science teaching. After taking up an academic position in initial teacher education, where formal training in the use of ICT was being introduced, I set out to explore teachers’ PD in the area of their use of the new ICTs.

1.4  **Context of the Study**

Over the last 30 years, as in many other countries, technology has transformed Australian life and become pervasive in workplaces, homes, and society. Consequently, since 1999 the integration of ICT into school curricula has been a major political focus, with the Australian Federal Government’s *Strategic Framework for the Information Economy* (Alston, 1998) calling for a national approach to deliver the skills and education required for Australians to participate in the global information economy. This document identified the use of ICT as an instructional tool that could provide students with rich learning experiences that foster critical thinking and problem-solving skills. As a direct response to this document, *The Adelaide Declaration on the National Goals for Schooling in the Twenty-First Century*, produced by the Ministerial Council for Education, Employment, Training and Youth Affairs (MCEETYA), stated,
School leavers should be confident, creative and productive users of the new technologies, including information and communication technologies, and be able to understand the impact of those technologies on society. (1999, p. 2)

Subsequent federal and state policy documents, for example, the *Blueprint for Education and Early Childhood Development* (Department of Education and Early Childhood Development [DEECD], 2008), the *Melbourne Declaration on Educational Goals for Young Australians* (MCEETYA, 2008), the Digital Education Revolution program (Department of Education, Employment and Workplace Relations [DEEWR], 2010) to list a few, have been developed in an attempt to create a ‘strategic framework’ to enable Australian schools and educational organisations to raise the profile of ICT and prepare a workforce that will enable Australia to compete in the knowledge society. Common goals guiding these policy initiatives and the allocation of accompanying funding have emphasised three major areas: (1) improving technology infrastructure, (2) increasing pupil and teacher access to technology, and (3) the provision of PD to enable teachers to develop their ICT capabilities in order to enhance and enrich teaching and learning.

Evidence indicates that over the last 20 years, these policy initiatives have been relatively successful in delivering the three goals (Finger & Trinidad, 2002; Law, 2008; MCEETYA, 1999). In most private and government schools there have been significant improvements in school technology infrastructure and an increase in the number of computers, which has improved both pupil and teacher access to ICT. In addition, many teachers have participated in PD programs that have improved their basic ICT skills and resulted in them using ICT for personal and administrative tasks. However, research (Bingimlas, 2009; Cox, 2008; Ertmer et al., 2012; Hayes, 2007; Howard, Chan, Mozejko, & Caputi, 2015; Jamieson-Proctor, Burnett, Finger, & Watson, 2006; Law,
2008; MCEYTA, 1999; Mueller, Wood, Willoughby, Ross, & Specht, 2008; Newhouse, 2002; Ng & Gunstone, 2003; Orlando, 2014; Watson, 1999; Yu, 2013) has highlighted that the integration of ICT into pedagogic practice and subject disciplines has been both variable and disappointing. Since the main drive of Australian policy rhetoric was to enhance and enrich the teaching and learning in schools, this would seem to be an area of concern, and it would appear that improving infrastructure and providing better access to ICT facilities have not addressed the main barriers to successful ICT integration in subject pedagogy.

Significantly, this issue of variable integration of ICT within teachers’ practice, and across subject disciplines, is not one that is isolated to Australian schools. Research has indicated that similar circumstances have been identified in many countries, including Canada (Goodson & Mangan, 1995; Sicilia, 2006), Denmark (Balanskat, Blamire, & Kefala, 2006), Turkey (Özden, 2007; Toprakci, 2006), the United States (US) (Cuban, 2001; Smerdon et al., 2000), and the UK (Jones, 2004; Cox, 2008; Hennessy, Ruthven, & Brindley, 2005; John, 2005; Rogers & Barton, 2004; Somekh, 2010). While each study highlights specific contextual issues related to national policies and curricula, a common issue has emerged in these and in Australian investigations. This highlights that while attention has been given to improving teachers’ personal skills in using ICT applications through PD programs, little attention has been undertaken to guide and support teachers in the use of ICT within their classroom practice.

In my opinion, this has been a major oversight in the implementation of Australian governmental policy associated with teacher PD, and I agree with the analysis of Kennewell, Parkinson, and Tanner (2002) that teachers need subject-specific PD to develop their ‘metacognitive knowledge and skills, in order to control the
computer as a tool and spot the opportunities for appropriate use’ (p. 92) in their everyday practice, as well as using ICT as a vehicle to transform pedagogy (Law, 2008). Conditions that can help integrate ICT use into teachers’ pedagogic practice include providing PD that will equip teachers with appropriate learning experiences that focus on the use of ICT within their subject discipline (Özden, 2007; Schoepp, 2005), time to practice using subject-specific ICT (Gomes, 2005; Sicilia, 2006), and the freedom to experiment and make mistakes without major consequences (Balanskat et al., 2006; Bingimlas, 2009). Notably, this is not all that is required, as I became aware in my role in the UK as an online tutor for a PD program that was subject specific for science teachers.

In addition, research suggests that many teachers will need to change their practice and epistemological beliefs in order to integrate ICT into their practice (Cox, Preston & Cox, 1999; Korte & Hüsing, 2006; Hedberg, 2011; Law, 2008; Schoepp, 2005; Yelland, 2006), and that this will only occur if teachers are convinced they will benefit from the integration of ICT in terms of improvement in their professional standing with colleagues in their schools and in their classrooms, with improved student learning. As Loveless, DeVoogd, and Bohlin (2001) remind us,

Technology doesn’t change practice; people do—as their knowledge understanding, skills, beliefs and goals change. If the practice in the use of ICT in schools changes, it will be because educators are being deliberate about shifting to a new pedagogy by changing the norms and routines that shape the daily work environment. (p. 73)

As far back as 1991, Fullan maintained that a supportive work environment is essential to achieve such a major change in teachers’ engagement, understanding, and re-interpretation of their role. The daily work environment, which shapes Australian secondary school teachers’ routines and practices, is the subject department. Siskin
(1994) proposed that the subject department is the dominant social structure in the secondary school, suggesting that the subject department rather than the individual teacher or the school should be the unit of analysis in educational research. It is here that the subject teacher learns how to plan, support, and evaluate student learning, in essence where they develop their subject pedagogy (Hennessy et al., 2005). The subject department also provides the social context in which teachers demonstrate their competencies, and through the negotiation of meaning, mediate the importance that particular artefacts (such as technologies) have on teachers’ practice (Beckett, 2011). In essence, the subject department provides the horizon of significance or value system of the community, and it functions to shape teachers’ sense of authentic and autonomous self as they develop their professional identities (Taylor, 1992). It is therefore reasonable to assume that the success of a reform, such as the integration of ICT, will be conditional on the impact that it has on both the subject department, personified as a group of colleagues, and upon the prevailing subject culture. Kennewell et al. (2002) stressed that ‘teachers are social learners, and change is likely to remain superficial unless it is based on their own desires for change arising from within the subject culture’ (p. 94).

While some UK studies have explored the effect of subject culture on the integration of ICT, they have tended to focus on comparisons across subject disciplines (Hennessy et al., 2005; John, 2005; Selwyn, 1999; Somekh, 2008) and explored the congruence between subject pedagogy, subject culture, and the integration of ICT. Only one study has specifically drawn attention to the impact of science subject culture on teachers’ integration of ICT, conducted by Baggott La Velle, McFarlane, John, and Brawn (2004). This study, which was part of the broader InterActive Education project, a research initiative that involved 50 staff from 10 schools (primary and secondary),
reported on the perceptions and experiences of five male science teachers. These teachers came from different schools and had volunteered to participate in the project to improve their ICT capabilities. A report of their research (Baggott La Velle et al., 2004) presented the views of the five science teachers with regard to the opportunities and problems they had encountered when they introduced ICT into the established subject culture of their science classrooms. Although this research clearly took into account the individual teachers’ personal theories, subject epistemologies, and pedagogical styles, it did not set out to formally investigate the influence that the sociocultural dynamics of the science department, to which each teacher belonged, had on their learning experience and subsequent integration of ICT into their pedagogy.

While I focused on the integration of ICT in this study, my research aim held a broader interest in relation to the social space, the ‘secondary school department’, as a professional learning environment.

1.5 Research Questions

The broad empirical question guiding my enquiry was:

What are the problems and prospects that shape the professional learning in the school subject department, and how can this influence individual teachers’ practice in the context of change?

In this study, the professional learning environment was the secondary school science department, and the change context was the integration of ICT into secondary science teaching, in accordance with federal and state government policy. To gain a deeper understanding of both the individual and collective experiences of science teachers as they attempted to integrate, assimilate, and accommodate ICT in their teaching and thinking about their teaching and ways the learning environment might facilitate or
forestall this, I operationally focused the broader question as three subquestions.

Through teachers’ personal accounts classroom observations of their practice and document analysis the following three subquestions were explored:

1. How have the subject teachers’ beliefs, values, and perceptions of their subject disciplines impacted their agency in the integration of ICT in practices?

2. How important have a shared repertoire, common practice, and culture existent within a department been in shaping the integration of ICT in teachers’ practices?

3. How important have personal and social relationships within department been in influencing the integration of ICT in teachers’ practices?

To answer these questions, I conducted my research in the science departments of three secondary girls schools in the Melbourne metropolitan region of the state of Victoria, Australia.

1.6 Research Design

To investigate the social context of the three science departments and how each might impact the learning of the individual science teachers within them, I chose the naturalistic approach of ethnographic collective case study (Rawls, 2011). Stake (1995) described the collective case study as an instrumental case study applied to several cases in order to investigate a particular phenomenon or issue. He explained that in a collective case study, each case is still looked at in depth, ‘its context scrutinized, its ordinary activities detailed’ (Stake, 1995, p. 437) and maintained that the researcher does this to gain a better understanding of the phenomenon and its applicability to a broader context.
Importantly, using this case study approach enabled the collection of detailed data about the science teacher and their respective departments. It was my goal to richly capture the teachers’ voices, witness their pedagogy, and understand the cultural context of their professional learning environment. To achieve this, I employed a multiple methods approach to data collection as advocated by Hitchcock and Hughes (1995), using one-to-one interviews, field observations, and document analysis. These are discussed in Chapter 3 (‘Methodology’). The data collected from each school is presented in the form of interpretive vignettes, which blend the findings with a discussion of each learning environment and the practitioners within it.

The schools that I approached to participate in the study were three girls secondary schools in metropolitan Melbourne. I purposely made this choice because I had spent quite a large amount of my own teaching career in girls schools, and felt that I would be more likely to be attuned to the cultural dynamics of this environment. Two of the chosen schools were state funded with a student intake from Years 7–12, and the third was a private school with a student intake from Years K–12. In addition to drawing on very different demographic areas, the three schools offered different organisation and access arrangements to their ICT facilities. In selecting these schools, I intended not only to gain a deep understanding into the practices of ICT integration of individual teachers in each science department, but also to compare the similarities and differences in practice between the three.

1.7 Conceptual Framework

1.7.1 Assessing integration

There has been considerable debate about the term ‘ICT integration’, and it has been defined in many ways in both policy documentation and research (Lloyd, 2005; Trinidad, Clarkson, & Newhouse, 2004). Lloyd (2005) contended that these varied
conceptions of ICT integration are the reasons that researchers have found it difficult to determine the level of ICT integration in Australian classrooms. This study did not seek to formally quantify ICT integration in science classrooms; rather, it presented an understanding of the professionally formative processes in which science teachers engage in the incorporation of ICT within their pedagogy. Therefore, to do this, I ‘loosely’ employed a model proposed by Puentedura (2010) to describe the processes by which teachers effectively integrate ICT in their classroom practice.

Puentedura proposed that teachers use technology in four stages: substitution, augmentation, modification, and redefinition (SAMR). The first two stages, substitution and augmentation, are when teachers use ICT in their practice to enhance student learning by directly substituting ICTs as tools to complete existing activities. An example of this is the use of word processing to write an experimental report or the use of a Smart board to present notes that could equally have been given in paper form. Modification and redefinition are transformational stages, when teachers recognise the opportunities offered by ICT and redesign or create new learning and teaching activities that would previously have been difficult or even impossible without its availability.

While this model has been criticised for being too simplistic to measure effective ICT integration in teachers’ practice alone (Angeli & Valanides, 2009; Phillips, 2015; Ward, 2012), it served my purpose as a point of reference alongside the interpretive analysis of the phenomenological–ontological accounts of the teachers in the three science departments in the three case study schools, which was the central research activity.

1.7.2 Learning to use ICT

Learning through PD activities that have been offered to teachers to improve their ICT capabilities have commonly taken the form of highly structured and formal training courses conducted away from the workplace (school and classroom setting). These
courses have had a tendency to focus on dissemination, often designed to provide teachers with what is seen as essential knowledge and/or skills. While this professional learning has supported teachers’ acquisition of personal ICT skill development and resulted in some cases in the substitution of ICT in practice (Puenteledura, 2010), it has not provided teachers with the opportunity to rethink the valuation system of an historically grown community. Imported PD programs have frequently been criticised for being individualistic and competency based (Hodkinson & Hodkinson, 2005), focusing on the ICT content to be acquired by the teacher and ignoring the process of socialisation of the technologies (Cox, 2008; Groff & Mouza, 2008; Harré, 2002). Hence, a disparity exists between socially dominant beliefs held in a school of what good teaching is and of what good teaching might look like with the new technologies.

Such formal PD courses, whether held in school, at an external venue, or online, often fail to acknowledge that learning is predominantly a social and cultural process (Billett, 2008). Hodkinson and Hodkinson (2005) maintained that a large proportion of teachers’ professional learning is informal, unplanned, and unstructured workplace learning, which is influenced by the social community—or community of practice (Lave & Wenger, 1991; Wenger, 1998)—to which they belong. Somekh (2008) challenged the widespread assumption that failure to integrate ICT in pedagogy is the result of teachers’ resistance to change. She argued the need for a wider analytic frame that takes into account complex cultural factors: ‘Teachers are not “free agents” and their use of ICT for teaching and learning depends on the interlocking cultural, social and organisational contexts in which they live and work’ (p. 450).

Therefore, it is important when considering professional learning to take into consideration both the individual characteristics of the learner and their ‘relational agency’ within the workplace (Billett, 2008; Edwards, 2010; Shotter, 2013).
1.7.3 Developing an analytical framework

In this study, I took the view that PD or workplace learning is a characteristic of the individual, their work environment, and their working relationships. Therefore, I began to explore science teachers’ experience of learning to work with ICT as members of their primary workplace site, science departments, situated in a school context. I used the work of Wenger, McDermott, and Snyder (2002) on communities of practice and Edwards’ (2010) theory of relational agency, in concert with Harvey’s (2002) interpretation of Bhaskar’s (1998) transformational model of social activity, to create an analytical frame to interpret the data collected during fieldwork.

1.8 Terms and Constructs

Throughout my thesis I incorporate some commonly used terms to describe ideas and concepts. In order that there is no confusion in my use of these terms and the meanings ascribed to them, I include several key definitions in this section. I also include, at the beginning of the thesis, a list of abbreviations employed throughout the thesis.

*ICT* refers to information and communications technology, and for the purpose of this study relates to the diverse range of technological tools that could be used to enhance the teaching of science. This includes computers (laptops and desktops), the Internet and related sites, plus software both generic and science specific, enabling information storage, publishing, modelling, simulation, measurement, and graphing. It also encompasses peripheral devices such as digital cameras, digital microscopes, sensory probes (or data loggers), and printers.

*Subject department* is used to identify both the organisational subunit to which secondary school teachers with similar subject disciplines belong, as well as a shared common physical location. In this study, I explored the experiences of individual science teachers and focused on the science department as an organisational unit and
location. I classified members of the science department as full- and part-time teachers of the biological and physical sciences plus science technical support staff.

*Subject culture* is used to describe the language, epistemology, and traditions used by teachers belonging to a particular subject department and to explain how these characteristics govern what is considered appropriate and important for teaching and learning within that subject. Teachers are often inducted into existing subject cultures and develop their professional identity in response to their experiences in relation to that culture.

*Student-centred pedagogy* is used to specifically infer pedagogy that encourages active rather than passive learning. It includes pedagogic strategies used by teachers that scaffold student learning and encourage collaborative and discovery learning through the exploration of scientific concepts through research and experimentation. I use this term student centred to distinguish between the style of pedagogy that requires students to passively listen and follow instructions, which I term teacher centred. While understanding that it is impossible to reduce teachers’ pedagogic practice to a binary notion such as student centred or teacher centred, I am aware that this distinction often occurs in ICT research literature (Cook, 2010; Voogt & Pelgrum, 2005).

### 1.9 Thesis Outline

My thesis is divided into seven chapters. In this opening chapter, in addition to showing how my personal teaching interests and professional situation combined to give me the motivation to commence this research, I present an outline of the research approach chosen and an explanation of the key terms and constructs that I used to form my research question.
Chapter 2 begins with an examination of the factors that have been most commonly identified, in both Australian and international studies, as contributing to the level of the variable integration of ICT in secondary schools and science pedagogy. It then provides a detailed exploration of the influence of the schools’ organisational structures on the integration of ICT. Finally, it presents an outline of the situated and workplace learning theories, which were used to illuminate the teachers’ accounts gathered in discussion in the research fieldwork.

Chapter 3 describes the ethnographic approach taken in my research and provides detail of the specific features of the study design and data collection techniques. It introduces the three research sites and the research participants, explains the approaches to presentation and interpretation of the narrative data, and defends the credibility of the research process including ethical considerations.

In Chapters 4, 5, and 6, I present my results in the form of narrative vignettes. This enables me to interweave the observational data, documentary evidence, and teachers’ voices from each case study into holistic pictures of the three science departments. It not only provides the reader with a description of the data collected, but also gives them an opportunity to view the cases relative to their own experiences. Each narrative vignette is followed by an interpretive commentary and an explanation of how the department’s structure has influenced ICT integration.

In Chapter 7, the final chapter, I present an analytical framework for future consideration when exploring a school subject department as a site for individual teachers professional leaning. While I acknowledge that the data for this thesis was collected over a decade ago, the cases developed are still relevant in the current discussion of ICT integration in science pedagogy and can readily be employed as case-based teaching resources in teacher education (Shulman, 1992).
Throughout my thesis, I interweave quotations from Lewis Carroll’s *Alice’s Adventures in Wonderland* (1865) and *Through the Looking-Glass and What Alice Found There* (Carroll, 1871) to capture poetically my intensely personal journey in the strange and vexed realms of educational research and academia.
Chapter 2: Searching for Pictures

*Once or twice she had peeped into the book her sister was reading, but it had no pictures or conversations in it, ‘and what is the use of a book,’ thought Alice, ‘without pictures or conversations?’* (Carroll, 1865)

2.1 Introduction

Building on policy documentation and literature presented in Chapter 1, which served to situate this study, this literature review focuses on the structural and agential influences on teachers’ professional interaction with the assimilation and accommodation of new technologies that may explain what has been considered by researchers to be poor uptake in the first 20 years of their introduction in schools.

The review begins by looking at historically perceived barriers that have widely been recognised as influencing teachers’ use of ICT. It then examines the importance of social structures, including schools’ organisational cultures, which more recently have been criticised as significant in the poorly conceived early teacher education programs that were centrally instituted and which focused primarily on imparting new technical skills to individual teachers. Since I focused this study on the interaction of structural and agential influences in the key social organisational unit in secondary schools, the subject department, and specifically on teacher practices within it, the review then explores the subject department in greater detail. Finally, I consider the transformational model of social activity in order to situate the subject department as a community of practice within the broader organisational context of the school.
Like Alice in her wonder world, I yearned for a commonsense explanation of the illogicalities I saw in teachers’ strange resistance to engagement with the new digital technologies in their teaching practice. Teachers’ stories in the research literature provided me with a broad sense of their different personal worlds of practice and the challenges of social and personal transformation reflected in their different levels of engagement with these technologies. This conversational research encouraged me to investigate the resistance further to understand the personal and social factors that still appear to be affecting the integration of ICTs into science teachers’ pedagogy.

2.2 Perceived Barriers to ICT Uptake

Since the mid-1990s, there has been an increased policy emphasis on the integration of ICT into the pedagogic practice of both in-service and preservice teachers in Australia. Yet research in the field still reports a disappointing uptake in the level of ICT integration, assimilation, and accommodation in secondary classrooms (Barak, 2017; Grosso, 2015; Organisation for Economic Co-operation and Development [OECD], 2015). The variability in ICT integration has been explained as the effect of what Ertmer (2005) termed first- and second-order barriers to technology integration. First-order barriers are those external to the teacher, for example, a lack of resources, limited infrastructure, and insufficient training and time to become familiar with the technology. Second-order barriers, described as internal, are teachers’ ‘beliefs and attitudes, knowledge and skills’ (Ertmer & Ottenbreit-Leftwich, 2013, p. 177).

2.2.1 First-order barriers

Historically, first-order barriers have been reported as playing a significant role in the integration, assimilation, and accommodation of information technology (IT), especially access to reliable resources and infrastructure (Hennessy et al., 2005; Jones, 2004; Selwyn, 1999; Watson, 1999). The initial arrangement of computers, in suites and
dedicated computer laboratories, was identified as detrimental to their use. Selwyn (1999) maintained that the arrangement not only limited teacher access to computer resources, it also resulted in the IT coordinator becoming a ‘gatekeeper’ to that access. This proved a contradiction to the promise that IT would readily offer teachers flexibility and a chance for students to experience open-ended and exploratory learning (Watson, 1999). In early exploration of computer use in science education, Newton and Rogers (2001) found teachers reported that wholesale movement of classes to a computer suite had the effect of focusing the educational activity on computing rather than the science. They, among others, believed that it encouraged both teachers and students to view IT as a ‘bolt-on’ activity (Cox et al., 2000; Haydn & Counsell, 2003; Wellington, 2004).

Technical issues were also a very real concern for teachers using IT in those early years and caused much anxiety (Musker, 2004; Newton & Rogers, 2001; Scrimshaw, 2004; Selinger, 2004). Selinger (2004) listed some of the problems that regularly caused ‘setbacks in the classroom’ (p. 39), for example, screen freezes, system crashes, and peripheral devices such as printers ‘refusing’ to work at crucial moments. These hardware issues added to teachers’ reluctance to use IT, as they deemed it time consuming and unreliable. It is important to remember that most schools did not command a budget big enough to employ a team of technical staff to support teachers on demand (Leask & Pachler, 2005; Musker, 2004).

PD has also been criticised as contributing to the limited integration of IT in the classroom. Ertmer et al. (2012) reported that the majority of early training focused on teachers’ acquisition of PC skills for administrative uses. They suggested it failed to support teachers in their use of IT for instructional purposes.
Significant and continued investment in the provision of ICT infrastructure over the last 30 years has considerably reduced the issues associated with the first-order barriers of access to reliable resources, PD, and technical support. Yet still researchers report inconsistent ICT uptake in teachers’ pedagogic practice (Ertmer & Ottenbreit-Leftwich, 2013; OECD, 2015; Vrasidas, 2015).

### 2.2.2 Second-order barriers

Ertmer and Ottenbreit-Leftwich (2013), among others, argued that since access to technology has increased second-order barriers, teachers’ knowledge and skills and their attitudes and beliefs have been the focus of research interest (Hew & Brush, 2007; Liu & Szabo, 2009; Palak & Walls, 2009).

Research indicates that to make judgements about the educational suitability of a resource and to recognise the benefit that it offers for learning, teachers need to have a good knowledge of the resource (Chandler, 2013; Dawes, 2001; Kennewell et al., 2002; Friedler & McFarlane, 1997; Pachler, 2002). This includes, researchers’ claim, understanding the functionality of the resources and applications, recognising the skills that students will need to master to be able to use these resources, and being aware of the difficulties that students might encounter (Grosso, 2015; Kennewell et al., 2002; Rogers & Barton, 2004). This has been described as the teacher’s technological pedagogical and content knowledge, or TPCK (Mishra & Koehler, 2006). As some researches have observed, with the plethora of applications available, it is impractical to expect teachers to have a good working knowledge of all applications or resources relevant to their subject area (Banas, 2010; Orlando, 2014).

Over the last 30 years, numerous attempts have been made to specifically support and guide science teachers in the use of ICT in their classrooms and improve their working knowledge of resources (Barton, 2004; Frost, 2005; Scanlon & Holliman,
These works have provided information about the value and relevance of ICT resources in science teaching and described how teachers could develop lessons that incorporate their use. These sources, as well as academic articles, teacher publications, and professional conferences (e.g., Science Teachers’ Association of Victoria, 2002–2016), have provided the science teacher with information regarding the availability of science-specific resources (sensors, digital microscopes, robotics kits, multimedia resources, science applications etc.) and illustrated how ‘generic’ resources (iPads, tablets, smartphones, scanners, digital cameras, printers, data projectors, spreadsheets, email, authoring software, imaging software, etc.) could be employed in science education.

Several authors have asserted that for ICT to be pervasive across the secondary curriculum, many subject teachers will need to be persuaded to change their beliefs and attitudes (Webb & Cox, 2004; Ertmer & Ottenbreit-Leftwich, 2013; Inan & Lowther, 2010; Tondeur, Hermans, van Braak, & Valcke, 2008). Change theorists have observed that changing a teacher’s epistemological and pedagogic beliefs is not an easy task, since these beliefs have usually developed over an extended period and are intimately bound to the school traditions and cultures that have shaped them (Fullan, 2007; Goodson & Mangan, 1995; Hargreaves & Goodson, 2006; Hargreaves & Macmillan, 1994). They have observed that if a change in teachers’ knowledge and beliefs is required to effectively integrate, assimilate, and accommodate ICT in schools and subject areas, then significant changes are likely to be required within the school’s organisational culture (Fullan, 2007; Goodson & Mangan, 1995; Lim, Lee, & Hung, 2008; Windschitl & Sahl, 2002). Section 2.3 of this review therefore explores the
organisational culture of schools and investigates how ICT integration has been affected by school organisational culture.

2.3 Schools’ Organisational Culture

In this section, I explore how school culture in the broader sense can influence the change process and suggest how this has affected ICT integration.

2.3.1 What is school ethos, or culture, and how can it influence change?

School ethos or culture can be defined as the totalising relationship between the beliefs and expectations of the teaching staff and management and the way these influence the day-to-day public enactment and practices of the school (Hargreaves & Fullan, 1992). The school ethos can be thought of as the lens through which the employees view the outside world and so create its working reality (Stoll & Fink, 1996). Stoll and Fink (1996) considered that to people outside the school staff, the school ethos often appears to be intangible and difficult to describe, and maintained that it is only through first-hand appreciation of a particular school’s culture, which can be seen as the corpus of shared meanings, that one can begin to understand and explain its influence upon the agency of individual teachers. They (Stoll & Fink, 1996), among others (Fullan, 2007; Hargreaves, 1994, 2003; Schein, 1985; Schoen & Teddlie, 2008; Stoll, 2002; Whitaker, 1993), suggested that one way to begin to understand a school’s ethos is to observe the school’s routines and rituals, for example, the organisation of the school day, the nature of the subjects offered, the behaviour expected of staff and students, the relationships and attitudes of the staff, and the school’s history and standing in the local community. But how does school ethos, told in the secret, sacred, and cover stories by teachers (Connelly & Clandinin, 1995; Dwyer & Garvis, 2012) affect changes in teaching practices?
It is generally assumed that as new teachers and students are inducted into a school, the historically generated shared horizons of significance or ‘norms’ of accepted behaviour of the school community (Hargreaves, 1994; Taylor, 1992), described as the ‘local moral order’ (van Langenhove & Harré, 1999), are reconstructed and maintained in everyday discursive and nondiscursive practices. Bolman and Deal (1991) pointed to the potential rigidity of school culture entrenched in dual social orders of practice and honour, implying that any newcomers will not act as agents for change and a school’s culture could even become hardened against change. This implied social isolation of the school was contested by Stoll and Fink (1996) who argued that a school’s collective doings and sayings will inevitably evolve, albeit slowly, with society at large, as the established members of the school community move on and the new members join, bringing with them different and perhaps more contemporary values, norms, and practices. The corpus of shared meanings in the staff room is not constituted solely by language but rather, as Archer (2000) argued, in causally efficacious practice, and hence, shared meanings are emergent properties of the culture. Stoll and Fink’s (1996) evolving practical intelligence seems a slow and perhaps unconscious process in the face of urgent contemporary social, economic, and political demands. A school’s organisational language and practice can, then, be seen by some both inside and outside the school, and indeed in teacher education, to impede educational change as an essential arm of social policy.

Whitaker (1993) observed that not all school cultures are entrenched in tradition; he considered that there are two extreme cultural conditions and that most schools lie somewhere along the resulting continuum:

Some cultures are implicitly stability prone—struggling to maintain the status quo in the face of demand and expectation of change. Others are stability phobic—anxious to avoid
any sense of sameness or complacency. Most [schools] live a life somewhere between these two extremes. (p. 93)

Schools that Whitaker saw as ‘stability phobic’ are likely to be struggling to respond to social demands, to prove their responsiveness, and to show they embrace reforms and innovations. They can also anticipate problems. Teachers at such schools are continually exposed to new initiatives and continually expected to change their practice. Fullan (2003, 2007) argued that while initial support and commitment to reforms may be evident, continual change can result in teachers becoming pressured and feeling deskilled and undervalued, leading to stress, fatigue, and resentment. Farber (1991) described this stress and fatigue as ‘burnout’ and implied that it is a result of teachers’ overcommitment to the school’s culture of change and their perceived inability to sustain self-improvement, which can be seen as agency in their own practice. Fullan (1993) warned that in a climate of escalating educational reform, schools have to be discerning about the reforms that they embrace. He argued that innovations have limited impact in schools that react to reform in a ‘knee jerk fashion adopting the latest hot items’ without considering the necessary ‘deeper change in thinking and skills’ (p. 23).

School change management research often addresses school organisational culture in terms of retrospective individual accountability to ‘institutional orders’ rather than prospective accountability to collaborative ‘constitutive orders’ (Rawls, 2011), the latter being constructed in the constructive socialisation of accessible resources. If the discursive circles in the school at institutional policy and constitutive staffroom levels do not mesh, then community and agency (Harvey, 2002) are disengaged from meaningful reform or maintenance of practice. Elder-Vass (2010) argued that in this case, reform either fails or is only superficially adopted at the classroom door. By failure or superficial adoption, Elder-Vass (2010), among others, does not imply that a
reform or innovation is totally rejected by a school, but rather that the reform generally speaking is likely to be accommodated and assimilated into a school’s existing culture in an ad hoc fashion, and any broader changes in horizons of significance ignored or misinterpreted (Fullan, 2007; Hargreaves & Goodson, 2006; Hargreaves, Earl, Moore, & Manning, 2001; Kennewell et al., 2002; Whitaker, 1993).

2.3.2 The influence of school ethos or culture on ICT integration

Both Papert (1989) and Cuban (1993, 2001) blamed school culture and the traditional organisation of schools for the slow integration of computers and IT. Cuban suggested that it is the dominant cultural beliefs about what teaching, learning, and authentic knowledge are that have contributed to a ‘lower’ value being put on learning technologies and, consequently, how those technologies are used. Cuban also reported that school rituals, routines, and organisation have greatly affected the way in which schools have historically taken up computer technology, implying that age-based curriculum, self-contained classrooms, subject disciplines, and a compartmentalised school timetable have all inhibited widespread computer use in schools. In secondary schools, where teachers tend to be socialised by subject specialism and departments, this has resulted in other cultural issues as tensions have developed between IT use and subject subculture (Baggott La Velle et al., 2004; Hennessy et al., 2005; Goodson & Mangan, 1995; John, 2005; Selwyn, 1999). In Section 2.4, I further explore the characteristics of the ‘subject department’ and consider how they influence school reform and innovation, especially in respect to ICT integration.

Later studies have argued that the social experiment of issuing computers, and hence IT, to teachers or schools was inevitably associated with the perceived urgent social economic need for the social adoption of ITs in a new globalised economic order, but a lack of thought was given to the educational, as opposed to the training, purposes
among educational policymakers (Fluck & Dowden, 2010; Nichol & Watson, 2003; Selwyn, 2016; Somekh, 2010). This supports Watson’s (2001) contention that a ‘dichotomy of purpose’ led schools to question whether IT was ‘a subject in its own right with a conceptual knowledge and skill base’ or whether ‘IT is a tool to be used mainly for learning in all subjects’ (p. 253).

Watson (2001) observed that the change of name, from IT to ICT, gave an answer to this question, as policymakers indicated a shift in emphasis from learning about computers to learning with them. The notion of ‘learning with ICT’ has been promoted as a crosscurricular element for all teachers irrespective of their professional biography or education. However, recent comprehensive curriculum policy change in Australia (Australian Curriculum, Assessment and Reporting Authority [ACARA], 2013) has called for ‘digital technologies’ (DT), a computer science-based subject linked to the teaching of coding. This workplace-oriented curriculum reform linked to international competitiveness is to be added to the academic curriculum from elementary years, in addition to ICT as an integrated learning tool in all teaching subjects (Falkner, Vivian, & Falkner, 2014; Gander et al., 2013).

2.4 Subject Department as an Organisational Unit in Secondary Schools

In this section of the review, I examine the school subject department as the primary organisational unit in which secondary school teachers work, and consider how the characteristics of this organisational unit (Siskin, 1994) have influenced the accommodation, assimilation, and integration of ICT in individual teachers’ practice.

2.4.1 The subject department

Stoll and Fink (1996) observed that secondary schools are relatively large organisational structures, and that the teachers who work in them often find it difficult to maintain close working and social relationships with all their colleagues. ‘Secondary school
teachers tend to frame their teaching in terms of their subject’ and look to the subject department as ‘their [primary] organisational unit’ (Keennewell et al., 2002, p. 87).

In her seminal sociological studies of U.S. high schools, Siskin (1994) acknowledged the subject department as being potentially the most significant and influential social organisational unit in academic schools. To support this notion, she (1994) identified four characteristics that define a subject department’s structure and contribute to its importance in influencing school reform:

1) It represents a strong boundary in dividing the school; 2) it provides a primary site for social interaction, and for professional identity; 3) it has, as an administrative unit, considerable discretion over micro-political decisions affecting what and how teachers teach; and 4) as a knowledge category it influences the decisions and shapes the actions of those who inhabit its realm. (p. 5)

Siskin’s studies were conducted in academic schools in which subject department structures were strong. Subsequent research taking subject departments as the unit of analysis has generally supported her social emphasis, but questions of just how the departmental characteristics she identified affect, or are affected by, school reform remain. Likewise, sociological studies of organisational influences in schools more committed to integrated curricular models and less strongly wedded to traditional academic boundaries require finer grained investigation of the type advanced in this study (Baggott La Velle et al., 2004; Childs, Burn, & McNicholl, 2013; Goodson & Mangan, 1995; Goodson & Marsh, 2005; Hargreaves & Macmillan, 1994; Harris & Jones, 2017; Siskin & Little, 1995).

2.4.2 Boundaries

Departmental boundaries are created and maintained by teachers as they become associated with a certain subject area or discipline (Siskin, 1994). These subject
boundaries can be viewed as both enabling and constraining. When working well, the subject boundary provides a mutually supportive environment, where colleagues with similar pedagogical interests work collaboratively to promote professional learning and embrace new ideas (Childs et al., 2013; Kennewell et al., 2002). When functioning at its worst, the subject boundary results in what Hargreaves and Macmillan (1994) termed ‘balkanised’ departments. In a Balkanised department, the teachers collaborate primarily to maintain the ‘status and fate’ of their subject and their own professional identities, often by promoting existing pedagogy and culture at the expense of implementing innovations that might be perceived as a threat to the status quo (Kennewell et al., 2002).

The boundaries created around Balkanised departments are virtually impervious to change, and the values and beliefs of teachers in such departments can become entrenched and isolated from those of other departments within the school (Hargreaves & Macmillan, 1994). Not all boundaries, however, are impervious; the boundaries around some departments can be relatively ‘permeable’, providing opportunities for both the exchange of ideas and professional growth beyond a teacher’s subject department. One factor that can facilitate permeability is the now common propensity for teachers to belong to more than one subject department. These teachers have the opportunity to become ‘boundary brokers’ (Wenger, 1998, p. 108), people who carry ideas and innovation from one subject area to the other and so act as change agents (Edwards, 2010; Fullan, 2007).

A second factor that Hargreaves and Macmillan (1994) considered to facilitate the permeability and even blurring of subject boundaries and so enable change was the levelling of subject status through the promotion of alternative organisational units and committees. The organisational units they proposed were not based around subject
disciplines but around the notion of school improvement and would evolve in response to continuing challenges and reforms. They called this model of organisational structure the ‘moving mosaic’ (p. 237) and noted that while it is an attractive prospect for school organisational development, it does rely on the deconstruction of years of subject supremacy, and that this is not an easy task.

If Balkanisation simply means working in smaller groups, then the antidote to it might be imagined as being either individualism or whole community attachment. If Balkanisation is defined by strong and lasting boundaries, by personal identification with the territories they delineate, and by the differences of power and status among these territories, then the antidotes to Balkanisation have very different properties. If the moving mosaic is to be successfully accommodated in the world of secondary schools, then one essential sacrifice will have to be the institutionalised career position of the department head (Hargreaves & Macmillan, 1994).

Cuban (2001), among others, argued that this element of subject subculture has impeded attempts to integrate ICT in the secondary school curriculum (Kennewell et al., 2002; Hennessy et al., 2005; John, 2005; Newton & Rogers, 2001; Selwyn, 1999). It would seem that some teachers are so tied to the ‘status and fate’ of their subject department in the discursive circles in the school, that they view the introduction of ICT as a threat to the established social orders of practice and status and will strongly resist it (Erixon, 2010; Orlando, 2014; Savage, 2010).

With this coarse-grained social understanding of the maintenance of subject departmental boundaries and the part they play in resisting ICT reform in mind, it is now necessary to examine the dynamic aspect of Siskin’s (1994) definition of the department; that is, the department’s role in providing a primary site for social interaction and the formation of professional identity.
2.4.3 Professional identity and social interaction

For Siskin (1994), the subject department is not only a primary site to nurture professional identity, it is also a ‘primary site for social interaction’ (p. 5). This sentiment is echoed by other researchers who believe that subject departments can promote a sense of collegiality and social interaction among teachers, thus allowing them to build strong professional and social relations, which encourage professional discourse and learning (Bush, 2003; Childs et al., 2013; Harris, 1998; Jurasaite-Harbison & Rex, 2010).

Possibly the most important factor influencing professional identity is the epistemological and pedagogical beliefs held by the teacher (Cox et al., 2000; Loveless et al., 2001). The research of Childs (1998), Kelly (2009), and Posner (1995) implied that the classroom practice adopted by a teacher is a reflection of how they view the content of their subject and the corresponding way in which they consider this content should be taught and learnt by students. Hargreaves and Macmillan (1994) suggested that teachers’ beliefs about their subject and its pedagogy are formed by their experience of learning at school, university, and during their teacher-training program. They, among others, stated that these beliefs are refined when teachers begin their professional careers and are subsequently inducted into the cultures and traditions of schools and subject departments (Burn, Childs, & McNicholl, 2007; De Lima, 2003; Jurasaite-Harbison & Rex, 2010). As stated earlier, teachers’ professional beliefs and values have been identified as a major influencing factor on their choice to engage with ICT in their teaching practice, so the practices of their subject department become an important site of psychosocial influence and reference.

Bush (2003) and Little (1990) remind us that not all subject departments are sites of collegial harmony and collaboration. They suggested that the members of some
departments are afforded less opportunity to engage in the social interactions that define their subject area and professional identity. To describe the social interactions that took place in her study, Siskin (1994) classified subject departments along two dimensions: ‘inclusivity’ and ‘commitment’ to the collective endeavour (p. 99). Using these dimensions, she maintained that departments fell into four social categories: bonded, bundled, fragmented, and split. Bonded departments display a high degree of social inclusion and commitment to common goals. Bundled departments are socially inclusive but have a low commitment to common goals. Fragmented departments are those that have both a low commitment to goals and social inclusion; they function purely for administrative purpose. Split departments have a high commitment to common goals, but members are divided into ‘conflicting factions’ (p. 100). With such complex social systems working in subject departments, and the inherent link between practice and teachers’ professional identity, it becomes evident that reforms or innovations will fall short of the desired outcomes unless handled sensitively and with reference to the particular department and individual teacher’s epistemological and pedagogical beliefs.

The introduction of ICT into the secondary school curriculum is perhaps one reform that has suffered from the complex social system that is the subject department in the secondary school. As Selwyn (1999) noted, in subject departments, some teachers might embrace the use of ICT while others actively resist it, viewing its use as incongruent with existing ‘deep-rooted norms and values’ (p. 86). While Goodson and Mangan (1995) saw an inevitable ‘culture clash’ between subject departments in terms of resource allocation, Cuban (1993) proposed that

The seemingly marginal use of computers and telecommunications in schools and classrooms is due less to inadequate funds, underprepared teachers, and indifferent
administrators than to dominant cultural beliefs about what teaching, learning, and proper knowledge are and how schools are organized for instruction. (p. 205)

Interestingly, over the years, government rhetoric seems to have ignored these and other warnings and has promoted ICT as a tool that can be readily introduced across all secondary school departments. This has been evident in the way PD initiatives have been promoted in many Australian schools as generic training sessions that often ignore the subject pedagogy and the teachers’ professional beliefs. For example, the International Computer Driving Licence, a PD package used by some schools during the time of this study, is targeted at developing individuals’ computer competencies. It offers modules such as ‘online basics’, ‘word processing’, and ‘the use of spreadsheets’. While this might be useful to teachers committed to skilling up their use of these resources in schools as a whole, such programs offer little support for integrating ICT into the subcultural world of the subject teacher. As Chandler (2013) stated,

The importance of professional development for teachers so that they can successfully implement the Australian Curriculum is clear, as so much about new media seems to be outside the mainstream of current classroom practice or teacher knowledge. Given the importance of the teacher and the school in introducing new media to students, the provision of systematic professional development needs to be taken very seriously. (p. 264)

Grosso (2015) echoed this critique of older technical models of PD, emphasising the need for teachers to feel capable and confident in the use of ICT (through regular PD) in their everyday practice. Successful ICT implementation would require successful integration of technology, which requires assimilation and accommodation of the technologies in the teachers’ everyday social practice in Australian schools.
2.4.4 The political power of the subject department

In addition to being sites of social and PD, secondary school subject departments tend to act as administrative hubs, and around and within these hubs, the political power of the department becomes evident (Hargreaves, 1994; Melville & Wallis, 2007; Siskin, 1994; Stoll & Fink, 1996).

The political power manifest around a department is associated with the position the subject holds within the school’s subject hierarchy (Goodson, 1989). Hargreaves (1994) proposed that certain subjects hold positions of power over others and as such are disposed to be politically more influential. Siskin (1994) suggested several tangible ways to identify a subject’s position within a school hierarchy; these include the subject’s priority on the school timetable, the number of staff employed to teach it, the accommodation it is endowed with, and the size of the school budget apportioned to it. Using these indicators, Siskin (1994) found that in U.S. secondary schools, mathematics, science, and English were subjects that were regularly afforded a much higher status compared to other academic and vocational subjects. This is also the case in the UK (Goodson, 1989) and Australia (Bleazby, 2015), which is not greatly surprising as these are subject areas that over the years have been elevated by ‘larger political and cultural processes in which schooling is embedded’ (Siskin, 1994, p. 120).

Once a subject and thus a department have gained status and a privileged position within the school curriculum, it is generally guaranteed a major share of the available resources (Bush, 2004). This leaves the department free from political battles with ‘lesser’ subject departments, who must fight for a share of the remaining resources (Siskin, 1994). Goodson (1989) warned, however, that shifts in the political and cultural landscape can quickly weaken one subject’s status and strengthen another’s. When IT was introduced into the school curriculum in the 1970s, a relatively large portion of the
school’s budget was initially required to purchase the expensive hardware and design specialised, secure classrooms in which to house it. As computers became more prevalent in the workplace, and IT moved from being an elective subject about computers to one providing all students with the essential skills to succeed in the modern workforce (ICT), its status became suddenly elevated (Kennewell et al., 2002). ICT thus demanded a larger share of curriculum time and school resources, and this has resulted in political battles within secondary schools as the existing hierarchy is threatened (Erixon, 2010; Kemmis & Grootenboer, 2008; Kennewell et al., 2002; Selwyn, 1999). Hargreaves and Macmillan (1994) noted that political battles between subject departments rarely result in positive educational outcomes, and this would seem to be the case in schools where departments have actively resisted ICT reforms. They (Hargreaves & Macmillan, 1994) contended that teachers fear innovation and reform that appears to be a threat to their career opportunities, resource allocation, or conditions of work. ICT could easily be perceived as a reform that would threaten teachers in each of these ways, and so it is not surprising that it has been met with such apprehension.

In addition to the political power constructed around the subject department, it is important to explore the political power manifest within the department, as this is the political power with the immediate effect on teachers’ working lives (Ball & Lacey, 1980; Busher, Hammersley-Fletcher, & Turner, 2007; Siskin, 1994). This political power, as defined by Siskin (1998), is related to the tangible rewards and sanctions that the subject coordinator governs. Examples of these rewards and sanctions might be the rooms in which teachers work, the courses and students they teach, and the equipment with which they are expected to teach (Siskin, 1994). Building on the work of Ball and Lacey (1980), Siskin (1994) maintained that regardless of the total resources allocated to a department, members will not necessarily be guaranteed an equal share of those
resources. She (1994) contended that the resources within a department are often distributed according to teachers’ biographies (new versus old members) and their areas of specialisation (physical verses biological sciences); this is, in turn, influenced by the dominant social norms and characteristics of the department described in Section 2.4.3.

Kennewell et al. (2002) considered that the promotion of ICT as a key skill, with the expectation that it will be taught across all subjects, has led to political tensions within some subject departments. More recent research (Chandler, 2013; Ertmer, 2005; Grosso, 2015; Law, 2008; Orlando, 2014) supports this and attributes this tension to the belief that ICT integration sometimes challenges the dominant pedagogy endorsed within a subject area, and so requires some teachers to change their practice, which in turn can cause stress and conflict among some or all teachers within a department. For instance, a teacher who challenges the dominant belief system held in the department might be viewed as a ‘traitor’ for teaching what is perceived a rival subject’s content, and their working environment could become decidedly uncomfortable (Busher et al., 2007; Siskin, 1994). As noted earlier in this section, the subject coordinator also has considerable influence on individual teachers’ working environments and therefore on reforms such as ICT integration. Hence, the subject coordinator’s management style and the way they control the department’s resources is important, as either can encourage or deter colleagues in their pursuit of reforms (Goodson & Mangan, 1995; Melville & Wallis, 2007).

It would appear that ICT reform has been affected by the political power exerted by the subject department, which has had a great deal to do with the historical rise of subjects within the secondary school curriculum. It would also appear that the power within a subject and the influence this has on innovation are associated with the way in which knowledge has traditionally been communicated within the subject. In Section
2.4.5, I explore in more detail how the department acts as a knowledge reference group for teachers and specifically focus on how science teaching has acknowledged ICT reform.

### 2.4.5 The department as a knowledge category

Considering the subject department as a ‘knowledge category’ supports the point made in Section 2.4.2 that teachers’ professional identity (Beckett, 2011; Holland, Lachicotte, Skinner, & Cain, 1998; Wenger, 1998) and their sense of working community (Wenger et al., 2002) relate directly to the teaching of their subject discipline. Siskin (1994) explained that a teacher’s professional identity is bound up in the actions and understanding of their knowledge category, and that this is evident when teachers describe who they are, what they do, and how they do it. She (1994) maintained that teachers demonstrate membership of a particular knowledge category as they use the language and epistemology of that discipline to ‘conceptualize the world, their roles within it, and the nature of knowledge, teaching, and learning’ (p. 152).

In secondary schools, teachers tend to view their colleagues in the subject department as fellow champions of their knowledge category and often expect these colleagues to display similar values, ways of thinking, and codes of conduct. It is by these values and codes that members of the department assess the actions of others, moderate their own actions, and in terms of the reference group appropriately respond to changes and innovations that might affect the department (Hargreaves & Macmillan, 1995; Siskin & Little, 1995). Since these values and codes are often tacit in nature, it might be reasonable to assume that a teacher not trained in the knowledge category would find it difficult to gain acceptance within the department. This again illustrates how the subject department can act to reinforce the subject boundaries that often slow
the process of change (Childs et al., 2013; Hargreaves & Macmillan, 1995; McLaughlin & Talbert, 2001).

The influence of teachers’ knowledge categories has undoubtedly had an effect on ICT integration across science disciplines, and this has been explored in several empirical studies (Brantley-Dias & Ertmer, 2013; Ertmer & Ottenbreit-Leftwich, 2010; McRobbie & Thomas, 2000; Ruthven, Hennessy, & Brindley, 2004; Shirley, Irving, Sanalan, Pape, & Owens, 2011). McRobbie and Thomas (2000), for example, investigated the experiences of a chemistry teacher as she began to use remote sensors in her teaching. Their research demonstrated a close fit between the way the teacher conceptualised chemistry, the way in which she taught, and the corresponding value she placed on the use of ICT. Chandler (2013) maintained that ‘the manner and extent of computer use is related to the opportunities it affords teachers to express their core beliefs and their pedagogical agenda’ and suggested that ‘practical theories of teaching are central to how computers will be used for teaching/learning’ (p. 9).

Studies conducted with science teachers favouring a student-centred approach toward the teaching of their disciplines (du Plessis, 2016; Ertmer et al., 2012; Laurillard, 2004; Linn, 2004; Selinger, 2001) have claimed that if organised in a way that encourages students’ active participation, ICT can help students become empowered learners (Jonassen & Carr, 2000). Barton (2004), among others, attributed this to the fact that ICT has reduced the time students spend focusing on lower order skills, such as learning facts, measuring, and recording, and has allowed them time to focus on higher order skills (Musker, 2004; Newton & Rogers, 2001; Scanlon & Holliman, 2004) such as researching, articulating, hypothesising, and problem-solving, all of which facilitate a deeper understanding of scientific concepts (Boohan, 2001; DiSessa, 2000; Linn & Hsi, 2000). As expressed in his early work and elaborated on in his later writings, Jonassen’s
Howland, Jonassen, & Marra, 2012; Jonassen, 1996) vision for the integration of technology focused on preparing students to use technology as a cognitive tool to accomplish authentic tasks and/or solve authentic complex problems: ‘Cognitive tools are essential components of a learning environment in which learners are required to think harder about the subject-matter domain being studied or the task being undertaken and to generate thoughts that would be impossible without these tools’ (Jonassen & Reeves, 1996, p. 697).

It would be wrong, however, to reduce the argument of whether a teacher will use and value ICT in their discipline to whether they prefer a student-centred or teacher-centred pedagogy. As Friedler and McFarlane (1997) found in their exploration of the use of a graphing package in mathematics classrooms, teachers favouring both constructivist and transmissive pedagogies valued the time saved when students were able to use the computer package to generate graphs. They suggested (1997) that while the constructivists valued the opportunity to use the additional time to focus on higher order analytical skills, the teachers who favoured a transmissive pedagogy valued the additional time they had to cover more of the syllabus content with their students.

Whatever their pedagogical preference, the research has progressively emphasised that if teachers perceive ICT use as a positive opportunity to further students’ learning, they will adopt and assimilate it to suit their purpose. But is teaching as clear-cut as this binary notion of student-centred verses teacher-centred methods suggests? Lárusson, Þórólfsson, and Macdonald (2008), while acknowledging that the use of ICT is dependent on teachers’ personal history of science teaching, emphasised that it is also dependent on their background in ICT use, hence technical developments in the wider society in which the schools exist.
2.4.6 Section summary

The integration of ICT within a subject department is a complex process and generally requires accompanying changes to the pedagogy and beliefs valued by the individual members (Kennewell et al., 2002). Kennewell et al. (2002) pointed to the tension, frequently ignored in instrumental policy-directed research, between teachers’ habits of interpretation of broader accountabilities and social responsibilities and their habits of belief based on their everyday working knowledge of their students and their situation. This tension is often expressed between practical epistemological functions and moral craft issues in their professional identity formation. If teachers interpret these changes as a threat to the very nature, position, and integrity of their knowledge category, and subsequently their professional identity, ICT integration will be subverted or actively resisted, as would any other innovation (Hargreaves & Macmillan, 1995).

Having established the importance of the context of the subject department in this study, I now turn to my theoretical framework for interpreting the processes of social transformation and reproduction in the workplace. This I posit in this review as a study of the everyday hybrid praxis of science teachers in my study between the social performance of their duties and their responsibilities toward their self-improvement.

2.5 School Subject Department as a Community of Practice

The term ‘communities of practice’ was coined by Lave and Wenger (1991) to describe the situated learning associated with apprentices in professional communities. Expanded on by Wenger (1998) and his associates (Wenger et al., 2002; Wenger & Trayner, 2011), the communities of practice model has since been used widely in business and industrial settings to explain and develop relationships between individual and organisational learning (Brown & Duguid, 1991; Orr, 1996; Saint-Onge & Wallace, 2003). Over the years, this model has also been used by educational researchers (Barab

2.5.1 Communities of practice

Central to the model of communities of practice is the belief that engaging in social practice is the fundamental process through which we learn and consequently become who we are as individuals (Wenger, 1998). Building on the work of other social learning theorists (Bandura, 1977; Bruner, 1996; Dewey, 2007; Schön, 1983; Vygotsky, 1978), the communities of practice model explores the overlapping ideas of community, meaning, social practice, and identity to provide a framework for thinking about learning as a process of social participation (Wenger, 1998).

At the core of the communities of practice model is the idea that a group of people sharing an interest in, or passion about, a particular subject will work collectively on an ongoing basis to broaden their knowledge and expertise about this subject (Wenger, 1998). As a consequence of their engagement, it is anticipated that the members of the community will develop shared practices, skills, resources, and common perspectives. Although they may take a variety of forms, communities of practice possess three elements that distinguish them from other organisational structures: mutual engagement, a joint enterprise, and a shared repertoire (Wenger, 1998). In a later discussion of communities of practice, the names of these elements are changed and their meaning subtly refined: mutual engagement becomes community, joint enterprise becomes domain, and a shared repertoire becomes practice (Wenger et al., 2002). It is the later version of the elements on which I now expand.
2.5.2 Domain

The domain of knowledge is what draws the members of a community of practice together; it is the joint enterprise that guides the community’s learning, defines its identity, and gives meaning to its actions (Wenger, 1998). Wenger et al. (2002) suggested that what shapes a community’s identity and the learning that takes place within it are the values and beliefs held by members about the domain. They (2002) proposed that in this way, the members of a community act as the custodians or stewards of the knowledge valued within their domain and so guide its development. Over time, members of a community of practice will encounter issues that may impact the domain and challenge their values and beliefs, and through ongoing negotiation they will determine how their practice will develop to respond to these issues and further the domain.

A well-developed domain legitimises a community in the eyes of its members and gives it status and visibility within a wider organisation (Wenger et al., 2002). This in turn leads to community members being recognised for the competence and expertise that they demonstrate within the domain. Wenger et al. (2002) maintained that communities with a well-defined domain would be afforded power and influence in an organisation and be consulted about major changes relevant to their domain. Conversely, if a domain is not well developed, it will experience a low status and not be valued externally; hence, the community’s influence will be minimal and its position marginal. These ideas echo those of Siskin (1994) with regard to the political power afforded to a school department and its subsequent positioning in the hierarchy of the school.

It is important to note, however, that a domain’s strengths can also be its weakness. Wenger et al. (2002) warned that sometimes a community’s hold on its
domain is so strong that its members will become arrogant and believe that as experts in the domain, they are the only ones capable of making decisions regarding the domain’s future. They also pointed out that a furtherance of the domain may not always coincide with the developmental direction of the wider organisation. Yet despite this, they contended that members of a well-developed domain will be expected to demonstrate their commitment to that domain or be considered ‘traitors’ to their community of practice.

2.5.3 Community

The community is the social fabric that develops while members pursue their interests in the domain. Lave and Wenger (1991) described the individual learner as a member of a community of practice whose learning is shaped by sharing both explicit and tacit knowledge offered by other members of the community. They considered that newcomers and/or novices to a community are often allocated a peripheral position in that community, and only once they have established their competence does the community consider them a veteran or an expert. Interestingly, Lave and Wenger (1991) emphasised that the gaining of competence or expertise does not warrant or indeed require a newcomer to relocate to a perceived centre or core of a community, and contended that it is quite common and even acceptable to remain on the periphery or boundary of a community yet still be viewed as an expert and community member. They saw this involvement by a novice or expert member as legitimate peripheral participation and maintained that the only integral condition of participation in the community is that the individual engages in the social practice of learning and furtherance of the community. Lave and Wenger (1991) emphasised that an individual’s level of participation and position in a community of practice is in tension with the power that one is afforded on the leveraging of that community. They warned that an
individual’s power can both help and hinder a community and that this can have effects on the information flow and practice of the community.

For collaborative participation to occur in all phases of the learning process, community members must interact regularly and learn in concert. Edwards’ (2010) theory of relational agency, that is, the ‘capacity to align one’s thoughts and actions with those of others in order to interpret problems of practice and to respond to those interpretations’ (p. 169), offers a way to cultivate the social fabric of the community. The theory initially developed to describe how strong forms of agency might arise in collaborations that involve working across boundaries between practices and can be used to inform understanding of the relationships between people who are positioned differently in the same practices, for example, novice and experienced teachers working collaboratively within a subject department.

Relational agency develops as a two-stage process within a constant dynamic, which consists of

1. Working with others to expand the “object of activity” or task being worked on by recognising the motives and the resources that others bring to bear as they, too, interpret it; and

2. Aligning one’s own responses to the newly enhanced interpretations with the responses being made by the other professionals while acting on the expanded object. (Edwards, 2010, p. 14)

Edwards (2010) maintained that through working with others in response to a complex problem or task, community members have the capacity to further the interests and learning of the community. She also considered that the fabric of the community provides support for those who are less confident in their knowledge and ‘is relevant to
the work of practitioners who may feel vulnerable when acting responsively and alone without the protection of established procedures’ (p. 14).

The concept of community can imply an inclusive communal identity and a common history developed over time through long-term interaction; however, it could also refer to an exclusive identity that denies external access or influence.

2.5.4 Practice

Wenger et al. (2002) described a third element indicative of a community of practice as practice, which is the use of a shared repertoire of resources that has been developed over time. This repertoire of resources is evident in the knowledge that is valued, the way community members behave, the common language used, artefacts and tools that are developed, and the way they approach common problems. It is through active participation in these practices that members of the community learn, develop their identity, and acquire their perspective on how the domain should be enacted. Holland et al. (1998) likened communities of practice to the concept of figured worlds in this particular respect, suggesting that established social orders of practice are key to learners’ identity formation. Figured worlds, as defined by Holland et al. (1998), are ‘socially and culturally constructed realm[s] of interpretation’ (p. 51) in which actors develop their identity through both cognitive and procedural practices. They provide sites in which people learn to assign meaning to artefacts such as events, objects, discourses, and the other people that populate that figured world, which leads to them ‘figuring out’ their place in that world.

Wenger et al. (2002) considered that a community of practice should ‘explore both the existing body of knowledge and the latest advances’ (p. 38) in the domain. This causes tension in communities, as new advances and innovations often require accompanying changes to the existing practice. In teaching, new policy initiatives and
innovations are usually implemented through the broader organisational structure of the school via a ‘top-down’ process. For school departments, these imposed changes can result in the need for PD, the restructuring of learning activities and documentation, the acquisition of new resources, and often, compliance with external benchmarks or standards. The success of innovations in schools is inextricably linked to the way they are managed within the school’s organisational structure and how teachers’ beliefs and values concerning the practice within their domain coincide with those innovations.

2.5.5 Section summary

Wenger et al. (2002) argued that for a community of practice to function effectively, all three elements—domain, community, and practice—need to be functioning in harmony, otherwise the community of practice will falter, become dysfunctional, and may even break down. The ideas presented by Wenger et al. (2002) resonate with those presented by Siskin (1994) with regard to situating a school subject department on a continuum of ‘inclusivity and commitment to the collective endeavour’ (p. 89) and her categorisation of departments as bond, bundled, fragmented, and split.

One of the criticisms of the concept of communities of practice is that we do not see how broader institutional duties and responsibilities, such as structures and agency, are related to the community of practice. Similarly, the lack of significance given to the wider organisational structure of the school is also a fault highlighted in critics of Siskin’s (1994) research on subject departments. In Section 2.6, I offer a way to resolve this issue by placing Wenger’s community of practice within Bhaskar’s (1994) transitional model of social activity.
2.6 Toward a Framework of Analysis

2.6.1 The transformational model of social activity

Bhaskar’s (1994) transformational model of social activity (TMSA) evolved from his reconfiguring of the sociologies represented by the work of Emile Durkheim, Max Weber, and Peter Berger, relating to how society and agency reproduce and transform one another (Harvey, 2002). In his early representation of the model, Bhaskar (1998) combined the diametrically opposed ideas of Durkheim (reification) and Weber (volunteerism) into two triads, the first of which illustrates the society’s impact on the individual and the second the individual’s impact on society (Harvey 2002, pp. 166–167):

\[
\begin{align*}
\text{Society} & \Leftrightarrow \text{Socialisation} \Leftrightarrow \text{Individual} \\
\text{Individual} & \Leftrightarrow \text{Reproduction/transformation} \Leftrightarrow \text{Society}
\end{align*}
\]

*Figure 1.* Bhaskar’s triads relating society and the individual (Harvey, 2002, p. 166).

Rejecting Berger’s dialectic of codetermination of ‘society creates man’ and ‘man creates society’, Bhaskar (1989) maintained that societies and individuals do not reciprocally reproduce each other. He explained,

> People do not create society. For it always pre-exists them and is a necessary condition for their activity. Rather, society must be regarded as an ensemble of structures, practices and conventions which individuals reproduce or transform, but which would not exist unless they did so. (Bhaskar, 1989, p. 36)

In his later version of TMSA, Bhaskar (1994) linked the structure and agency triads and provided an ‘historical flow of material processes and institutional shifts’ (Harvey, 2002, p. 178). He achieved this by incorporating additional elements to the model ‘istory’; that is, the personal story provided by the individual and ‘biography’. Also, by
providing a time dependency, as illustrated by the subscript T1 and T2 in Figure 2, he was able to imbue the model with a sociohistorical perspective that implied an irreversible timeline in history for the society and the individual.

Figure 2. Bhaskar’s transformational model of social activity emphasising the geo-historical and agent-dependent nature of the social transformation process (Harvey, 2002, p. 178).

Harvey (2002) further developed this model, incorporating a central region to illustrate how by merging the elements of ‘history’ and ‘biography’, through the ‘material nexus’ (p. 183) of community, it is possible to explore the development of individual agency. This addition creates a tension between the individual and the collective and provides both a spatial and temporal dimension to the model.

The community is now the “material nexus” in which men and women actually go about reproducing and transforming their society, and through which society itself socialises...
and channels the transformative powers of human agency. . . . Community becomes the totality of practically available “positioned practices” [within] which human agency operates. (Harvey, 2002, p. 183)

Harvey’s (2002) revision of the TMSA framework to include a central structure of community offers a way to explore how the composition, the culture, the setting, and the resources combine to influence the praxes of the individuals occupying that community. This now presents a way to position the community of practice—that is, the school subject department and individual teachers belonging to it—in the broader context of the school organisational structure and intuitional order during the time of change.

2.6.2 Analytical framework informed by TMSA

![Diagram](Figure 3. Curriculum innovation and teacher agency after Harvey (2002) and Bhaskar (1994).)

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**Figure 3.** The diagram illustrates the relationship between school subject departments and individual teachers, and the influence of historically accessible practices on teacher agency and self-cultivation. The figure highlights the existing institutional practice and the dominant ICT curriculum policy.
The framework I propose for analysing individual teachers experiences, in school departments, in the context of change (Figure 3) is a refiguring of Harvey’s (2002) TMSA after Bhaskar (1994). The triads to the extremes of the model still represent Bhaskar’s dual praxis of society and agency. However, in this versioning of the model, the society triad represents the organisational structure of the school with teachers as products of the institutional order of social expectations of that structure, while the individual agency triad represents the agency given to teacher(s) with the moral authority to further the learning and practice of the community. At the centre of the framework between the discourse of structure and agency is the school department as a community of practice, containing the biographical domain of the subject, the historical practice of the department, and the community or social fabric, which acts as the site of relational agency within the department. This social fabric provides the setting where Simmel’s ‘dialectic of self-cultivation and cultural appropriation’ (Harvey, 2002, p. 184) is enacted, as teachers try to find a position in the local moral order of the subject department and broader organisational structure. The solid lines on the framework indicate the existing institutional practice of the school, and the red broken lines the introduction of ICT as a dominant curriculum policy innovation.

2.7 Conclusion

In this chapter, I have reviewed past and current literature pertaining to the introduction and integration of ICTs into schools, and specifically science teachers’ pedagogy, to illustrate that variable integration is not merely an historic phenomenon, but is one that is still puzzling administrators and researchers (Section 2.2). I claim that despite the continued investment in ICT provision for schools, there remains a gap between policy rhetoric and the reality of ICT integration, assimilation, and accommodation in science pedagogy. In Sections 2.3 and 2.4, I have argued that the integration of ICT has been
noticeably influenced by the organisational structure and culture of the secondary school. I have emphasised the subject department as the primary organisational site in which secondary school teachers’ professional praxis and identities are shaped, yet I contend these are sites frequently ignored in policy-directed research in ICT integration.

To further the research into the science subject department as a site for PD for the use of ICTs, I therefore drew on literature relating to subject departments (Siskin, 1994), communities of practice (Wenger, 1998; Wenger et al., 2002) and relational agency (Edwards, 2010) to explore the influence of the subject department on teachers’ use of ICT in the science departments of three girls schools. To situate the science department as a community of practice within the broader organisational structure and institutional practices of the schools, I adapted Harvey’s (2002) TMSA to create an analytical framework with which to examine individual teachers’ agency and positioned practice within these three science departments.
Chapter Three: Opening the Door

‘But what am I to do?’ said Alice.

‘Anything you like,’ said the footman, and began whistling.

‘Oh, there’s no use in talking to him,’ said Alice desperately . . .

And she opened the door and went in. (Carroll, 1865)

3.1 Introduction

This chapter introduces the research methodology adopted, which is social phenomenological in that it explores the agency of the teacher subjects in a social narrative of change. It includes my own positioning in the conversational interviews in which the teachers’ accounts and the social order of the teachers are explored, how the research sites were selected and the subjects chosen, and how the narrative material was analysed, reduced, and presented in case study form.

3.2 Interpretive Perspective-Taking in This Research

Since this study examines teachers’ practices, a social phenomenon, I used a qualitative research paradigm. Qualitative research is a diverse field covering a range of techniques seeking to describe, decode, translate, and construct meaning rather than attempt to measure phenomena in the social world (Lincoln & Denzin, 2003). Taking the perspective of others is important in everyday life as well as in research. As Martin (2005) observed, in the social sciences there are several different approaches to perspective taking in research, for example, empathic, intentional, and interpretive. Researching the perspectives of others in interaction is interpretive research. It is a specific term that is defined in terms of an actor’s knowledge and belief. It seeks to
understand how the teachers in this study construct meaning, and the key concept is intersubjectivity. Meanings are taken to have their roots in human activity and the totality of human interactions with social artefacts and cultural objects.

The underlying principle of interpretive research is that knowledge is gained through developing an understanding of the socially constructed nature of reality experienced by the research participants. My research sought to understand the extent to which the professional learning environment, provided by science departments, enabled and/or constrained teachers’ integration, assimilation, and accommodation of ICT into their pedagogic practices. To explore these phenomena, I needed to develop an understanding of the participants’ habits of interpretation, their social orders of practice, and the culture of their professional environment. This included the individual and shared meanings that they held with regard to pedagogic practice and the professional relationships that they had developed. To explore these social orders in the naturalistic setting of the school science departments, I used an interpretivist methodology, and I present these social phenomenologies in the form of three ethnographic case studies.

When using an interpretive methodological approach, it is important to acknowledge that in processing collected data, the researcher uses their own experiences and reality to interpret and represent that data (O’Toole & Beckett, 2010). Martin (2005) went further in describing perspective taking in interpretive research as a dialectic between self and other, which celebrates both human agency and sociality, residing as much in the sociocultural world as within individuals. Drawing on perspectival realism, he explained that through engagement with others and objects, such as ICT, researchers become part of the transformational process they are investigating, indicating that interpretive research is as much to do with self-
development as it is to do with social development. As such, this study was informed by critical social theory and Bhaskar’s TMSA (Harvey, 2002).

3.3 The Development of an Ethnographic Case Study Framework

In this study, I drew on an ethnographic case study framework to explore teachers’ practice and the professional environment in which they worked in each of three school science departments. I used this presentational device to represent how the teachers in their practice communities dialogically and collaboratively interpret and construct the educational meaning of the new technologies. In their agential accounts, they discussed practice habits, interpretations, beliefs, and social relationships that existed within their school science departments, which influenced their individual integration of ICT in their pedagogic practice. In the following sections, I discuss the development of my case study framework, which has ethnographic qualities.

In social research methodology, case study is a broad description of an approach to conducting research (Merriam & Tisdell, 2015). Educational case study approaches are often shaped by the ideas and methods from other disciplines such as ‘anthropology, history, sociology, and psychology’ (Merriam, 2009, p. 43). Two critical dimensions of case study research are that it is a systematic study of a bounded phenomenon and that it draws on multiple sources of data.

In this respect, I adopted Creswell’s (2013) definition of the term:

Case study research is a qualitative approach in which the investigator explores a real-life, contemporary bounded system (a case) or multiple bounded systems (cases) over time, through detailed, in-depth data collection involving multiple sources of information (e.g., observations, interviews, audiovisual material, and documents or reports), and reports a case description and case-based themes. (p. 97)
Categorisation of two different forms of case study, namely, the intrinsic and instrumental case study, is a useful distinction for this thesis as it asks what the purpose of the case is (Pole & Morrison, 2003; Stake, 2005). In an intrinsic case study, research into a particular situation is undertaken for its own sake regardless of external concerns. In contrast, an instrumental case study is used to conduct research into a particular situation to try to understand an external concern in order to develop theories or general meanings, which could be applied to further cases. ‘The case is still looked at in depth, its context scrutinised, its ordinary activities detailed, but all because this helps the researcher to pursue the external interest’ (Stake, 2005, p. 445). Yet because most researchers simultaneously have several research concerns, it is hard to draw a distinct line between intrinsic and instrumental case study, and therefore, Stake proposes an overlapping area between the two, which he calls ‘a zone of combined purpose’ (p. 445). In this thesis, each case is first intrinsic, though instrumental outcomes occur as the reader generalises from the cases to their own experiences.

Bringing three case studies together (Creswell, 2013; Merriam & Tisdell, 2015; Stake, 2005; Yin, 2013) in this thesis, I used a collective ethnographic case study approach as a method of exploring a particular issue or phenomenon across several different settings. The value of this case study design is that it allows the researcher to replicate their study to gain different perspectives on a particular issue or phenomenon (Yin, 2013).

Creswell (2013) argued that while qualitative case study researchers are reluctant to generalise across cases due to the differing contexts of each case, the best way to compare cases is through the careful selection of representative case sites. In this study, I adopted an intrinsic collective case study structure to investigate the experiences of science teachers in three different schools (cases) in integrating or resisting integration
of ICT into their pedagogic practice. Three girls schools with distinctive identities were selected as representative cases.

Creswell (2013) also suggested that case comparison can be achieved through a ‘within-case analysis’ followed by a ‘cross-case analysis’, explaining that through detailed analysis of the individual case sites, it is possible to build an understanding of the complexities of each case and then look for common themes or issues that traverse the cases. In this study, data was collected and used to conduct within-case analyses. Conversational interviews were used to explore the perspectives of individual teachers in relation to their school and department setting to build a picture of their experiences, and this led to the identification of common themes that were explored in a cross-case analysis.

O’Toole and Beckett (2010) remind us that a case study can be viewed as a ‘shell’ or framework used to host a methodological approach. In my study, I combined a case study framework with an ethnographic methodology. Since this study centres on understanding the relationships and workplace practices of science teachers, in particular their use of ICT within that practice, it was important that I had an in-depth understanding of both the culture of the school and the department setting.

Willis and Jost (2007) maintained that case studies are about real people and real situations . . . [they commonly] rely on inductive reasoning . . . [and] illuminate the reader’s understanding of the phenomenon under study. . . . Used within an interpretivist framework, researchers do not seek to find universals in their case studies. They seek, instead, a full, rich understanding (verstehen) of the context they are studying. (p. 239)

Further, this interpretive study sought to present the perspectival selves of the teachers created in those contexts in which indexicality and reflexivity are central ideas.
Therefore, to gain a rich understanding of the context of the three schools investigated in my study, and to compare emerging themes from cross-case analysis, I used what I have termed a collective ethnographic case study.

Ethnography developed as a research approach in cultural anthropology and was essentially concerned with the holistic study of human society and culture in remote locations over an extended period of time (Pole & Morrison, 2003) with a view to grasping, as Malinowski (1922), an early proponent of the ethnographic technique, argued, ‘the native point of view, his relation to life, to realise his vision of the world’ (cited in Hitchcock & Hughes, 1995, p. 119). Its relevance to this study is its concern with the in-situ study of an identifiable group of people. I was seeking

an approach to social research based on the first-hand experience of social action within a discrete location, in which the objective is to collect data which will convey the subjective reality of the lived experience of those who inhabit that location. (Pole & Morrison, 2003, p. 16)

Creswell (2013), drawing on the work of others (Fetterman, 2010; Wolcott, 2008), strengthens this definition in his discussion of the features that define ethnographic research. He maintained that ethnography is not purely the study of a culture, but the study of the patterns of the social behaviours of an identifiable group of people or community. These social behaviours include the ideas and beliefs expressed by the group and the way these are enacted within and through the organisational structure of the group.

Applying an ethnographic approach to educational research, O’Toole and Beckett (2010) suggested that ethnographers use their data to ‘describe, interpret, analyse and represent the lived experiences of schools, classrooms and workplaces’ (p. 52), thus creating an holistic understanding of the setting and the relationships therein.
Merriam (2009) suggested that there are many ways to undertake ethnographic research; however, she maintained that these features are common to most ethnographic studies:

- Data is collected in the natural setting through fieldwork (Wolcott, 2008).
- The researcher primarily collects data through the process of participant observation.
- Multiple sources of supporting data are collected during fieldwork.
- Analysis of the collected data is an inductive and iterative process.
- The final product is a detailed ‘cultural portrait’ of the group, or ‘thick description’. (Merriam, 2009, p. 28)

In this study, my primary objective was to collect data from the teachers belonging to three secondary school science departments in order to convey the subjective reality of their lived experience as they attempted to integrate ICT in their pedagogic practice. To do this, I applied the five features of ethnographic study presented by Merriam (2009), which are discussed in Section 3.4.

### 3.4 Fieldwork Design

#### 3.4.1 Collecting data in the natural setting

Since ethnographic research is concerned with developing a deep understanding of the culture, organisation, behaviour, language, and issues facing a particular group, it is essential to conduct the research in the context of the setting where the group lives or works—their natural setting (Creswell, 2013). Wolcott (2008) described the process of collecting data in the natural setting as fieldwork, and suggested that the researcher needs to spend a prolonged period in situ to collect detailed information about the lived experience of the individuals who inhabit the setting.
3.4.2 The fieldwork sites and participants

I selected three different girls secondary schools in metropolitan Melbourne for my study. I purposely made this choice because I had spent eight years of my own teaching career in girls schools, and considered that I would be more likely to understand the cultural dynamics of these environments. Two of the chosen schools were state funded with a student intake from Years 7–12; the third school was a private school with a student intake from K–12. Serving different demographic areas, the three schools offered different access arrangements to computer facilities. In selecting these schools, I anticipated that I would be able to address the questions arising from the literature review.

Nine science teachers were invited to participate in the study; these included the science coordinator from each school and two other science teachers from the respective science departments. I purposefully targeted the science coordinators of each department as they were potential gatekeepers, and I sought to understand and show how they prioritised aspects of the curriculum in their school and managed the day-to-day professional learning environment. The additional six teacher participants were volunteers who had responded to the plain language statement, which was distributed to staff in each department. They were not chosen based on their pedagogic or technical skills or their specific scientific discipline. Selection of participants also did not discriminate based on the number of years’ teaching experience or their length of time employed at the school.
Table 1: Participant Details

For ethical reasons pseudonyms have been used for school and participant names

<table>
<thead>
<tr>
<th>Participant (pseudonym used)</th>
<th>Position</th>
<th>Number of Years Teaching Experience</th>
<th>Length of Time Working at the School</th>
</tr>
</thead>
<tbody>
<tr>
<td>St Clair’s – Sally</td>
<td>Science coordinator and biology teacher</td>
<td>20</td>
<td>6 years</td>
</tr>
<tr>
<td>St Clair’s – Carol</td>
<td>Biology and general science teacher</td>
<td>11</td>
<td>5 years</td>
</tr>
<tr>
<td>St Clair’s – Nina</td>
<td>Biology and general science teacher</td>
<td>20</td>
<td>5 years</td>
</tr>
<tr>
<td>Slyfields – Estelle</td>
<td>Science coordinator and physical sciences teacher</td>
<td>10</td>
<td>7 months</td>
</tr>
<tr>
<td>Slyfields – Andrea</td>
<td>Biology teacher and general science teacher</td>
<td>1 (first year out)</td>
<td>7 months</td>
</tr>
<tr>
<td>Slyfields – Patrick</td>
<td>Physics teacher and general science teacher</td>
<td>1 (first year out)</td>
<td>7 months</td>
</tr>
<tr>
<td>Redlands – Jenny</td>
<td>Science coordinator and chemistry teacher</td>
<td>11</td>
<td>11 years</td>
</tr>
<tr>
<td>Redlands – Natalie</td>
<td>General science teacher</td>
<td>4</td>
<td>18 months</td>
</tr>
<tr>
<td>Redlands – Carl</td>
<td>General science teacher</td>
<td>20</td>
<td>10 years</td>
</tr>
</tbody>
</table>

3.4.3 Gaining access to the sites and participants

Gaining access to research sites needs to be carefully negotiated and managed to obtain the cooperation of the proposed participants (Creswell, 2013; Krathwohl, 1998; Patton, 2001). Creswell (2013) explained that qualitative researchers tend to spend a lengthy time in the research setting gathering data, and therefore, they need to develop ‘more than a casual relationship’ (p. 182) with the people participating in their study. He believed that to ensure this relationship begins well, the researcher needs to give careful consideration to how they will gain entry to the setting and make initial contact with prospective participants, warning that ‘a poor initial impression can hamper the research study from start to finish, making participants hesitant to fully cooperate’ (p. 182).
Initially, I approached the principal of each school for permission to conduct this research study, and in each case, they referred me to a representative, seen as a gatekeeper, who then negotiated access to the site and the science department (Creswell, 2013). In two of the schools, the gatekeepers were quite difficult to contact and made the process of access to the sites time consuming and frustrating; however, once they were reached they proved to be supportive of the study.

In the first two schools (St Clair’s and Slyfields), the science coordinators acted as the main gatekeepers, and they provided assistance in recruiting science teachers to participate in the research. In the third school (Redlands), the vice principal took the role of gatekeeper. Since the data collection at this school took place toward the end of the school year, he provided details of science staff who still had significant teaching loads, which gave me a better prospect of collecting classroom observation data.

Having secured access to each site from the respective gatekeeper, I was careful not to disrupt the participants’ daily routines without prior arrangement. Disruption to daily routine can cause constraints that limit what the researcher is allowed to do:

Only a limited amount of time can be taken from classroom teaching. . . . Because most institutions try to maintain business as usual come what may, those institutions that allow their schedules to be disrupted by research are unusual. Such disruptions bear testimony to some combination of the negotiating skill of the investigator, the perceived value of the research, and/or the typicality of an institution. (Krathwohl, 1998, p. 198)

Accordingly, I constructed interview and observation schedules and followed these strictly. In each initial interview, I gave the interviewee an open indication of the purpose of the research and made it very clear that every attempt would be made to assure anonymity. I knew that this was an important guarantee to give, since I was expecting the interviewees to share their personal views and circumstances, and
recording these could impinge on their standing within their community and their self-esteem (Stake, 2005). I also considered that this would create a trusting relationship with the participants, and that they would therefore be encouraged to volunteer information that was accurate and reliable, which would strengthen the credibility of the data collected.

3.4.4 Data collection

As discussed in Section 3.4.2, the ethnographer relies on multiple sources of data to ensure that they compile a detailed description of the research setting and the individuals who inhabit it. To ensure a holistic understanding of the classroom or school setting, it is important for the ethnographer to obtain and compare different types of data from a variety of sources (O’Toole & Beckett, 2010). In addition to observations, interviews, and field notes, ethnographers may also collect artefacts produced by the group, documents, research diaries, photographs, videos, and make records of personal feelings and impressions of events that they have witnessed (Fetterman, 2010; Merriam, 2009). In addition to the observations, interviews, and field notes, where possible I tried to gather examples of units of work and lesson plans.

3.4.4.1 Participant observation

Participant observation is the primary method of data collection used in ethnographic studies and can be described as the gathering of data through observations, interviews, and interactions with group participants, while the researcher is immersed in the research site or field (Creswell, 2013; Merriam, 2009; O’Toole & Beckett, 2010; Wolcott, 2008).

The role of the observer seems to vary depending on the nature of the research methodology; indeed, Merriam (2009) suggested that there is a continuum of observational positions, which range from ‘complete participant’ to ‘complete observer’
(p. 125). The complete participant is a member of the community under observation and hides their role as observer from the community. The complete observer watches a community from a vantage point so that the community under observation is unaware of their presence. I decided that the nature of my study did not align me with either of these positions, but placed me on the continuum as ‘an observer as participant’ (Merriam, 2009, p. 124). That is to say, the teacher participants were aware of my research agenda, and I had some interaction with them, but my role remained primarily that of an observer gathering general impressions of the teachers within each of the school contexts.

Irrespective of the position one takes on the observer–participant continuum, there are drawbacks and limitations that have to be considered when conducting observations.

Participant observations are time consuming, demanding, and may raise ethical issues regarding the researcher’s role and potential biases in representing an accurate picture (Bell, 2014; Cohen, Manion, & Morrison, 2013; Merriam, 2009). As Merriam writes,

An observer cannot help but affect and be affected by the setting, and this interaction may lead to a distortion of the situation, as it exists under non-research conditions. (2009, p. 137)

Other potential weaknesses of observational research include poor reliability and validity, as well as an inability to generalise to another culture or event (Adler & Adler, 1994). Yet a reliance on direct observation rather than secondhand or self-reports can be seen as a strength when combined with other methods of data collection, such as interviews and artefact analysis, as it provides a ‘holistic interpretation’ of the situation under investigation (Merriam, 2009, p. 136).
3.4.4.2 Semistructured interviews

The teachers from the three schools were asked to participate in two in-depth semistructured interviews. The first of these interviews was conducted at the beginning of the research in each case and attempted to understand the world from the participant’s perspective (Patton, 2001). The interview focused on (1) each participant’s beliefs about, and interpretation of, their role as a science teacher in their school, (2) their perceptions and experiences of using ICT in the classroom, (3) the issues that they faced when trying to integrate ICT in their everyday science teaching, and (4) their ICT PD experiences. (See Appendix C for examples of the interview questions and Appendix D for a sample audio transcription.)

These interviews were used to collect information that was not directly observable and were concerned to explore the institutional practices and structures that constituted the participants’ concrete social existence as made available in and through analytical description of the teachers’ acts of intentional consciousness. Bell (2014) suggested that interviews typically inquire about the feelings, motivations, and experiences of individuals in relation to their purposes and intentions. However, as Heiskala (2011) observed, the actor’s reflections should be seen only as a point of departure in the study of habits of interpretation and beliefs. Yin (2013) wrote,

> In-depth interviewing’s strength is that through it we can come to understand the details of people’s experiences from their point of view. We can see how their individual experience interacts with powerful social organizational forces that pervade the context in which they live and work, and we can discover the interconnections among people who live and work in a shared context. (p. 112)

I chose a semistructured interview approach, because although I wanted to ask the participants a general set of pre-established questions, I also wanted the flexibility to
follow unanticipated contributions that would arise during the conversational process. Merriam (2009), among others (Cohen et al., 2013; Hitchcock & Hughes, 1995), supported the semistructured interview, considering that it allows the researcher to pursue the interviewee’s emerging views and ideas or meanings not initially explicated or fully articulated.

My dialogically constructed perspective taking required that I conduct these interviews face-to-face, as this would present me with an opportunity to modify the line of inquiry based on the interviewee’s nonverbal responses. Gordon, Baxter, Rozelle, and Druckman (1987) highlighted four categories of nonverbal communication that I found important in facilitating the research conversations:

- Proxemic communication is the use of interpersonal space to communicate attitudes,
- chronemics communication is the use of pacing of speech and length of silence in conversation, kinaesthetic communication includes any body movements or postures, and paralinguistic communication includes all variations in volume, pitch and quality of voice. (p. 335)

As well as using the participants’ nonverbal responses to guide my line of questioning, during and after the interviews I made brief field notes regarding the participants’ body language and facial expressions. As well as adding to the richness of the transcription data, it was useful in the subsequent authoring of the interview narratives.

As Fontana and Frey (2000) suggested, through face-to-face interviews I sought to establish a professional rapport with the participants that would lead to the development of trust, an intense sharing of experiences, and enable understanding of the participant viewpoint.

The interviews were conducted at the participants’ schools to enable me to observe first-hand the participants’ working environment and experience the school
culture and professional work environment. In addition, I considered Bassey’s (1999) warning that the interview process might be a disconcerting or uncomfortable experience for the participant since it results in a formal recording of their views. She also suggested that the time the interview takes may be a ‘source of irritation’ (p. 81). I considered that interviewing participants in school would therefore offer them a sense of security and comfort in their surroundings and reduce the impact of the interview process on their time.

The second, and in some cases third, round of interviews gave me the opportunity to revisit the issues raised in the transcriptions of the first interview and provided the opportunity to follow up classroom observations.

All the interviews were between 30-60 minutes in duration, audio recorded and transcribed and shown to the participants to ensure that the transcriptions were a true record of the interviews. The transcription process took place as soon as possible after the interviews, since I wished to capture and report the atmosphere of the conversations. This again was an attempt to gather data rich in detail significant to the participants.

Bell (2014) highlighted the procedural challenges that we might encounter when conducting interviews, for example, the time consuming nature of the interview and transcription process, the stressful aspects of interview organisation, and the unexpected nature of participant management, but these were relatively easily to overcome. My concerns were related to issues raised by Merriam (2009), among others (Fontana & Frey, 2000; Hitchcock & Hughes, 1995), regarding the influence that the researcher’s history and identity have on the interview process. She (2009) observed,

The interviewer–respondent interaction is a complex phenomenon. Both parties bring biases, predispositions, attitudes and physical characteristics that colour the interaction and the data elicited. A skilled interviewer accounts for these factors in order to evaluate
the data being obtained. Taking a stance that is non-judgemental, sensitive, and respectful of the respondent is but a beginning point in the process. (p. 109)

Fontana and Frey (2000) suggested that it is not only the interview process that can be affected by the bias of the researcher that is, in principle, unavoidable in any educational research in the framing as well as the interpretation of interview data. They considered that the researcher is responsible for selecting ‘what part of the data will be reported and how it will be reported’ (p. 455). As indicated at the outset of this chapter, the researcher’s taking of the participant’s perspective can often appear unreflective and untheorised in published work, and so I sought explicitly to engage the participants in a dialogic co-construction of meaning about technologically mediated transformations in their teaching practice and thinking about their practice.

3.4.4.3 Classroom observations

Since my study required an understanding of the teachers’ teaching and learning practices and their interaction within their professional work environment, it was important for me to observe the teachers in their natural setting (Erickson, 1985).

Qualitative observations of the participant teachers in their classrooms were used to inform my interview data. As Nisbet and Watt (1984) pointed out, it is important to follow up interview data with other data collection techniques validate participants’ comments. Their warning suggests that the teacher’s perception of what occurs in their classroom may not always coincide with the assessment others may have of what has occurred. Therefore, to confirm that the teachers’ interview responses corresponded to their classroom practice, I considered that a series of observations would be appropriate. During the initial interviews, I arranged to conduct at least two classroom observations with each of the participant teachers over a period of 4 weeks, these observations varied in length as dictated by the lesson duration and were between 50-100 minutes. Through
these classroom observations, I hoped to discover further information regarding (1) the teachers’ pedagogic beliefs, (2) their interpretation of the processes of ICT assimilation and accommodation in their professional practice, and (3) the variety of ICT applications being used.

During all classroom observations, I took field notes and sketched diagrams of the physical settings. This I considered would ensure detailed accurate representations of the events. In addition to the field notes taken during the lessons, I also annotated the field notes with my own thoughts and feelings relating to the lessons once I had left the teachers’ presence. This data was transcribed from handwritten notes to computer soon after each session.

3.4.5 Data reduction and analysis

Data analysis is not a distinct phase in ethnographic research as it ‘occurs simultaneously and continuously as a key aspect of the research design and process’ (Pole & Morrison, 2003, p. 74) and draws on both inductive and iterative processes. This is evident in the way that analysis of ethnographic data incorporates both the views of the participants (emic) and the researcher (etic) as they jointly explore the multiple meanings and relationships that exist in the group and research site (Creswell, 2013). The researcher uses this data to illustrate how they have identified and used emergent themes to challenge their pre-existing ideas and understandings to develop a cultural portrait of a particular cultural setting (O’Toole & Beckett, 2010).

Aware of the amount of data I was likely to gather during each phase of the research process, I conducted data reduction and analysis during the collection process (Merriam, 2009). This analysis process was divided into several steps (Cohen et al., 2013; Hitchcock & Hughes, 1995; Merriam & Tisdell, 2015); I began by reading and re-reading the transcripts from the interviews and summarising and coding these initial
findings. The initial coding categories were developed in the interview questions. I then began to highlight emerging themes and cross-referenced these with subsequent transcripts and my field notes. Using these, I generated a map of emerging themes and related these to my research questions. To further my understanding of these emerging themes, I added summarised data from the classroom observations to the map. This process was repeated for each school, and by the end of the data collection period I had a series of analysis notes and categorised themes from which I began my refining and reflection process (Merriam & Tisdell, 2015).

Early reading (Czarniawska, 2004; Erickson, 1985; Lather, 2006; Lather & Smithies, 1997; Richardson, 2000; Tillmann-Healy, 2001) shaped my decision to present analysed data and emerging theoretical understandings in the form of narrative vignettes. Erickson (1985) suggested that the narrative vignette should provide the reader with a particular and a general description of each case, followed by interpretive commentary. The particular description in my research consists of the teachers’ quotations, extracts from the observational field notes and documents, and the narrative vignettes. The general description informs the reader whether the information contained in the vignettes is representative of the data as a whole. In weaving together observational data, documentary evidence, and the teachers’ voices, I produced narrative vignettes that provide a holistic picture of each school’s science department, followed by my interpretive commentary and a description of my subsequent theoretical analysis.

3.4.6 Cultural portraits and thick description

The final product of the ethnographic study, the cultural portrait (Creswell, 2013) or ‘thick’ description (Geertz, 1973), is designed to present the researcher’s analysis of the collected data and a detailed description of the setting. Creswell (2013) maintained that
this cultural portrait should be a credible synthesis of both the perspective of the 
participants and the interpretation of the researcher. It is considered that if this 
description is suitably detailed, the reader will be provided with a clear understanding of 
the cultural and educational meanings emerging from the study (O’Toole & Beckett, 
2010).

In this ethnographic case study, I sought to present cultural portraits of three 
science departments to understand how each practice community enabled or constrained 
the integration of ICT into their pedagogic practice of member science teachers.

3.5 Trustworthiness

Bassey (1999) suggested that the concepts of reliability, validity, and generalisability 
are derived from scientific or positivist research paradigms. She stated,

Reliability is the extent to which a research fact or finding can be repeated, given the 
same circumstances, and validity is the extent to which a research fact or finding is what 
it is claimed to be. . . . Internal validity is concerned with the relationships between 
cause and effect, and external validity is concerned with the extent to which a cause-and- 
effect relationship can be generalized to other contexts. (Bassey, 1999, p. 75)

However, as Bassey (1999) and others (Carr & Kemmis, 2003; Lincoln & Guba, 2000; 
Stake, 2005; Wolcott, 2008) have discussed, applying these criteria to qualitative 
research proves problematic and suggest we need to use alternative terms to discuss the 
rigour of data collected from this research approach.

Lincoln and Guba (2004) used the terms credibility, trustworthiness, and 
dependability to discuss the data collected in qualitative research, proposing that we 
should focus on whether results are consistent with the data collected rather than 
whether they can be repeated. Walcott’s (2008) work supported this idea, suggesting
that we should not become obsessed with looking for one right answer, but focus on interpreting our data thoroughly to develop an understanding of the situation or case in question.

To ensure research meets standards of trustworthiness, Lincoln and Guba (2004) recommended several steps be followed. First, they considered prolonged engagement in the research setting in order to gain a better understanding of the context or phenomenon being studied. Second, they promoted ‘triangulation’, which involves the verification of data with multiple methods of collection and/or the use of more than one research site. Richardson (2000) presented the notion of ‘crystallisation’ of meaning in research analysis as opposed to ‘triangulation’, promoting storytelling and representation of data as a means to enable researchers to think beyond triangulation. She deconstructed the traditional idea of validity as triangular and one-dimensional. She saw data as open to interpretation from different angles and perspectives, and this links with Walcott’s (2008) ideas relating to multiple truths. Hence, crystallisation is used as a metaphor to capture the idea that a rich dataset can be examined from different angles to develop a multifaceted understanding of the research.

Third, Lincoln and Guba (2004) considered that a process of member checking be incorporated; this technique involves the validation of collected data by the participants to ensure that it has been accurately reported and interpreted.

I used the three steps recommended by Lincoln and Guba (2004) to ensure the trustworthiness of my research data and represented my findings as narrative vignettes (Richardson, 2000). Using this combination, it is my expectation that the data will be transferable and of use in the comparison of similar cases and studies.
3.6 Ethics

I gained approval for my study from the University of Melbourne Human Research Ethics Committee and the Department of Education, Employment and Training (Victoria) in February 2003 (Appendix A). I then contacted the principals of each of the three schools, providing them with plain language statements describing my study and requesting their permission to conduct research in the schools (Appendix B).

Participation was, as far as I could negotiate, voluntary. On gaining consent from each principal, I arranged meetings with the science coordinator at each school to explain my study and to negotiate access to members of the science department who might be willing to participate in the research. In order to ensure their anonymity of participants is maintained pseudonyms have been used for both school and participant names.

3.7 Limitations

While this study was carefully designed, I recognise that several issues might be considered as limitations in my research.

As noted earlier in this chapter, a major criticism of ethnography is that the researcher’s bias cannot be divorced from the study design and the reporting process. However, it could be argued that all research has bias, since the person choosing the topic of the research must have some fundamental interest in carrying out the study. As Lincoln and Guba (2004) pointed out, inquiry of any type cannot be fully objective or value free. It appears that our beliefs, values, and frames of reference influence what we study and tell us how to interpret what passes before our eyes (Merriam, 2009). Since researchers are unable to separate themselves from their experiences, it seems prudent that they position themselves in the study by identifying and acknowledging their bias.
In Chapter 1 of this thesis, I positioned myself by acknowledging my previous role as the coordinator of the science department, in a girls secondary school, discussing my experiences of managing the integration of ICT across this department and in my own pedagogic practice. In addition, I highlighted my role as an online tutor responsible for supporting science teachers in other school settings as they attempted to integrate ICT into their pedagogic practice.

The fact that I had little control over the selection of the participants taking part in my study, as they were identified and recruited by the gatekeepers at each school, could also be seen as a limitation. Conversely, this process of selection could also be considered a strength; being unaware of the participants’ previous experiences of ICT, I could not show researcher bias. In addition, conducting my research in three school settings that displayed distinct differences in their arrangement of computer facilities ensured a variance in the experience of staff participating in the study. It could also be argued that another potential limitation of this study is its location in three girls’ schools and I acknowledge that it is hard to know whether the findings are transferable to boys’ or co-educational schools.

A final limitation that the reader could perceive is that the data collected in this research is no longer relevant, since it was gathered in 2003. However, the big issue of technologically supported change in social practices such as teaching, I argue, is just as pertinent today, and thus, this research is of significant benefit as it offers an historical perspective. This study asks how the relationships in the science departments of these three schools, at the time, were transformed or maintained during the introduction of technology. I contend that the materials generated from these three case studies provide rich data that can be used in concert with current literature, pertinent to understanding
the socialising of ICT in teachers’ pedagogic practice, as a pedagogical approach in teacher education termed case-based teaching (Shulman, 1992).

3.8 Summary

In this chapter, I have discussed the research design to justify my use of a collective ethnographic case study approach as fitting to answer the research questions stated in Chapter 1 in relation to technologically driven change.

In Chapters 4, 5, and 6, I turn to a close analysis of my three case studies, in which I use narrative vignettes to present teachers’ accounts of the everyday social interactive processes they constituted or resisted at work. Each narrative begins with an introduction to the case study school, the school science department, and the participant teachers. Through the inclusion of excerpts from interview data and lesson observations, they present a detailed narrative and discussion of each teacher’s pedagogic practice and their experience with new technologies. Finally, at the end of each chapter I discuss how each community of practice has managed the integration, assimilation, and accommodation of new technologies.
Chapter 4: Case Study 1
The Queen’s Croquet Ground

‘If everybody minded their own business,’ the Duchess said in a hoarse growl, ‘the world would go round a deal faster than it does.’ (Carroll, 1865)

4.1 Introduction to the School and Science Department

At the time of this research study St Clair’s is a relatively small, independent K–12 girls school in the wealthier eastern suburbs of Melbourne, Australia, and has 250 students in its secondary division. The school prides itself on the quality of its teachers and their understanding of current educational research into how children learn and boasts an excellent academic record. St Clair’s mission statement claims that girls are encouraged to become independent thinkers and competent discerning users of ICT. It is also suggested that the ‘laptop for every girl’ policy and inquiring environment in the school allows for a freedom and flexibility in learning. Indeed, the school has just opened a state-of-the-art learning centre that allows for open-plan classrooms and has full wireless capability. In addition to this, St Clair’s well-planned renovation program has seen most classrooms in the older school buildings refurbished and connected to the wireless network. On the surface, this school appears to have a positive approach to ICT and innovative learning approaches.

The secondary science department comprised six science teachers and one full-time science technician, offering a curriculum that led to the standard Years 11–12 subjects in biology, chemistry, and physics. Nina and Carol were both biologists who had joined the staff five years prior and were jointly responsible for Years 11–12 biology teaching. They also taught most of the Years 7–10 science curriculum with
Sally. Jim was responsible for Years 11–12 physics and taught in the mathematics department. He had been teaching for over 12 years and had been at the school for 10 of those. Tom was a chemistry specialist; he had been at the school 18 months and was replacing another long-term member of the department who had taken leave to work for the Department of Education and Training Victoria. Tom was seeking a tenured teaching position in the school. Jill, the newest member of the department, was principally a health and physical education teacher and taught a Years 7–8 class ‘to make up’ her teaching allotment; she joined St Clair’s at the beginning of 2003 direct from university. Marge was the department’s only technical member of staff and was responsible for the organisation of all experimental equipment and teaching resources; she had been at the school for eight years.

Sally suggested that in addition to her, I should interview Carol and Nina who did most of the middle school science teaching where, consistent with the school’s stance, capability in ICT was developed. She indicated that these two biology/science teachers were the only two members of the department who had shown an interest in participating in the study. I accepted her suggestion and left some additional invitations explaining the research in case other members of the department reconsidered and decided to participate.

4.2 Sally (Science Coordinator)

Sally had been teaching science in the independent sector for 29 years and had been the science coordinator at St Clair’s for the past six years. She described herself as a biologist, and in recent years, she had become a Years 7–10 general science specialist, as she saw this as an area in most need of development at St Clair’s where the sciences were not as popular at senior level as she thought they should be. In such a long career, it was reasonable to expect that Sally had seen many changes in the structure of the
secondary science curriculum and the way science is taught, and I asked her to tell me if she had experienced many changes over the years, to which she responded:

*I have and I haven’t really. I mean I’ve seen a lot of changes in technology, but not the basics of teaching science, the particle model is the particle model, atoms don’t change, and plants still photosynthesise, gravity is gravity, and really, apart from the add-ons like genetic engineering and biotechnology and where those sorts of thing have taken us. Really when you’re looking at it in particular in years seven to ten, which is what I’m most interested in, you know it doesn’t alter.* (S.1.1)

While acknowledging changes such as the reforms of Years 7–10 Curriculum and Standards Framework (1995) and the Victorian Certificate of Education (1992) leading to tertiary entry, she maintained that these had not dramatically altered the science curriculum or her approach to teaching.

Sally began her teaching career in 1974, which coincided with the publication of the Australian Science Education Project (ASEP), a groundbreaking initiative that was designed with a view to making science learning more interesting for students (Fawns, 1984; Owen, 1978). ASEP consisted of general science units expressly designed for use in new school science laboratories and was not constrained by the use of a set textbook. Sally had fond memories of using ASEP and the Junior Secondary Science Project (JSSP), its immediate precursor. Sally described these as *‘off the shelf resources’*, which included detailed topic guides, equipment packages, and student booklets (or cards) through which the teacher could plan units of work for their classes. She explained the excitement she felt teaching at this time of innovation:

*The JSSP, that was fantastic, you know and it had a sequenced set of cards for activities and it was all very well designed. . . . There was all sorts of fabulous stuff. Then ASEP came along, we trialled all that stuff and so I have always been in a school that was sort*
of out there that way. Sort of at the cutting edge and very aware of having a balanced curriculum, in my second school we did the same thing. So really since I have been teaching these programs I have covered everything . . . basically to make science for the illiterate, I mean you’re going to have kids that go out in year 10, you know they have to know about certain things around them whatever they go on to be. (S.1.2)

ASEP was developed by teams of science teachers in different Australian states who were charged with producing science topics using a core plus option design embedded in a social context that would increase student engagement. Forty-seven topic units plus service units were each designed for about a month of teaching and learning in the science curriculum from Years 7–10. Teachers in science departments in schools throughout Australia were to develop their own four-year science programs, selecting from the ASEP units. The use of ASEP at the time was a government-sponsored initiative to increase junior secondary school students’ interest in science. As explained in the Teacher’s Guide, ASEP strongly promoted ‘small group’ classroom pedagogy, which was an innovative feature at that time.

In Sally’s early career, she experienced cutting-edge changes to the curriculum, as the more descriptive JSSP (1966 to 1968) was replaced with the innovative ASEP unit booklets (1969 to 1974). Fawns (1984) observed that the use of these unit booklets placed young science teachers, like Sally, in the vanguard of progressive education in their schools. It seems reasonable to assume that these resources and the manner in which they were implemented comprised a structure of feeling (Williams, 1977) in the science department in which she began her teaching career, which would have significantly shaped Sally’s epistemological and pedagogic beliefs.

Sally considered that perhaps one of the reasons she was so fond of the JSSP cards and ASEP booklets was that they were a resource that offered a flexible but
integrated unit plan, with a progressive flow of laboratory activities and ideas. She emphasised that if learning in science was to be effective then students needed a program with an organised structure, and this extended to their written work:

*Loose leaf is not an option, we get the students to stick their worksheets into their work book so that everything is in the right order, because if they have got a bit of the particle model here and then three pages on they’ve got something else, like changes of state, then they are going to be confused, it doesn’t make sense.* (S.1.3)

This is just one of the changes that Sally instigated since her appointment as science coordinator at St Clair’s. Her most significant change, however, involved the restructure of the Years 7–10 curriculum. When she first arrived, the school’s science curriculum had been based on a ‘discovery approach’, which Sally had found most unsatisfactory. Sally had been appalled to find that her Year 11 students could not explain what photosynthesis was and suggested that this was because the discovery approach had not provided the students with a ‘real foundation in basic scientific concepts’. She continued,

*I’m not into discovery learning in a major way, for these kids to get a lot out of their science, they need to have the basic concepts under control. So really what we do [the science staff] is we give them the basic concepts and we illustrate with activities as we go along, rather than giving them a whole series of activities to do, and saying, you go work it out. I just find it’s far more efficient, you don’t get as many misconceptions, and when I say efficient I mean we get through probably three times as much work.* (S.1.4)

Opposed to what she saw as ‘abandonment’ (Roberts, 1996), she said she set out to achieve a more efficient and structured program at St Clair’s, and with the help of Carol and Nina, she said they had completely rewritten the Years 7–10 science course:
We’ve really, turned the whole general science course around and I think they [the students] find it less frustrating. I think you know you get, one [student] in twenty who will be able to design an experiment and work out what they are doing without any background knowledge, but for the rest of them it’s incredibly frustrating . . . and you find it frustrating because the students are not seeing what they should be seeing, and of course they [the students] can’t see it because they haven’t got the basic concepts.

(S.1.5)

Sally’s epistemological beliefs are reflected in her comments and the structure of the schemes of work that she has created. She viewed secondary science as a collection of laws, theories, and facts that need to be delivered in a highly structured, teacher-led program. She considered that this would provide students with the best possible opportunity to develop an understanding of the modern world and to prepare some of them for further study in science disciplines. Sally’s pedagogical practice supports the epistemological beliefs she favours: a teacher-led approach to what is effectively knowledge transfer. This approach has been very successful for Sally and she is considered a very competent teacher by her colleagues in the science department and the wider school community.

What is interesting is that this teacher-centred and transmissive approach does not hold with the comments that she made earlier in her discussion of the ASEP program, which was criticised in research studies for its perceived lack of structure and teacher direction (Owen, 1978). It appears that somewhere along the way, Sally had changed either her pedagogic approach or her interpretation of the ASEP classroom experience to suit current needs.

When asked about the ICDL, the favoured PD package used in the school, Sally informed me of her competency in the use of ICT, explaining that she had almost
finished her ICDL. She also remarked that the ICDL had not really been that helpful in developing her personal skills.

I asked Sally whether the new Years 7–10 science course incorporated the use of ICT activities. She explained that ICT activities had been built into some of the new units of work, but added that

really, in science, time and safety constraints did not allow for the use of ICT on a regular basis. (S.I.6)

She detailed several problems that she had encountered when using ICT, such as students forgetting to bring their laptops to class, or arriving with laptops uncharged, which resulted in trails of wires across the classroom.

To observe Sally’s pedagogy and see how she incorporated ICT in her classes, I attended four of her lessons. In Figures 4 and 5, I present excerpts from the first two observations, which occurred with a Year 7 class and were among the first laboratory-based science lessons the Year 7 girls had experienced. They were both single periods and a day apart. The colours indicate the teacher and student conversation, and the black shows the observer’s field notes.

<table>
<thead>
<tr>
<th>Observation 1. Sally (10/3/03) Monday period 3</th>
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<tr>
<td><strong>Year 7, 22 students, 53 min</strong></td>
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In this lesson, the pupils were conducting an experiment to find the boiling point of water. They were working in pairs and following a practical sheet that Sally had designed. The practical sheet was a recipe style and the pupils were expected to follow step-by-step instructions. She spent about 15 min going through the sheets to be sure that all the pupils were clear on exactly what they had to do. Sally then demonstrated how to light the Bunsen burner safely and highlighted some safety precautions. Pupils then began to collect the equipment for their practical.
When wandering around supervising the pupils, Sally came over and told me that in the previous week’s lesson, she had taught her pupils about changes of state, and this was a way to make this theory concrete.

Pupils took temperature readings every 30 sec and noted these down in their exercise books. Once they had collected their data, Sally told all the pupils to turn off their Bunsen burners and to return to their seats so that she could come around and check their results. After about 10 min, the students were instructed to return to their apparatus and to check carefully if it had cooled, and if it had, they were able to clear away; if not, they were to leave it for the science technician to clear.

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**Figure 4.** Excerpt from Observation 1, Sally’s Year 7 science.

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**Observation 2. Sally (11/3/03) Tuesday period 2**

**Year 7, 22 students, 53 min**

Sally told the girls to quickly go and fetch their laptops because they were going to be ‘typing up’ what Sally referred to as ‘a formal prac report’.

Sally: Ok girls, what I want you to do is type up the prac we did yesterday using your laptops. When you get to the results section, you will have to create a table and put your results in it. Then you can leave a space to add a diagram.

Student 1: Can we draw the diagram using the computer?

Sally: Yes, but don’t spend forever trying to do that.

The students dutifully began transferring the information on the sheet to their laptops; some girls were very quick and were already creating their diagrams using a drawing package. Sally wandered around checking that they were all working and came over to speak to me: ‘I may as well be a fly on the wall when they have the laptops’.

When some students are nearing completion of the task, Sally issued graph paper for them to plot their results.

Sally: Ok girls, stop what you are doing and tilt your screens to 45o. Now I want you to use the graph paper this way up [she holds it up for them to see] and draw a graph of your results. The x-axis should be the time and the y-axis the temperature. She proceeds to draw this on the board.

Student 2: Miss, can we plot it on the computer?
Sally: No, I want you to use the graph paper. And if you don’t finish in class you can complete it for homework.

Sally came over to talk to me again and expressed her surprise at the girls’ skill with the drawing package: ‘You know some of them are quite good at the graphics and I haven’t taught them that you know’.

Sally: Remember you will have to print out all your work and stick it into your lab books.

The lesson continued in this vein, with a few students plotting the graph and the majority continuing to type up their ‘formal prac’.

Figure 5. Excerpt from Observation 2, Sally’s Year 7 science.

Both classroom observations demonstrate that Sally favoured a more teacher-centred approach, but curiously, in the second lesson (11/3/03) she appeared much firmer than in the previous lesson (10/3/03), even though the students had been in possible danger of scalding themselves during the experiment. This might be because Sally felt uncomfortable when the students were using their laptops, as her role in the classroom had changed from instructor (10/3/03) to supervisor (11/3/03); this is illustrated by her fly on the wall comment.

Even though there were no major safety issues in the second lesson (11/3/03) and time did not seem to be an issue, Sally still seemed reluctant to allow her Year 7 students to use Microsoft Excel to plot their graphs. Perhaps she had not considered that using the computer to plot the graph would have been beneficial, as it would have provided her with time to discuss with her students how to interpret their experimental data and connect with the scientific concepts under investigation. I felt a tension existed between Sally’s pedagogical practice and that required to make the best use of available technology.

Lesson Observation 3 was with Sally’s Year 9 class, who were working on a unit called The Antarctic.
Observation 3. Sally (12/3/03) Friday period 6

Year 9, 19 students, 53 min

Sally’s lesson was located in the lab adjacent to the library, and conveniently, the library wireless connection covered this area. So students who had not previously managed to download the required data-logging software from the network were able to do so at the start of the lesson.

Sally began the lesson by showing the students the temperature probes and the data-logging units and how they connected to the students’ laptops. She then discussed safety issues and organised the movement of desks to ensure that the students would have minimal chance of spilling water onto laptops or tripping over power cords. The students were quick to move the furniture and collect the required equipment: black and silver can, the data loggers, and the cables. They set their equipment up very quickly and most were ready to face the front by the time Sally was ready to go through the instructions she had been writing up on the whiteboard.

**Sally:** *Okay, now what you need to do is [indicating to the instructions on the white board] type this into your laptops. Once you have done that then select the experiment from the drop-down menu. Go to x in vhs and select temp. Go to select temp probe, put 0°C, call that black or silver. Now do the same to select the next probe. Put your probes in the cans and run the experiment.*

Sally moved around the class assisting some groups of students who had not quite grasped the instructions and were struggling to set up their scales. For the remainder of the lesson (approximately 15 min), the girls stared at the computer screens watching their graphs form, or chatted. Sally circulated attempting to troubleshoot when pupils’ sensor probes were not functioning correctly or they needed help selecting a graph scale. During this period, she came over to me and said, *‘You see what I mean: It takes the whole lesson to set up and then they end up not putting the probes in the water so they are measuring the air temperature. You can see all the reorganisation we have to do so that the laptops are safe’.*

3.25 p.m., Sally asked the pupils to stop what they were doing and to pack away. Some pupils enquired whether they should save the data that they had collected, and Sally explained that this was just a trial run and not to bother.

*Figure 6. Excerpt from Observation 3, Sally’s Year 9 science.*
It appears that this was the first time the students had ever used the data loggers, and that Sally had designed the lesson to familiarise them with the equipment and the software. If this was so, then the students were extremely efficient in their reorganisation of the room and were quickly ready to begin their experiments. It is evident from the comments Sally made to me during that lesson that she had not expected her students to be able to collect any useful data in this single period. This is further corroborated by the fact that she had not organised an activity to further the lesson once data collection had begun, and this resulted in the girls sitting watching their graphs form, or chatting.

The next lesson for this group of Year 9s was a double period on the following Monday morning, and I was there when the students arrived.

### Observation 4. Sally (5/5/03) Monday periods 1 & 2

**Year 9, 23 students, 106 min**

The students came in quickly and sat down while Sally called the roll. She then explained that they were going to do the practical they had practised on Friday afternoon, and that the data they collected would be used to see which can was the best insulator: the black or the silver. Sally told the students that the prac was to be written up formally, and that once they had set up their apparatus they could begin to do their write up. Sally took a minute to remind the students about safety, and then they were able to collect their apparatus.

The students rearranged the room and organised their apparatus quickly, and most had begun collecting their data within 10 min from Sally’s final instruction. Some students did require help to ensure that the graph was of an appropriate scale to fit on their computer screen, but on the whole, there were few problems.
Sally helped a group who were absent on Friday and then circulated, checking on the girls’ progress. She had to remind a number of them that they should be writing up the practical as the data was being recorded. She then decided to write the outline of the experiment on the board for them.

The students dutifully copied the information down and began to draw a diagram of their apparatus.

Several groups were even able to begin an extension activity, which involved lagging their tin can with bubble wrap.

Figure 7. Excerpt from Observation 4, Sally’s Year 9 science.

This second lesson with the data loggers ran very smoothly, and all the students managed to collect their data efficiently without incident. They were also able to complete the practical write up in the class and interpret their results; some girls even managed to move on to an extension activity. It appeared to be a very successful lesson.

In our discussion to debrief the lesson (5/5/03), Sally concurred with my appraisal of the lesson and considered that ‘on the whole the lesson had worked’, even though a minor printing issue had resulted in her having to save the students’ work to print out later. She also took this opportunity, however, to restate the concerns she had mentioned in our first interview (6/3/03) regarding safety:

*The wholesale movement of the desks is a nuisance and the other day I nearly broke my neck, as I tripped over one child’s power cord. It is just too dangerous. You can’t have*
them plugged in and walking around with water and chemicals, it’s just too hazardous.

(S.2.1)

Sally’s continued reference to safety and concern over the time required to rearrange the classroom when using ICT appears to be the justification that she regularly used for not using ICT. In the four lessons that I observed, the students were efficient in the minimal reorganisation required to accommodate the use of ICT, and Sally’s safety instructions were heeded by the girls, as all lessons were incident free.

The data logger had clearly ‘freed up’ time for the students to discuss scientific concepts and compare the insulation properties of the tin cans, but Sally still maintained ‘that it would have been easier to use a thermometer and plotted the graphs, as students would have understood a lot better’. She went on to explain:

It’s not so bad with the temperature probes, but you still can’t do more than one at a time because they don’t know which is which and they don’t make the right links in their mind. It’s this reason we chose not to use data loggers for speed and acceleration [experiments], you see we think that it’s far more visual seeing the dots formed on the ticker-tape than to have this nebulous thing that comes out of cyber space and suddenly gives you a graph. We think it’s important particularly for the weaker kids to see the dots being formed. The students actually know what they are looking at. So I think it’s far better to give them a piece of graph paper and to make them do it properly. (S.2.2)

Once again, these statements highlight the importance Sally placed on teaching her students how to use traditional experimental methods to collect data and present results. She seemed to be concerned that the use of ICT tools would in some way detract from the students’ manual skills and their conceptual understanding, though her students demonstrated several different manual skills such as keyboarding and mouse manipulation. Her concerns seemed somewhat contradictory. If traditional measuring
and graphing skills were identified as a priority, and taught and over learned in Year 7, as Sally had indicated, then why did they need to be continually rehearsed in Year 9? While her comments could be interpreted as underestimation of the students’ ability to interpret the graphs produced by the data-logging software, they could also be interpreted as her being very thorough and considerate of all students. However, the Year 9 students that I observed appeared to competently analyse the experimental data that they gathered.

During the lesson debriefing, I asked Sally if she believed that ICT offered any value or learning opportunity for students in science. She replied,

*I think that you see a sort of collaboration when they are using the data loggers, because you get troubleshooters that you can use, and it is interesting because these are not always the kids who finish their work the quickest. So the ones who always finish their work quickly are not always the ones comfortable using the computers. Which is good really because it gives those kids who are lacking in confidence a chance to say, “hey hang on I can do this”. But, really I don’t use data loggers or computers frequently enough, so you would have to ask some one else. (S.2.3)*

Even though Sally identified several positive outcomes from the use of ICT with her students, she did not seem keen to adapt her practice or her lessons to include ICT on a regular basis. For Sally, the use of ICT did not seem to be something that she considered would add any value to her already successful classroom practice:

*Really it’s more trouble than it’s worth. We do put information up on the Intranet for them and they can write up their formal practical reports, and plot graphs, or do research on them [computers] at home, but I just don’t find it an effective use of class time. (S.2.4)*
Sally implied that this was the general attitude of her colleagues in the science department, which she indicated was somewhat against St Clair’s school policy promoting ICT as a crosscurricula skill:

You see we have to report on a set of skills such as time management, ICT, literacy etc., and you see what we have done is, had the reports changed for science to “use of technology” rather than “use of information communication technology”. Because we [Sally and her colleagues] think that learning to use a microscope, light a Bunsen burner, reading a balance and those sorts of things all come under the heading scientific technology. So to just define it as ICT is rather limiting. (S.2.5)

Sally’s revised wording of the school report for science might be viewed as an indication that she had complied with the school’s ICT policy and integrated ‘technology’ within the science curriculum. Her actions, however, illustrate that her interpretation of ICT as ‘technology’ led to ICT being assimilated into the science department’s practice in a way that neutralised any potential it might have had for enhancing the learning of science at St Clair’s. Sally made use of ICT in the lessons that I observed, but really only reached what Puente-dura (2010) would describe as a first step—direct substitution of ICT as a device to complete an activity that had already been designed. This is illustrated by her use of a word-processing package to write up a practical and recording temperature of an experiment using a sensor probe.

4.3 Carol (Biology and General Science Teacher)

The second member of the science department that I interviewed at St Clair’s was Carol; she was also a biologist and had been employed at St Clair’s for six years. She had begun her teaching career in 1981 and had taught for four years before taking an 11-year career break to raise a family. During this 11-year period, Carol had set up a craft business, but managed to stay in touch with the profession by undertaking casual
relief teaching (CRT) and examination marking. Furthermore, Sally, whom Carol had known for many years prior to her employment at St Clair’s, had kept her up to date with new curriculum issues. Carol recounted,

“Yes well obviously I knew what the Curriculum Standards Framework was, being a parent and having children in primary school, and I know Sally as a personal friend, and she has kept me informed of changes, as she was on various Boards of Studies. Also, I did a course run by the State Education Department for retuning science teachers before I started here. So I was able to keep up with things, I don’t think there have been major changes to content, but in other things like reporting. You know the CSF II is a little prescriptive and we have to cram so much into the VCE Biology, sometimes I wish we had more time. You know the girls really get interested in some topics but we have to move on, we just don’t have the time. (C.1.1)

Carol’s decision to take a refresher course before returning to the teaching profession illustrates her acknowledgement that changes would have occurred during her career break. Similarly to Sally, she also perceived the main change to the curriculum in the CSF II to be the inclusion of more theoretical content, rather than any required change to the way in which science was taught. She reflected on her pedagogic approach:

“...I suppose I am still fairly teacher centred a lot of the time, for example if they [the students] have an anatomical diagram without the labels, I will put the diagram on the overhead projector [OHP], and we will go through the labels one by one adding them on. In experimental situations, there have been a few occasions where I have let them [the students] design their own experiments, but usually I provide an outline and direct extensively. You see you have to make sure that everything is super safe. The girls do like the practical side, well that is they love the doing, but are less enthusiastic about the writing up and pulling ideas together and sometimes I feel worn out trying to get them to do it. So I impart knowledge in my lessons a bit too much, rather than letting the girls...
extract it, but I get enthusiastic and want to tell them [the students] information, and I
know some of them will just waste time if I ask them to work it out alone. (C.1.2)

It was evident from my first interview with Carol (2/4/03) that she was enthusiastic and
critically reflective of her science teaching and eager for her students to succeed in her
classes. But it appeared that her horizons of significance, teacher-centred pedagogy, and
epistemological understanding of science rarely afforded her students the opportunity to
develop their scientific skills independently.

Carol told me that she did not think she would be able to offer much insight into
the use of ICT in science at St Clair’s as she rarely used it in her classroom. She
suggested that even though activities were included in the science curriculum, the time
it (ICT) took to set up and the safety issues that one had to consider were really too ‘off-
putting’. Again, the logistics were prominent in her thinking:

*Well, firstly, we have to rearrange the furniture because invariably the laptops won’t all
be charged up so they will need power cords connected as well as their network cables
connected, to the hub, and so that people aren’t tripping through all of those, you need
to move the tables to the side of the room. But then of course you’ve got the problem that
you’re near the sink and the taps, which are over on the side. You see there was a
problem in one class once with data logging, water got spilt on a student’s laptop and
the laptop was actually ruined, and had to be replaced [by the school]. So you’ve got to
be careful if you’re over near the sinks and data logging means you’ve got more leads,
and organising these leads to in experimental situation is really tricky. (C.1.3)*

Carol added that since this incident of the student’s laptop being ruined, Sally had
implemented safety procedures to ensure that this would not occur again. She explained
that now, laptops were to be kept up high and water (and other chemicals) kept low, so
that there was less chance of spilling liquids on to the keyboards.
While Carol’s initial reservations about using ICT can be attributed to this incident and issues of safety, several deeper issues became evident as she described her personal experience of running a data-logging experiment with her Year 12 students:

I have done a Year 12 practical where we’ve used data logging. It involved measuring the skin temp of the finger, but it required the person to exercise at the same time, so we had the problem of devising an exercise that could be done on the spot while still connected to their leads [smiles and laughs], and hooked up to the data loggers and their laptops. So in the end we had two laptop stations in the lab going with that and then other people using a thermometer in their mouth for their core temperature, so it was quite difficult to organise and the actual range of results was quite tricky and unreliable. It was a learning experience! (C.1.4)

The problems encountered by Carol in this lesson were related to the way that she had designed the practical. Her limited ICT training, in the form of the ICDL, had not given her the practical intelligence required to use the data loggers in an effective manner with her class. The design flaws in her data collection process and the class organisation illustrates poor planning and resulted in Carol having to think of a suitable alternative while the students were waiting to carry out the experiment. This situation would probably have made her feel professionally vulnerable in front of the students, yet she endeavoured to complete the task with the class. In a later discussion, she reflexively described it as a learning experience for her.

Carol told me that she had tried several other ICT activities with her classes and considered that she had also learnt useful lessons from conducting the activities:

In the past, I set research projects for the girls using the Internet, but found that they just cut and paste chunks from indiscriminate websites, so I quickly realised I needed to be very careful when doing this. Now when I give the girls research projects, I try to stop
them going to highly scientific medical sites or just copying chunks of information from the Internet that is meaningless. I have tried to set research activities so that they [the students] have to extract the information and somehow format it. In Year 10, for example, the girls do a brochure on diseases of the nervous system and they also have to write a diary of a person with a disease, a day or week in the life of coping with the disease. That way the girls have to find the information about the symptoms and the treatment, rather than copying a whole load of gobbledygook that they don’t understand, which is what I found they did before I structured the activity. You know they did [it] very well and seemed to enjoy it. (C.1.5)

Carol considered that the use of the Internet research activity had eventually been very effective and that her Year 10 students had managed the task enthusiastically. Consequently, she had convinced Sally that the inclusion of Internet research activities would be a good way to include ICT in the scheme of work that they had designed.

Carol also believed that although simulation activities could be advantageous and might be a good way to replace ‘outmoded activities such as dissections’, she did have reservations:

*I haven’t used simulations much because of the time constraints. I would have liked to do more, but I seem to be so short of time to get all the facts in. And to use simulations properly in class I think you really have to commit a good block of time so that the girls learn how to use all the features, otherwise they don’t get the most out of it. And look, we just can’t afford to lose that time with all the content we have to get through. Look there are some terrific simulations that show you demonstrations of chemical reactions, allow you to do a dissection and even let you genetically modify plants. And the girls enjoy using them. You know last open evening, we had Year 11 girls queuing up to demonstrate the plant pollination simulation that we have. It was amazing.* (C.1.6)
Taking the previous three quotations together, Carol’s attitude to ICT use in her pedagogic practice varied. Ostensibly, she did not seem opposed to using some ICT tools, such as word processing, search engines, and interactive media, to enhance the teaching and learning of science, and apparently, she learned much from these. Clearly, Carol had felt personal success with the learning activities she had designed that incorporated these ICT tools. However, her successes, both her own and the students’, seemed to be at odds with the responsibility she felt to cover the content of the science curriculum within a limited time frame. One illustration of this in her comment (C.1.6) references the need for students to be fully conversant with simulation software if they are to use it effectively, which perhaps indicates that she felt if she used simulations she would be obliged to teach ICT skills in what she regarded as ‘science’ time. That Carol had not been given time by the school to work through the pedagogical practicalities of using ICT with colleagues or students could be considered as a practical local moral order problem (Rawls, 2011).

Having discussed several of Carol’s lessons with her, I arranged to observe her Year 9 class during the Antarctic topic, as this topic involved the use of ICT. The colours indicate the teacher and student conversations.

**Observation 1. Carol (4/4/03) Friday period 9**

**Year 9, 22 students, 53 min**

The lesson began with Carol asking the students to get out their laptops, but from a class of 22 only 11 had remembered to bring them to this lesson and Carol had to let several girls run to their lockers to fetch them. Once they had all returned, Carol began to explain the ideas of heat transference and the reason they were going to use data loggers to measure temperature. She also explained that today they were going to practise setting up the equipment, and this way they could get an idea of what the graphs might look like, and then in the Tuesday lesson, they were actually going to collect several sets of data and try variations on the basic experiment.

*Cara*: Okay girls, if you could listen please. Now to get the program you will have to follow the
instructions I am going to write on the board and then we are going to choose the scale size together, because we want it to be sensible and be able to follow it clearly on the screen.

Student 1: Miss I don’t have the program.

Carol: Why not?

Student 1: We couldn’t get to download it last week.

Carol: How many of you do not have the program?

Over half the class that had laptops with them put up their hands. This left seven pupils with laptops loaded with the required software. Carol was not impressed and told the pupils this, but carried on.

Carol: Okay, well, we will have to get into groups, but all of you make sure you write down the instructions and draw the diagram of the apparatus.

The girls copied the instructions down and then moved the desks so that they could plug in their laptops.

They then collected the equipment and began to set up their experiments, and it was at this point that Carol suddenly realised there was a problem; many of the girls could not get the probes to fit into their laptops. It seemed that the newer laptops had only USB ports and the probes required serial ports. This was the last straw for Carol, and she told the students to put the equipment away.

For the rest of the lesson, the girls worked noisily on questions on heat transference from a textbook.

Figure 8. Excerpt from Observation 1, Carol’s Year 9 science.

In our debriefing interview directly after the lesson, Carol informed me that she considered that this lesson had been a ‘total and utter disaster’ and was acutely embarrassed. I assured her that we all have these lessons. Carol confessed that the issue with the USB connections had been the last straw, especially after she had informed the girls in the previous lesson to bring their laptops with the software preloaded:
Well the first lesson was a waste of time. It was useless—I just ended up filling in time, because we didn’t have enough students with the software downloaded and then the connections wouldn’t work. Although I suppose in terms of setting up some did get that sorted before the next lesson. (C.2.1)

The issues that Carol encountered in this lesson are once again an indication of her lack of experience in designing practical lessons that involve the use of ICT, specifically data loggers. The fact that she had neglected to anticipate that some girls would not have downloaded the software was not necessarily a major issue, because as Carol had quickly realised, the girls could have worked collaboratively in groups. What really obstructed the furtherance of the lesson was Carol’s lack of technical knowledge relating to the compatibility of the data-logger connections and the girls’ computers. The fact that Carol was the first member of the department to discover this issue of connection compatibility is a clear indication that the use of the data loggers in science lessons was a very rare occurrence. (It is important to note that Carol’s lesson was the first observed in my research at St Clair’s.)

Lesson Observation 2 with Carol’s class of Year 9 students was conducted the following week, on the Tuesday morning.

**Observation 2. Carol (8/4/03) Tuesday periods 1 & 2**

**Year 9, 24 students, 106 min**

Carol began by reviewing the beginning of the last lesson and demonstrating how to set up the apparatus for the basic ‘black can versus silver can’ experiment. She spoke about safety and illustrated using her own apparatus how she wanted the equipment set up. The students were then allowed to collect their apparatus and begin the experiment. Only eight girls actually had their laptops, but Carol did not appear fazed by this and arranged the class into groups of three and assigned each group member a task. One group at the back did very little during the lesson, but the rest of the class were very engaged.

Carol spent the first 15 or so minutes troubleshooting and then circulated, asking students if
they were okay and what they were finding out. She also suggested to some groups that they might want to try some of the alternative experiments that were on a sheet on her desk. One variation was to pretend that the cans were people in the Antarctic and to ‘dress’ them up in different materials to see which was the best insulator. Another alternative was to coat a probe in a blob of putty and immerse this in water to see if the size of the putty blob made a difference to how quickly the temperature changed. This was supposed to be a simulation of how body fat might affect a swimmer’s temperature. A number of discussions accompanied the experiments and interaction was occurring between teacher and students and among students within the groups.

I observed that the only real technical issue in this lesson was the students’ inability to print the graphs immediately. However, Carol overcame this by saving all the data to disc and suggesting that she would print these out and give them to the form captain to hand out after lunch, during the form period.

She told the pupils that for homework, they would be required to complete a write up of the findings from each of their experiments and needed to be prepared to share these findings with the rest of the class.

*Figure 9.* Excerpt from Observation 2, Carol’s Year 9 science.

Things ran more smoothly in this lesson; the class collected some meaningful data and were able to conduct variations on the basic heat loss experiment. This led to some interesting informal discussion and interaction between Carol and her students. Carol appeared much happier with the lesson outcome and seemed excited about the way the girls had responded to the activity and how they had engaged with her in discussion about the experiment. Carol had previously explained (2/4/03) that she often found it difficult to engage this particular class during science lessons, and that she usually found it quite demanding to keep them on task:

*Yes, well, I think they really enjoyed it you know, and a few misconceptions really came to light in that they thought that the dressed up cans would warm up like people would, and I found that it was quite a useful thing to explain about the difference between mammals and reptiles. And the one experiment that really didn’t work, and so I had to*
use my results, was the one where they had wrapped their probe in a big hunk of putty and that represented a big putty person in ice water compared to a small putty person. But we had to use my results, and those who did manage to get results and save them they did really well. And you know they are really very quick, once they have done it once, and they are able to reset it for the next experiment and they see if it’s not set up or running correctly. (C.3.1)

In our debriefing after the lesson, Carol informed me that only a few girls had laptops and that gathering data in groups had really worked quite well and reduced the number of wires ‘dangling around’. I asked Carol to explain how she felt about her role in the classroom while the students were carrying out this practical activity, and she decided that actually, she had felt closer to the students because she was learning with them, and she felt that the students liked having the ‘expert role’. She also claimed that she would use this approach again and had already asked the science technician to investigate purchasing the connection adaptors for the data loggers.

Lesson Observation 3 took place later the same week on the Friday afternoon.

Observation 3. Carol (11/4/03) Friday period 6

Years, 22 students, 53 min

Carol ran the third lesson in this sequence as a plenary session, where the students shared their experimental findings. Since all the pupils had tried slightly different variations on the two experimental themes, they were able to raise some interesting discussion points, and Carol was able to guide their understanding. She had also prepared a worksheet for the girls, which reinforced the data-logging experience and allowed them to build on their knowledge of heat transfer. In addition to the data-logging activity, Carol had also organised for the students to view the Australian Antarctic Division website and organised a rota for groups to record data from the weather station webcams, which they were going to process for homework and review in a subsequent lesson.

Figure 10. Excerpt from Observation 3, Carol’s Year 9 science.
During this lesson debrief, Carol confessed that she had deviated from the recommended lesson plan in the Antarctic unit and designed her own. She explained that the way the Year 9 students had engaged with the activity in the previous lesson (8/4/03) had inspired her to try something different, and she thought that the Australian Antarctic website would add reality to the classroom experiment.

Across less than a fortnight of timetabled classes, Carol’s persistence in running the data-logging experiment is an indication that she had recognised the technology afforded the engagement of her Year 9 students in science. As well, she had altered the third lesson plan in the Antarctic unit to include another ICT activity, indicating that she had begun to identify opportunities to use ICT to enhance her students’ learning. In the three lessons that I observed, Carol showed she was able to meet this challenge of including ICT in constitutive sense making with her classes that would facilitate the assimilation of the computer as a social tool to advance her students’ learning. Carol was not only substituting ICT, she was beginning to see how she might use it to redesign her lessons to transform learning.

4.4 Nina (Biology and General Science Teacher)

Nina, another biology specialist, had been a teacher for approximately 20 years; however, she had not always worked in a secondary school setting. Before joining St Clair’s and returning to classroom teaching, Nina had held an administrative role in the State Department of Education, and prior to this in Melbourne Museum services, working on educational aspects of displays. She had found work in the museum very exciting and believed that this and work as a CRT were where she had developed her ‘creative approach to teaching’: 
I have always tried to be a little bit more creative, to be a bit out there, not with ICT, but with other activities. Sally and Carol just look at me sometimes and roll their eyes, but I am the one who is prepared to take risks and sort of jump in there. (N.1.1)

Nina detailed some of the projects she had been working on with her Year 9 students:

Well, so far this year we have been working on a forensic mystery run by Triple J [a national radio station] involving the use of forensic skills to solve a crime, and a revision activity where the students set their own test questions using Bloom’s taxonomy, and next I am thinking about doing a Morse code activity with them [her Year 9 class]. (N.1.2)

Nina explained that the forensic activity was based around a competition organised by a national radio station, Triple J. Schools were encouraged to register for the competition with Triple J and were then sent a starter pack, which included packets of forensic samples. The students conducted experiments on the samples and each week were able to log on to the Triple J website to access clues, upload their findings, and vote on the guilt of suspects. The activity culminated in a live video link trial of the culprit, and Nina’s students brought their laptops in to science to view this. Nina gave details:

We received the forensic samples packs from Triple J, which contained about four or five things, and then once a week they [the students] could get clues on the Internet. At the end, you had to send in who the students thought had done it, based on the evidence. The radio station then pulled one of the winning entries out and the school got a prize. Triple J also had a whole trial based on the evidence that students [across the state] had collected. That was really exciting and my girls brought their laptops and we were able to watch the trial on the Internet. The whole activity was great and the girls got really quite excited by the whole thing. (N.1.3)

Nina continued enthusiastically, describing the test generation activity she had mentioned earlier:
With the Year 9 and 10s, I get them to set the test and that’s their revision . . . so I’ve picked out a number of headings for the topics and I go through Bloom’s taxonomy with them so that they sort of know what sort of question to ask and I give them the stem of the question to help. I let them do it in pairs and they are only allowed to ask one “knowledge” question . . . and it’s good revision because they have to know the work really well as they have to give me the answers to the questions as well. They set tougher tests than I would in the end . . . At the minute the girls give the questions to me on paper, but I would rather get them to type them up using their laptops, because otherwise I spend an awful lot of time typing them up. (N.1.4)

While the two tasks Nina described might have been enjoyed by her students and, in her perception, might be more creative than those run by her colleagues, they did not seem to be especially novel, or in Nina’s words, ‘out there’. Neither did they appear to be particularly ‘risky’. Forensic science units have been available for secondary school science courses since 1989. For example, the forensic science unit in the Science at Work series by Longman publishers in 1989 has been widely used in schools in the UK. The activity was technologically innovative in the sense that students had the opportunity to link to the radio station and possibly students from other schools via the Internet; however, Nina did not seem to have recognised it as such. It occurred to me that while the use of the Bloom’s taxonomy in test construction was sensible, as an activity it could have been made less arduous with the use of ICT.

The two tasks that Nina had conducted, and the proposed Morse code activity that she had mentioned, did not seem to match any of the activities outlined in the Years 9 and 10 schemes of work, and I asked if this was a problem. Nina explained,

Well, you see, the schemes of work are a guideline—we wrote them about five years ago because there was no real structure. The previous science coordinator had preferred discovery learning, but it wasn’t really working. I hardly ever stick to the schemes of
work. I just look at the things we need to do, to make sure that the girls have all covered
the information for the assessments. You see our reports are set up around the
assessment tasks, but really how you actually get there is up to you, so long as the girls
have the basics. (N.1.5)

This is quite a revealing statement regarding the schemes of work, and Nina seemed to
be implying that so long as she addressed what was on the common test and taught the
‘basics’, she really did not have to follow the scheme of work too closely and could
effectively ‘pick and mix’ activities. I asked Nina if this was general practice across the
department:

Well, I can’t really tell you what others do, but I tend to have my own activities when I
am teaching something I’m really into, like the genetics or environmental topics, and I
tend to digress quite a bit. But subjects the girls find boring like energy or electricity I
will look at what needs to be covered and then do the activities I know that work. Sally
knows what I’m like; she agrees that some of the physics topics are just so dry. I suppose
we really should rewrite some units, but we haven’t got round to it yet. We did add ICT
activities two years ago, when all the girls got laptops, but I suppose we need to do a
real overhaul. (N.1.6)

Nina’s background education in biology filtered through in the comments that she made
and illustrate a somewhat negative bias toward physical science topics. She also implied
that her attitude toward these topics was justified since Sally, also a biologist with a
similar background in science, was aware of her practices and also considered some of
the topics to be uninteresting to the girls.

Following on from her comment regarding the relatively recent inclusion of ICT
in the schemes of work, I asked Nina if she included any of the suggested activities in
her lessons.
Well, yes and no, you see the parents spend so much money on them [laptops] you feel that the girls should use them, but in science it’s really impractical. In Year 8, we’ve moved it to Year 9 now, we used to run this unit on heat [the Antarctic unit] and we had a program that we could load on to the computer [the data-logging program], but one drop of water on their keyboards and you know there’s an amazing pop and their parents are just [raises hands and eyebrows] . . . and there are other safety issues as well, even though you tell them to charge up their batteries they don’t, so they have them plugged into the wall, and so you are moving furniture and if you have seen our science labs . . . [raises eyebrows]. Well, you’ll know that you move the furniture and you block the cupboards and you can’t get into anything so that makes it really awkward. So usually we get the girls to use it for writing up their practical reports and downloading worksheets. You know, Sally has been really proactive about putting a lot of the Year 9 and 10 worksheets on the Intranet. (N.1.7)

Once again, the issue of safety was prominent, and it appeared that Nina had experienced first-hand a situation of water damaging a laptop. It was therefore not surprising that she was apprehensive about the girls using their laptops for anything other than word-processing activities.

*We use the laptops to get them to write up their practicals, but their handwriting is absolutely atrocious and if you’re trying to get them ready for a Year 12 exam one of the things you’re improving all the way through is their handwriting, and if they’re doing all this you find they can’t spell to save themselves. At Year 12 they are expected to spell a whole lot of words that sound really similar. For example at the moment we are doing sugar levels in the blood stream so you’ve got a lot of words that sound the same like glucose, glycogen, glucagon, and you know they’ve got to know how to spell them and how to use them accurately and be able to write them in a legible hand. (N.1.8)*
From her comments, Nina appeared conflicted in her support of ICT use in science teaching. On the one hand, she felt an obligation to use computers since the girls’ parents had paid so much for them. Nonetheless, this feeling was overshadowed by her concerns related to safety and her opinion that the use of computers constrained the development of students’ scientific vocabulary and basic scripting skills. The only concession that Nina made to using technology was with her Years 7 and 8 students who were allowed to use writing frames on their laptops to help them learn how to ‘write up a formal practical’. Even this had its issues, as Nina explained,

Well, you see in Year 7 and 8 we have writing frames for experiments and the girls use these to learn the way a formal practical should be written up. But then they say we want to put this picture in there and then I have to have it scanned [raised her eyebrows], so next year I am going to try to get a scanner in the laboratory and they can figure it out and adjust the size, ’cos they are really good and really confident, [but] I’m absolutely hopeless. (N.1.9)

I used Nina’s intentions regarding the use of the scanner to ask her about her own competency with computers. She told me that she had ‘obviously used them’ during her time working at the education department, but confessed that she really was not that far along with the PD program, ICDL. Nina suggested that she found little relevance in the ICDL units, as they focused mainly on using the software applications in business situations, and she would rather have had PD in something of more use to teachers.

Look, it’s not even targeted at teachers, it’s a business package, and it’s got 7 or 8 modules and you just have to go through them. . . . and I would have preferred PD on something like Inspiration, a program that all the kids have got. I have played with theirs a bit and I know you can do concept maps and things, but I am sure you can use it more effectively, but I haven’t worked it out. (N.1.10)
Nina had in the past attempted to use some of the suggestions in the schemes of work, but found that they really had not been effective:

When you try an activity with the whole class you end up running around trying to troubleshoot. They are all at different levels; some are really good on the computer, some are like “oh I can’t open this” or “I lost it”. And you know they all have different versions of Microsoft Office or whatever and that makes the instructions slightly different and then the smart ones are bored and on MSN messenger [MicroSoft Network] or the web when you’re not looking. You have to be really on the ball and I don’t get half of what I want to get covered done, because I am not teaching. (N.1.11)

Nina’s comments (N.1.11) echo those of Carol (C.1.4) and again illustrate a significant lack of experience in the design and delivery of lessons involving the use of ICT. For example, Nina had not anticipated that some students would be more skilled in their use of the technology than others and therefore would require extension activities. Nor had she anticipated that she might have to assist students in their use of the technology, and that this would place her in the role of technical troubleshooter. Nina was consequently left feeling that she had lost control of the class and that she was ‘not teaching’: a very revealing comment, as it implies that Nina had decided teaching science was a necessary and sufficient definition of her ‘role’. Teaching her students to use ICT to enhance their learning in science, to meet the school’s broad charter, apparently fell outside her operational definition. It seemed to me that for Nina to further integrate ICT effectively into her pedagogic practice, she would need to be convinced in the social orders of practice or honour about being a good science teacher in her school to change this belief.
4.5 Discussion

In light of the claims made in the school prospectus, it might be expected that the integration of ICT into the social orders of teaching within the science department at St Clair’s would be achieved. The school’s infrastructure allowed for easy access to hardware and wireless technology, PD had been provided for teachers, and senior management were supportive of staff using ICT in their teaching. However, it would appear from the interview data that ICT integration within this successful science department had stalled, illustrating the importance of looking further than school policy and accessibility of resources to teachers’ epistemologies and the working relationships within their communities of practice (Baggott la Velle, Wishart, McFarlane, Brawn, & John, 2007; Hennessy et al., 2005; Voogt, 2010).

Science coordinator Sally and her two biology colleagues Carol and Nina formed the core of the science department’s community of practice at St Clair’s, and over the years, they had established a solid reputation for good examination results and, among other staff at the school, a perceived competency in their roles. Yet as new technologies were included in the school’s teaching and learning prospectuses, these three teachers experienced tension between their habits of practice and their habits of belief and true belief and the need to adapt these to integrate ICT within their science teaching. This led to the manifestation of several disorders associated with the constituent elements of their community of practice—domain, community, and practice—and this resulted in the science department at St Clair’s becoming entrenched in what Wenger et al. (2002) considered the ‘stewardship’ stage of development.

4.5.1 Domain disorder

Sally and her two colleagues are undoubtedly passionate about the teaching of biology and science in general and have developed strong ownership of their domain. Sally, in
particular, takes great pride in the way the core group have structured science knowledge within the schemes of work. She also takes pleasure in the department’s wider recognition in the school community as a successful subject department, which is measured by the popularity of optional courses and good external examination results. This pride of ownership, shown by her comments regarding the new schemes of work (S.1.5) and her vision for how science should be taught (S.1.4), has led to her somewhat pedagogic conservatism in relation to socialising ICT in shared professional sense making at St Clair’s and a desire to protect the current high status of the science department as a community of practice. Sally’s two colleagues often defer to her as the expert pedagogue, so she has assumed the department’s collective voice and influenced the wider school community. This is illustrated by her successful move to influence the school reporting system by changing ‘ICT use’ to ‘technology use’.

This domain issue could be seen as an example of what Wenger et al. (2002) termed ‘imperialism’ in that with the responsibility to develop a domain comes the ability to decide how to approach it, which issues matter, who can have a say, and what the organisation should do about it. However, focusing on areas members are passionate about can lead to a community to think that their domain is more important than others or that their perspective on the domain should prevail. (p. 142)

They (Wenger et al., 2002) go on to suggest that because of the passionate belief that their perspective is the right one, imperialistic communities are not open to new methodologies, the help of outside experts, or alternative views. This would appear to be the case with this community, since the beliefs and values demonstrated by Sally, Carol, and Nina have resulted in them becoming the ‘pedagogy gatekeepers’ for this domain. Any initiative that requires changes to pedagogic practice, such as the
integration of ICT, needs to be sanctioned by this core group of three if it is going to have any chance of success. Success here is not a matter of following or accepting pre-established institutional orders, but constituting new orders of sense making or significance.

4.5.2 Community disorder

In addition to causing a domain disorder, the close relationship that has developed between Sally, Nina, and Carol has resulted in the formation of a clique, and, as Wenger et al. (2002) reminded us, ‘cliquish communities tend to stagnate’ (p. 145).

The other three teachers that belong to this community of practice (Jim, Tom, and Jill) do not appear to have a voice, and there is very little evidence of their active involvement in moving the community’s practice forward. It could be said that these three teachers have been marginalised by the community’s core group, and it is evident that two classes of membership have been created, ‘insiders’ and ‘outsiders’, which have prevented the community from evolving or developing a common identity.

Research contends that useful knowledge is not restricted to core participants and that ignoring the knowledge of peripheral members can stall a community’s development (Barton & Tusting, 2005; St Clair, 2008; Wenger, 1998). This is because a community of practice requires an influx of new ideas, approaches, and relationships to maintain the relevance of that domain (Wenger et al., 2002). However, there is no implication here that the three teachers interviewed actively excluded their colleagues or that these colleagues sought membership of the junior science team. In all likelihood, these colleagues viewed the teaching of junior science as a lower priority than teaching senior classes or had been asked by the school management to see themselves as contributing more significantly to teaching in other subject departments, such as mathematics or physical education.
It could also be argued that through the nature of this cliquish relationship and the influence Sally espouses as the head of department, pedagogic expert, and self-confessed ICT expert, she has constrained the individual growth of her two biology colleagues in this area. This is evident in their reluctance to deviate from the uniformity of the department’s current practice and scheme of work. For example, Nina was concerned that Sally and Carol thought that her teaching ‘was a bit out there’, implying that she was trying radically creative pedagogic strategies (N1.1 to N.1.4). In fact, her activities were still very much in tune with the pedagogic convention of the current scheme of work. However, Wenger et al. (2002) imperialistic account does not adequately describe the full operation of circles of discourse or orders, within which is the discourse of the science group’s conservatism in relation to how ICT operates at St Clair’s.

Further and significantly, it cannot explain Carol’s changed perception of ICT in relation to pedagogic practice over the period of my observations and as she began to use ICT with her Year 9 science class. Initial interviews (C.1. 3 and C.1.4) indicated a position strongly aligned with Sally’s, that ICT was rather more trouble to organise than it was worth and detracted from teaching science content (C.1.3). However, in subsequent interviews with Carol, following lessons with her Year 9 science class (C.3.1), I have shown that her position began to change. Carol acknowledged the affordance technology offered and admitted to deviating from the science scheme of work to include more ICT activities in her teaching (C.3.1). I believe that this is the result of two events: the opportunity Carol had of discussing her ICT activities with someone outside her community of practice (the researcher) and the change in attitude that she had witnessed in the engagement of her Year 9 students.
The local moral order and professional friendship would have made Carol reluctant to challenge Sally’s emerging pedagogical authority and expertise regarding ICT use in science. Additionally, her sense of loyalty to her colleague and their common epistemological beliefs led her to initially reject anything more than a superficial use of ICT in science. Wenger et al. (2002) stated,

Pushed to an extreme, close friendship and a desire for a sociable atmosphere can prevent members [of a clique] from critiquing each other or from seeking to deepen their understanding about their domain. The community then becomes locked in a blind, defensive solidarity as members strive to protect each other from challenges. (p. 145)

Interestingly, in this quotation, Wenger offered no explanation of change, only a lack of change.

4.5.3 Practice disorder

In addition to the social fabric provided by the community and the common interest provided by the domain, for members of a community to work together effectively, a shared repertoire and common practice need to exist (St Clair, 2008). This shared repertoire is reified in artefacts such as the documentation that the community of practice develops, the language (jargon) it uses, and the stories that are repeated. The science department at St Clair’s had a clearly defined scheme of work that structured the learning for Years 7–10 and provided members of the community with ideas, strategies, and lesson plans to use in their teaching. However, this scheme of work was predominantly created by Sally and her biology colleagues Carol and Nina, and was written before Tom and Jill joined the community. Sally maintained (S.1.4 and S.1.5) that it was written to establish a science course that provided a sound basis to support student learning, replacing the previous discovery approach that in her opinion lacked
scientific rigour: ‘I’m not into discovery learning in a major way; for these kids to get a lot out of their science, they need to have the basic concepts under control’ (S.1.4).

Teaching is not a simple process of following an institutional rule such as to integrate ICT in your teaching. No general rules in teaching apply specifically and prospectively in a particular context; the process of constructing a collaborative constitutive order around new practices is closer to what these teachers describe as their professional learning (Rawls, 2011).

Wenger et al (2002) observed that a repertoire of common practice, for example, in the form of documentation of that practice, can be a useful way to leverage past experience and create new knowledge, but it is imperative that this knowledge is updated and extended if it is to remain valuable. The scheme of work created by the core group of this community of practice was three to four years old and, as they freely acknowledged, would have benefited from being updated. This process might have also provided new staff members with an opportunity to contribute to the furtherance of the domain’s practice. As Wenger et al. (2002) reminded us, ‘we need others to complement and develop our own expertise’ (p. 10).

The only change that had been made to the scheme of work was the inclusion of a number of ICT activities, which appeared to support the school policy for the integration of ICT. Significantly, none of these ICT activities was compulsory nor actively encouraged, and in Sally’s words, ‘time and safety constraints do not allow for the use of ICT in science on a regular basis’ (S.1.6). Sally further qualified her position on safety and the use of ICT when recounting an incident that resulted in a student’s laptop being damaged and detailed the safety procedures that she had established in response to this accident (S.2.1). During the interviews, both Carol and Nina recounted the story of the destroyed laptop (C.1.3 and N.1.7) and drew attention to the new safety
procedures for ICT use. Clearly, this incident had become part of the community of practice’s shared repertoire and one way for the core group to justify the limited use of ICT within science.

Time constraints were also offered as a reason for the limited use of ICT in science lessons, specifically the time required to implement the new safety procedures, upskill students in the use of particular applications, and the time spent troubleshooting technical problems during ICT use. It was intimated by all three teachers (S.2.4, C.1.6, N.1.11) that this time would be better spent teaching science content.

The relegation of ICT to the sideline is not likely to be solely the consequence of the core group’s epistemological beliefs and pedagogic practices; it is also a reflection of the school’s academic priorities. It is evident that dual social orders operate in this research environment: the practical order of getting the job done and the moral order or status, of being well regarded in the workplace.

The socialisation of ICT in science teaching at St Clair’s had also been influenced by the ICT PD program chosen by the senior management and the ICT coordinator, the ICDL. The teachers interviewed were quite disparaging of the ICDL and had found little connection to their pedagogic practice, as evidenced by Nina’s comment, ‘Look, it’s not even targeted at teachers, it’s a business package’ (N.1.10). The ICDL program was designed for a business context and the development of personal ICT skills. It is marketed as a package to help train people in the competencies required for the use of common computer applications such as word processing, use of spreadsheets, image editing, and navigation of the Internet. It is not a PD package designed to provide teachers with the pedagogic strategies to support their practice and the use of ICT within the classroom setting. Perhaps the selection of a PD package more relevant to the
teaching of science, or even based around classroom pedagogy, would have been more enthusiastically received.

4.6 Summary

From the data discussed in this chapter, it is evident that the science department at St Clair’s had well-established practices, a solid foundation of teaching expertise, and a trusting relationship between the three female biology teachers who formed its community’s core. According to research conducted by Saint-Onge & Wallace (2003), these qualities could make this department a good site to support learning and the introduction of new initiatives, such as the integration of ICT. However, Wenger et al. (2002) would argue that these specific qualities impede the change process and often act as a barrier to organisational learning:

The very qualities that make a community an ideal structure for learning—a shared perspective on a domain, trust, a communal identity, long standing relationships, an established practice—are the same qualities that can hold it hostage to its history and its achievements. (p. 141)

In this particular case, I agree with the propositions of Wenger et al. (2002) and believe that this is exactly what had occurred in the science department at St Clair’s. The tightness of the core group, the success of current practices, the continued support of senior management, and the lack of PD appropriate to pedagogical application of ICT have all contributed to this community of practice remaining impervious to the integration of ICT in its collective pedagogic practices.
Chapter 5: Case Study 2
A Mad Tea Party

‘It’s a poor sort of memory that only works backwards,’

the Queen remarked. (Carroll, 1865)

5.1 Introduction to the School and Science Department

At the time of this research study Slyfields Girls College was established in 1994 and was in effect a merger of three schools. Although the new school constructed an entirely new identity and mission as a girls science and technology college, many of the founding staff and initial intake came from the three original schools. The school has grown in reputation and size, and the demand for enrolments often exceeds the available places. The school boasts a culturally and geographically diverse intake and reports an enrolment of approximately 1,200 students from 60 countries. The school offers students the option in Years 7–8 to participate in a laptop stream. Students rent laptops from the school or purchase their own and use these on regularly in their classes.

On my initial visit to the school, I discovered that Slyfields had just completed a major rebuilding phase and had a new science area and resource centre. Slyfields is one of six state secondary colleges in Victoria that were rebadged as science and technology schools in Melbourne in the late 1990s. These schools were to function as ‘lighthouse schools’ in the system for other schools, modelling innovative teaching in science and technology, teaching around the new ICT and often equipped with new, custom-built facilities. Slyfields was the only girls school included in this program. The new science area is impressive: five large, bright laboratories with half-glassed walls, wet and dry areas, and multiple electrical and Internet connection points. In addition to this, there is
a well-equipped technicians room, a science staffroom, and two computer pods. Each computer pod houses 12 networked computers and a printer and is situated between laboratories, being accessed via either the corridor or the laboratories.

The resource centre is also contemporary, combining the traditional resources of a library with computer and audiovisual resources. The students and staff have access to group booking, as well as individual use. Again, this area is very bright and designed to be a flexible learning space, with clusters of tables, soft chairs, computer pods, and floor space.

The science department at Slyfields comprised nine science teachers and two technical staff. Estelle, the science coordinator, had taken up her appointment at the beginning of the 2003 academic year, and at the time of interview had been in her role for seven months. The other members of staff included four staff members who had survived the merger of the three schools and had begun teaching 15 to 20 years prior to this research. These four teachers also held positions of responsibility in the wider school management structure and were considered senior members of the school community. The other teachers making up the science community were two newly qualified teachers (Andrea and Patrick), who had started at the same time as Estelle, and two science teachers who had no other positions of responsibility and had been at the school for approximately six years (Peter and Sarah).

5.2 Estelle (Science Coordinator)

Estelle joined the staff at Slyfields at the beginning of the 2003 school year. She explained that she had five years’ experience as a science coordinator in her previous school and had been teaching for 10 years. Estelle described herself as ‘a physical science specialist’, indicating that her undergraduate degree and her teaching
certification had focused on physics and chemistry. She did feel, however, that as a Years 7–10 general science teacher, she had the background to cover all the required biological and environmental aspects of the CSF II with confidence. As this was her first year at the school, Estelle had decided not to take a VCE chemistry class but to focus on general science teaching, as she wanted to ‘get to grips with department organisation’ and audit the junior science program (Years 7–10).

Look, this is my first year here so I need to make sure that I have a clear idea of how the department runs and what specialisms people have. You see, as well as having two brand new teachers who need my support, I have got to try to manage teachers who are only teaching into the department part time, because they have roles elsewhere in the school or teach into other learning areas. I wanted to try to manage everyone’s allotments fairly and try to maintain continuity across year groups and classes, but if I am honest it’s been a bit hectic and some people have rather unbalanced timetables. I knew I’d need to get to grips with the department organisation and teaching programs this year so I didn’t give myself a VCE group. It’s not that I don’t want to teach VCE, I love it, but I know how much of a drain it is on my time and energy, so I’ve decided that I have to prioritise. The major thing is a review of the Year 7–10 programs and let’s face it the best way to do that is teach it [laughs]. (E.1.1)

Estelle anticipated that the organisational structure of the science department might be somewhat complex. Importantly, the role included allocation of classes, subjects, and levels to full- and part-time members of her department; she clearly had some timetabling challenges. However, structuring her own teaching allocation around Years 7–10 had afforded her the time to support the two newly qualified teachers and the opportunity to gain a better understanding of her new community of practice. In this regard, Estelle commented on the problem of maintaining and expanding the science program in the school while meeting the special requirements of colleagues who
divided their teaching in other departments in the school or had other responsibilities outside the science department.

*Well, there’s nine of us in science, that’s including me, and four of those have management responsibilities, so they are like part-time science teachers and when I’m planning I have to fit their commitments into the timetable first, and they want certain year groups and not others [raises eyebrows]. Then I have Patrick and Andrea [the two new teachers] who need to be looked after; they need to get a reasonable allocation, and you know they are only on one-year contracts and there’s no guarantee they will be here next year. Then there are the three of us who are full-time science . . . well, even then Sarah is doing some psychology teaching this year. And from my understanding this has been the situation for the last few years and really it’s led to people doing their own thing with their classes and not really using the work programs for Year 7–10. You see, there has been no real department structure and what I want to do is get us all working together more and making sure we are teaching the same ideas. I mean, we have this great new science floor and this staff office, and yet it’s such a struggle, to get people to communicate. (E.1.2)*

It appeared that Estelle had a challenge on her hands. In the seven months that she had been at the school, she had identified that her department was quite fragmented and recognised the need to find a way of bringing them together to develop a more cohesive working environment and unified identity. I enquired if she had considered how she would do this, and she explained her plans:

*Well, from my audit of the programs so far I’m planning a total revamp of the Year 7–9 programs and what I’ve proposed in our department meetings is that we move to a project-based program, which I think will engage the girls and really make science connect with everyday life. Look, I got the backing of the principal and have been working with a local university and they are coming in to give us a series of PD sessions*
and help us design the units. I think people realise that we need to revive the Year 7–9 curriculum, especially if we are going to get numbers into VCE. But it won’t be easy; I fully expect some [pauses and lowers her voice] shall we say energised discussions about what should be in the units and how things ought to be taught, and that project based will dilute the content. But even that will be okay, because we’ll have a focus, and it will hopefully get people talking, even if we’re disagreeing [smiles]. So we’re going to start with Year 7 units and then over two to three years develop the Year 8 and 9 units. People will work in pairs and design the units together, so we get crossover of discipline expertise. I’m not quite sure on pairings yet [pauses and screws up face] . . . it’s something I will need to work out once we begin the PD sessions. (E.1.3)

Estelle’s strategy, to develop a more cohesive working environment in the community by requiring each staff member to design collaboratively one unit of a new curriculum/teaching structure that allowed more student choice, was quite ambitious. Interestingly, her concerns regarding possible conflict over the choice of a project-based scheme of work had not deterred her from following this option. She had the support of the principal and believed that her colleagues would have to accept the project-based approach, as it was essential to the ongoing success of the department. Estelle’s reasoning was that the project-based approach would engender student interest in science, which would encourage them to choose science electives in Years 11 and 12 and thus strengthen the identity of the science department within the school community.

I asked Estelle why she had decided to focus on a project-based scheme of work as opposed to other possible approaches. She responded,

The program of work that we have at present is pretty traditional. It doesn’t really take into account the girls’ interests it’s so dry. It’s more focused on learning content, rather than learning about scientific process and how important science is in our world. It really doesn’t connect with the girls’ interests; you see, I believe we need to nurture the
enthusiasm they [the students] bring from primary school, for science. People here have slipped into a sort of lecture-style model of teaching and the girls are bored. They rarely get the chance to do or even see a practical, and that’s why I want us to move to a more project-based approach, with lots of hands-on activities and flexibility. (E.1.4)

She elaborated on what she had in mind for the structure of the project units:

Personally, I like to include a lot of variety and hands-on activities and to link these with things they [the students] can relate to; I feel that’s the way they [the students] really learn; I think it helps to generate interest in a topic. So in the new 7–9 programs, each unit will have an overarching scientific theme or concept, and a number of different tasks or activities, and the girls will be able to choose a selection of activities to complete in each unit. Obviously it won’t be completely open-ended; there needs to be some structure and guidance, but I hope that having activities that are more relevant to the girls’ interests and the flexibility to choose will be more engaging. (E.1.5)

In her comments, Estelle (E.1.4 and E1.5) focused on a need to reengage the students with science by offering them more responsibility for their own learning and the need to present them with opportunities to be actively involved in that learning. She sought to enact change from what was a very teacher-centred approach to teaching science at Slyfields to one that was more student centred. This was alluded to in her description of the program structure, which would offer the students a choice in the tasks that they conducted within each topic and a link to their interests. However, she did not provide any details relating to the overarching concepts, the topics that had been selected for the new units, or the type of tasks students would be able to select from. She explained that this was something to be discussed in future departmental meetings and PD sessions. Conspicuous by its absence was her lack of reference to the use of ICTs and the potential that these may have in peaking student interest or making science more relevant.
Estelle’s brief explanation of the new program structure did begin, however, to reveal her own epistemological and pedagogical beliefs. This was further explored in lesson Observation 1 that I conducted with her Year 8 class (7/8/03).

**Observation 1. Estelle (7/8/03) Thursday period 1**

**Year 8, 26 students, 70 min**

The lesson began with a recap of the homework—pupils were asked to explain why some elements in the periodic table were represented by their initials like carbon, C, and oxygen, O, but some elements were represented by other letters that seemed to be nothing to do with the name like iron, Fe or lead, Pb.

Several girls put up their hands and Estelle picked one.

**Student 1:** Miss they are old names that we don’t use anymore and sometimes they are foreign names.

Estelle: That’s a good answer. Does everyone agree or does someone want to add something else?

**Student 2:** Some names were Latin like lead was plumbite, and then the names were changed to modern English. So that’s why it’s Pb. They kept the old initials.

Estelle: That’s exactly right, well done. Does anyone see a pattern to the names from this answer? [Estelle makes sure she picks another student.]

**Student 3:** It’s the older elements that have the odd initials, the ones found by the alchists.

Estelle: That’s right, but they weren’t called alchists; they were called alchemists, but that is very close, well done.

Estelle explained that today they were going to explore the difference between elements, mixtures, and compounds. She asked the students to work with a partner and posed three questions:

1. Name something that is an element
2. Name something that is a mixture
3. Name something that is a compound

Pairs shared their ideas and a discussion ensued. Estelle gave the students some beads, which linked together, and asked the girls to represent an element, mixture, and compound. She then
got some groups who had got the right idea to show the others. She suggested that they draw
diagrams to represent an element, mixture, and compound.

She then conducted a simple demonstration with sulphur and iron filings to illustrate how the
properties of the elements in a mixture are different from when they are combined in a
compound.

Estelle finished the lesson by giving the girls a handout, which consisted of a jumbled
explanation and illustrations of the experiment that she had demonstrated; the girls’ homework
was to cut out and correctly arrange and stick the handout into their books and to write/draw
their own descriptions of the results.

*Figure 11.* Excerpt from Observation 1, Estelle’s Year 8 science.

Directly after the lesson in our debrief, Estelle said that this lesson format was
‘*relatively typical*’ for her Years 7–10 science classes. She explained that she believed
being exposed to a variety of learning activities gave the girls an opportunity to
experience ideas in different ways, which she hoped would appeal to their different
learning styles. She considered that this was also why she used a lot of questioning with
the girls:

> I feel that if they [the students] try to express the ideas in their own words to each other
and me, then they have to process the ideas and so actually think about them rather than
blindly copying from the board or a book. Sometimes I help by writing definitions on the
board, but I usually ask for ideas from the girls so that in effect we write the definition
or whatever together. I don’t always pick the ones with their hands up either; I want
them all [emphasises] to be thinking and contributing, so sometimes I pick people who
look like they are not paying attention . . . [Estelle pauses and then adds] . . . that can
backfire of course, but I still think it’s worth it. (E.2.1)

I asked her to expand on this last comment, and she said that trying to get some girls to
answer a question or offer ideas was ‘*like pulling teeth*’, and she felt that this was due to
several factors: shyness, a fear of failure, and in a few cases a lack of language: ‘*A few
students are new to Australia and still developing their English skills; they don’t have the scientific vocabulary’. One strategy that Estelle used to combat these factors was to build confidence by asking girls questions when she was walking around the group.

Some girls don’t want to answer in front of everyone so I try to get them involved when they are doing activities, rather than making them answer in front of the whole class. So as I go round, I will ask a few questions and try to extend their understanding or wrinkle information from them. This usually works and I think it builds their confidence; but you know there are still those who are generally just not interested in science and I need to get them more involved, usually a few Year 9 or 10s. (E.2.2)

Lesson Observation 2 was conducted with Estelle’s Year 8 class took place four days later on the Monday morning (11/8/03).

<table>
<thead>
<tr>
<th>Observation 2. Estelle (11/8/03) Monday period 2</th>
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<tr>
<td><strong>Year 8, 25 students, 70 min</strong></td>
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<tr>
<td>This lesson began with a review of the previous lesson’s homework, which led into an introduction to practical activities that the pupils would be conducting during this lesson.</td>
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<td>Pupils were organised into groups of three to four and were given an experiment sheet, explaining their specific practical activity. Estelle reminded the girls of safety precautions and allowed them to collect their relevant equipment trays. (The experiments were relatively simple tests to explore the physical and chemical properties of some common elements, mixtures, and compounds).</td>
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<tr>
<td>For the next 30 minutes, girls worked on their experiments and generally chatted, but appeared to be on task. Estelle moved around the room helping groups, now and again asking questions, and reminding some to put their safety goggles on.</td>
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<tr>
<td>With 20 minutes to go before the end of the lesson, Estelle asked the girls to start finishing off and packing up.</td>
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For homework, pupils were asked to individually answer the research questions listed on their experiment sheets. They were also informed that in Thursday’s lesson they would have 30 min to prepare a presentation about the particular experiment they had conducted and then have 5 minutes to present this to the rest of the class.

*Figure 12.* Excerpt from Observation 11, Estelle’s Year 8 science.

After the lesson, I asked Estelle if the lesson had progressed how she had wanted it to, and she said she was very pleased, admitting that usually the girls took much longer to pack away when they were doing practical activities. She confided that as she walked around she had noticed that some students were off-task, but considered that her presence and questioning technique had quickly rectified this. I invited Estelle to explain why she had given each group slightly different experiments, and she elaborated on her strategy:

> Well, you know, you’re science trained, they weren’t that different, but one reason was I guess I wanted them to be able to report something different next week, when they do their presentations. And I think if your group is doing something different from someone else then you actually think it’s like doing “real science”; we’re not all following the same recipe and getting the same results. But I have to admit, I know this class really well now, and I was being a bit strategic. I gave the most complex experiment to Jenna’s group and the questions they have are quite challenging compared to Donna’s group who have an experiment which is more basic. So I suppose the main reason was differentiation, and they all finished on time and managed to get results. So everyone hopefully feels some success in what they have done and will have confidence to present their findings. (E.3.1)
I asked if the class would be expected to make use of ICT to research and develop their presentations for the next lesson and whether the girls would use the ICT pods. She replied,

No, we won’t use the pods; it’s too difficult to make sure that the girls stay on task when they’re out of the lab. See, only half the class will be able to use the pod at a time so I would have to split them up and I can’t be in two rooms at once, so that’s a safety issue and then it would take twice as long to complete. The pods are only really useful for Year 11 and 12. (E.3.2)

I found Estelle’s reasoning quite confusing, as the ICT pod linked directly to her laboratory and had large windows, which allowed full vision of the students when they were working in the pod. Also, since the class had been split into seven work groups and were collaboratively generating their presentations, the 12 computers in the ICT pod would have allowed for at least one person or pair from each group to make use of the facility, while the others worked on other aspects of the presentation. Estelle’s reluctance to use ICT is a common trait of teachers who are not confident with the change in pedagogy required to manage the inclusion of ICT into their regular practice. Even though she had demonstrated a very good understanding of her Year 8 group and excellent classroom management skills, she was concerned that using ICT would somehow lead to a lack of efficacy in relation to her purpose of engaging all the girls.

I asked Estelle whether she preferred to make use of ICT in her laboratory as all the students were in the one room. She said,

Look, personally I don’t use ICT much in my teaching. A few science staff do, but most don’t, and there aren’t any ICT activities written into our current work programs, and although the labs have network connections and we have the computer pods, most
teachers would tend to take their classes to the computer area on level three, if they are going to do an Internet assignment. (E.3.3)

She added that if she wanted an ICT task or Internet assignment done then it could be taught in ‘discovery’, which I later found was a compulsory subject taught in Years 7 and 8 that focused on the use of ICT and the teaching of ICT skills. This was achieved through a combination of introducing students to the Logo programming language using MicroWorlds, as well as the use of standard Microsoft Office applications and common search engines. Subject departments had been encouraged to set ICT tasks that could be conducted in discovery lessons. Estelle explained,

*Discovery teachers work with the subject teachers to see what assignments they could do in the discovery subject and then they [the teachers of the discovery subject] teach the girls ICT skills through this.* (E.3.4)

This comment, taken in conjunction with Estelle’s previous comment regarding the current schemes of work (E.3.3), seems rather contradictory. If discovery teachers were expected to work with subject teachers to identify assignments that could be completed using ICT, why were there no ICT activities built into the current science schemes of work? More importantly, in the writing of the new schemes of work and with the science laboratories now so well equipped for ICT access, what provision was there for including ICT activities, and was the inclusion of ICT being given any serious consideration in the pedagogical discussions relating to the new project-based program?

Estelle’s comments regarding ICT use (E.3.2, E.3.3, and E.3.4) and her lack of previous consideration of ICT in our discussion of the new schemes of work (E.1.4 and E.1.5) gave me the impression that ICT did not fit in with her definition of a hands-on activity that could be used to enhance science learning and was more of an activity for improving students’ ICT skills. This led me to two important assumptions about her
lack of ICT use: (1) that Estelle had a limited understanding of the pedagogical opportunities offered by ICT in relation to science teaching and learning, and (2) that she did not view her role, as a science teacher, or importantly the science coordinator, to be one which involved improving her students’ ICT skills.

In an attempt to gain a deeper understanding of her comments and confirm my assumptions, I asked Estelle about her personal ICT skills and experience of ICT use in the classroom. She told me that she was ‘relatively ICT literate’ but ‘mostly self-taught’, as ICT PD at her previous school had been rather limited. She also explained that although ICT PD was offered at Slyfields, it was usually scheduled after school and was rather inconvenient and really quite basic.

Look, I am relatively ICT literate; I keep all of my marks etc. on Excel and make worksheets for the girls, as you have seen. Look, I also do PowerPoints for VCE, when I’m teaching it, and use websites and things. So I do quite a lot with ICT. I am mostly self-taught though. I haven’t had much PD even though it is on offer; it’s quite basic, it’s mainly personal computer skills. I don’t use a lot of simulation activities; we do have some, but I prefer hands-on activities, real experiments. (E.3.5)

While Estelle seemed to have knowledge of personal computing skills and used these to assist in her planning and production of resources, she could be seen to have a rather limited outlook when it came to the use of ICT in science pedagogy. This confirmed my previous assumptions.

Acknowledging Estelle’s current personal ICT capabilities, I inquired if there were any specific areas of ICT PD that she thought she, or other members of the science department, would benefit from if the school offered them. She considered,

It might be quite useful to have some PD on the use of sensory probes [data loggers] or simulation activities, but really for now the focus for the department is the new project-
Estelle’s limited experience with the use of ICT to enhance science pedagogy and her lack of science-specific PD in the use of ICT had resulted, it seems, in her underestimating its importance and potential in the development of the new project-based scheme of work. I had expected that her pedagogical stance of a student-centred approach to teaching and her epistemological view of science as an enquiry- and processes-driven subject would allow her to integrate ICT relatively easily into her practice. However, her limited knowledge of the resources available and the most effective ways to use these had resulted in them being seen as not particularly relevant as a way to engage students or a priority in unit development. Perhaps the PD sessions conducted by the university, which the department was collaborating with, would address this issue and initiate an appreciation of the potential of ICT use in science education.

5.3 Patrick (Science Teacher)

Patrick informed me that this was his first school position after completing his teacher training. He explained that he had previously completed a PhD in astronomy and had lectured in higher education for several years, but this was his first experience teaching Years 7–10 science. He considered the transition from university teaching to school teaching to be ‘huge’ and was quite overwhelmed with the number of classes he was expected to teach and be prepared for.

*I am teaching the two Year 7 general science classes, a Year 8 general science class, two Year 9 advanced science classes, and I also do a mathematics class. It’s huge in terms of the number of classes I have to juggle at once. At university, I had more like one or two lecture streams in one go. Whereas here in a week, I’ve got to handle four*
different streams of teaching and juggle the whole practical set up and marking, and then we have a different timetable next week, so you might not see the same classes at the same time. You see, at university, I basically had three hours of lectures, and the rest of the time I was either preparing lectures, or work for tutors and writing. I didn’t have to do much of the face-to-face teaching and marking. (P.1.1)

Patrick viewed his transition to the school setting as quite a departure from his previous role as a university lecturer. He had obviously discovered that the workload, while perhaps being less demanding on an intellectual level, did necessitate considerable rigour in areas such as planning and marking, and he appeared to be finding these tasks quite time consuming.

Patrick had also noticed that his teaching style had changed since being in the school setting. He felt he now had to plan his lessons to be far more student centred compared to his university lectures. He was also very positive about the opportunity he had to interact with the students on a personal basis and told me he spent little time in the front of the class.

Well, as a lecturer you stand up the front and just deliver the information really, so you’re up the front all the time; you don’t get to ask questions and wander round. But here I would say the only time I spend in the front of the class is when I take the roll and at the start of a lesson. Or where I am trying to get the students to focus at the beginning of the lesson; I like to give a kind of motivational challenge at the start of a lesson, something engaging. So I guess I only use that space at the front when I am trying to get their [the students’] attention, or to get them thinking about science. Then as soon as possible I go straight into it and walk around and see how they are going. That’s the thing I enjoy most about teaching, the engagement with the students. (P.1.2)

I had organised with Patrick that my Lesson Observation 1 would be with his Year 7 general science class, a week after our first interview, on the Wednesday (13/8/03). I
arrived early, met with Patrick, and took up a position at the back of the laboratory as he suggested.

Observation 1. Patrick (13/8/03) Wednesday period 4

Year 7, 26 students, 70 min

Patrick began the lesson by showing the girls a glass of cold water with condensation on the outside and asked them to explain why the glass had droplets of water on the outside.

Student 1: *The glass has got wet, sir.*

Patrick: *Put your hand up please to answer.*

Student 2: *Sir, its condensation like on the bathroom mirror.*

Patrick: *Can anyone explain why it forms?*

Student 3: *It happens when something is colder than the water and it makes the water in the air cold so it makes drops.*

Patrick: *Well done, can anyone tell me any more?*

Student 2: *Sir, sir, it’s the same as when you breathe on a cold day and you can get it to make steam on the mirror.*

Patrick: *Well done, that is excellent; it is all to do with the water molecules in the air losing energy.*

Patrick then introduced the topic for the lesson: classification keys. One pupil asked what that had to do with condensation. Patrick explained that what they had just done was an energiser to get them in the frame of mind to think about science. A few pupils looked rather confused; one pupil close to me sighed and whispered to her friend, ‘another wasted lesson’.

The rest of the lesson was spent talking about classification keys, and pupils were given worksheets on which they had to identify characteristics of cartoon people. They had to use the keys to identify which family the people belonged to, and then they had to design their own key for pictures of leaves in their science text.

Patrick walked around and helped the pupils during this activity; one girl got up and left the room, and she was later brought back by another teacher.

Homework was to finish the task (which many pupils had already done).
The motivational challenge that Patrick gave the girls at the beginning of this lesson regarding condensation on the glass got the girls very involved; however, it did not relate to the rest of the lesson content. In our lesson debriefing directly after the lesson, I asked Patrick why he had selected this particular challenge and not something related to the topic that he was going to teach. He told me that he wanted the girls to ‘think laterally’ and that it did not really matter if the topic connected; it was ‘a tuning in exercise to get them warmed up’.

Lesson Observation 2 was conducted five days later and with Patrick’s Year 9 advanced science class.

**Observation 2. Patrick (18/8/03) Monday period 2**

**Year 9, 22 students, 70 min**

Patrick entered the class and the students followed. The students sat down and Patrick spent the first 15 min trying to make appointments for the ensuing parents’ consultation evening. The girls talked while this was happening, and one student, the ‘hairstylist’, moved about the room playing with her peers’ hairstyles.

Patrick: *Okay, today we are going to get with our partner from last lesson and work on the five revision questions you had to set. Has anyone finished the questions?*

Student 1: *We have, sir. [Puts up her hand and indicates the pair.]*

Patrick: *Okay, you can test them on each other and see if you can answer each other’s.*

Student 2: *[Shouts out] This is so boring [gets up and moves to another desk, and gets out what looks like maths homework].*

Patrick ignores her and walks to another group of girls who are cutting out paper doilies from scrap sheets of paper; he begins questioning them on the nature of snowflakes.

Hairdresser: *Who’s got a brush? [She obtains one and moves to work on another friend’s hair.]*

The lesson continued, and Patrick walked around talking to groups of students.
Three pairs of students were working on their revision questions; the rest of the class seemed to be doing other work not necessarily science, or just talking quietly.

10 minutes from the end of the lesson there was a sudden flurry of science books and pupils looked active as the vice principal was spotted in the corridor; she entered the room and removed the hairdresser. Once she had gone, the girls returned to their previous activities. Patrick continued to wander round the class talking to groups of girls.

Homework was to finish the five revision questions

*Figure 14. Excerpt from Observation 2, Patrick’s Year 9 biology.*

In our lesson debrief, I asked Patrick what objectives he had set for the lesson and if he felt that he had achieved these. Patrick indicated that the objectives for this particular lesson had been for the students to generate a bank of five revision questions for a forthcoming test, to trial these on each other, and for them to use him as a resource on the genetics topic that they had just covered to help with this task. He considered this had been achieved and felt quite happy with the lesson outcome. I asked about the students who were cutting out paper doilies, and he said,

> Ah yes, that led to quite an interesting conversation about the uniqueness of snowflakes; it’s one of those moments where we might go off at a tangent that the girls are really interested about. I find it very effective. (P.2.1)

From Lesson Observation 2, it appeared that Patrick was oblivious to the fact that many of the girls had completed the set task in the first 20 minutes of the lesson. He also seemed unaware that most students had stopped working on science activities and were busy completing work from other subjects or quietly chatting, and that little science revision was actually occurring.

Patrick told me that his approach to teaching was quite flexible and said this was reflected in his lessons; although he went in with an idea of the lesson content, he was
quite prepared to digress depending on the student questions and attitudes to the subject matter, linking this to little preparation:

*I don’t have the luxury of time to prepare lessons like I would lectures in university. There I would spend five times the length I spend on a lesson here. But even so, if I plan it doesn’t always work, because then if we hit on something in the lesson that relates to the girls’ experience we go off and look at it. I think this helps with the ones who are not really motivated by the scientific concepts.* (P.2.2)

Patrick expanded on this by telling me about a situation that had occurred in his Year 9 class:

*Well, an example from last week really was a Year 9 girl who brought a magazine into class and was reading it; I guess she was bored [laughs]. I said to her, I bet you could turn to any page in that magazine and we could find something related to science on it. And she got really excited so she could prove me wrong. She picked a page with a film actor, but I then had a whole lesson on the science of what makes people attractive to other people and they were fascinated.* (P.2.3)

In the two lessons that I observed and the lesson debriefings, I concluded that Patrick was struggling with pedagogical approaches, lesson planning, and classroom management. While he had some good ideas like the energiser task, he had not used it effectively in his classroom to support the curriculum area being studied.

The lessons I observed also did not include any ICT use, and I enquired about Patrick’s personal competence in the use of ICT and how he used ICT in his teaching. He confided that he was reluctant to use ICT because it raised class management issues. He explained that to use the pods of computers, he had to split the class, and this meant that some would be in the laboratory and some in the computer area, which wasn’t ‘really safe’. Patrick told me that he had used some PowerPoint presentations in his
teaching, but that he really liked to focus on the science aspect of the curriculum and was not particularly confident in teaching with ICT:

_I don’t think I have been prepared to teach science with IT; we only had one workshop, in my Dip. Ed course, and really that wasn’t enough. I don’t think I have a clear idea of what I am trying to achieve with the IT. So really I don’t often use it. My first priority is teaching the science content, so IT use is really secondary for me at this point._ (P.2.4)

Patrick also suggested that the PD he had received had not been relevant:

_I haven’t had time to explore many things and I have never used data loggers, and well, the IT PDs offered are geared more to using IT personally like how to use Photoshop; it does not cover using IT in the class and I think this is what I would find more useful._ (P.2.5)

Patrick’s knowledge of the students’ capability with ICT was also limited, and he told me that the students did a subject called discovery, but really, he was not sure what they covered in this subject. Patrick had obviously not been engaged with any assignments that incorporated science schemes of work intended to be completed using ICT in the discovery subject. This is another indication that the process of incorporating ICT activities into the current science schemes of work was not occurring.

As this second interview ended, Patrick offered to escort me to my car, and on the way said that he thought he was really experimenting in his teaching. He felt that the girls were far too ‘reliant on a linear program’ and he was ‘trying to do something different’. I was not sure what he meant by this and asked him to explain. He told me that he wanted to create an ‘open environment that allowed the girls to explore their own ideas’ and then admitted that it was, however, quite difficult to achieve this goal. I was still unsure of his meaning but thought it interesting that he had chosen to tell me this after the recorded interview and ‘beyond the school gate’ as it were.
5.4 Andrea (Science Teacher)

Andrea was also a beginning teacher at Slyfields, and she described herself as a biologist since her undergraduate degree had been in biological sciences. Her previous work experience had included a part-time role as an English as a second language teacher at a secondary school and a role as an educational officer at an interactive science museum. Andrea felt that both positions had given her a firm grounding for teaching at Slyfields, and she considered that her experience at the museum had helped her understand the importance of providing ‘accessible’ science, which catered for a varied audience:

The museum job taught me to use practical tasks and demonstrations, to ask questions and get the kids’ thoughts and ideas, so I suppose now I try things to get them [students] engaged and involved. I think that is the most important thing; you can’t expect the girls to be interested unless you can actually show them the relevance and importance science has in everyday life. (A.1.1)

I asked Andrea to describe a typical lesson and she told me that although she did not have a set pattern, her goal was to make the lesson relevant to the girls. She maintained that if the content held some relevance to their lives and that they could see how this might affect them or their environment, they would be inclined to remain engaged. Andrea also indicated that she usually incorporated a practical activity in her lessons and tried to promote individual learning activities to appeal to different learning styles, but regretted that the program design for lower and middle school science, at Slyfields, was quite ‘traditional’ and did not include much opportunity for being creative. Andrea, however, confided that she had deviated from the schemes of work and incorporated some of her own ideas. She told me about a mining activity she had incorporated in her Year 9 class, which involved the girls designing their own practical investigation. The
activity used separation techniques to discover the composition of an ‘unknown sample extracted from a mine’ (a mixture of chalk, sand, soil, metal filings, and salt), which she had provided for the girls. She said that this had been a real struggle and the girls had needed a great deal of support:

*I wish you’d been here earlier in the term, in my Year 9/10 general science class. I got completely fed up with the unit of work I was supposed to teach and the way it was structured, it was so dry. There was no scope for the girls to explore or experiment; they were just following directions from me and the experimental work was all recipe based [raises eyebrows]. So I gave the girls an experimental design exercise and they didn’t like it at all. I said to them that we were research chemists and we were working for a mining company and going to do an analysis to discover the salt content of an unknown sample. It was actually an old Year 7 activity that incorporated many separation techniques. But instead of telling them what to do, I got them to research the methods of separation and design a multistep activity to extract a salt sample and measure their yield. They moaned so much and needed a great deal of scaffolding because they [students] are not used to researching and planning their own practicals. I mean the information is accessible in their texts and on the Internet and I gave them plenty of hints and web links, and time to use the computers; you’ve seen our computer pods have you? (A.1.2)*

Andrea indicated that she had tried this experimental design approach several more times and that the students were slowly getting better at it but ‘still moaning’. She suggested that this was because they were used to a structured ‘spoon-fed approach’ promoted by the current schemes of work, but believed that some students were ‘actually beginning to be more self-reliant’.

Andrea’s epistemological and pedagogical approach did not appear to resonate with the teacher-centred activities promoted in the current science schemes of work at
Slyfields. She expressed a belief that her students should ‘learn to explore and expand their scientific knowledge through research and experimentation, and not to always rely on her [the teacher] to provide the answers’. She also seemed undeterred in her attempt to develop these skills within her Years 9–10 class and persisted in her efforts to encourage her students, even when they seemed reluctant to embrace this new approach. This tenacity is not often observed in teachers that have just begun their teaching careers, yet Andrea had perhaps been encouraged by the positive effect the approach was beginning to have on some of her Years 9–10 students and the impending policy change to a project-based scheme of work.

During this first interview, Andrea invited me to observe her Years 9–10 class and told me they were just about to look at adaptation in living organisms.

**Observation 1. Andrea (25/8/03) Monday period 2**

**Years 9–10, 20 students, 70 min**

The class comprised four Year 10 students and the rest Year 9. The group were studying evolution and the way animals and plants adapted. Andrea had the girls bring their chairs to the front of the room away from the computers and then began with a quick recap of the last lesson. She then asked if anyone would like to read the beginning of the chapter on evolution in their science texts.

A number of hands went up and Andrea picked one student and asked if she could read to a certain point and then the next student could take over. During the reading, a number of new words came up and another student wrote these on the board. After the readings, Andrea asked if anyone could explain any of the new words. Some students had a go at some words and then together with Andrea they developed definitions and wrote these in their own words in their notebooks.

After this, Andrea got the students to think about how people might evolve over the next 1,000 years; she then organised them in pairs and told them to go to the computers. Using PowerPoint, the pupils had to design a future human and to annotate their designs. They also had to create an imaginary animal and to list its adaptations relative to its environment.
The girls were all engaged apart from the group of Year 10s who were being disruptive, Andrea quickly dealt with these girls, and when it was time to present their ideas to the rest of the class ensured that they had to wait until last.

Some of the designs were extremely creative, and some groups had included little animations in their slide shows.

\textit{Figure 15}. Excerpt from Observation 1, Andrea’s Years 9–10 science.

In the lesson debrief, I asked Andrea if it was usual to have the group in a computer classroom. She explained that on some days, there were not always enough laboratories for all the science classes scheduled, and so some groups were booked into a classroom. Andrea indicated that her Years 9–10 class were usually in an English classroom for this lesson, but today she had specifically booked a computer room to make the lesson a bit more interactive:

\begin{quote}
You see, the evolution topic is rather dry and there are not a lot of opportunities for experimental work, but getting the girls to use the computers to design their future animals and humans is a way to make it more interactive; it’s quite a basic activity really, but I want it to be more engaging. Next week we will be using this room again to do some research activities on fossils and areas where evidence of certain species have been found; it will be a mapping activity. I’ve also found a little animation that simulates how the tectonic plates have moved and the continents evolved. I hope they enjoy it; I am trying to bring the topic to life a bit. (A.2.1)
\end{quote}

Andrea appeared to have good personal ICT skills and demonstrated the confidence to use ICT in her pedagogic practice. As students worked on their tasks, she was willing to troubleshoot minor technical issues. She also had a good working knowledge of PowerPoint, so she was able to help the girls who had decided to try some animation and more advanced presentation techniques. Andrea informed me that she had been immersed in ICT:
Working at the museum, I was using technology nearly all the time. Some of our shows were wholly computer reliant, for example “Optical Illusions” was all on computer. Which was a real problem when it crashed, because there goes the whole show [laughs]. But no, I am used to using technology. You see, I’ve grown up with it. I was introduced to computers in primary school, so to me it’s not all new, I mean the Internet was brand new for me, but word processing and the idea of just using a computer wasn’t new, and I do lots of research on the Internet now and make resources. I suppose what I have had to learn is how to use ICT with my classes and this can be tricky when you don’t have access to a laptop or data projector, but I am trying to adapt things where I can so I can incorporate more ICT. (A.2.2)

Andrea continued, telling me that most members of staff had a laptop, but because she was on a one-year contract, she did not. This limited her teaching:

I get really frustrated. You see, I am only contract for a year so I don’t get a laptop; I have to book one out from the library and there are only two and sometimes other people are using them. On my teaching rounds last year I was lucky I had access to a laptop and a data projector all the time, so I could show simulations and do things like link to the digital microscope and do all sorts of things. Now sometimes I get one of the girl’s laptops and use that up the front and get the girls to come and sit around. It’s not ideal. Also, the pods are good because you can get a group to work in there on a task and still be able to see them. I think it’s important to use ICT; it can make things easier for the girls, you know, simulations and being able to change variables quickly takes away some of that hit and miss of practical work. (A.2.3)

I asked her to expand on this comment regarding practical work, and she went on:

Well, for example, we were doing work on rates of reaction and I got the girls to use a simulation to see how surface area, temperature and concentration affected the speed of a substance dissolving. We generated graphs from the computer simulation and then we
did a series of practicals where we used the computer data to predict what would happen when we altered these variables for a Berocca dissolving. The girls also used the computers in the pod to plot their graphs, and they could compare the shapes in the analysis of their experiment with the ones from the simulation. It was really useful. (A.2.4)

Andrea’s view of the computer pods seemed a complete contrast to those expressed earlier by Estelle and Patrick. She viewed the ease of access that the pods provided, and the fact that the girls were still within close proximity, as a bonus and not as a safety concern or a control issue.

I suggested it must be difficult if there were several science classes scheduled at once to actually organise access to the computer pods, but Andrea disagreed:

*Well, I have never really had an issue with using the pods. Sometimes there may be a couple of Year 11 or 12 students in the pod doing research or assignments, but I really don’t think they are used that much by many staff. Of course, we do have a laptop stream and the girls in those classes bring their own machines, so apart from printing queues there is not a problem. I suppose because there aren’t many ICT activities built into the schemes of work so people don’t use them. Rick, he teaches chemistry, sometimes does data logging activities with his Year 11s or 12s, but then even that’s not often. (A.2.5)*

Andrea’s comments regarding the availability of the computer pods reveal that they were not extensively used by the other members of the science staff and perhaps illustrate that ICT use was not considered a priority within this community of practice. This would seem somewhat contradictory to the school’s status as a science and technology college.
I finally enquired about Andrea’s formal PD in the use of ICT and whether she had taken advantage of the PD provided at the school:

*Well, as I told you, I have grown up with ICT, but my real use of computers as an interactive teaching tool came from the museum, and we had very good training on all the applications and time to learn how to really get to grips with things. Personally I have not been to any technology PD here, as it has not really been appropriate to the areas I need to develop in. It’s all really basic PD to develop personal ICT skills.* (A.2.6)

She continued,

*I can see why some people don’t bother with ICT here. It’s because they’re not confident and haven’t had time to develop their own knowledge of the applications. So they’re scared of looking stupid in front of the girls, when it all goes pear-shaped. And look, you know, it’s going to go pear-shaped at some stage, but then personally I think that’s a risk worth taking. Plus as you know, the more you use computers the easier it gets, it’s like anything.* (A.2.7)

Andrea’s comments were candid and would perhaps be true for many teachers in many schools, and not only those working within her immediate community of practice. Unlike many of her colleagues in the science department, Andrea’s personal career trajectory had enabled her to develop her personal ICT skills and begin to use these for pedagogical purposes. This previous experience in ICT use and the fact that she had willingly and confidently begun to develop teaching strategies that integrated ICT into her teaching indicate her personal awareness of the learning opportunities afforded by the technology. She had clearly entered the transformational stage of integrating ICT (Puente, 2010) and had redesigned and even developed new activities that would support student learning.
5.5 Discussion

The promotion of Slyfields as a girls science and technology college in the prospectus implied that these two subject areas were prioritised in the school curriculum. It also raised my expectation that the pedagogies in these subjects would be relatively progressive and that the use of ICT would be pervasive in the science curriculum. The school’s new infrastructure in the shape of a technology-rich learning resources centre and new science wing indicated that this might indeed be the case. However, interview data and analysis of the schemes of work for Years 7–10 indicate that this was not so. While an opportunity was available to integrate ICT with science content through the discovery subject, no provision for such integration, or any other use of ICT in science activities, appeared to be enacted. More alarmingly, in the planned redevelopment of the Years 7–9 curriculum, ICT integration did not appear as a priority. I found this quite surprising, as the infrastructure in the new science wing provided an ideal opportunity to use ICT, and the existence of a laptop stream in Years 7–9 would have necessitated the inclusion of some ICT activities. As with St Clair’s, it appears that provision of resources and the existence of school policy, promoting the use of technology in the form of ICT, was not the main issue restricting ICT use within this department. Once again, it is evident that staff interactions within the community of practice strongly influenced innovation and learning, as the following discussion will argue.

5.5.1 Exploring this community of practice

At the core of the community of practice model is the idea that a group of people sharing an interest in, or passion about, a particular subject will work collectively on a continuing basis to broaden their knowledge and expertise (Wenger, 1998). As a consequence of their engagement, it is proposed that the members of the community will develop shared practices, skills, resources, and common perspectives. Lave and
Wenger (1991) claimed that situated learning occurs in a community of practice through the process of legitimate peripheral participation. Newcomers to a community begin in a socially peripheral position within the community and over time learn how to belong to it, progressively moving to full membership and participation through workplace learning. They also suggested that learning is not a one-way process, and that established community members learn from ideas brought to the community by newcomers, ensuring the evolution of the community.

At the beginning of the school year, the science department at Slyfields welcomed three new members of staff: Estelle, Andrea, and Patrick. These three newcomers took up social positions at the periphery of the community, as suggested by Lave and Wenger (1991), and after seven months, I would have expected these staff to move toward fuller membership and acceptance within the community. However, the data collected at this time indicates that this was not the case, and this seemed to be the result of a major community disorder—disconnectedness (Wenger et al., 2002). The fieldwork reveals that while members of the science department were linked through their commitment and interest in the domain, there seemed to be little community cohesion and only a nominal development of shared practice. For example, Estelle described five of the science staff as teaching into the department on a part-time basis, implying that their connection to the science department was superficial due to their commitments to other subjects or management duties within the school (E.1.1 and E.1.2). She also raised concerns regarding staff on one-year contracts, implying that this had a detrimental effect on their acceptance within the community of practice and possibly also on their commitment and ability to contribute to the development of practice (E.1.2).

Wenger et al. (2002) suggested that when a community is ‘too diffuse or dispersed to actively engage members’ (p. 146), individual members do not connect with the
community in professional ways that show enthusiasm and a willingness to contribute to the collective. This has led to people ‘doing their own thing’ (E.1.2), rather than advancing the shared practice of the community or developing a joint pedagogical repertoire. In spite of the inclusion of a science staffroom in the construction of the new science wing, allowing for co-location of its members, this department has remained disconnected. Consequently, the opportunity for them to share their experiences, knowledge, and pedagogic practices has been unrealised. For example, the struggles Patrick reports with time management and planning (P.1.1 and P.2.2) might be lessened through discussion of strategies with more experienced colleagues, yet this does not seem to have occurred. Also, Andrea’s ICT skills might be beneficial to her colleagues, but she does not seem to have been able to share these (A.2.6 and A.2.7). Workplace learning in the form of legitimate peripheral participation does not seem to be occurring in this community (E.1.1 and E.1.2) and there appears to be limited community growth. Therefore, I conclude that situated learning in this department may have stalled, and, as a theory, that ‘communities of practice’ is perhaps not an adequate framework to explore the existing relationships within this department.

5.5.2 Developing relational agency

Billett (2009) contended that workplace learning should be conceptualised as a relational interdependency between the social and personal factors experienced in the workplace. He considered that an individual’s learning is shaped by two things: their ability to use their personal history and past work experiences to interpret current workplace encounters, while at the same time being influenced by the ‘social experience’ encountered in their current workplace. By social experience, he is referring to the cultural norms, practices, and techniques that are common to the current workplace. This relational interdependence is how Billett suggested individuals learn
and use their personal agency to shape the culturally derived practices that they become part of, thus demonstrating relational agency. However, it is important to note that an individual’s personal agency and relational agency is limited to the social learning opportunities their work environment affords them. As the data reported in this chapter illustrates, there had been little opportunity for the three new members of staff to engage in social learning, and so they had not been able to develop their relational agency within the workplace. Consequently, they had maintained a strong relational legacy with past working environments, which is evident in the references made to past experiences, and these had continued to shape their personal agency, as I now explain.

Patrick continually referenced his past experiences as a university lecturer as a way to explain his current situation. For example, he considered that as a teacher he was required to do a far greater amount of planning in a much shorter time frame (P.1.1) and used this to justify why he often deviated from the curriculum, getting sidetracked by student questions (P.2.2). He also believed that his pedagogical approach had changed from his time as a lecturer, suggesting that he had moved from a teacher-centred approach to one that was much more student centred (P.1.2). He did not, however, discuss how successful this change had been, as he really had no point of comparison in his current environment. This is illustrated in his lack of appreciation for the need to set clear objectives, critically appraise lesson outcomes (excerpt from Lesson Observation 2, Patrick) and be aware of how successfully he was managing the learning environment.

Andrea also relied heavily on her past experiences to describe her practice at Slyfields. She particularly referenced her time working at the museum as the setting in which she had developed the belief and skills of making science accessible and relevant to students (A.1.1 and A.1.2). In addition, Andrea attributed her ability to successfully
integrate ICT into her pedagogic practice to her prior personal experience of ICT use and how it had been incorporated into her work at the museum (A.2.2, A.2.26, and A.2.27). The only link that Andrea made to her current work at Slyfields was her frustration at not being able to have the access to technology that she had been used to in the past (A.2.3).

Estelle was in an unusual position as a newcomer to this department, because she was appointed as science coordinator and was expected to lead the department. While experienced in the role of coordinating a science department, having gained promotion in her previous school, the move to Slyfields would have posed several additional challenges to those usually experienced in leadership roles. For example, in her previous school she had been a member of the workplace before she took on its leadership. Therefore, she would have had an understanding of the existing culture and practice and be seen as an ‘old-timer’, having established a sense of agency within that community. The move to Slyfields, however, meant Estelle entered the community as both a newcomer and a leader. Consequently, she needed to promptly demonstrate her competence as a science teacher within this community and develop an understanding of Slyfields science department’s local practice order. In the process of doing this, Estelle realised that what she had inherited was a fragmented community that had intermittent communication (E.1.1 and E.1.2). She recognised that what was needed was a strategy to revive the department and encourage both knowledge sharing and social learning to grow (E.1.3).

Edwards (2010) contended that to encourage a group of professionals to collaborate, it is useful to encourage individuals to work on a joint project or problem. She suggested that this can be achieved through a two-stage process that consists of:
i. Working together to expand the object of activity or task being worked on by reorganising the motives and resources that others bring to bear as they, too, interpret it; and

ii. Aligning one’s own responses to the newly enhanced interpretations with the responses being made by the other professionals while acting on the expanded object. (Edwards, 2010, p. 14)

This, she maintained, is a way to develop the capacity for relational agency within the community, as it involves people working with each other ‘toward mutually agreed outcomes’ and provides support for novices and those who might feel that they are operating outside their area of expertise (Edwards, 2010).

So, Estelle’s intention to bring individual agents in this workplace together through collaborative action around the joint task of redesigning the Years 7–9 science curricula may be a fruitful example of working together to expand the collaborative capacity of this science department. She said,

_I fully expect some [pauses and in another tone] shall we say energised discussions about what should be in the units and how things ought to be taught, and that project-based will dilute the content. But even that will be ok, because we’ll have a focus, and it will hopefully get people talking, even if we’re disagreeing [smiles]. . . . People will work in pairs and design the units together, so we get crossover of discipline expertise._

(E.1.3)

With increased collaboration and sharing, Estelle sought in her paired project curriculum initiative a framework for both established and new members of this department to develop relational expertise and interdependency.
5.6 Summary

The data discussed in this chapter indicates that the majority of teachers in this department, while cooperating to deliver the science curriculum, maintained what Hodkinson and Hodkinson (2005) termed a loose integration. The research participants suggested that their science colleagues conducted the majority of their work independently and seldom made use of the newly constructed science staffroom, preferring to work in other locations.

This individualistic situation has inevitably made it difficult for the two newly qualified teachers to learn alongside their colleagues and share pedagogic strategies. Edwards (2010) maintained that personal agency, found in this department, does not support or develop a collective competence. She drew on the work of Hakkarainen, Palonen, Paavola, and Lehtinen (2004) to emphasise the importance of developing skills and expertise, which she considered mutually benefits the members of what becomes a community and enhances the collective ability to create new knowledge.

The individualistic nature of work and learning in this department appears also to have been reflected in the department’s approach to the use of ICT. Teachers have been allowed to manage ICT in their own way, and it does not seem that staff have contributed science tasks to the discovery subject or benefited from their colleagues’ experience. Andrea, for example, who has had considerable practice in the use of ICT in her previous work setting, could have cascaded her knowledge and been encouraged to contribute to the development of ICT activities in the new schemes of work being created for Years 7–10.

The new teachers to the science department at Slyfields relied on their past workplace experiences to shape their pedagogical learning. This is not surprising, as
they had not been afforded the opportunity to participate in what Hager (2013) termed the unintentional or unplanned learning that occurs through social interaction with colleagues in their department. Estelle’s bold move to redevelop the Years 7–10 curriculum provides an opportunity for this prospective collaborative constitutive learning to occur through the curriculum design projects at each level in which she sought to create a culture of relational agency.
Chapter 6: Case Study 3
Alice’s Version

But it’s no use going back to yesterday,
because I was a different person then. (Carroll, 1865)

6.1 Introduction to the School and Science Department

At the time of this research study the third case school, Redlands Secondary Girls College (Redlands) is situated in the northern suburbs of Melbourne and is a Years 7–12 college with a roll of approximately 1,300 students. RSGC attracts students from a wide geographical area and from diverse cultural backgrounds; languages taught at the school include Arabic, French, Italian, and Japanese.

Redlands aims to be at the leading edge of technology innovation in teaching and learning, providing challenging experiences that emphasise the development of leadership for women in a rapidly changing world. The school offers both VCE and vocational qualifications, and 90% of the Year 12 cohort continues to tertiary education studies.

Redlands had what might be considered the most traditional organisation of computers, with four dedicated computer laboratories that could be booked by teachers if they wished to use them for a class activity. These computer laboratories were often in demand, as it was expected that Years 7–10 students would learn basic ICT skills through subject disciplines. Certain subjects had been given the responsibility for promoting specific ICT skills; for example, mathematics and science were expected to teach the use of spreadsheets for calculations and graphing activities, while English focused on word processing and publishing activities. In addition to the four computer
laboratories, staff and students had access to eight computers located in the school library. Again, these had to be booked if students wished to use them during lesson time and after school. As in the other two schools, teachers at Redlands also had laptop computers, and the majority of school administration was managed via email and through the school’s Intranet system.

Years 7–10 students also had to participate in a compulsory subject called ‘technology studies’, a discrete subject area that incorporated the teaching of food technology, resistant materials (manufacturing using wood, plastics, and metal), robotics, and textiles. Technology studies was a relatively new subject area that had benefited from a significant government grant. This had been used for the refurbishment of several old practical workshops and the purchase of state-of-the-art equipment that allowed students to be involved in the design aspect of the technology subject through to the manufacturing process.

The science department at Redlands occupied four older style laboratories with fixed wooden benches arranged in rows, with a teacher demonstration bench located at the front of the room. In addition, there were two newly designed laboratories with movable octagonal tables in the centre of the room and workbenches located around the perimeter. The science staff comprised six full-time teachers, two part-time teachers, and two science technicians. At the time of this fieldwork, the science coordinator Jenny was coming to the end of her time in the role, and her colleague Natalie had just been appointed to take over. While staff in this department did not have a dedicated science staffroom, their desks were closely located in the communal work staffroom, and informal meetings often took place in one of the newer science laboratories or the social staffroom.
6.2 Jenny (Current Science Coordinator)

My interview with Jenny was conducted in the school social staffroom and began with a discussion of her teaching resume:

*Well, I have been teaching for about 20 years I think [counts on fingers] yes 20 years. I began teaching in the eastern suburbs of Melbourne, then I spent five years here at Redlands as a biology and general science teacher between 1985 and 90, but then I had kids and took family leave for seven years, where I did some CRT work. And I have been back at Redlands for six years and when I returned here it was in the role of science coordinator, but I’m actually giving up that role at the end of this school year, and taking on a part-time teaching load due to a family illness. (J.1.1)*

Jenny continued to describe her personal journey as a science teacher:

*You know, when I first started teaching I think I would have probably described myself as a biology teacher, and to be honest I’m still passionate about biology as a subject. I expect that’s probably because biology is what I studied at university, but I don’t think I would consider myself just a biologist or biology teacher now. Once I started teaching I quickly realised that I would be teaching more than biology as a science teacher, and I had to learn to broaden my discipline knowledge pretty quickly. In those first years of teaching I didn’t get a chance to teach exam biology classes, I think I was probably considered too raw, and I had to prove myself teaching junior science [Years 7–10]. You know what it’s like when you are the new kid on the block, but on reflection I think that did me good, because I guess it forced me to learn and deepen my understanding about teaching chemistry and physics. I guess that could be the reason why I now also teach some ICT; only to Year 7 and 8 of course. (J.1.2)*

I asked Jenny to expand on her last comment regarding ICT:

*Well, you see, the science coordinator before me, Tom, was really keen on ICT and when he became the VP [vice principal] he initiated a school-wide program to introduce ICT*
into all subject areas and asked for volunteers from each department to learn ICT skills, sort of be ambassadors [laughs] for its [ICT] use in subjects. I think I already had good personal IT skills, you know from the laptop rollout to teachers [a Victorian State Government initiative], so I thought it would be a good move for the department if I volunteered. You see, I thought it might get us a bigger slice of the budget maybe some specific IT equipment, like remote sensors and simulation software, and what I was really hoping for were a couple of computers in every laboratory. (J.I.3)

Jenny’s comments indicate (J.1.2) that during her early career she was required to develop her skills and knowledge both within and around her subject area, and this led to her being open to Tom’s request to further develop her ICT skills and become an ‘ambassador’ for ICT integration in science and across the school. It is also evident that Jenny had underlying motives for volunteering, as she hoped to gain ICT equipment for use in her department. The fact that she had already considered the resources that would most enhance the teaching of science at Redlands clearly illustrates that she had begun to strategise on how ICT might best be used in the classroom.

The interview proceeded with Jenny telling me how science was currently structured at Redlands:

*In the past we have tried to stick to the Curriculum Standards Framework quite rigidly, but in the last few years we have had the amount of time allocated to science for Years 7–9 reduced to three 48-minute periods and to try to cram all the content in during that time is near impossible. So now we have decided that our schemes of work will only loosely be based on the content of the CSF II and we are putting more emphasis on scientific method and questioning. We have chosen topics that we think the girls will have an interest in and have developed schemes of work around those. We all still cover the same theories, but it allows for people to really promote their interests and to be a bit more creative and passionate about their teaching. We have also identified*
opportunities for people to integrate ICT, but we haven’t pushed or prescribed ICT use. You see, I think that you can’t force people to change their practice; if you do they just shut up shop and become really resistant to anything, so it’s often a slow process. (J.1.4)

I asked whether introducing the two initiatives at the same time had been a challenge:

The majority of the teachers in the [science] department have been keen to go with this new approach because they see it as more contextual and appropriate for our girls, so we’re hoping they [the students] will be more engaged in science lessons. But there are a few teachers who are reluctant; you know, there are those of us who really love teaching and those who see it as just a job and minimal change means minimal effort. Look, I am realistic, I know the success of any change is dependent on individual teachers, but it is also the way you sell it. I have noticed that when people hear about what others are doing with ICT in their science lessons, like Carl and Natalie [two science colleagues], discussions are beginning to occur, and people are asking for advice on how to use certain applications and software with their class. I like to think of it as spreading a few breadcrumbs; they [science colleagues] see or hear success in other teachers’ classes, then they [science colleagues] get involved at their own pace and level. I must admit I have had a lot of help from Tom; he has been very supportive of our attempts to change things and has given us time to develop the new schemes of work. He has not been too pushy; he knows the science staff pretty well. (J.1.5)

Jenny demonstrated a very pragmatic approach to both the engagement of her science colleagues in the new schemes of work and the use of ICT. She saw value in encouraging colleagues to adopt the new schemes of work and the ICT activities, but recognised that to force either initiative on her colleagues rapidly might result in the rejection of both. Jenny’s close working relationship with Tom and their intimate knowledge of the science staff have enabled this process of change to occur slowly, which may not have been the case in other subject departments at Redlands.
Our interview continued with a discussion of Jenny’s pedagogical approach, and I asked Jenny whether she preferred a particular lesson structure:

*I do not think I have a specific structure that I follow every lesson. Of course, I have routines, like I always take the roll at the beginning of the lesson to quieten them [students] down. Then either recap last lesson’s ideas, or introduce new ideas, but I might do this in different ways. For example, I might recap myself, or I get one of the girls to, or I’ll ask questions to prompt them [students] for ideas, and sometimes I will do a quick pop quiz in their books. I suppose I do the same when introducing a new topic as, you know, you can’t take their [students] knowledge for granted. I like to find out what the girls know about a topic before I launch into it; I think a demo can often help here. I find that some might know quite a lot of about some topics, while others might have some really strong misconceptions.* (J.1.6)

She continued,

*But we are hampered by short periods of 48 minutes, so I have to make sure I am really organised. So sometimes if we are doing a practical I will do a demonstration one lesson and ask volunteers to assist, then the next lesson the girls will do something similar. We are always moving on in a topic and the girls can see that they’re not just copying my demo and results, but building on it. Of course I do not do practicals every lesson, but I always try to have a task that the girls have to actively be involved in. I must admit I’ve been aware that with my Year 10s this year I have become really teacher centred and I am not happy with that at all. Really it has been a battle to get through the content and I have found myself teaching to a test and it’s just not like me. I am determined to be more inquiry based next year because I have been really frustrated and I am sure they [the students] must have been.* (J.1.7)

I was able to witness Jenny’s teaching approach in Lesson Observation 1 with her, which was a Year 9 class looking at energy transfer in different materials.
Observation 1. Jenny (10/10/03) Friday period 4

Year 9, 22 students, 48 min

For this lesson, Jenny had set up a circus of experiments to help the students answer questions on energy transfer, specifically the concepts of convection, conduction, and radiation.

The pupils were expected to move around the circus of activities and complete a handout reporting their observations; for each task, an activity card had been prepared providing pupils with procedural instructions. One of the activities was set up on Jenny’s laptop and was a simulation activity, which illustrated how the particles in solids, liquids, and gases were affected by changes in temperature. Pupils were able to alter the temperature on the software and see how this affected the various materials.

After an explanation of the lesson objectives, Jenny split the pupils into groups, sent them to an activity, and they began working.

Jenny spent most of her time roving around the group, ensuring the pupils moved through the experiments in a timely manner so that there was not a hold up at any activity. As she did this, she fielded questions on the tasks and asked the girls to explain to her what they thought was occurring in the experiments.

Toward the end of the lesson, Jenny asked the pupils to tidy up and then gathered them together. She then asked several pupils questions on the activities that they had just completed and asked them to come and write or draw their findings on the whiteboard. The girls were quite happy to do this and ended up writing a list of summary dot points of what they had found from the experiments.

Jenny then gave the girls a homework task from their textbook and let them leave.

Figure 16. Excerpt from Observation 1, Jenny’s Year 9 science.

Jenny’s pedagogic approach in this lesson was constructivist in nature and learner centred, as the girls were given initial procedural and safety instructions and then allowed to work relatively independently within their groups. She acted very much as a facilitator during the lesson, helping the girls manage time and asking questions to further students’ understanding, and the students appeared to be used to this style of teaching. Even when Jenny gathered the students together toward the end of the lesson
to consolidate their learning, she used effective questioning to get the students to review
the concepts, rather than summarise them herself.

During the lesson debrief, which was conducted directly following the lesson, I
asked Jenny if she thought safety was a factor that might make teachers reluctant to use
ICT in the science laboratory:

*I think that it is the same as doing any practical work in science; you inform the girls of
the dangers and make sure they are acting in a sensible way, then there is no problem.
You have to trust the girls and make sure you set things up carefully. Look, I suppose I
am only usually looking out for one laptop, because we have to move to a computer lab
for whole-class use, but still it is really a matter of common sense and our girls are not
badly behaved. As you saw in this lesson, we had hot water and Bunsen burners going
and they were all really quite sensible. They used my laptop carefully and look, if I had
more laptops I think they would be sensible and take care. (J.1.9)*

I prompted Jenny to tell me more about how she used ICT with her classes, and she
readily gave me some examples:

*Well, for example, in Year 7 we use simple applications, you know, like PowerPoint,
Publisher, and how to do basic Internet searches. But whatever we do, it is aimed at
promoting science learning; for instance, when we do Internet search strategies I get the
girls to do a project on a famous scientist. They find the information and then they can
choose the way they want to present it, for example, a PowerPoint or an information
leaflet. In Year 8 I get my class to do PowerPoint animations. Not everyone does this
with their classes, but because I am happy using the software, I get my group to create
an animation around the theme of digestion and they have to show the journey of a food
particle, and explain each step of the journey. In fact we are doing that this week, if you
want to come and see. (J.1.10)*
I accepted this invitation and attended Jenny’s next Year 8 lesson on Wednesday third period. Jenny’s Year 8 class had been working on the topic of digestion in their previous two lessons, and to consolidate their understanding of the topic, she had asked them to create an animation to illustrate the journey of a piece of food through the digestive system. At each significant point in the digestive system, the students had to add an annotation to the animation.

**Observation 2, Jenny (15/10/03) Wednesday period 3**

**Year 8, 20 students, 48 min**

Jenny’s class had relocated to a computer laboratory, and students were seated in pairs at computer terminals. Prior to this lesson, Jenny had given her students written instructions on how to create their animation and provided them with the images that they were going to use to build their animation. The pupils had also written little descriptions of what was happening at each stage of digestion; some of these were quite humorous as they had taken on the persona of the food particle and were giving it a voice.

The girls had the task of putting the animation together and adding their descriptions to annotate it, demonstrating their understanding of the process.

**Jenny:** Okay girls, what I would like you to do is to get out the help sheet that I gave you last lesson, log on to our shared file and begin to create your animation. Remember I have put the images in that shared file so no need to go searching for your own pictures. Also I will be coming round to check your descriptive notes for each stage.

**Student 1:** Miss, do we have to use your pictures; can’t we look for our own?

**Jenny:** No, I want you to use the ones I have provided, because we only have this lesson in the computer room and I want to make sure we don’t waste any time searching the Internet for images or drawing. Okay, any more questions?

**Student 2:** Miss, I can’t log on.

**Jenny:** Okay, I will come over and help you.

Jenny was able to get the pupil logged on and the pair started their work.

**Student 3:** Miss, our screen’s frozen.
Jenny went to help the pair whose screen had frozen and then moved them to another terminal, as she could not get their original machine to work.

After 10 minutes, most pairs had managed to get at least one feature of their animation active.

Jenny moved from pair to pair troubleshooting and making sure all pupils were on task. As she circulated, she asked the girls questions about the science involved in their animations and about the annotations they were going to add at the various stages.

The girls appeared to be quite competent in their use of the PowerPoint software, and the only issues that seemed to be causing trouble related to the fonts, colours, and sounds that they were going to use.

At the end of the lesson, Jenny reminded the pupils that they had to save their work in a particular shared file, and then asked them to log off and be ready for the bell.

Figure 17. Excerpt from Observation 2, Jenny’s Year 8 science.

During my debrief with Jenny the following Friday morning (17/10/03), I asked why she had chosen to conduct the digestion activity in this way and not just do a straightforward PowerPoint presentation:

*Well, I think I did it because it’s a little bit more creative and you get to see the food particle actually moving through each section; plus it shows them other features of PowerPoint. You know, the girls do PowerPoint presentations in other subjects and I wanted it to have a different slant, so that they’re not getting bored and saying, oh no not another PowerPoint presentation, we did one this morning in history. Here I think they are thinking of it more as making a cartoon; it’s like an electronic flipbook really. Yes, I know it’s the same software, but they seem to get a lot more out of it. In the past we would have just had the girls annotate a diagram, but I think they actually remember more about the sequence when they do this animation process. (J.2.1)*

I also questioned Jenny about her decision to create the images for the students to use and not let them draw their own.
Well, that’s a time decision really; you see, we have to relocate to a computer room if we are going to have everyone working on a computer and it is often a nightmare to get a booking. So when I can get the class into a computer lab I like to use the time as effectively as possible, and you know what, girls are like, they take ages deciding on the aesthetics. I mean, you heard them squabbling about background colours, fonts and what transitions they were going to use for the annotations, can you imagine the time they would take if I let them do the drawings as well [raises eyebrows]. In fact I was pretty pleased so many finished it in the lesson; last time I did the activity I had over half the class finishing off in their own time. (J.2.2)

Lesson observations and Jenny’s comments (J.2.1 and J.2.2) indicate that she was competent in her own use of ICT and aware of the affordance technology offers for learning in science. For example, she had not just used the PowerPoint software as a presentation tool, but had also chosen to use the functionality of the software to design a learning activity that she considered would further enhance the students’ understanding of the scientific concept under investigation, the digestive system. This example illustrates that Jenny had recognised a purpose for ICT, which would allow her to use it on her terms, and the fact that she had taken the time and adapted the software demonstrates a high level of integration. Jenny demonstrated a transformational approach in her use of ICT by redesigning her science activities to support student learning.

I asked Jenny if she thought that the organisation of the computers in the school affected her use of them in science.

Absolutely, our real problem in science is access; we have a computer lab style set up here, as you have seen, and you have to book the rooms. But mostly the rooms are block booked by technology, maths and LoTE [Language other Than English]. Sometimes you might get in there at a time coinciding with your science lesson or get a cancellation, but
it is never seamless, and of course that’s a good excuse for some people never to use ICT. What I would really like is a couple of computers in every lab to allow continuous access, by students as required, plus a trolley of laptops that we could book just for science, so we could do whole-class activities. But I can’t see us getting finances for that any time soon. (J.2.3)

I must have looked perplexed because she went on to explain,

You see, while the push in this school is to integrate ICT in every subject, there hasn’t been a great deal of money to improve computer facilities across the curriculum. The school secured IT funding, but it was really to set up design and technology as a subject area. You see, in Years 7–9 the students take a subject called “technology studies” where the students do all sorts of design and making activities involving technology, such as robotics, rocket making, and plastic moulding. But money has not really been available to the other KLAs [Key Learning Areas]; we get $170 a year each for PD, but you know that doesn’t pay for the CRT cover. I was hoping for a little more really, but I think it is going to take time. (J.2.4)

Jenny continued, illustrating her story with a tale about a recently purchased digital microscope:

Look, we did get a great new digital microscope I saw at a conference. I invited the company in to school to give us a demonstration. Then we managed to get one [digital microscope] on loan, and I convinced Tom that it would be a great teaching tool. So in the end he came up with the money to buy it, but we have had to learn how to use it in our own time and that’s okay because people are keen, but it’s probably all we will get out of the budget for a while. (J.2.5)

Jenny’s comments illustrate that she was frustrated at the current organisation of the computer resources available and the fact that budget constraints were not going to
enable her or her successor to further develop ICT integration in science lessons in the near future.

6.3 Natalie (Future Science Coordinator)

Natalie had been at Redlands for 18 months and had just been appointed to the position of science coordinator for the coming year. She told me that this was only her fourth year teaching, and that before Redlands she had worked in a lower socioeconomic status school in the western suburbs of Melbourne, which had been a very different experience from Redlands, but she felt it had shaped her pedagogy significantly:

*The first school I taught at was coeducational and most of the students were newly arrived in Australia. In fact, many of my students were not native English speakers and had only had six months of intensive English tuition and of course they were not really conversant with the technical language we often use in science, or the double meanings words might have. You know, a classic example is when we use the word ‘key’ in biology for classification; it has a very different meaning to the kind of key you open a lock with.*

(N.1.1)

She continued,

*That experience really affected my teaching style and helped me reflect on my teaching. As well as thinking about the importance of language, I also had to rethink the way I explained a lot of science concepts and ideas. See, I had to make things relevant and more contextual to the students’ experiences and not just to mine. They [the students] came from such different backgrounds; I really had to do a lot of rethinking. I also realised it’s really important to find out what kids know about the meaning of a word or what they understand about terms, and that applies to the topics you cover as well. You know some kids know quite a lot about the topics we cover, but they often encounter them in a different context.* (N.1.2)
Natalie provided me with an example:

For example, my class were working on the genetics unit the other day and we were focusing on the inheritance of family traits through dominant and recessive genes. Out of the blue, one girl puts her hand up and says that her parents are dog breeders and had all the family history and details of the dogs that they had bred. The next day she brought in some of the photos of the dogs and their pedigrees, and did a short presentation to the rest of the class. It was great; it led to a really good discussion on genetic engineering and really gave the topic an authentic feel for the girls. (N.1.3)

Natalie’s comments (N.1.1 and N.1.2) regarding her first teaching position implied that the environment had been a catalyst for her pedagogical growth. The need to devise teaching strategies, which would convey scientific concepts and language to students with a limited grasp of the English language, required her to reflect on the way she envisioned science teaching. Natalie had realised that her experience and perspective of science concepts might be vastly different from her students and recognised a need to alter her pedagogy in order to create shared understanding.

The interview continued with a discussion of Natalie’s pedagogic approach and her lesson structure:

Personally, I learn by relating new ideas to what I already know, or to my lived experience, and if I really want to understand something then I usually need a visual representation. So I am a visual learner and I guess understanding my own learning style has made me aware that I need to know about the students’ preferred styles. I mean, anyone can learn to regurgitate facts and knowledge, but what’s really important is to have a deeper understanding and be able to relate that knowledge to new situations. So I try to use a variety of activities for the girls and hope that I am appealing to their various learning styles. (N.1.4)
Natalie continued to provide details of her lesson structure:

I don’t think I have a typical lesson structure, but I have a sort of routine for my lessons. For example, I like to start by putting up an agenda for the lesson so that the girls know what they are going to cover. I think that an agenda gives the girls a sense of progression and accomplishment and reminds them that the activities are going to vary; I find this keeps them engaged for longer. I also like to get the girls involved even if we are not all doing a practical experiment. For example, I invite the girls to come up to the board to draw diagrams, solve problems, record experiment results, or take part in demos. Of course, for that to work, I have to set the right environment and I do this at the beginning of the year. I suppose my aim is for the girls to feel comfortable in the science classroom and to feel like they can have a go. I don’t mind if they get it wrong, I want them to be able to say I tried; I had a go. (N.1.5)

I arranged to observe one of Natalie’s Year 8 classes the following week to witness her pedagogical approach.

Observation 1. Natalie (24/10/03) Friday period 2

Year 8, 22 students, 48 min

The pupils had been studying a unit on electricity, and this was the second lesson in the unit sequence. The focus of the lesson was an introduction to series and parallel circuits. Natalie had organised a whole-class practical activity that would enable them to investigate the relationship between current and potential difference in the two types of circuit.

Natalie wrote a brief list of activities on the whiteboard, and at the start of the lesson, she drew the class’s attention to the activities that they would be covering:
To begin the lesson, Natalie selected several pupils to come and draw a circuit symbol on the whiteboard, and the other pupils had to decide what it represented. She then drew two circuits and told the pupils that one was called a parallel and the other a series circuit. She explained that ‘a way to remember the names of the circuits is to visualise the parallel bars in gymnastics for parallel circuits; and the episodes in a soap opera following on from one another which is called a series’.

She then split the class into pairs and told them they would be investigating the properties of these two different types of circuit. While the practical sheets looked similar, I noted there was some variation, and several pairs seemed to have more tasks or questions on their sheets.

Pupils conducted the practical experiments quite efficiently, and Natalie moved around the class helping them when difficulties were encountered, mainly dead cells (batteries). She also began asking questions about what they were finding out. Toward the end of the lesson, the pupils cleared away and returned to their seats. Natalie asked what they had found out in relation to their experiments. Most pupils willingly contributed, but a few girls seemed a little reluctant and Natalie asked them some specific questions.

She then used her laptop and the data projector to demonstrate how the two circuits worked using a software simulation called Crocodile Clips, which the girls seemed very enthused about.

The lesson ended with a reminder to complete the questions from the experiment sheet.

_Figure 18._ Excerpt from Observation 1, Natalie’s Year 8 science.

Directly after the lesson, I discussed some of my observations with Natalie, and I asked her why some of practical sheets were slightly different.

Well, all our classes are mixed ability in science, and some girls need a little bit more support and some need stretching. So I usually have two versions of the work sheets or

<table>
<thead>
<tr>
<th>Today:</th>
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<tbody>
<tr>
<td>1. Recap circuit diagrams and symbols (~5 mins).</td>
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<tr>
<td>2. Read through the practical sheets (~5 mins).</td>
</tr>
<tr>
<td>3. In pairs work on your particular practical (~15 mins).</td>
</tr>
<tr>
<td>4. Gather our results (~10 mins).</td>
</tr>
<tr>
<td>5. Review on Crocodile Clips (~5mins).</td>
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</tbody>
</table>
practical sheets. In this lesson they all had the same basic activities, but some had a few harder questions to answer. I don’t do it every lesson and I don’t do it at the beginning of the year; I need to get to know them first and monitor the work they hand in. Then if I think some need more support I will give them a few more clues, or if some girls are getting stuff really quickly I will give them some extension tasks. (N.2.1)

I also queried why she had closed the lesson with the Crocodile Clips simulation.

Oh yes, well, you see, I wanted them to see the Crocodile Clips software there at the end, initially because I thought that using the software was a good consolidation of the series and parallel circuit experiments and it appeals to the visual learners. More importantly though to illustrate how scientists work nowadays, using simulations to help plan their investigations and test hypotheses to see what might occur before they carry it out. Really I would have liked them [the students] to first make their circuits with Crocodile Clips so that we could alter the number of bulbs easily, and put too much current through and blow the bulbs up, of course they [the students] love that. Then we could have done the actual experiment or planned something a bit more ambitious. I think they [the students] would have got a lot out of that, but I couldn’t book a computer room for this lesson; they’re all in use [rolls her eyes]. (N.2.2)

Natalie’s confident pursuit of her authentic purposes as a teacher was evident in the way that she delivered her lessons and the care she demonstrated in developing an understanding of her students’ needs. Her teaching philosophy focused on developing the students’ understanding of the scientific process and the importance of applying that process to novel situations so that they could work things out for themselves. While correcting her students if they made errors, Natalie was keen for her students to answer questions and encouraged them:

Don’t be afraid to get things wrong; many early scientific discoveries were outcomes of mistakes, or even accidents. (N.2.3)
Natalie’s pedagogical practice had also been strengthened by the realisation of her own learning style (N.1.4) and the subsequent understanding that she needed to plan activities that appealed to the varied learning styles of her students. From Lesson Observation 1 and Lesson Observation 2 conducted the following week (28/10/03), it became apparent that Natalie’s teaching approach transcended clichés of teacher-centred and student-centred practices. In the lessons that I observed, she alternated between being the centre of attention and leading the class in discussion or performing a demonstration, and scaffolding activities that gave students the opportunity to explore the concepts that she had introduced.

I probed deeper with regard to Natalie’s use of ICT in her lessons, and she became quite animated in her response:

*I really would like to use ICT more, but it’s really difficult to get access to computer rooms. I always take my laptop so that I can put up notes and images on the whiteboard; that way I cut down on paper and I can make things colour, which helps to make diagrams clearer. I also book classes into the computer rooms, when I can, and get the girls to work on external websites or software we have on our Intranet. I also use the Intranet to store all my materials so the girls have access to them. You see, I have a class policy: I give one handout and if the girls lose it they can go to my Intranet page and get another copy. Also all my lesson notes and experiments are posted, so if a girl is away she can see what we have done. With the seniors [VCE Years 11 and 12], I use email and they send me work or questions and I email them back. But there is so much more we could do.* (N.2.4)

I asked Natalie to elaborate on how she would like to develop the use of ICT in science, and she readily shared her plans:
Well, there are several stages. First off I am going to conduct an inventory of all our resources and an audit of people’s skills. I know many of my science colleagues are using ICT in their lessons, but I don’t know exactly what people are doing and what skills they have or PD they need. I have downloaded this survey [shows a survey] that I have adapted for our department and I am going to use it initially to get an idea of what people are confident to use and how they are using ICT already, even if it’s just to make a worksheet. (N.2.5)

She continued excitedly, calling up a screen on her laptop:

Now see here [points to screen] I have already started putting all our teaching in strand order, and then year topics as they occur in terms 1, 2, 3 and 4, and then I am adding the ICT resources and activities that I am aware have already been developed. I want to make it easy for people doing the same topic to be able to share their ideas and ask colleagues who might be more confident in a particular ICT application how to use it. Here you can see [points to another link and clicks on it] I have also set up links to school policies, agendas and minutes of our department meetings, science staff handbook etc. (N.2.6)

Natalie continued in her enthusiastic tone and told me of her plans to set ‘end-of-topic tests on computers’; apparently, at the culmination of a science topic, students were expected to take a test to assess their understanding of the content taught:

One thing that I want all of us to work on is the use of online end-of-unit topic tests. We have the capability using “Hot Potato” and the school Intranet. I have been trialling it with my Year 11s and it seems to work quite well; they love the fact that they get immediate feedback and that they don’t have to wait for me to get round to marking. Sometimes I get carried away and I have to stop myself when I have ideas, because so much depends on access . . . whether we can get into a computer room, or if the kids have a computer and Internet access at home. So I have to be careful to make sure that
what I plan is practically viable and equitable; Jenny’s good—she reminds me to keep my feet on the ground. (N.2.7)

Natalie had obviously considered several ways that she could improve the integration of ICT within the science curriculum and was undoubtedly enthusiastic at the prospect. She had used her administrative skills to conduct an audit of her colleagues’ strengths and weaknesses in ICT use and was beginning to improve the availability of current science activities and resources by creating a centralised archive. Frustrations were also evidenced in Natalie’s comments (N.2.6), and her main concerns focused on student access to technology, both inside and outside the school timetable.

Having witnessed the work Natalie had already started and listened to her plans, I inquired about the PD provision for ICT at Redlands and her personal ICT competence:

Oh look, I am no expert; most of what I know I have taught myself or learnt by asking other people, and I am always running off to the techie guys for help. My friend Teresa in maths has also been a great help—she is quite ICT smart—but you know I just love the possibilities that ICT offers for science teaching. I don’t think any formal professional development I have experienced here [Redlands] has really been that useful. Oh look, some of it is okay for admin, but I can’t say the PD has really been relevant for my teaching. For me it’s been more my own need to find out how to use ICT to improve my science teaching that I have found useful, so mostly my PD is learning from others in the department and through trial and error [laughs]. (N.2.8)

She then continued in a quiet voice:

To be honest I think at the moment the PD on offer here [Redlands] is not appropriate; it’s not really relevant to subject areas and people are all at different levels. Plus some people are reluctant to change from their old routines if they can’t see the relevance, or think it is all too difficult. ICT has kind of been rammed down peoples’ throats a bit and I think it’s led to a backlash effect on the use of ICT. A couple of colleagues in science
are really reluctant to use ICT; they think they know less than the kids and are really
digging their heels in. That’s why I think doing our own in-house ICT PD in science will help. Personally I have to use an application regularly to get confident with using it. So I think if we had a focus on a maximum of four ICT activities over next year, then we wouldn’t be overloading or stressing people, and they would get to learn those activities or applications really well and at their own pace. It’s still going to be a slog with some colleagues, but I am sure we can get everyone on board gradually, and some people of course will still be doing heaps more, like Jen and Carl and hopefully me [smiles broadly]. (N.2.9)

Natalie illustrated a clear commitment to use ICT in science; she was aware of the issues that concerned colleagues and was developing sound strategies to embed the technology within the curriculum without it becoming overwhelming for staff. She had begun to see the possibilities that ICT offered for redesigning the curriculum and had thought of ways to include new activities that had previously been unachievable without ICT. However, access was clearly creating a barrier to her plans and adding another level of complexity and frustration to ICT integration.

6.4 Carl (Science Teacher)

Carl had been a science teacher for over 20 years, and for the last 10 years, he had taught at Redlands. He considered himself a general science teacher ‘with a leaning’ toward environmental science.

Oh look, over the years I have taught all sorts of science topics and really what some people might consider odd stuff that has been labelled as science. Back in the 80s, I taught agriculture at a boys school here in the city; we were basically looking at farming and that was classed as a science stream. To be honest I had to learn all about the topic as I was teaching it. I’m a city boy and had no experience really, but neither
did the kids and we sort of learnt together, it was one of the best classes I ever taught.

(C.1.1)

Carl explained his role at Redlands:

Well, I have been here for about 10 years and I guess I’m quite adaptable. I think I am really more comfortable with biology topics if I am honest, and I would teach that at VCE, but I am quite happy teaching anything in Year 7–10 science. I teach some maths classes to make up my timetable, but I am not really maths trained; I can do it, but it’s not really me. Science is my passion. (C.1.2)

I encouraged Carl to elaborate on this last statement about science being a passion:

Well I’ll sound like a real geek, but look, I love science; it can be so much fun and I think if you get the girls interested they think it’s fun as well. I mean, I have girls in my class that are really excited by science. Well you can just see, here, look. (C.1.3)

Carl led me to his desk in the staffroom and presented me with a box of optical instruments:

Okay, so we have been doing a topic on optics and I first introduced them to the topic by showing them some pictures of old optical instruments. I then got the girls to research a particular optical instrument. Then they [the students] had to find out who invented the instrument and how it worked, and then I got them to make a simple version and look at what they have produced. It’s fantastic; every girl has handed in her work. Not just the instrument, but also the history and design specifications. See, I have it here all via email. (C.1.4)

Carl’s excitement about science was evident in the pride he took from the girls’ work and the enthusiasm with which he discussed science and science teaching. Carl’s comments regarding his early teaching career (C1.1.) and current role at Redlands
(C.1.2) also indicated his willingness to teach outside his specialism of biology and demonstrated his willingness to learn with his students.

I asked Carl how his ‘passion for science’ was manifested in his pedagogy:

*I think I try to engage the girls with the topic I am teaching and find activities that I think will appeal to them. I am a bit of an Internet junkie and find some great ideas out there. I mix things up a bit; I do a variety of activities in each lesson. I don’t really do a lot of teacher-focused work if I can help it. Of course I will explain concepts when needed, but I do things to get them [the students] involved.* (C.1.5)

Carl elaborated, describing a recent lesson:

*For example, I found this great website last week and it just complemented the subject I was teaching. I had Year 10 and we were covering the genetics topic and I wanted to put the ideas into context for them, and I found this website on the Romanoffs and Anastasia. Well, most of the girls knew the name from the Disney movie and I explained the story of Anastasia and then got the girls to use the site to investigate whether or not Anastasia was really related to the Russian Royal family. They were like genetic detectives; they really enjoyed it. I used the site as a way to discuss why knowing about genetics is important, and to introduce them to genetic disorders. Which is actually what we are investigating in the lesson you are coming to observe.* (C.1.6)

Later that day, I was able to witness Carl’s teaching approach when I observed his Year 10 class.

<table>
<thead>
<tr>
<th>Observation 1. Carl (28/10/03) Tuesday period 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Year 10, 23 students, 48 min</strong></td>
</tr>
<tr>
<td>Carl had relocated his class to one of the computer laboratories. The pupils were seated around the edge of the room at computer terminals, two to a machine.</td>
</tr>
<tr>
<td>Carl: <em>Now we are going to look at five websites that will give us information about several illnesses or disorders that are passed on genetically. The addresses of the sites are on this</em></td>
</tr>
</tbody>
</table>
handout along with the questions that you need to answer about each disorder. Also, when you are looking at the sites there are some things I want you to think about which will be helpful for your homework.

Carl turned to the board and wrote:

<table>
<thead>
<tr>
<th>For each site make notes on the following:</th>
</tr>
</thead>
<tbody>
<tr>
<td>What does the website look like?</td>
</tr>
<tr>
<td>Can you find your way around it easily?</td>
</tr>
<tr>
<td>Who owns/has published the site?</td>
</tr>
<tr>
<td>When was it last updated?</td>
</tr>
<tr>
<td>Do you like the site? (What are the good features/not so good features?)</td>
</tr>
</tbody>
</table>

Carl checked the students’ understanding of the task; one student asked if they could work alone, but Carl said pairs only. The students then turned to the computers and began. A few hands went up, and Carl circulated giving students assistance where needed. Three girls were looking at ‘chat/phone site’ and Carl asked them to stop this. The girls flicked onto one of the suggested websites and Carl went to help other students. As he wandered around, he asked students questions regarding the sites and what they had found out.

The girls who were off-task earlier had flicked back to the chat site, and Carl was suddenly at their side. He asked them to close the window this time and to reopen one of the recommended sites in a new window. He explained to them if he had to speak to them again they would not be able to work on the computers.

Ten min before the end of the lesson, Carl asked the students to log off the computers and asked the students for the answers to the worksheet. Homework was to write a short review of each site using the questions he wrote up as a guide, and they were then to email this task to him.

*Figure 19. Excerpt from Observation 1, Carl’s Year 10 science.*

Carl demonstrated a learner-centred approach in this lesson and allowed the students to find information on genetic disorders for themselves; he was on hand to help if there was a problem and to ensure students remained on task. Carl had obviously thought about how he could use technology in this topic, even with limited access to the
computer laboratory, and had made what can often be a very interesting but heavily theoretical topic more student centred.

In our subsequent lesson debrief, which occurred a week later, I asked Carl if the lesson I had observed had been typical.

Well, not really, you see I can’t always get into a computer lab easily so I do have to make sure I book early; this slot on the timetable is actually one of the busiest times, so I was lucky to get it last week and this. But I suppose if you are talking about my teaching style then yes, that was pretty typical. I like the girls to be involved rather than me to be out the front all the time. (C.2.1)

I also enquired how common it was to accept emailed work, and Carl acknowledged that while some teachers were reluctant to alter their practices, he was quite happy for the girls to email him tasks. I invited Carl to explain how he could be sure that the girls had completed the work themselves.

Well, it’s important that you know your students and what they’re capable of. For example, I usually get my students to submit their final piece of work by email; that way I have seen their research work and drafts, so if suddenly I get a piece of work that seems out of place, I check it up, most teachers would. There have always been cases of parents doing their kids’ homework, or kids copying. But really I think teachers are on the ball; they know when a piece dramatically improves and it’s not the girl’s own. (C.2.3)

He continued,

I suppose technology might make copying easier, you know with kids cutting and pasting, but it’s still pretty obvious. I tell the girls that they should not just cut and paste irrespectively from a website as I will know the language is not theirs. If they find out information, they have to put it in their own words and reference the source, just like if
you used a textbook. Most of them get it, especially when I ask them to explain ideas they have written about in front of the class. You soon know the ones who have thought about things and digested it. (C.2.4)

My second lesson observation (30/10/03) corroborated Carl’s pedagogic strategies. He used questioning to ensure the Year 10 students had indeed understood the homework and completed it themselves. In this lesson, Carl asked students to volunteer general comments on the websites that they had explored in the previous lesson. Several students were then invited to come to the front of the classroom to present their specific site review. After the short presentations, other members of the group were encouraged to ask questions, and this led to a healthy discussion on the validity and usefulness of the information gained from the particular websites surveyed and the validity of websites in general.

During this and the previous class (28/10/03) that I observed, Carl taught the girls a very important lesson about the reliability of information retrieved using ICT and made them aware of how to check the validity of a website. Use of ICT in this way illustrates that Carl was happy for students to use the Internet as a reference source, but appreciated that he would have to teach them to critically evaluate the reliability of the information that they found.

During our interview after Lesson Observation 2, I encouraged Carl to tell me about his PD in the use of ICT.

I haven’t really had any professional development that I can think of, except when we had the people come in and show us the electronic microscope. Oh, and years ago I went to a workshop at Monash University where I learnt how to use sensory probes and data logging. For the most part though I am self-taught; as I said I am a bit of an Internet junkie and I spend time playing with applications or ask other people to show me. Also I
suppose playing computer games with my kids has helped. I think if you use computers all the time you get used to them and they just become another part of your toolbox. (C.3.1)

I asked Carl how important the senior management team’s support had been for the integration of technology in science:

*Well, the management team have been encouraging the use of ICT across the whole school not just science, and see, this is where the problem lies. It’s created a situation where everyone is trying to get into the computer labs at the same time and so they are constantly booked out. Sometimes you can be lucky and get a room like I was for two lessons in a row. But you can’t guarantee access so you have to plan really far in advance or just use your own laptop. I get the girls to use my laptop, or do a demo using it. Earlier in the year I had it set up with a sensory probe and we were measuring temperature change in chemical reactions. I would have liked to have several probes set up to use with the girls, but we need more laptops for that. I do set some research homework that the girls have to do on the computer, but not all our kids have Internet access at home, so some have to go to the library to use the PCs there; it’s not ideal.* (C.3.2)

I inquired whether there were plans to make ICT more accessible, and Carl pointed to the policy dilemma of resource allocation:

*Well you see, the school’s got a grant to set up design and technology as a subject, but the money that is coming in for that is really going to the technology for that area and not into general computer resources.* (C.3.3)

He continued to explain,

*What we really need is more computer access in each science lab. That would make our lives easier; then we can have some groups working on the computer, some doing experiments and so on. But you see, instead of that they [senior management] have just*
spent the money on robotics and rocketry equipment and a plastics injection-moulding machine, for D and T. Which is great for our girls because they are really into the whole design subject, and obviously it will expand the Vocational Education and Training programs here, but it puts a strain everywhere else. Actually I would say robotics and rockets might be considered science subjects really, but I doubt we will be involved in teaching it [shrugs.] (C.3.4)

Carl has clearly taken the opportunity to redesign the activities that he uses with his students and is keen to use technology in his teaching. He has spent time developing his own personal skills and has been confident to use ICT in his classroom as a tool to transform student learning. However, Carl’s comments (C.3.4) illustrate two grievances: first, he felt there had been a bias in the distribution of the technology funds, and second, a frustration about the appropriation of robotics and rocketry into design and technology when he thought they would have sat better in science.

6.5 Discussion

The school prospectus states that Redlands was at the leading edge of technology innovation in teaching and learning. From my initial visit to the school, I wondered how this could be possible given that, in comparison to the other two case study schools, Redlands appeared to be underresourced in respect to computing hardware and, indeed, subject departments had to vie for access to four computer laboratories. However, it seemed that Jenny and her two colleagues (Carl and Natalie) had developed strategies to overcome these constraints. For example, when access to computer laboratories was not available, they allowed the students in their classes to make use of the ‘teacher’ laptop provided for staff (excerpt from Lesson Observation 1, Jenny; excerpt from Lesson Observation 1, Natalie). They had also developed tasks that effectively made use of the limited access to computer laboratories, for example, the animation task used by Jenny
(J.2.1) and the research task used by Carl (C.2.3). These three science teachers were clearly demonstrating ICT integration that both enhanced and transformed student learning (Puentedura, 2010), albeit somewhat opportunistically. For instance, Carl was not merely substituting the Internet as a reference source to support student understanding of the ‘evolution’ topic; he had redefined his task to also teach his students how to be critical evaluators of the websites that they were visiting (excerpt from Lesson Observation 1, Carl). Likewise, Jenny had transformed her teaching of the topic ‘body systems’ and supported her students’ learning by asking them to create an animation of the digestive process (J.2.1).

Generally, it appears that through the leadership of Jenny, the science staff at Redlands worked collaboratively through constructivist teaching strategies and community and agency to respond to the wider school policy requiring staff to integrate ICT within their subject disciplines. Jenny’s relationship with Tom, the vice principal as the active institutional gatekeeper promoting this policy, had empowered her to persuade science colleagues of the benefits of integrating ICT in the science curriculum (J.1.3 and J.1.5). Also, aware that some staff were not as keen as others to incorporate the use of ICT, she had not pressured them to rapidly alter their pedagogic practice, but instead had allowed them to witness the successes of some of their science colleagues (J.1.5). Natalie, her successor as science coordinator, seemed to be continuing in the same vein, initially focusing on integrating just four ICT activities in the science curriculum (N.2.9). She was encouraging staff to share their expertise in a particular ICT application, or tool, to develop what she termed ‘in-house PD’. I claim that, when faced with the complex task of integrating ICT into the science curriculum at Redlands, both Jenny and Natalie have cultivated a sense of ‘relational agency’ (Edwards, 2010) among the science department staff. As Edwards and D’Arcy (2004) stated,
Relational agency is not simply a matter of collaborative action on an object. Rather it is a capacity to recognize and use the support of others in order to transform the object. It is an ability to seek out and use others as resources for action and equally to be able to respond to the need for support from others. (p. 150)

### 6.5.1 Teachers working agentively across boundaries

Also evident at Redlands was that teachers were prepared to work across subject boundaries. For example, Jenny agreed to be an ‘ICT ambassador’ when vice principal Tom proposed the policy that ICT would be integrated into all subject areas (J.1.2). Admittedly, Jenny had hoped that this would also allow her to gain access to a larger ‘slice’ of the school’s ICT funding to provide more ICT resources for the science department, but it had also resulted in her becoming a member of the ICT teaching staff itself (J.1.2 and J.1.3).

Natalie was also prepared to look outside the science department to improve her ICT skills. She spoke of the support and advice regarding ICT that she had received from her colleague Teresa in the mathematics department (N.2.8) and was also quite ready to ask for help from the technology technicians when she was unsure of how to use ICT: ‘I am always running off to the techie guys for help’ (N.2.8). Edwards (2010) reminds us that while boundaries are constructed to sustain practices, they should not necessarily restrict the development of practices; I claim that the fieldwork at Redlands indicates that both these science teachers were prepared to work across boundaries to further the pedagogic practice of the department, as well as their own practices.

### 6.5.2 Teachers reconfiguring their practice

In describing their teaching trajectories, all three teachers referred to having to adapt their practices early in their careers. Carl, for example, spoke of his experience of having to teach agricultural science in his first school position. He explained that
although he had no background in agriculture or farming, he was expected to teach this subject and admitted that he had to learn the topic alongside the students (C.1.1). Similarly, Jenny described herself initially as a biology teacher, but noted that in her first teaching position she had to develop pedagogical content knowledge in physical science disciplines. In her opinion, this success helped her development as a teacher. She considered that this had made her confident, open, and prepared to teach other subjects over the years such as ICT (J.1.1). Natalie’s experience in her first school, which had a large proportion of students who came from non-English speaking backgrounds, also had an impact on her PD. She stated that her first teaching role alerted her to the importance of language use in science and of connecting science topics to students’ prior experience. She believed that she now made a concerted effort to develop students’ understanding of scientific language and connect science topics with students’ interests and experiences (N.1.1 and N.1.2).

While these accounts reflect transitional experiences in each teacher’s past, I claim that the agency and purpose that each individual had already demonstrated elsewhere has also affected their future. As Billett (2009) stated, early experiences of learning in the workplace provides the foundation for how people interpret and engage with subsequent experiences. These three teachers appear to have viewed their past learning experiences as integrated social and personal elements in a reflective ‘reconfiguration’ of their pedagogic practices and their professional identity. It is not therefore surprising that when faced with the wider school policy to integrate ICT across the curriculum, they approached the task positively and began to again reconfigure their individual practice to transform their teaching of the science curriculum.
In the process of reconfiguring their own practice, these three teachers also began to impact on the wider practice of the science department, their figured world. For example, Jenny and Natalie encouraged science colleagues to share their successes with ICT use in the classroom and to cascade their expertise in certain ICT applications (N.2.6). This collaborative participation allowed staff to begin to reshape the figured world of the science department and so transform or reconfigure that world.

6.6 Summary

There is a marked difference in the way the three teachers at Redlands approached the integration of ICT within their practice compared with the teachers interviewed in the other case study sites. The three science teachers, Carl, Jenny, and Natalie, reflexively reconfigured their practices to include ICT in their pedagogic practice in their intention to improve student learning. They did not explain their dispositions in terms of following social orders. They sought to employ the resources available at the school and work collaboratively in ‘relational agency’ to share their expertise within the figured or preconstructed world of the science department to transform the social organisation. As Hakkarainen (2009) suggested, educational practices are not simply transformed by the provision of a technology-enhanced learning environment, or the right external policies, but structures and agency evolve interdependently, and I would claim with time through collaborative site-based practical innovations.
Chapter 7: Will You, Won’t You?

‘Will you walk a little faster?’ said a whiting to a snail,

‘There’s a porpoise close behind us, and he’s treading on my tail.

See how eagerly the lobsters and the turtles all advance!

They are waiting on the shingle—will you come and join the dance?

Will you, won’t you, will you, won’t you,

will you join the dance? (Carroll, 1865)

7.1 Introduction

The Lobster Quadrille (Carroll, 1865) seems a fitting metaphor to describe the tension between the institutional policy reform of integrating ICTs across the curriculum and the reality of this reform as enacted in teachers’ pedagogic practice. While some teachers eagerly embrace ICTs, others are still deciding whether they ‘will or won’t join the dance’. As evident in the cases discussed in Chapters 4, 5, and 6, the integration of ICT into the pedagogic practices of the participant science teachers was a highly complex and varied occurrence and heavily influenced by the subject department in which they were situated.

In the opening chapter of this thesis, I asked the overarching research question:

*What are the problems and prospects that shape the professional learning in the school subject department, and how can this influence individual teachers’ practice in the context of change?*

I defined the professional learning environment as the secondary school science department and the change context as the integration, assimilation, and accommodation
of ICT into secondary science teaching, in accordance with federal and state
government policy. To gain a deeper understanding of both the individual and collective
experiences of science teachers as they attempted to integrate ICT in their teaching
praxis and the ways the learning environment might facilitate or forestall this, I posed
the broader question as three subquestions:

1. How have the subject teachers’ beliefs, values, and perceptions of their subject
disciplines impacted their agency in the integration of ICT in practices?

2. How important have a shared repertoire, common practice, and culture existent
within a department been in shaping the integration of ICT in teachers’ practices?

3. How important have personal and social relationships within department been in
influencing the integration of ICT in teachers’ practices?

To answer these questions, I drew on Siskin’s (1994) work and identified the school
department as the primary organisational site in which teachers’ social, cultural, and
epistemological learning occurred. I suggested that school departments in essence f
unction as communities of practices (Wenger et al., 2002) in which teachers develop
both individual and relational agency (Edwards, 2010) to further the learning of the
whole community. Appreciating that a school subject department exists within the
organisational structure of the school and is bound by the institutional orders associated
with it, I proposed a reconfiguration of Bhaskar’s (1998) transformational model of
social action as developed by Harvey (2002). This allowed me to situate the three
science departments within their respective school structures and to explore the effects
of each community of practice on integration, assimilation, and accommodation of ICT
(see Chapter 2, Figure 3).

In Chapters 4, 5, and 6, I presented and discussed in detail the individual experiences of the participant science teachers and the ways ICT integration was affected by the existing community of practice, represented by the science department. In this final chapter, I show how these three departments can be located in the respective broader school organisational structure through the framework I proposed in Chapter 2, illustrating the dialectic between curriculum innovation and teacher agency after Harvey (2002) and Bhaskar (1994).

7.2 Applying the Curriculum Innovation and Teacher Agency Framework

7.2.1 When community becomes too much of a good thing

In Chapter 4, I presented the narrative case study of St Clair’s, a successful independent girls school, priding itself on both a contemporary approach to teaching and learning and a sustained excellence in the academic record of its students. I introduced the science department as a community of practice and provided an interpretive analysis of its response to whole-school curriculum policy innovation to integrate ICT in order to transform the teaching and learning in all subject learning areas. In Figure 20, I now situate the science department at St Clair’s as a community of practice within the broader local setting of the school and explain how the institutional order of social expectations and the constitutive order of self-cultivation have contributed to the reproduction, rather than the transformation, of teaching through the integration of ICT.
The heavy solid lines featured on the left-hand triad of Figure 20 indicate the dominance of the existing institutional practice and local social order of the school. The fainter red broken lines represent the introduction of ICTs as a whole-school curriculum policy innovation. I have used a lighter rendering for these red lines to signify how this curriculum policy seems to have been positioned with respect to the more dominant existing institutional practice of maintaining the school’s excellent academic reputation and standing in the independent school ranks. It appears that in this school, the tension between the constitutive order of transforming teaching practice through the integration of ICT is outweighed by the social order of expectation that teachers maintain proficient
teaching practices, resulting in students gaining good grades. I claim that this has led to
the science coordinator, Sally, being allowed to assimilate ICT into the current science
curriculum to maintain the status quo by continuing to reproduce current teaching
practice.

At the centre of Figure 20 is the community of practice with emphasis placed on
the social fabric of the community, representing the strong relationship between the
three science teachers at the core of this community: Sally, Carol, and Nina. As
discussed in Chapter 4 these three biology teachers have become the ‘pedagogy
gatekeepers’ of the science department, with the power to endorse or veto any initiative
which requires changes to pedagogic practice within this community of practice.

Supported by these two colleagues, Sally the science coordinator has been given
the agency and freedom to decide how ICT will be integrated into the science
curriculum and teachers’ pedagogic practice (represented by the double-headed red
arrow). The choices that Sally makes are shaped by what Harvey (2002) described as a
‘dual praxis of self-production’ (p. 185); that is, the publicly formed ‘self-as-product’
who appears to be meeting institutional requirements and the privately formed ‘self-as-
process’ with strategic personal beliefs and goals. In accordance with the self-as-
product, she publicly appears to be endorsing the integration of ICT in the practice of
the department by ensuring ICT activities are written into science curriculum
documentation. However, strategically, she has not made these activities compulsory;
more importantly, she has successfully influenced the school reporting system, by
insisting on changing ‘ICT use’ to ‘technology use’, thus assimilating ICT into her
personal belief system of what technology means in science education—self-as-process.

The absence of broken red lines on the right-hand triad of Figure 20 indicates that
the teachers in this science department have not achieved the transformation of practice
envisioned at the institutional level. The historical practice favoured by Sally and this community of practice has disrupted the curriculum policy to integrate ICT into the science curriculum. As Harvey (2002) warned,

> Certain historical conditions can transform the promise of orderly social renewal into a set of disrupting forces that can bring down the very institutional order within which that freedom of personal realisation operates. (p. 187)

### 7.2.2 The influence of a fragmented community

Figure 21 represents Slyfields Girls College, discussed in Chapter 5, which was badged as a ‘lighthouse school’ and charged with modelling innovative teaching in science and technology. In accordance with its status as a science and technology school, I would reason that the ICT curriculum policy, as represented by the heavily rendered red broken arrows, has become the dominant authority or ascending hegemonic force directing the institutional order of this school and the self-cultivation of its teachers (Harvey, 2002). Arguably, the new custom-built science facilities equipped with state-of-the-art ICT resources could be construed as an attempt by the institutional gatekeepers of this school, senior management, to direct the self-cultivation of the members of this community of practice toward the integration of ICT in their science pedagogy.

Fieldwork at Slyfields established that the science teachers, who were recognised as members of this department, were not working relationally within the dynamic of a community of practice; they were instead following individual institutional orders. Therefore, this interpretation of the framework returned to a version closely resembling the framework of TMSA proposed by Bhaskar (1998). Conspicuous by its absence is the social fabric of the community of practice, the ‘material nexus . . . in which
personal identities, social structures and reproductive mediations are materially and practically fabricated’ (Harvey, 2002, p. 183) through relational agency.

This scenario proposed a challenge for the two newly qualified teachers, Patrick and Andrea, who were denied the opportunity to work relationally within a community of practice of science teachers. Rather than furthering their personal agency and pedagogic practice through the community, they constantly had to rely on their experiences to solve domain issues and practicalities, such as knowing how to cover the mandated
curriculum or managing student behaviour. For these two emerging teachers, the development of their biography in the context of the domain was definitely constrained.

The lack of social fabric in this science department led to a varied level of ICT integration within the teaching of science at Slyfields. While some science teachers, like Andrea, were actively making use of it, others were not. Estelle, the coordinator of the science department, admitted that she had no immediate plan to develop a cohesive or consistent transformation of practice in relation to ICT. Her main priority was to develop a sense of relational agency in this department through a redevelopment of domain resources, and this did not include ICT. The right-hand triad on this version of the framework (Figure 21 therefore lacks a red broken line, indicating neither a reproduction nor transformation of practice linked to the integration of ICT.

7.2.3 Curriculum innovation and agency working in tandem
Chapter 6 presented the case of Redlands, a school that claimed to be at the leading edge of technology innovation in teaching and learning, and yet out of the three schools studied was the one that was most underresourced in terms of access to ICTs. At Redlands, I encountered a community of practice in the science department that was working successfully within the institutional order of the school to pursue the dominant ICT curriculum policy through self-cultivation. The department was coordinated by Jenny, who had been given both moral authority by the school and agency by her colleagues in the science department to lead the initiative to integrate ICT within the practices of this community. At the time of this fieldwork, Jenny had just begun to work in tandem with Natalie, her successor as subject coordinator, who was equally supported in her endeavours to further the pursuit of the integration of ICTs.
Figure 22. Template emerging from School 3, Redlands, which illustrates little importance being placed on historically accessible practice.

The major emphasis in this community, as illustrated in Figure 22, is the replacement of the historically accessible practice by what I have termed the sponsored transformation of practice. This sponsored transformation is derived from two actions: first, from the relative freedom these two leaders have been given by the institutional gatekeeper, Tom, the vice principal responsible for driving this curriculum policy; and second, from the cooperation and trust of their community, the science teachers entering into this process of self-cultivation with them. I suggest that at Redlands, the community that is the science department operates to engage in self-improvement through the
collaborative construction of a new constitutive order around the material use of ICT in science teaching in their school.

7.3 Why This Study is Important

As I stated in Section 4.5.3, teaching is not a simple process of following an institutional rule, such as to integrate ICT in your teaching. There are no general rules in teaching that apply specifically and prospectively in a particular context—it is the process of constructing a collaborative constitutive order around new practices that is closer to what teachers describe as their teaching. In secondary schools, teachers describe their practice in terms of the subject they teach and the department to which they belong. I would argue that it is therefore time to reposition the school subject department as the primary site of learning in the secondary school (Siskin, 1994) and to recognise the significance of the social fabric, the community (Wenger et al., 2002), which provides the relational agency required to support that learning (Billett, 2008; Edwards, 2010).

This study presents an attempt to construct a conceptual framework ‘to describe and analyse the challenges’ (Shulman & Shulman, 2004, p. 257) that have and still face science teachers maintaining and transforming science teaching while integrating new information technologies in three science departments. The science department is seen as the “material nexus” in which the teachers’ transformative powers of human agency are socialized and channelled. In particular the social realist framework presented conceives science teaching being reproduced and transformed at the intersection of duties and responsibilities in the everyday discursive and non-discursive practice in the science department. This conception, illustrated in the case studies of the type presented here, allows us to upscale understanding of the variety of ways teachers respond in the process of identity formation and ‘illustrates the ongoing interaction
among individual teacher learning, institutional learning and the policy environment critical to the success of theory intensive reform in settings’ (Shulman & Shulman, 2004, p. 257) which vary with the subject department settings in which they teach.

What is important about this study are the possibilities afforded by the framework for curriculum innovation and teacher agency, after Harvey (2002), when used as an operational tool to ‘fabricate’ a collaborative approach to teachers’ learning within secondary school subject departments. The framework, when used in conjunction with the three templates generated in this study, offer those responsible for managing change in the secondary school objects of comparison (Shotter, 2013) with which to begin collaborative discourse. It is anticipated that through this discourse, teachers will identify the problems and prospects existent in their subject department that are likely to shape their professional learning associated with the introduction of a major policy innovation.

7.4 And Finally

Throughout this thesis, I have interwoven quotations and metaphoric references from Lewis Carroll’s *Alice’s Adventures in Wonderland* (1865) and *Through the Looking-Glass and What Alice Found There* (1871). The reason for this is that I have often felt that my journey as a teacher–researcher and teacher–educator in the realms of educational research has been analogous to Alice’s journey. In pursuing this research, I have encountered duchesses, hatters, and Cheshire cats, and entered into illogical and often vexing worlds. While I anticipate that these quotations and analogies will offer the reader some entertainment, I hope that more importantly, they will illustrate my personal journey.
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Appendix A: Ethics Approval

Appendix A1: Ethics Approval From the University of Melbourne

27 February 2003

Dear Christina and Melanie

The Department Human Ethics Advisory Group (DHEAG) of the Department of Science and Mathematics Education has considered your application to conduct research involving human participants, as identified below.

DHEAG Application No.: 03/01
Researchers: Christina Hart and Melanie Nash
Project title: Integrating Information Communication Technology into the Science Key Learning Area: How successful has this initiative been and what effects has it had on teachers’ pedagogy?

We are pleased to inform you that approval has been granted by the DHEAG for your research project to be undertaken as indicated in the proposal. We note that approval is now required from the Department of Education and Training, and so research may proceed once this approval has been given. Please supply the DHEAG with evidence of this approval once it has been received.

Best wishes with your research

Dr Helen Chick
(Chair of the Departmental Human Ethics Advisory Group of the Department of Science and Mathematics Education)
Appendix A2: Ethics Approval From the Department of Education and Training

Department of Education & Training
Office of School Education

SOS 002352

12 May 2003

Ms Melanie Nash
DSME
Level 8, Doug McDonnell Bld
University of Melbourne
VICTORIA 3010

Dear Ms Nash

Thank you for your application of 7 May 2003 in which you request permission to conduct a research study in Victorian government schools titled: *Integrating Information Communication Technology into the Science Key Learning Area: How successful has the initiative been and what effect has it on teachers’ pedagogy*.

I am pleased to advise that on the basis of the information you have provided your research proposal is approved in principal, subject to the conditions detailed below.

1. You obtain approval for the research to be conducted in each school directly from the principal. Details of your research, copies of this letter of approval and the letter of approval from the relevant ethics committee are to be provided to the principal. The final decision as to whether or not your research can proceed in a school rests with the principal.

2. No student is to participate in this research study unless they are willing to do so and parental permission is received. Sufficient information must be provided to enable parents to make an informed decision and their consent must be obtained in writing.

3. As a matter of courtesy, you should advise the relevant Regional Director of the schools you intend to approach. An outline of your research and a copy of this letter should be provided to the Regional Director.
4. Any extensions or variations to the research proposal, additional research involving use of the data collected, or publication of the data beyond that normally associated with academic studies will require a further research approval submission.

5. At the conclusion of your study, a copy or summary of the research findings should be forwarded to me at the above address.

I wish you well with your research study. Should you have further enquiries on this matter, please contact Louise Dressing, Senior Policy Officer, Schools, Communities and Networks, on 9637 2349.

Yours sincerely

Judy Curson
Manager
Schools, Communities & Networks

encl.
Appendix B: Plain Language Statement

Appendix B1: Plain Language Statement (Principal)

Re Research Project: Integrating Information and Communication Technology into the Science Key Learning Area: how successful has this initiative been and what effects has it had on teachers’ pedagogy?

Dear (Principal),

I am a DEd student in the Department of Science and Mathematics Education at the University of Melbourne. I am currently conducting a research project for my thesis titled: ‘Integrating Information and Communication Technology into the Science Key Learning Area: how successful has this initiative been and what effects has it had on teachers’ pedagogy?’

I am writing to invite your school to participate in this project.

The main intention of the study is to investigate how teachers are interpreting the DEET recommendation relating to integrating Information Communication Technology (ICT), into their science lessons. The research procedure will involve:

1. An initial in-depth interview with 3-4 science teachers, to ascertain their views’ on:  
   - science pedagogy;  
   - ICT use in science;  
   - the professional development they have experienced in relation to the use of ICT;  
   - the educational culture that exists within the school.

The interviews are expected to last approximately 50 mins.

2. Observations of between 2 and 4 science classes taught by each participating teacher, in order to experience, first hand, the way they integrate ICT in their classroom teaching. These observations will be recorded using field notes.

3. Debriefing interviews with teachers, lasting approximately 30 mins after the final class observed.

4. A review of faculty schemes of work and school and department policy documents.

The interviews and observations will be recorded on audio-tape, and subsequently transcribed in full or in part. Care will be taken to ensure that classes are not disrupted in any way, and to minimise the overall demands on teachers’ time.

It is anticipated that the findings will inform the design of a program of professional development, specifically for science teachers, to promote the use of ICT in lessons.

Department of Science and Mathematics Education  
Doug McDonell Science Education Building  
The University of Melbourne Victoria 3010 Australia  
Telephone: +61 3 8344 8443/8419 Fax: +61 3 8344 8739
The data from all case studies collected as part of the research project will be used as the basis for my thesis and research articles. In both the thesis and articles teachers will be referred to anonymously, for example through the use of pseudonyms. However due to the small number of science teachers that will be involved in this project, (probably 10-12), anonymity cannot be guaranteed.

If you consent to your school participating in the research project, you may withdraw your consent at any time. You may also request that any unprocessed data collected from your school may be destroyed. Data will be kept in a secure location at the University of Melbourne for a minimum period of five years. The data will be destroyed after five years, or at the final conclusion of the project, whichever is the later.

If you have any further queries, please feel free to contact either myself on 8344 3749, or my supervisor Dr Christina Hart on 8344 8561. If, during the conduct of the research project, you have any concerns which we are not able to address to your satisfaction, you may contact the Executive Officer, Human Research Ethics, The University of Melbourne. The phone number for the Ethics Office is 8344 7507, and the Fax number is 9347 6799.

Yours sincerely,

Melanie Nash
Appendix B2: Plain Language Statement (Science Teacher)

Re Research Project: Integrating Information and Communication Technology into the Science Key Learning Area: how successful has this initiative been and what effects has it had on teachers’ pedagogy?

Dear (Science teacher),

I am a DEd student in the Department of Science and Mathematics Education at the University of Melbourne. I am currently conducting a research project for my thesis titled: ‘Integrating Information and Communication Technology into the Science Key Learning Area: how successful has this initiative been and what effects has it had on teachers’ pedagogy?’

I am writing to invite you to assist me by participating in this project.

The main intention of the study is to investigate how teachers are interpreting the DEET recommendation relating to integrating Information Communication Technology (ICT), into their science lessons. The research procedure will involve:

1. An initial indepth interview with you, to ascertain your view on:
   - science pedagogy;
   - ICT use in science;
   - the professional development you have experienced in relation to the use of ICT;
   - the educational culture that exists within the school.

The interviews are expected to last approximately 50 mins.

2. Observations of you teaching between 2 and 4 science classes, in order to experience, first hand, the way you integrate ICT in your classroom teaching. These observations will be recorded using field notes.

3. Debriefing interviews with you, lasting approximately 30 mins after the final class observed.

4. A review of faculty schemes of work and school and department policy documents.

The interviews and observations will be recorded on audio-tape, and subsequently transcribed in full or in part. Care will be taken to ensure that your classes are not disrupted in any way, and to minimise the overall demands on your time.

It is anticipated that the findings will inform the design of a program of professional development, specifically for science teachers, to promote the use of ICT in lessons.

Department of Science and Mathematics Education
Doug McDonell Science Education Building
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The data from all case studies collected as part of the research project will be used as the basis for my thesis and research articles. In both the thesis and articles teachers will be referred to anonymously, for example through the use of pseudonyms. However due to the small number of science teachers that will be involved in this project, (probably 10-12), anonymity cannot be guaranteed.

If you consent to participate in the research project, you may withdraw your consent at any time. You may also request that any unprocessed data collected from you may be destroyed. Data will be kept in a secure location at the University of Melbourne for a minimum period of five years. The data will be destroyed after five years, or at the final conclusion of the project, whichever is the later.

If you have any further queries, please feel free to contact either myself on 8344 3749, or my supervisor Dr Christina Hart on 8344 8561. If, during the conduct of the research project, you have any concerns which we are not able to address to your satisfaction, you may contact the Executive Officer, Human Research Ethics, The University of Melbourne. The phone number for the Ethics Office is 83447507, and the Fax number is 9347 6739.

Yours sincerely,

[Signature]

Melanie Nash
Appendix B3

Project Title: Integrating Information and Communication Technology into the Science Key Learning Area: how successful has this initiative been and what effects has it had on teachers’ pedagogy?

Chief Investigator: Dr Christina Hart

Researcher: Ms Melanie Nash

Consent from collaborating teacher

I, ......................................................, hereby agree to participate in this project, which has been explained in the attached letter.

I understand that:

1. Data is to be collected for the purposes of research.

2. Data will include interviews or classroom activities recorded on audio-tape, or observations made during classes.

3. I am free to withdraw from the project at any time, and may withdraw any unprocessed data previously supplied.

4. Where data is used in research publications, anonymity of participating teachers will be protected through the use of pseudonyms. However, due to the small number of participating teachers, complete anonymity cannot be guaranteed.

5. Confidentiality of any information will be safeguarded, subject to any legal requirements.

6. Data will be kept in a secure location at the University of Melbourne for a minimum period of five years. The data will be destroyed after five years, or at the final conclusion of the project, whichever is the later.

Signature: ............................................... Date: ...........................................

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Appendix C: Interview Questions

Appendix C1: Initial Interview With Teachers

Re: Research Project: Integrating Information and Communication Technology into the Science Key Learning Area: how successful has this initiative been and what effects has it had on teachers’ pedagogy?

Schedule A: Initial interview with Teachers.

These interviews will be semi structured. The questions below indicate the nature of the matters to be addressed, but the questions will not necessarily be followed strictly, and other relevant matters that the interviewees raise may be pursued.

1. How long have you been teaching science?
2. What are your major areas of expertise? (Biology, chemistry, physics, general science, CSF, VCE)
3. Could you describe for me a typical science lesson.
4. How would you describe your approach to science teaching?
5. How often might a class do practical work /experiments?
6. Do you use information communication technology, (ICT) in your administrative work?
7. What computer applications might you use in your administrative work?
8. How often would you say that you use ICT in your administrative work?
9. Do you use information communication technology, (ICT) in your science lessons?
10. What computer applications might you use in your teaching?
11. How often would you say that you use ICT in your science teaching?
12. Do you organise science lessons differently when using ICT?
13. Do you think using ICT in the class has any effect on your teaching role?
14. How do you assess work when students have used ICT in science lessons or for homework?
15. Do you think that the use of ICT has any impact on particular groups in your classes?
16. Have you had any professional development in the use of ICT for science?
17. What kind of support exists within your department/school for teachers to learn new ICT skills?
Appendix C2: Debriefing Interview With Teachers After Observing Classes

Schedule B: Debriefing interview with Teachers after observing classes.

These interviews will be loosely structured. The questions below indicate the nature of the matters to be addressed, but the questions will not necessarily be followed strictly, and other relevant matters that the interviewees raise may be pursued.

1. What did you want the students to achieve in the lesson?
2. What science skills or objectives were covered in this lesson?
3. How did you plan to meet the lessons objectives by using ICT?
4. Can you comment on how you organised this activity?
5. Did the use of ICT create or use more time for you or the pupils? How was this time used?
6. Can you comment on how you maintained the science focus of the lesson?
7. Do you think that using ICT allowed the pupils to develop higher order skills? (for example were students focusing on analysis of data rather than manipulation?)
8. Did you need to teach students ICT skills for this lesson? How did you prepare for this and did you know you would need to do this?
9. Did the use of ICT help or hinder specific groups of students? (support/extension)
10. How did you monitor the students’ achievement in this lesson?
11. Could you comment on whether the way you monitor student achievement in lessons which involve the use of ICT are any different from those which do not involve ICT?
12. What were your criteria for success in this lesson?
13. Would you like to make any further comments on the lesson?
Appendix D: Sample of Audio Transcription

Excerpt from Tape 1: Interview with Sally, Head of Science at St Clair’s

I indicate the interviewer’s comments, S indicates Sally’s comments

1. I: So really, first I wanted to be nosey and ask you how long have you been teaching (laughter)
2. S: Twenty-nine years and three terms... no, no, twenty-nine years and one term, that’s problematic depending on whether, you work on three terms or four terms but yes (laughter) it’s far too long!
3. I: (Laughter) so you’ve seen a lot of changes over the times
4. S: I have and haven’t really. I mean I’ve seen a lot of changes in technology but the basics of teaching science, the particle model, atoms don’t change, and plants still photosynthesis, ah. Gravity is gravity, and really. Apart from the add-ons like genetic engineering and where biotechnology and where those sorts of things have taken us, really when your looking at in particular years seven to ten, which is what I’m most interested in, that what um, you know, it doesn’t alter.
5. I: So do you, do you think…. change when something like the VCE came in and the curriculum standards framework, and things like that, I mean, did they affect you greatly? I mean I know, because it’s a private school.
6. S: It didn’t really, um, we do we do actually account all the CSF outcomes in our course. Most of the geology is done in geography. So you’ll find if you go through the geography outcomes that they have, their disciplines, you find the CSF earth science or whatever they call it these days….
7. I: ....
8. S: It’s in there
9. I: Right
10. S: Um, the one area that we fall down on is astronomy but I think that’s something that happened all over the place. I actually think, cause I started teaching at [another school], and that was back in the days when JSSP the head of our department had written a number of JSSP units, then we....
11. I: What’s JSSP?
12. S: Junior Secondary Science Project
13. I: Oh right, ok
14. S: That was a fantastic, you know, and it had sets of cards for activities and it was all very well designed to go through and was sound and materials of the universe and substances….. all sorts of fabulous stuff. Then they had ASEP which is the Australian Science Education Project. We tried all of that stuff, so we’d always, I’d always been in a department, which is sort of out there
15. I: Sort of at the cutting edge
16. S: At the cutting edge and very much aware of having a very balanced curriculum, um, I went from there to [another school] and we did the same thing there. So really in all the time that I’ve been teaching the programs that I have taught have covered everything. Basically to make science for the illiterate, I mean you’re going to have kids that go out in year ten, you know, they’ve got to know about certain things around them whether they go on to be ??? whatever
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Nash, Melanie J.

Title:
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