Communities of Practice: the privileged locus for knowledge acquisition and innovation in science-based SMEs

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DECLARATION OF ORIGINAL AUTHORSHIP

I hereby declare that this thesis is my own work and effort and that it has not been submitted anywhere for any award. Where other sources of information have been used, they have been acknowledged.

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ABSTRACT

This thesis contends that communities of practice (CoPs) are an effective instrument for supporting collaborative activities in science-based small and medium-sized enterprises (SMEs) that often have no formal strategy for knowledge acquisition and innovation. A review of the existing body of knowledge has indicated that this matter has not been the subject of thorough, in-depth research; and that this issue is important, given the relatively high level of efficacy that has been afforded to the role of CoPs in the innovation processes of large organizations. Indeed, the original communities of practice model had little to say about innovation per se; however, more recent theorizations have shown that CoPs can contribute to organizational innovation. This research makes a number of contributions to our understanding of CoPs as an enabler of knowledge acquisition and innovation: (i) theoretical: recontextualizing CoPs and demonstrating their applicability in science-based SMEs; (ii) methodological: extending the use of thematic template analysis; and (iii) applied: through the development of a contextualized framework for constructing CoPs in science-based SMEs.

An exploratory case study of science-based SMEs was conducted using thematic template analysis. The study employed critical case sampling, a technique that focuses on selecting cases on the basis that they make a point dramatically or because, as in this instance, they are important in relation to the research questions In depth interviews were conducted with 25 individuals employed in technical (i.e. scientists and engineers) and commercial roles (i.e. operations, finance and purchasing). Although there was no evidence of managed CoPs, a range of emergent/informal and cultivated CoPs were leveraged for a variety of purposes, including facilitating knowledge acquisition, enhancing absorptive capacity, and improving the firm's ability to generate innovative solutions. Apprentice-based CoPs emerged that supported individual learning, and both intra and inter-organizational CoPs emerged to support a range of radical and incremental innovation activities. Social capital was leveraged in CoPs, generating trust and reciprocity between SMEs and customer organizations, thus enhancing knowledge-sharing and innovative potential. Finally, this research confirms that CoPs are the privileged locus for knowledge acquisition and innovation in science-based SMEs.

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Table of Contents

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: INTRODUCTION

1 .1 INTRODUCTION

This chapter provides an overview of the study, beginning with the contributions of this research and followed by an outline of the research questions. The rest of the chapter then situates the topic within the pertinent literatures, relating these to the original contribution to knowledge that is addressed by the empirical research. Following this section, the research framework and its boundaries are described. Finally, there is an outline of the rest of the study's structure, together with a summary of each of the remaining chapters.

1.2 CONTRIBUTIONS OF THIS RESEARCH

Whilst innovation arises out of interaction between individuals and groups, the transition to collaborative forms of innovation is demanding for science-based[1] small and medium sized enterprises (SMEs). This thesis contends that communities of practice (CoPs) are an effective instrument for supporting collaborative activities in science-based SMEs that often have no formal strategy for knowledge acquisition and innovation. The purpose of this study is, therefore, to gain a deeper understanding of how SMEs construct CoPs to acquire new knowledge and generate new innovations. The study also considers whether CoPs help them to develop more focused innovation processes. This research makes a contribution to our understanding of CoPs as an enabler of knowledge acquisition and innovation in science-based SMEs. A review of the existing body of knowledge has indicated that this matter has not been the subject of thorough, in-depth research; and that this issue is important, given the relatively high level of efficacy that has been afforded to the role of CoPs in the innovation processes of large organizations.

The study was motivated by Teesside University's engagement with science-based SMEs through a European Regional Development Fund (ERDF) project, the Science to Business Hub (S2B Hub), which ran from February 2009 to October 2011. The project aimed to foster collaborative approaches to innovation in science-based SMEs and highlighted that science-based SMEs often have no formal collaboration

[1] 'Science-based' organizations attempt 'not only to use existing science but also to advance scientific knowledge and capture the value of the knowledge it creates' (Pisano, 2006, p.2).

strategy for knowledge acquisition and innovation. The S2B Hub, in collaboration with One Northeast, the (then) Regional Development Agency, sponsored the first year of this PhD, whilst Teesside University sponsored years two and three. As a PhD student located within the S2B Hub project I came into contact with a range of individuals working in science-based SMEs. Through my conversations with, and observation of, these visitors it became clear early in my studies that science-based SMEs lack formal strategies for knowledge acquisition and innovation. This study makes a number of theoretical, methodological and applied contributions to knowledge outlined below.

1.2.1 Theoretical contribution

This research study makes a theoretical contribution to the literature on CoPs by re-contextualizing CoPs in the setting of science-based business. By focusing on innovation, this study demonstrates that the construction of CoPs in science-based SMEs is often inhibited by a lack of shared repertoire, especially for those firms considered to be 'knowledge leaders' in their scientific field. Furthermore, the study found that individuals who displayed high levels of social presence were able to overcome lack of shared repertoire and were better equipped to build stronger, longer-lasting, trust-based relationships and, in addition, provides in-depth insight into claims that CoPs can be managed and aligned with organizational goals. The literature illustrates that recent conceptualizations of CoPs have resulted in much misapplication of the term, which has resulted in the 'CoPs' label being applied to a wide variety of organizational groups that could more accurately be described as formal teams or in similar terms. Although the empirical data revealed no evidence of managed CoPs, both emergent and cultivated CoPs were identified in science-based SMEs. This study, therefore, demonstrates the applicability of CoPs in a new situation, i.e. in the context of science-based SMEs, demonstrating how knowledge acquisition and innovation occur through participation in CoPs, thus making a significant contribution to our understanding of how CoPs are constructed in science-based SMEs.

1.2.2 Methodological contribution

This study makes a methodological contribution by extending the use of thematic template analysis, an approach that incorporates hierarchical coding to initially

identify some broad *a priori* themes before then encompassing successively narrower themes generated through iterative analysis of the data. Usually, the research starts with the assumption that certain aspects of the phenomena under investigation should be focused on, or that the importance of certain issues in relation to the research questions are so well-established that one can safely expect them to arise in the data. Identification of these rather deductive *a priori* codes is necessary in order to achieve a more interpretive level of understanding that comes from the iterative process of generating successive themes from the coding process. In an extension of this method, I developed a 'deductive-inductive' approach to coding the data. I incorporated *a priori* coding of the data *across* the hierarchy of the three levels of codes in my template (see Table 14) rather than just using *a priori* coding at the first level as King (2004) suggests. For example, the Level 1 themes (Communities of practice, knowledge acquisition and innovation) were derived from the research questions and overall aim, but in addition to this I also applied *a priori* themes at Level 2 (Building social capital) and at Level 3 (Community, Domain and Practice).

1.2.3 Applied contribution

This study makes an applied contribution extending our understanding of how CoPs can be constructed to support innovation within and between science-based SMEs. The contextualized framework (see Figure 15) developed from the findings shows how science-based SMEs can promote the cultivation of CoPs in a number of ways. The framework demonstrates how intra-organizational CoPs can be promoted by SMEs by first identifying the presence of any existing and potential CoPs and then encouraging their construction by allocating time and resource to their cultivation. In addition, inter-organizational CoPs can be promoted by SMEs by encouraging employees to mobilize their personal networks and by firms taking part in, as well as organizing, networking events. SMEs should also encourage individuals that display high levels of social presence to act as brokers and boundary spanners, drawing external knowledge and expertise into their organization, thus enhancing their firm's absorptive capacity. The framework shows that collectively, SMEs who pursue these activities can encourage the cultivation of CoPs, thus building trust and reciprocity and leading to enhanced social capital. The benefit from participating in intra-organizational CoPs is that it increases firms' absorptive capacity, whereas

participation in inter-organizational CoPs stimulates open innovation (Chesbrough, 2003), both of which help SMEs build new networks and ensure better knowledge transfer leading to more focused innovation in science-based SMEs.

1.3 RESEARCH QUESTIONS

The purpose of this study is to gain a deeper understanding of how science-based SMEs engage with Communities of Practice (CoPs) to acquire new knowledge and what innovations, if any, are generated through such engagement. The study also considers whether CoPs help them to develop more focused innovation processes. This research, therefore, addresses a number of research questions:

1. Are CoPs to be found in science-based SMEs?
2. If so, how and why are CoPs constructed in science-based SMEs?
3. How is knowledge acquired in science-based CoPs?
4. What innovation is generated from collaborative activities in CoPs?

This study explores knowledge acquisition and innovation through a qualitative, interpretive approach which is required for a number of reasons. Firstly, it is the most appropriate way to address my research questions. A qualitative approach is necessary in order to understand the deep meaning and nuances associated with the experiences of the interviewees. Secondly, a qualitative approach follows my own ontological position that knowledge is socially constructed. Thirdly, a qualitative approach provides a good 'fit' with the CoP theory and the view that learning is socially situated. These research questions guide us to the overall aim of the study which asks the question: 'to what extent are CoPs a 'privileged locus' for knowledge acquisition and innovation in science-based SMEs?' This question assumes a link between knowledge acquisition and innovation, using CoPs as a theoretical lens to explore the relationship between these interconnected elements and examine their impact in science-based SMEs.

1.3.1 Research framework

The study employs critical case sampling, a technique that focuses on selecting cases on the basis that they make a point dramatically or because, as in this instance, they are important in relation to the research questions (Patton, 2002). In depth interviews were conducted with 25 individuals employed in technical (i.e. scientists and

engineers) and commercial roles (i.e. operations, finance and purchasing). On gaining access to an organization I was usually directed to a 'gatekeeper', i.e. someone who decided who I could have access to, which restricted my choice of interviewees.

Interviews took place between April 2011 and November 2012 and lasted for between 40 and 80 minutes. Semi-structured interviews were used because they provide an open, yet structured framework allowing for focused, conversational two-way communication. The interviews were audio recorded with the permission of the interviewee, and subsequently transcribed verbatim. The names of the organizations and interviewees have been anonymized for confidentiality reasons. Template analysis (Crabtree and Miller, 1999; King, 2004) was used to thematically analyze the resultant qualitative data. This deploys hierarchical coding, beginning with broad *a priori* themes, moving to sequentially narrower, more defined themes as the analysis progresses.

This method was chosen because when combined with a social constructionist epistemology it is a useful method for exploring relationships and meanings as well as for capturing the different perspectives of interviewees. It is worth noting that there is some debate over whether the correct term to use is 'constructivism' or 'constructionism' when describing this epistemological viewpoint and Bryman and Bell (1991), for example, note that both terms are used interchangeably. However, for Papert and Harel (1991) the term constructivist, with the 'v', expresses the theory that knowledge is built by the learner, not supplied by the teacher. On the other hand, constructionist, with the 'n', expresses the further idea that this happens especially felicitously when the learner is engaged in the construction of something external, or at least sharable. It is useful to separate these two definitions, constructivism representing the view that meaning is constructed internally, through the mind, by reflecting on one's practice. Constructionism, on the other hand, represents the view that meaning is constructed through shared practices. I take an integrated view of these two approaches.

Nvivo qualitative data analysis software was used to code the data and create the final thematic template. Nvivo proved to be a useful tool for organizing and storing the data as well as providing a structure organized as a hierarchy. It also supported

the iterative process, allowing for codes to be added, or deleted, or changed more easily than a 'cut and glue' paper-based approach. It did not replace the iterative process of generating codes, but it did make the process easier to manage.

The analysis began with three broad themes: 'knowledge acquisition', 'innovation' and 'communities of practice', coding new themes as they emerged from the analysis. This flexible, iterative methodology facilitates a systematic, yet reflexive approach to data analysis (King, 2006). The final template reflects the themes which emerged during coding. Whilst this research makes no claims of 'representativeness' of the data sample in relation to the wider population of science-based firms, it does maintain that the literature review and new empirical material on CoPs and innovation in SMEs makes a contribution to our understanding of how CoPs are constructed and deployed in science-based SMEs. Having outlined the research framework, I will now discuss the rationale for the study.

1.3.2 Rationale

1.3.2.1 The CoP literature

Early CoP research focused on the way people learn and contributed to an important argument in learning theory: the notion that learning is socially situated, the product of the activity, context, and culture in which it is developed and used (Brown and Duguid, 1991; Hamilton, 2011). Learning is viewed as a process that involves becoming part of a community, and becoming an effective learner involves participation and collaboration within the community. Brown and Duguid (1991), in (re)assessing the relationship between work, learning and innovation, concluded that significant learning and innovation is generated and takes place within practice-based CoPs. Hsiao, Tsai and Lee (2006) support the view that the situated learning occurring in CoPs is important for innovation, noting that 'capability-based knowledge' (i.e. knowledge generated from practitioners' work activities) is acquired through the process of 'learning by doing', which CoPs support. Similarly, Sense and Clements (2006) refer to CoPs as 'situated learning opportunities' which contribute to learning and innovation. Also, Chen and Tseng (2011) posit that situated learning is essential for innovation, and CoP membership enables effective knowledge transfer by providing access to other local 'experts'. Anand, Gardner and Morris (2007) concur that CoPs support learning and knowledge-based innovation,

and note that the role of 'key actors' in embedding CoPs within organizations is often downplayed in the literature.

'Reimagining' CoPs as structures to support situated learning, might help solve problems for organizations' customers (Dougherty, 2001), which can be viewed as an example of incremental innovation. In a similar vein, Heiskanen, Johnson, Robinson, Vadovics and Saastamoinen (2010) posit that CoPs might support knowledge transfer in user-led innovation. Brown and Duguid (1991) and Wenger (1998) argue that CoPs contribute to innovation through their flexible structures, which are constantly adapting to changing circumstances and membership. Wenger's (1998) and Wenger and Snyder's (2000) later reformulation of CoPs raises the question of how they now differ from other forms of organizational network; the short answer is that they are informal, self selecting of both their members and leadership, and self-organizing.

It can be speculated that CoPs may potentially provide an introductory vehicle for SME knowledge management (KM) (Du Plessis, 2008), a means to boost technological learning, and the ability to commercially exploit new innovations (Autio, Kanninen, and Gustafsson, 2008). Research to date has focused on CoPs large firms (Brown and Duguid, 1991; Loyarte and Rivera, 2007; Probst and Borzillo, 2008; Swan, Scarbrough and Robertson, 2002; Wenger, McDermott and Snyder, 2002) and thus there is a limited amount of data relating to their construction in SMEs.

1.3.2.2 Science-based business

Science-based SMEs are distinct from other types of SMEs, and larger organizations, in a number of ways. They present 'unique challenges that require different kinds of organizational and institutional arrangements and different approaches to management' (Pisano, 2006b, p.4). Some science-based industries, including life sciences such as biotechnology, have distinctive characteristics that require industry-specific knowledge development (Stremersch and Van Dyck, 2009). According to Pisano (2010), the three major challenges faced by science-based businesses are risk, integration and learning and combining the first two challenges almost inevitably leads to the third. Science-based business is inherently more risky than other types of

business because such firms 'often face decades or more of highly risky and highly uncertain research before they even hope to earn a profit' (Pisano, 2010, p.467).

According to Pisano (2006a; 2006b; 2010) science-based businesses suffer from additional issues related to integrating diverse scientific and related disciplines, such as engineering. For science to advance, each of these disciplines needs to be able to pool its collective knowledge and leverage its collective wisdom to generate innovation and gain economic advantage (Kreiner and Schultz, 1990; Von Hippel, 1987). Much of the research linking CoPs with science-based innovation and knowledge acquisition has focused on their emergence, cultivation or management in large organizations (Macpherson, Antonacopoulou and Wilson, 2009; McDermott and Archibald, 2010; Probst and Borzillo, 2008). For these reasons, science-based SMEs were selected as the focus of this research. I will now outline the research boundaries of the study.

1.4 RESEARCH BOUNDARIES

The research was bounded in several ways. First, the empirical research was restricted to science-based SMEs located in the Northeast of England, primarily in the Teesside[2] area. Second, interviews were conducted principally with scientists and engineers, some of whom were managers. Third, the structure of the interviews and analysis of the subsequent data focused on those factors most related to the research aims. This research does not aim to produce findings that are applicable beyond the immediate boundaries of the study. However, this approach follows from the constructionist epistemology adopted in this study which is less concerned with issues related to generalizability and validity and more concerned with providing a rich picture of the experiences of the interviewees within their organizations.

1.5 STRUCTURE OF THE THESIS

The rest of this study is divided into five subsequent chapters (Figure 1) and a brief outline of each of these chapters is provided below.

[2] The local authority districts (LADs) Middlesbrough, Stockton, Hartlepool and Redcar & Cleveland.

Chapter 2: SMEs, science-based business and innovation

The purpose of this chapter is to contextualize the study, providing background on the three main themes of SMEs, science-based business and innovation. The chapter begins by discussing definitions of 'SMEs' and 'science-based business' before outlining the models of innovation relevant to the study. The chapter shows how the three main themes are bound together by the research questions and overall aim of this study.

Chapter 3: Literature review

This chapter begins with an outline of the systematic literature review methodology before going on to discuss the origins and evolution of CoP theory. The chapter then goes on to discuss CoP governance, highlighting the conflicting views regarding management and cultivation approaches to CoP construction in organizations. The chapter examines the literature on CoPs, in particular focusing on their changing role from a theory of learning in apprenticeships to their repositioning as an inter-organizational KM tool to support knowledge acquisition, social capital and innovation for organizations often located in regional clusters. The chapter reveals that prior research has focused on CoPs and innovation in large organizations, leaving the concept underdeveloped in the context of SMEs.

Chapter 4: Research methodology

This chapter begins by stating the research questions and overall aim of the study. This is followed by an outline of my personal research journey, explaining how I came to my thesis. The chapter then presents an outline of the philosophical framework adopted in the study, describing and justifying the choice of a qualitative interpretive approach. The research design is described in detail, as is the choice of a case study approach and how the participants were selected. It also describes how the data was collected and analyzed, drawing upon the transcripts of 25 semi-structured interviews with a range of individuals employed in technical roles and commercial roles in 7 'science-based' SMEs. It also outlines the ethical considerations, along with a number of methods adopted to demonstrate a reflexive approach throughout the design and execution of the research.

Chapter 5: Findings and analysis

This chapter begins by identifying the research participants and the data analysis process. The chapter then presents the key findings of the empirical data analysis, examining how CoPs are constructed in science-based SMEs, how knowledge is acquired within CoPs and what innovations result from the activity that occurs in CoPs. The findings of the data analysis are presented under the three main themes of the thematic template: Communities of practice, knowledge acquisition and innovation. Communities of practice explores the three types of CoPs identified in the SMEs – apprentice-based, intra and inter-organizational - and how they support the development of social capital. Knowledge acquisition explores individual learning, knowledge sharing and collaboration in CoPs. Innovation explores the interviewee's views of innovation as novelty and problem solving.

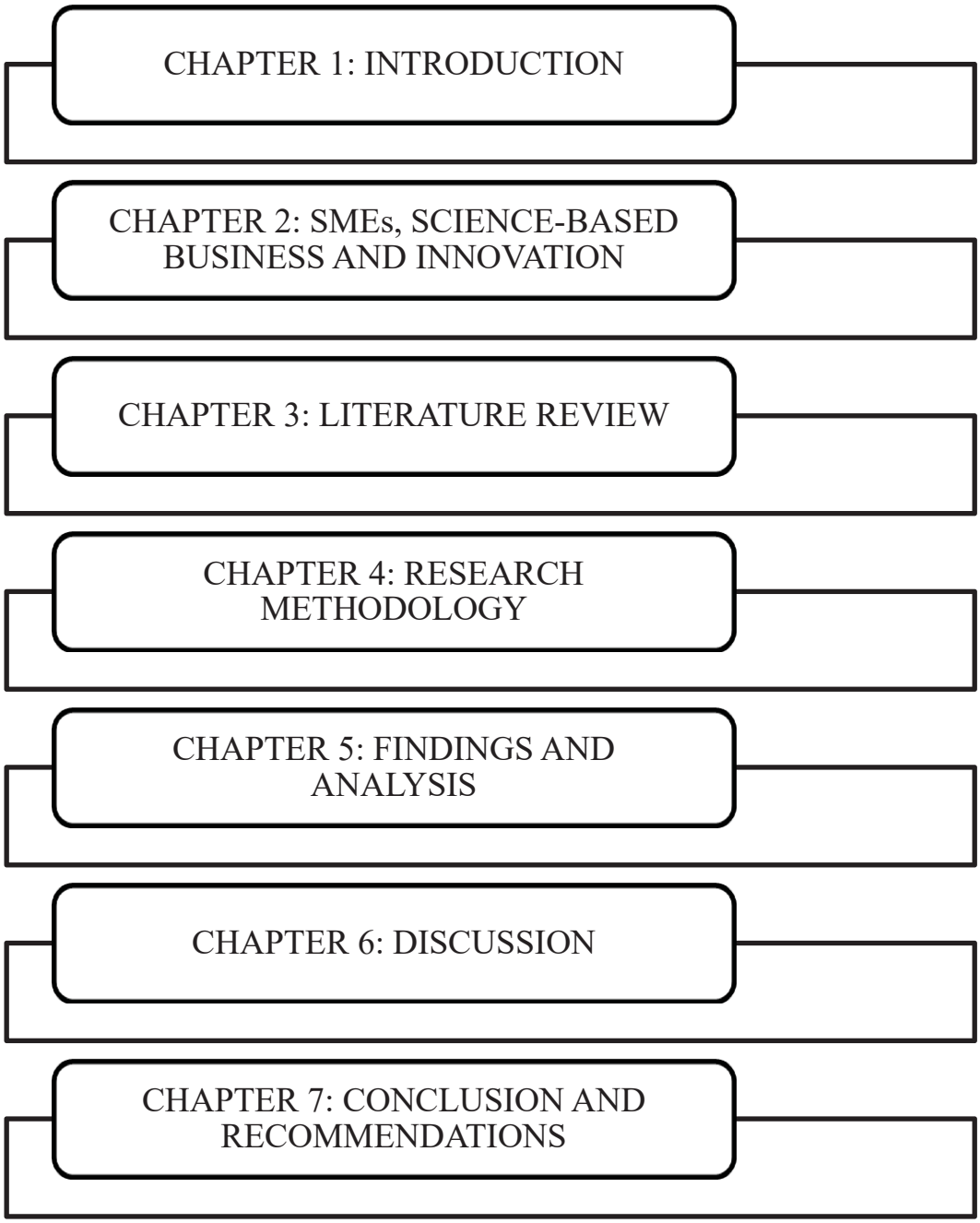
Chapter 6: Discussion

This chapter discusses the research findings and their significance in relation to the research questions and overall aim of the study. This relates specifically to how CoPs are constructed in science-based SMEs and what knowledge acquisition and innovation occurs through this process. In this chapter I present my contextualized framework for the construction of CoPs in science-based SMEs. This chapter confirms the status of cops as a privileged locus for knowledge acquisition and innovation in science-based SMEs.

Chapter 7: Conclusion and recommendations

This chapter begins with a summary of the previous chapters of the study. It then goes on to present the three contributions of the study – theoretical, methodological and applied. This is followed by a summary of the limitations of the study and recommendations for future research.

Figure 1 Thesis structure



CHAPTER 2: SMES, SCIENCE-BASED BUSINESS AND INNOVATION

2.1 INTRODUCTION

This chapter begins by discussing the nature and importance of SMEs before placing them in the context of 'science-based' business. The chapter then goes on to define innovation, examining relevant models of, and approaches to, innovation. The chapter concludes by outlining the motivation for choosing to study this phenomenon and what it potentially adds to our understanding of innovation in science-based SMEs.

2.2 SMALL AND MEDIUM-SIZED ENTERPRISES

Small and medium sized enterprises (SMEs) occupy an important place in wealth creation and the European Commission considers SMEs to play a significant role in the European economy. SMEs make up at least 95% of enterprises within the European Union (EU), while in the United Kingdom (UK) they account for 99% of all businesses (Carter and Jones-Evans, 2006). They are seen as an essential source of jobs, as well as fostering entrepreneurial spirit and innovation within the EU. The current European Commission definition of an SME is an enterprise with fewer than 250 employees and which has an annual turnover of less than 50 million Euros, or an annual balance sheet not exceeding 43 million Euros (European Commission, 2005).

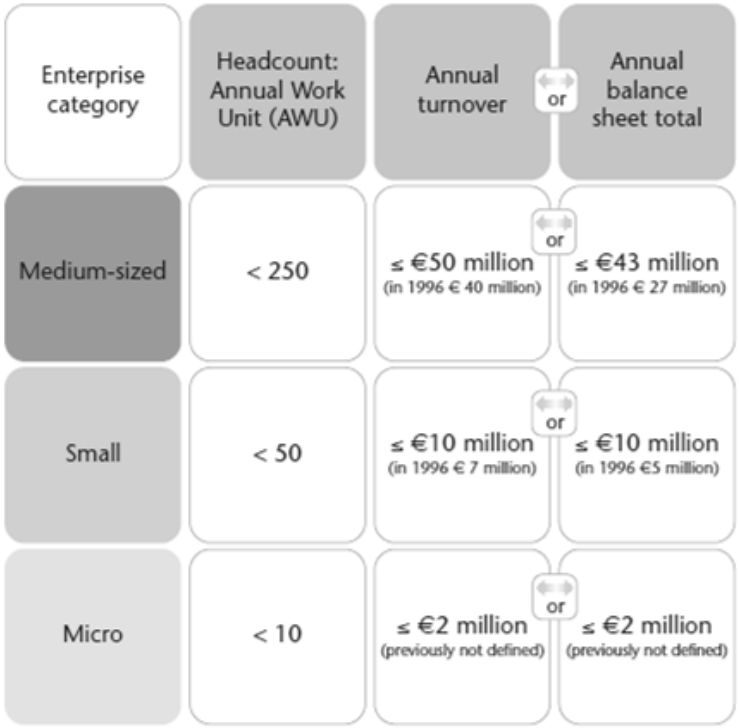
The three sub-categories of SMEs within this definition – micro, small and medium-sized firms – are based on a calculation combining head count of staff, annual turnover and balance sheet (Figure 2). Micro enterprises employ less than 10 people and have an annual turnover or balance sheet total of less than €2 million. Small enterprises employ less than 50 people and have an annual turnover or balance sheet of less than €10 million. Medium-sized enterprises employ less than 250 people and have an annual balance sheet total of less than €50 million and a balance sheet of €43 million. Part of the reason for these new categories, introduced by the Commission in 2005, was to promote innovation and improve access to R&D for innovative SMEs by encouraging their interaction with non-commercial organizations, such as universities and other research institutions, as the European Commission (EC) user guide and model declaration explains:

Specific provisions now apply to universities and non-profit research centres enabling them to have a financial stake in an SME. This cooperation will benefit both parties. It strengthens an enterprise by giving it a worthwhile financial partner and access to R&D. It also offers universities and research centres a route for the practical application of their innovative work.

(European Commission, 2005, p.10)

Figure 2 New thresholds for SMEs

(European Commission, 2005, p.16)



Collaboration between SMEs and 'non-profit research centres', such as universities, is considered to be an essential element in encouraging new innovation start ups and assisting the competitiveness and growth of existing SMEs. The next section provides a definition of 'science-based' business and outlines the unique challenges they present in the context of innovation.

2.3 SCIENCE-BASED BUSINESS

A science-based business has been defined as a business that 'attempts not only to use existing science but also to advance scientific knowledge and capture the value of the knowledge it creates' (Pisano, 2006a, p.2). This definition differentiates

science-based business from strict research and development activity and, in the context of this study, provides a suitable definition that encompasses the key elements of science, business and innovation that are central to this study. Pavitt's taxonomy (1984, p.354), although focused mainly on large firms, identifies four categories of industrial firms, including science-based businesses, involved in both incremental and radical innovation.

Supplier-Dominated firms are made up of mostly large traditional manufacturing firms, e.g. the textiles industry, agriculture and housing that are reliant on sources of innovation external to the firm. Scale-Intensive firms are mainly large firms producing basic commodities and consumer durables, e.g. the glass and steel industries. Sources of innovation may be both internal and external to the firm with a medium-level of appropriability. Specialized Suppliers are represented by smaller, more specialized firms producing technology to be sold into other firms, e.g. specialized machinery production and instrument manufacturers. There is a high level of appropriability due to the tacit nature of the knowledge. Lastly, science-based firms reliant on R&D from internal sources as well as university research, e.g. the electronics and chemical industries. Firms in this sector are involved in both incremental and radical innovation and generate new products or processes. They have a high degree of appropriability from intellectual property rights, secrecy, and tacit know-how. Appropriability refers to 'The different means an economic agent may use to profit from its inventions or innovations by temporarily enjoying some kind of monopolistic power over the knowledge it creates' (López, 2009, p.47).

However, some researchers suggest that the definition of science-based business has become broader, encompassing a wide range of organizations that might not have been considered as traditional science-based businesses such as consumer electronics, finance, and media, where technology and science often meet (Sato, 2008). This broadening definition implies a convergence of science and technology-based business that goes beyond the inclusion of firms directly involved in scientific R&D. Coriat, Orsi, and Weinstein (2003), for example, discuss the links between scientific knowledge and industrial technology, highlighting the diversity of science-based regimes engaged in innovation and the complexity of the relationship between the science and technology. Coriat et al. (2003) establish two sets of contrasting

characteristics that distinguish science-based innovation from engineering-based alternatives.

In the first, they identify the 'scale-intensive'' and 'specialized suppliers' sectors (Pavitt, 1984) and 'complex systems' and 'product engineering' regimes (Marsili, 2001) that display several innovation characteristics:

1. Innovation is mainly the result of *development* (as opposed to research) or *engineering* activities;
2. The innovation capacities of firms are based mainly on specific and largely tacit organizational capabilities, formed by *internal collective* learning processes;
3. One of the key challenges for firms is their capacity to combine various elements of technical knowledge and capabilities.

In the second (ibid, p.233), they identify science-based technological regimes, which, in contrast, have the following characteristics:

1. Innovation is significantly based on *research* and, since much of this takes place *outside firms*, the access to external knowledge produced by universities and public research institutions is a critical factor in innovation; innovation thus means *the commercial use of a type of knowledge that is often at the leading edge of state-of-the-art developments, this knowledge coming largely from noncorporate organizations*.
2. Technological opportunities are particularly rich and persistent: scientific advances create a large spectrum of potential new products (Marsili, 2001).
3. Product (and process) design is thus based on *the commercial exploitation of a cluster of scientific results* belonging to related but often distinct disciplines.

Although superficially, the needs of science-based businesses might appear to be little different from other types of business, they present 'unique challenges that required different kinds of organizational and institutional arrangements, and different approaches to management' (Pisano, 2006b, p.4). Some science-based industries, including life sciences such as biotechnology, have unique characteristics that require industry-specific knowledge development (Stremersch and Van Dyck,

2009). The three major challenges faced by science-based businesses are risk, integration and learning and combining the first two challenges almost inevitably leads to the third and Pisano (2010) frames these three central challenges of science-based businesses in terms of: (i) managing and rewarding long-term risk, (ii) integrating knowledge across technical disciplines, and (iii) learning.

Science-based business is inherently more risky than other types of business because such firms 'often face decades or more of highly risky and highly uncertain research before they even hope to earn a profit' (Pisano, 2010, p.467). Science-based firms can be differentiated from other types of knowledge-intensive firms. Pisano (2010) points out that, although innovation pioneers in other industries (such as electronics, e.g. Texas Instruments) did face significant technical challenges unlike science-based firms in biotechnology or nanotechnology, they were working from a reasonably well-developed scientific base. This base, therefore, allowed them to launch commercial products relatively quickly.

Science-based businesses suffer from additional issues related to integrating diverse scientific disciplines. For science to advance, each of these disciplines needs to be able to pool its collective knowledge and leverage its collective wisdom to economic advantage. Sharing experiences over a sustained time frame is, therefore, essential to the success of science-based businesses involved in innovation. In science-based business, the role of the 'star scientist' was initially viewed as the primary source of commercial success (Zucker and Darby, 1998) with the role of 'inventor' and 'entrepreneur' being inseparable (Braguinsky, Yuji, Sadao, and Kenta, 2010; Pisano, 2010; Zingales, 2000). In an essay discussing Chandler's work on knowledge management and innovation in large firms, Mowery (2010) suggests that knowledge management also plays a key role in creating intra-firm organizations for creating and managing knowledge and innovation, and for the acquisition of technologies from external sources.

Some writers speculate that, during early periods of growth, science-based organizations are reliant on the strength of the networks of personal relationships that entrepreneurs form with external partners, such as universities, research laboratories and other science-based firms (Andersen and Jack, 2002; Lee, Lee, and Pennings, 2001). Lechner and Dowling (2003) point to these as the 'basic building blocks' of

firms' knowledge, innovation and technology relationships which play an important part in their commercial success. Science-based innovations often take a long time to yield commercial products, for example in the pharmaceutical industry a typical R&D process lasts up to 13 years and, therefore, some firms have been seeking to adopt open innovation approaches to help them to strike a balance between their R&D activity and commercializing their innovations (Gassmann and Reepmeyer, 2005). Having defined 'science-based' business in the context of innovation, I will now consider the nature of innovation in greater depth.

2.4 INNOVATION

Innovation has had a variety of interpretations and definitions applied to it (Christensen, 1997; Drucker, 1985; Schumpeter, 1934) and is often seen as a key driver for economic development (Schumpeter, 1934). The current definition of innovation being used by the UK Department of Trade and Industry (DTI) echoes this view, stating that innovation is successfully exploiting new ideas (DTI, 2003). For others, innovation is seen as the work of thinking rather than the work of doing (Drucker, 1985). Drucker sees innovation as a specific tool by which entrepreneurs exploit change in order to create new business opportunities. Innovation does not simply mean being creative; creativity in itself implies the development of new ideas or inventions, but not necessarily the use of them in any meaningful way that brings about change (Bessant and Tidd, 2007).

In business terms innovation should, perhaps, be viewed as applying creativity and new ideas in order to bring about the changes that result in improvements in a service, product or process (Ovum, 2006). A definition of innovation suggested by Luecke and Katz (2003) considers that innovation is generally understood to be the successful introduction of a new thing or method that results in new products, processes, or services. This definition encompasses the three key elements of newness, originality and added value that contribute to innovation in the context of firms' efforts to gain competitive advantage. Van de Ven (1986, p.1), on the other hand, points to innovation as: 'the development and implementation of new ideas by people who, over time, engage in transactions with others in an institutional context'.

This definition provides a strong link to CoPs as a vehicle for sharing new ideas and, in the context of this research, is the one I have adopted as being the most appropriate. It is important to provide an understanding of innovation in the context of this study and a summary of the most relevant models of innovation are now presented.

2.4.1 Models of innovation

The theories of creative destruction (Schumpeter, 1934), disruptive innovation (Christensen, 1997), or discontinuous innovation (Tidd and Bessant, 2009) are closely aligned to notions of radical innovation and models that present innovation as 'new to the world' innovations that either improve on, or displace old products or processes in unexpected ways, create new markets and become the consumers preferred choice. On the other hand, incremental views of innovation view suggest that innovation is about the smaller incremental steps and improvements that are associated with collaborative models of innovation (Bessant and Tidd, 2007). Innovation is clearly a complex area (Tidd and Bessant, 2009) and simple linear innovation models do not explain the innovation process adequately (Van de Ven, Polley, Garud and Venkataraman, 1999). Much of the early literature makes a distinction between technology-push and market-pull models of innovation and is summed up by Martin (1994) in Figure 3 below.

Figure 3 Technology-push versus Market-pull

(Martin, 1994, p.44)

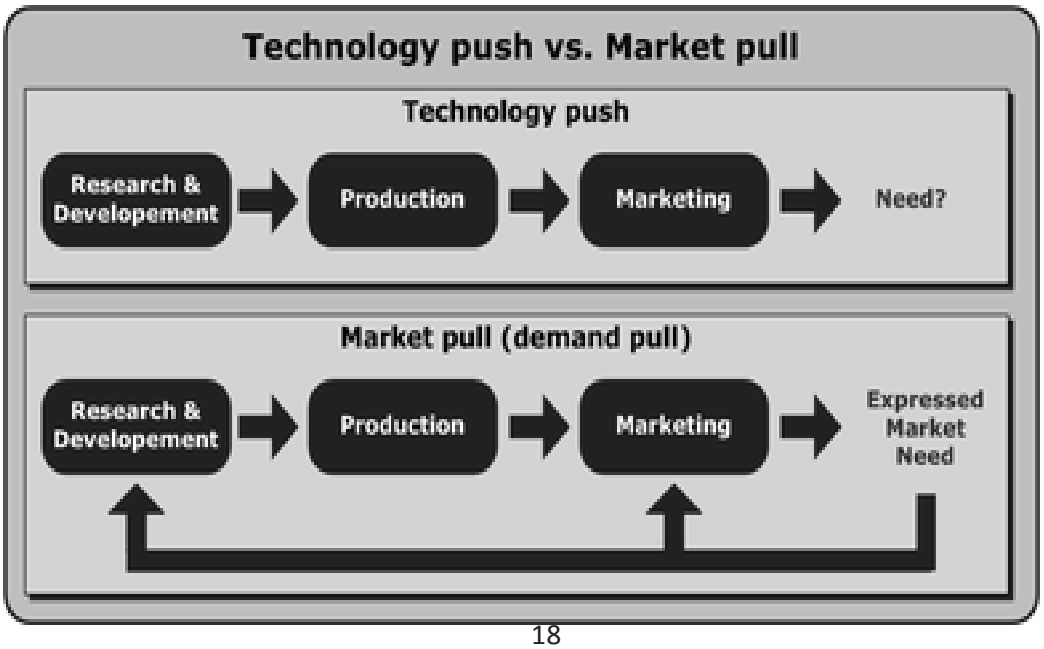


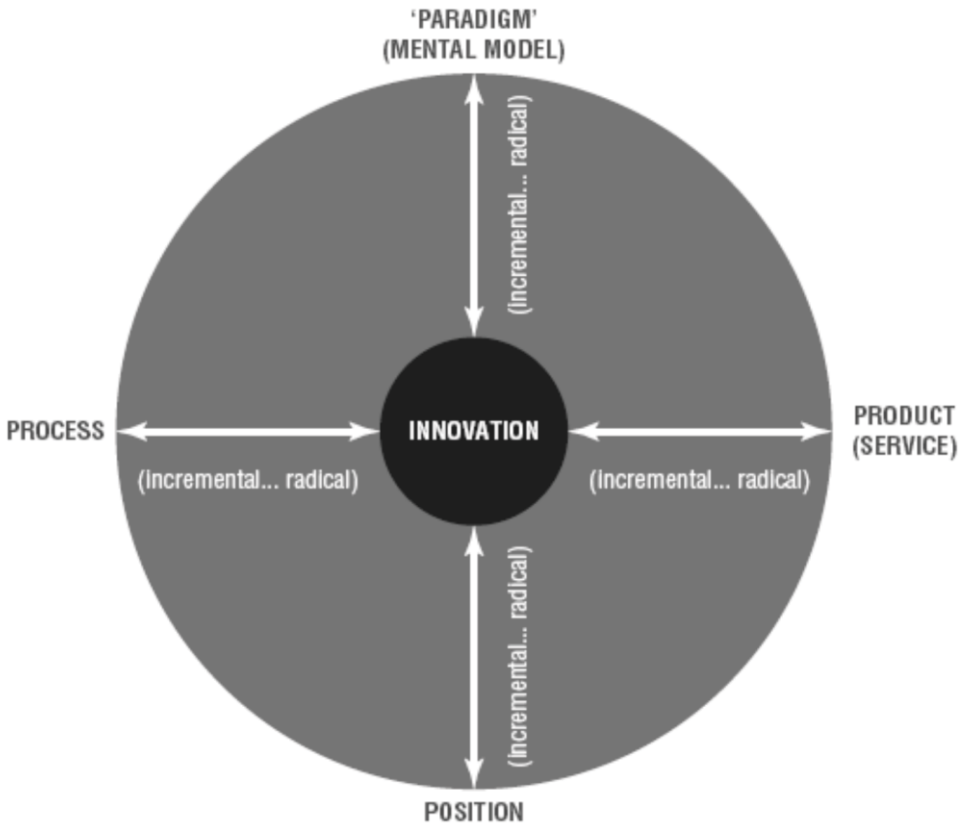
Figure 3 shows the technology-push hypothesis which posits that innovation is driven by internal research and development (R&D) activity without much thought about whether there is market demand for the innovation. In the technology push model a linear process is followed where research and development leads to new products which are then marketed in an attempt to generate market need. On the other hand, the market-pull hypothesis suggests that innovation is driven by express market need linked to research and development that focuses on new products with an identifiable market demand. Models of innovation are, therefore, closely linked to change and models such as Francis and Bessant's 4 P's of innovation (2005) aim to help organizations identify innovation opportunities in relation to change.

2.4.1.1 The 4 P's of Innovation Space

Francis and Bessant (2005) identify four dimensions of change that they have developed into the 4 P's of innovation space. The 4 P's provide a framework for mapping the innovation space (Figure 4) available to any organization.

Figure 4 The 4 P's of Innovation Space

(Francis and Bessant, 2005, in Tidd and Bessant, 2009, p.22)



The framework examines four potential types of innovation:

- Product innovation is where changes occur to the products or services that a business offers;
- Process innovation involves changes to the way in which products and services are delivered;
- Position innovation refers to changes in the context in which products or services are introduced;
- Paradigm innovation is where there is a change in the underlying mental models that frame what the business does and how it does it.

The area represented by the circle is the potential innovation space and this model can be used to map organizations' current innovation projects and identify where they might move in the future. It can also be used to investigate relatively unexplored areas which might offer new innovation opportunities. This framework can also be used to map an organization's current innovation space against other similar organizations and allows them to explore both incremental and radical innovation opportunities that might lead to improved competitive advantage (Tidd and Bessant, 2009). Rothwell and Gardiner (1985) distinguish between radical innovation and incremental innovation. Incremental innovation refers to those small-scale changes that take place on a regular basis.

Radical innovation, on the other hand, refers to the commercialization of major advances. Radical innovation, i.e. 'new to the world', whilst often considered more exciting, happens less often than incremental innovation (Tidd and Bessant, 2009). Most innovation is about incremental change, i.e. 'doing what we do better', by making regular on-going improvements to existing products and services (Bessant and Tidd, 2007, p.14). The distinction between radical and incremental innovations is not always clear and Hage (1980) argues that innovations vary along a continuum between incremental and radical. The variety of definitions, meanings and interpretations of innovation demonstrate its complexity and Rothwell (1992) provides an interesting appraisal of the development of innovation models since the 1960s.

2.4.1.2 Rothwell's 5 Generations of Innovation

In his historical review of five generations of innovation models, Rothwell (1992) suggests that there has been a move from these simple linear models of technology-push/market-pull models of innovation to more interactive models that emphasize integration and networking at both intra-firm and inter-firm level (Table 1).

Table 1 Rothwell's Five Generations of Innovation

(Rothwell, 1992)

Generation	Key features
First and second (1960's)	The linear models – need-pull and technology-push
Third (1970's)	Interaction between different elements and feedback loops between them – the coupling model
Fourth (1980's)	The parallel lines model, integration within the firm, upstream with key suppliers and downstream with demanding and active customers, emphasis on linkages and alliances
Fifth (1990's onwards)	Systems integration and extensive networking, flexible and customized response, continuous innovation

Unlike the earlier generations (first to third), the latter two generations (four and five) emphasize that innovation is not sequential, but cross-functional and often multi-actor. Therefore, the emphasis in these later models is on collaboration, external networking and speed to market for determining a firm's competitiveness, particularly in knowledge-intensive areas of innovation (Assimakopoulos, 2007). The Triple Helix innovation model can be seen as a further development of Rothwell's (1992) Five Generations of Innovation model. The Triple Helix innovation model was first posited by Etzkowitz and Leydesdorff (2000) and also promotes an integrated, networked approach to innovation that focuses on a collaborative approach to innovation between university, industry and government.

2.4.1.3 Triple Helix Innovation Model

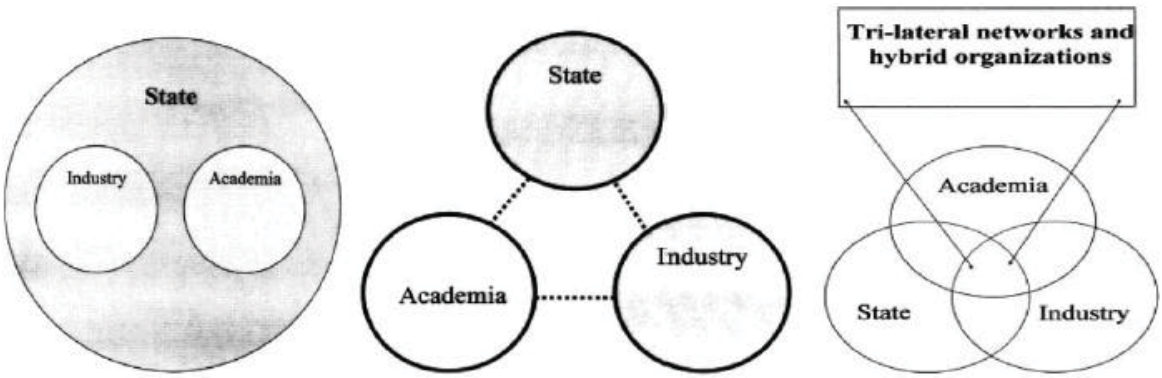
Innovation is increasingly based on the Triple Helix (Etzkowitz, 2003) model that has become increasingly relevant as a conceptual framework for supporting regional development (Etzkowitz and Ranga, 2010). The Triple Helix thesis is that a

university can play a superior role in an innovation process that is increasingly knowledge-based (Etzkowitz and Leydesdorff 2000). Integration between the three helices can generate new institutional formats and relationships where each helix can take on non-traditional roles or even adopt the role(s) of others (Etzkowitz, 2006).

This adoption of others' roles might be particularly relevant in view of the current lack of government intervention in the UK chemical industry. Etzkowitz and Leydesdorff (2000) posit three institutional arrangements that can represent Triple Helix configurations (Figure 5). In the statist model, the government controls academia and industry. In the laissez-faire model industry, academia and government are separate from each other, only interacting discreetly across strong boundaries. In the Triple Helix model, the interaction between the helices leads to tri-lateral networks and hybrid organizations, where each institutional sphere maintains its special features and unique identity, while also 'taking the role of the other'.

Figure 5 Triple Helix configurations

(Etzkowitz and Leydesdorff, 2000, p.4).



(1) A 'statist' model (2) A 'laissez-faire' model (3) The Triple Helix Model

The Triple Helix model has been recognized as a facilitator for the emergence of regional clusters (Frykfors and Jonsson, 2010; Lawton Smith and Bagchi-Sen, 2010) and as a basis for regional development with an emphasis on the integration of innovation through collaboration. Hayes (2011) suggests that research based knowledge-stewarding communities within industry/research/government innovation collaborations have important implications for innovation management practice, where issues of trust can often have a negative influence knowledge sharing and communication. The Triple Helix of industry/academia/state has been described as a

social system linked to knowledge generation (Etzkowitz and Ranga, 2010) and the diffusion of innovation (Rogers, 1995) which I discuss in the following sub-section.

2.4.1.4 Rogers' Five Stage Model of the Innovation-Decision Process

Rogers (1995) suggests a five step process for the diffusion of innovation, defining diffusion as: 'the process by which an innovation is communicated through certain channels over time among the members of a social system' (ibid, p.35). He suggests that, because decisions are not authoritative or collectively made, each member of the social system faces his or her own 'innovation-decision' that follows a 5-step process:

1. Knowledge – person becomes aware of an innovation and has some idea of how it functions,
2. Persuasion – person forms a favourable or unfavourable attitude toward the innovation,
3. Decision – person engages in activities that lead to a choice to adopt or reject the innovation,
4. Implementation – person puts an innovation into use,
5. Confirmation – person evaluates the results of an innovation-decision already made.

(Rogers, 1995, p.162)

If, as Rogers (1995) claims: 'the diffusion of innovation is a process in which an innovation is communicated among the members of a social system, where participants create and share information in order to reach a mutual understanding' (ibid, p.5), then CoPs can provide support to enable this process (Peansupap, Walker, Goldsmith and Wilson, 2003). If innovation is embedded in such social relationships (Doloreux and Parto, 2004) then networks rich in social capital, such as CoPs, might equally support innovation partnerships within regional clusters of SMEs.

2.4.1.5 Network Approaches to Innovation

Network approaches to innovation place emphasis on the strategic importance of relationships and have been explained as a model of innovation based on two old ideas; that innovation is determined by research (borrowed from the engineering theory) and disorderly interaction processes (borrowed from the technical networks

theory of innovation), and one insight; that knowledge plays a crucial role in fostering innovation (Landry, Amara, and Lamari, 2002). There is a growing body of evidence to support the view that networks play a crucial role in successful innovation (Assimakopoulos, 2007; Doloreux and Parto, 2004; Nooteboom, 2000; Rothwell, 1992) and this theme is reflected in the models of innovation previously discussed. Indeed, the Porter Report (Porter and Ketels, 2003) recognized that inter-organizational networking is crucial to the development of innovative capability in firms.

Such inter-organizational, or business-to-business, networks have been defined by Perez and Sanchez (2002, p.261) as 'a firm's set of relationships with other organizations' and can be formal or informal. Möller and Rajala (2007), also point to the importance of networks and identify three categories of innovation networks within SMEs. The first is social networks that consist of parity-based personal networks, certain forms of industrial districts and centralized arrangements such as sub-contracting arrangements. Secondly, bureaucratic networks made up of trade associations and consortia, which are formalized in exchange or associational contractual agreements. Finally, proprietary networks such as joint ventures and capital ventures, which include inter-firm cross-holding of equities and property rights. Conway (1995) focuses on informal networks, suggesting they contribute a significant proportion of inputs to the development of successful product innovation.

Networks are also critical in enabling firms' ability to access internal knowledge required for 'in-house' innovations and for supporting innovation diffusion (Watson, 2010), and for learning about innovative work practices in other organizations (Biemans, 1991; Erikson and Jacoby, 2003) because they promote social interaction (Pittaway, Robertson, Munir, Denyer, and Neely, 2004). It has been suggested that CoPs, where individuals are informally connected by a shared need, help underpin the conversion and connection of knowledge exchanges between networks (Tidd and Bessant, 2009). It has further been suggested (Allee, 2000; Lesser and Prusak, 1999; Wenger, 1998) that communities of practice (CoPs) might be an effective way to capture and share tacit knowledge as well as leverage the social capital (Lesser and Prusak, 1999) necessary for innovation (Landry et al. 2002).

However, small, science-based firms often have limited networking capability (Havnes and Senneseth, 2001). Additionally, SMEs often struggle to participate in collaborative or open innovation (Chesbrough, 2003) due to knowledge transfer problems caused by organizational and cultural differences (Van de Vrande, De Jong, Vanhaverbeke De Rochemont, 2009). This thesis argues that engaging with CoPs could offer science-based SMEs a means to support the networks and relationships that Partanen, Möller, Westerlund, Rajala and Rajala, (2009) argue are an essential precondition for innovation.

2.5 CHAPTER SUMMARY

This chapter has contextualized the study, providing an overview of innovation and placing it in the context of science-based SMEs. The chapter demonstrates that models of innovation have moved away from the early linear, 'push' models towards network models that support collaboration and open innovation, and where knowledge and relationships are prime considerations. However, for a variety of reasons to be discussed later in this study, SMEs often encounter difficulties engaging in networks, such as CoPs, and building the collaborative relationships associated with open innovation. It has been suggested that CoPs offer organizations a way to improve their networking potential and therefore their ability to innovate. However, the role of CoPs, in science-based SMEs has not been the subject of thorough empirical research and given its importance in terms of supporting innovation and SME competitiveness this lacuna is worthy of further investigation. The next chapter presents a critical literature review of communities of practice.

CHAPTER 3: LITERATURE REVIEW

3.1 INTRODUCTION

This study is concerned with how science-based SMEs engage with CoPs to acquire knowledge and use it for innovation. The overall research aim asks the question: 'to what extent are CoPs a 'privileged locus' for knowledge acquisition and innovation in science-based SMEs?' A CoPs lens has been adopted to explore this phenomenon because it is both conceptually and theoretically connected with my own constructionist view that both individuals and groups participate in the construction of their perceived social reality and, therefore, their knowledge. The purpose of this chapter is to examine critically the literature on CoPs in order to understand how they are constructed and how organizations – and SMEs in particular – can acquire knowledge and innovate by participating in CoPs.

Knowledge is a key factor that enhances competitiveness and stimulates innovation for SMEs (Handzic, 2004) and those firms that do not formally or informally exchange knowledge in networks such as CoPs limit their knowledge base and reduce their ability to enter into such exchange relationships (Pittaway, et al. 2004). Conversely, there is an argument regarding whether SMEs can spare the necessary resources required for cultivating CoPs (Roberts, 2006). Given that CoPs are becoming more commonly seen as a KM tool for supporting innovation (Swan, et al. 2002), this literature review examines whether CoPs offer a net benefit as a KM tool that supports knowledge acquisition and innovation in science-based SMEs. This hypothetical benefit is an important issue in terms of the aim of this study; and this chapter, accordingly, presents the debates relevant to the research questions and thus relates them to the context of innovation and science-based SMEs.

Hughes, Jewson and Unwin (2007), summarizing a review of the CoP literature that they and other authors within their edited book undertook, observe that: 'the entire model is one of transmission and reproduction of knowledge, rather than creation or invention. It is not a theory of innovation' (ibid, p.174). I concur with Hughes et al. (2007) that the CoP model as originally formulated by Lave and Wenger (1991) had little to say about innovation *per se*; however, more recent work, using amended CoP theorizations, such as that of Wenger (1998) and Wenger et al. (2002), did show that

CoPs can contribute to organizational innovation. This assumption triggered the systematic literature review presented here, which found that the theorization of CoPs has, indeed, undergone a number of transmogrifications over recent years, and that a number of researchers have addressed this matter by identifying various ways in which CoPs can contribute to innovation and a number of challenges faced in the process. The systematic literature review methodology is outlined below, followed by the literature review itself.

3.2 SYSTEMATIC LITERATURE REVIEW METHODOLOGY

The systematic literature review was organized in such a way as to facilitate a degree of flexibility, whilst at the same time minimising researcher bias in the choice of literature as suggested by Tranfield et al. (2003). Drawing upon Pittaway et al.'s (2004) methodology, the review process consisted of five stages, and was undertaken as detailed below in the order specified:

Stage 1 - Identification of key words

Given the research questions posed in this study, and based on my prior reading and knowledge of the subject area, the key words selected for the initial search were: 'communities of practice', 'innovation', 'knowledge acquisition', 'tacit knowledge', 'social capital', 'learning', 'knowledge management', 'absorptive capacity', 'open innovation', and 'collaboration' and 'SMEs'.

Stage 2 - Search strings

The second stage involved assembling the key words into suitable search strings for the systematic review. The use of the asterisk (*) as a truncation symbol allows each database to look for different endings, so 'communit*' allows the database to search for both 'community' and 'communities' of practice. The initial search string incorporated the key words most relevant to the overall aim of the study:

Communit* of practice AND innovat* AND SME*

This initial search of title/abstract was conducted in July 2013 across four databases that cover the social sciences – EBSCO, Emerald Management, Science Direct and SCOPUS – and revealed a dearth of empirical papers on CoPs and innovation in

SMEs (Table 2). This search process produced a total of 8 papers, although one paper (Du Plessis, 2008) occurred in all three of the databases reducing the number to 6 papers.

Table 2 Initial search for CoPs, innovation and SMEs

Database	Number of papers	Author/Year
EBSCO	2	Du Plessis (2008), Nicholls and Cargill (2008),
Emerald Management	0	0
Science Direct	2	Du Plessis (2008), Rolandsson, Bergquist and Ljungberg (2011)
SCOPUS	4	Du Plessis (2008), Gordon, Hamilton and Jack (2012), Powell (2012), Porumb and Analoui (2008)

Only two of these papers (Du Plessis, 2008 and Nicholls and Cargill, 2008) were identified as relevant to my research questions, thus prompting a need for a broader systematic review of the literature on CoPs and innovation in order to explore these lacunae in more depth. In order to encompass this broader systematic review, a range of suitable search strings were generated. This revealed some interesting results when the term 'SME*' was excluded from the string search. To take an example, the search string 'Communit* of practice AND Innovat*' yielded 3,587 papers across the four databases, when applied to title/abstract, and incorporated a wide range of disciplines, including linguistics, computing and education, as well as management.

Search limiters

I combined the initial search criteria, 'Communit* of practice AND Innovat*', with search limiters, such as restricting the subject area depending on the functionality of each database. The limiters included searching the years from 1991-2013 only, i.e. from the year of Lave and Wenger's original paper on CoPs to the present time. Limiting the search to specific subject areas was possible in some of the databases, for example in EBSCO the search could be restricted to 'Business and Management'.

Restricting the search to business and management related journals generated 440 articles.

Stage 3 - Databases

The search terms were then entered into the following databases: EBSCO, Emerald Management, Science Direct and SCOPUS, which cover the full range of disciplines in the social sciences. The search was limited to peer-reviewed journals. There was a high degree of variation in the search results generated due, at least in part, to the differences in the search options offered by each database. I decided that, given the focus of the literature review, the most suitable approach would be to use the search strings to identify papers with 'communit* of practice' and 'innovation' in the title and/or abstract of the papers. This approach would help to filter out articles where either CoPs and/or innovation are mentioned in a publication, but are not the main concern of the paper.

Inclusion/exclusion criteria

The citations identified as a result of the above process were then reviewed according to the inclusion criteria (outlined below in Table 3) and the exclusion criteria. The exclusion criteria were designed to prevent other terms that were similar to 'communities of practice' being included in the search and, therefore, generated a further set of search strings that were used to narrow the search.

Exclusion search strings generated and used in the database searches:

AND NOT Network of Practice
AND NOT Network of Practice OR Research Consortia
AND NOT Network of Practice OR Research Consortia OR Personal Network
AND NOT Network of Practice OR Research Consortia OR Personal Network OR Communit* without Propinquity
AND NOT Network of Practice OR Research Consortia OR Personal Network OR Communit* without Propinquity OR Communit* of Scholars

AND NOT Network of Practice OR Research Consortia OR Personal Network OR Communit* without Propinquity OR Communit* of Scholars OR Occupational Communit*

Table 3 Inclusion and exclusion criteria

Inclusion criteria		Exclusion criteria	
Criteria	**Reason**	**Criteria**	**Reason**
Communities of practice in title/abstract	Guarantee relevance	Networks of Practice	CoPs not mentioned
Innovation in title/abstract	Guarantee relevance	Research Consortia	CoPs not mentioned
Qualitative and quantitative empirical studies from peer-reviewed journals	Maximize empirical evidence capture	Personal Networks	CoPs not mentioned
Published since 1991	Date of Lave and Wenger's original papers on CoPs and situated learning	Community without Propinquity	CoPs not mentioned
All sectors	Examine how CoPs differ between sectors in the UK	Communities of Scholars	CoPs not mentioned
English language publications		Occupational Communities	CoPs not mentioned

This process, applied to the four databases, generated 340 articles published between 1991 and 2013. These papers were manually cross-referenced in order to identify and remove any duplication from the four databases, generating 282 papers. This list was further reduced to 114 papers by excluding articles in subject areas not directly related to CoPs and innovation in business organizations, including the following subject areas:

- accounting/ finance – these papers dealt with accounting processes rather than organizational innovation *per se*
- agriculture

- environmentalism, sustainability, and/or social communities
- healthcare
- higher education
- lifestyle
- marketing
- public administration
- pure science and technology
- quality management
- tourism

Stage 4 - Qualitative assessment

The titles and abstracts of the remaining 114 articles were then read and reviewed for a qualitative assessment of their relevance to the inclusion and exclusion criteria (Table 2). This review resulted in 63 papers being rejected, reducing the list to 51 papers. The main reason for this reduction was that the search terms used in the early search - 'Communit* of practice AND Innovat*' - generated a large number of papers with the words 'community' or 'communities' and 'practice' in the title and/or abstract which were not actually about CoPs. For example, to highlight this point, one paper (Page and Scott, 2001) contains the key search words 'Communit* of practice AND Innovat*' in the title/abstract, but the paper is about 'Change agency and women's learning new practices in community informatics', rather than being related to the research questions of this study, i.e. communities of practice and innovation.

The full texts for each of the remaining 51 papers were then read and reviewed, leading to the exclusion of a further 13 papers on the basis of the inclusion/exclusion criteria. These papers all mention CoPs but they are not the main focus of the paper; for example, in one paper, Kodama (2002) distinguishes 'strategic communities' from 'communities of practice', but the paper focuses upon the former and CoPs are only briefly referred to in the paper. Finally, I manually checked through the citations in the remaining 38 articles for any papers not previously identified from the systematic review to this point, and then checked these papers for any relevance to CoPs and innovation; this identified a further 54 articles, giving a total of 92 articles which form the basis for the literature review.

Stage 5 – Synthesis

Critical interpretive synthesis (CIS), a means of conducting an interpretive synthesis of research in a specific field, was employed to analyze the literature on CoPs and innovation (Dixon-Woods, Cavers, Agarwal, Annandale, Arthur, Harvey and Sutton, 2006). CIS differs from more 'aggregative' approaches to conducting a systematic literature review, which usually seeks to compile and summarize the main findings of a body of evidence (Annandale, Harvey, Cavers and Dixon-Woods, 2007). Using CIS, on the other hand, enabled me to engage critically with the literature and capture the complexity of data from a diverse set of subject areas. Four key themes were identified: (i) CoP theory has evolved over time, (ii) the governance of CoPs, (i.e. whether they can be cultivated or managed by organizations), including SMEs, is a disputed literature,(iii) inter-organizational CoPs support knowledge sharing/acquisition, help build social capital, and support collaboration and open innovation, and (iv) CoPs can support networks within regional clusters. These themes are now discussed in depth, but before doing this it is necessary to first of all review the early theorizations of CoPs.

3.3 THE ORIGINS OF COP THEORIZATIONS

Initial research into CoPs (Lave and Wenger, 1991) focused on the way individuals learn and discussed an important theme in learning theory: the notion that learning is socially situated, meaning that it is the product of the activity, context, and culture in which it is developed and used (Brown, Collins and Duguid, 1989). Learning is viewed as a process that involves becoming part of a community and becoming an effective learner involves both participation and collaboration within the community. Lave and Wenger's (1991) early work indicates that initial participation in CoPs is often limited at the periphery of the community. They refer to this approach as legitimate peripheral participation (LPP). In this situation, the learner has limited responsibility for any collaborative participation. As members become more involved in their community, they move from a position of legitimate peripheral participation into a CoP where they can benefit from learning more effectively.

This early research centred on how apprenticeships helped people learn. Lave and Wenger observed how over time, apprentices joining a community moved from an

initial position of legitimate peripheral participation into a CoP. Through participation in peripheral activities, the apprentice gradually moves from the position as a 'newcomer' to become a full participant as an 'old timer'. The apprenticeships studied by Lave and Wenger (1991) included claims processors in an insurance firm, midwives, US navy quartermasters, meat cutters and even non-drinking alcoholics. Thus learning is seen as part of a process of social participation.

Other writers (Collins, Brown and Newman, 1990) have also suggested that, historically, apprenticeships, rather than formal classroom teaching, have been used as an effective way to pass on knowledge or expertise to the next generation of learners. This approach to learning, often referred to as 'situated cognition', claims that knowing is inseparable from doing and is an important element of Lave and Wenger's original theory, and suggesting that learning is closely linked to the use of authentic activities, context, and culture (Brown et al. 1989). The idea here is that it is more difficult to learn from 'unnatural' activities such as reading a description from a textbook, than it is to be involved in activities that are 'situated' and have some basis in reality.

More recently, however, CoP theory has been adapted by knowledge management theorists and used to highlight their value in relation to learning and innovation in organizations (Assimakopoulos, 2007; Scarbrough, Swan, Laurent, Bresnen, Edelman and Newell, 2004). In knowledge management terms, a CoP is now defined as a group of people informally bound together by shared expertise and a passion for a joint enterprise (Wenger and Snyder, 2000). Wenger (1998) describes the structure of a CoP as consisting of three interrelated elements: mutual engagement, joint enterprise and shared repertoire. Through mutual engagement, i.e. their participation in the community, CoP members establish behavioural norms and build collaborative relationships.

These relationships represent the ties that bind the CoP members together. By engaging in joint enterprise, through their interactions, CoP members create shared understanding of what binds them together. The joint enterprise is negotiated by CoP members and is sometimes referred to as the domain. By sharing practice, i.e. shared repertoire, the CoP develops communal resources that are used in the pursuit of their joint enterprise and can include both literal and symbolic meanings. These three

related definitional elements are used in the data analysis of this study. They form part of the *a priori* codes in the thematic template that are used to identify the presence of CoPs in the participant SME organizations.

Lave and Wenger's (1991) original work has been criticized for being a study of rather simple social configurations, such as apprentice meat cutters and midwives (Assimakopoulos, 2007). The main accusation here is that CoPs fail to acknowledge that in complex, knowledge intensive industries, such as ICT, innovation usually occurs across, rather than within organizational boundaries (Carayannis and Alexander, 1999). Innovation in these more complex industries is often approached through the creation of joint ventures and personal information networks (Assimakopoulos and Macdonald, 2002), rather than through attempts to construct CoPs. A further criticism of Lave and Wenger's apprenticeship model is that, to some extent, it ignores power relations amongst different CoP members and the level to which democratic practices could exist within the CoP structure (Hay, 1996). In practical terms, this means that full participation by novices might be denied by more senior or experienced practitioners (Handley, Sturdy, Fincham and Clark, 2006).

This further issue is closely linked to more central issues regarding the participation and status of members in relation to their relative centrality or peripherality to the community (Harris and Sheswell, 2005). Legitimate peripheral participation is central to Lave and Wenger's (1991) initial conceptualization of CoPs and they even suggest that: 'there may very well be no such thing as an 'illegitimate peripheral participant' (ibid, p.35), inferring that all participation is legitimate. Harris and Sheswell (2005), on the other hand, discuss participation in terms of 'legitimate conflicts' (ibid, p.55) that can have both negative and positive impacts on a CoP. Legitimate conflict occurs when the legitimacy of one participant is brought into question by other members of a CoP, which can marginalize the participant involved and can sometimes result in withdrawal from the CoP. On the other hand, Lave and Wenger's view is that participation is an empowering process and CoPs have been criticized for marginalizing issues related to the power relations within CoPs (Contu and Willmott, 2003; Fox, 2000).

That said, in his later work, Wenger (1998) abandons the concept of legitimate peripheral participation to focus on social identity where meaning, and identity are

negotiated through the interaction of two processes, participation and reification, i.e. making or viewing abstract concepts as real, real which form a duality. Wenger identifies four dualities that exist in CoPs. The participation-reification duality is concerned with meaning and making an abstract and concise representation of complex practice, thus making it easier to share knowledge within the CoP. The designed-emergent duality is focused on the tension between planned activities, intended to achieve specific goals, and emergent activities that develop through CoP participation. The identification-negotiability duality refers to how individuals build their identity and concerns the balance between belonging and the power to shape the CoP. Local-global duality refers to how CoPs relate to each other, i.e. sharing knowledge outside of the CoPs domain.

Wenger (1998) suggests reification produces boundary objects, i.e. shared artefacts, discourses and processes, together with managers in brokerage roles could be used to encourage knowledge-sharing between CoPs. Reification is central to the notion of practice and, although it is essential in transforming the abstract into tangible form, an effective CoP needs to achieve a balance between reification and participation. For example, emergent activities that occur in CoPs might be viewed as contrary to the planned activities of the organizations or their aims. In addition to Wenger's (1998) suggestion that CoPs support learning within organizations, this study seeks to extend our understanding of how CoPs are conceptualized as both intra and inter-organizational networks for supporting knowledge acquisition and innovation in science-based SMEs. The remainder of this chapter goes on to explore CoP theory in greater depth, examining how it has been reconceptualized as a tool for organizational learning, before then considering its potential as an inter-organizational tool that contributes to knowledge acquisition and innovation in science-based SMEs.

3.4 THE EVOLUTION OF CoP THEORY

CoPs have become an important focus within organizational development and knowledge management and have considerable value when considering their role in organizational learning (Assimakopoulos, 2007), the development of social capital within organizations, (Lesser and Prusak, 1999) and for contributing to innovation (Assimakopoulos, 2007). In this context, Wenger et al. (2002) relate CoP theory to

knowledge management and organizational structure in an attempt to make it more accessible as a tool for organization leaders. According to Assimakopoulos (2007), the significance of Wenger et al.'s (2002) work is that, rather than considering the traditional organizational structures based on functional areas, departments, or even as other types of informal networks, organizations are conceptualized as constellations of informal CoPs (Wenger, 1998). Whilst organizations have a formal structure, documented in their policies and procedures, this can be contrasted with the informal nature of CoPs, in the sense that they are often unknown to, or unrecognized by, the organization (Lesser and Prusak, 2006) and support informal approaches to learning.

The structural characteristics of CoPs (that they are emergent and self-selecting of their membership) brings organizational benefits because they add value, helping to drive strategy and innovation, starting new lines of business, solving problems quickly, transferring best practice, developing professional skills and helping recruit and retain talent (Wenger and Snyder, 2000). Through the sharing of practice participants learn together, focusing on problems directly related to their work (Wenger and Snyder, 2000). This view has some affinity with Orr's (1996) ethnographic study of photocopy repairmen, although Orr used the term 'occupational communities' (Van Maanen and Barley, 1984) rather than CoPs. Sharing practice also has an indirect benefit to the organization as it can make each member's work easier and can improve organizational effectiveness in the long term.

The work of Brown and Duguid (1991) draws heavily on Orr's (1990) case study of photocopy repairmen, soon after consolidated by Orr (1996) in the book 'Talking about Machines'. This body of work is consistent with Wenger's view of the organization as a learning organism, but Brown and Duguid's interpretation takes the concept more directly into an organizational setting. Their research reassesses the relationship between work, learning and innovation and challenges the conventional view that they necessarily have to conflict with each other. In a similar vein to Lesser and Prusak (2000), they argue that organizational descriptions of jobs hide the significant contribution to learning and innovation that is generated within the informal CoPs that both they and Wenger (1998) claim exist in all organizations. My systematic literature review has highlighted that CoP research to date has focused on

large organizations and, therefore, one of the research questions this study asks is: 'are CoPs to be found in science-based SMEs?'

Orr's (1990) original research studied the work of Xerox photocopy repairmen from the perspective of their collective memory (Kimble, Hildreth and Wright, 2001), recounting how their ability to repair photocopiers was based on their ability to share tacit knowledge within a CoP. The repairmen used a process of storytelling to share knowledge and find solutions to repairing photocopiers. As these 'war stories' were passed around the community, they created new knowledge within the community. As Kimble et al. (2001) explain: 'War stories serve to legitimate a newcomer as they move from peripheral to fuller participation' (ibid, p.223). Orr's study showed that when the repairmen could not complete a repair using the manual, they contacted a supervisor and through the telling of these 'war stories' they found a solution.

The work of Brown and Duguid (1991) and Orr (1990; 1996) suggests that there might be some disparity between espoused practice, i.e. the organization's formal work practices, and the actual practice, i.e. how work practices are actually performed by the organization's members. An organization's reliance on these espoused practices, referred to as canonical practices, can often be to the detriment of non-canonical practices, i.e. the actual practices of its members. Non-canonical practices, they argue, are more likely to determine the success of an organization (Brown and Duguid, 1991). Organizations that fail to acknowledge the importance of non-canonical practices might also fail to recognize the importance of informal networks, such as CoPs, in supporting organizational learning and innovation. On the other hand, although CoPs might be seen by some as drivers of innovation, their non-canonical practices are often seen by management as counterproductive to the organization's aims and objectives. Another possible criticism of Brown and Duguid's research is that it assumes that all canonical practices are inevitably flawed, inflexible and limited (Cox, 2005).

Nevertheless, Brown and Duguid's (1991) work does suggest that, in the context of CoPs, the connections between work, learning and innovation become more apparent, and should be viewed as complimentary. They conclude that: 'with a unified view of working, learning, and innovating, it should be possible to reconceive of and redesign organizations to improve all three.' (ibid, p.40). They still

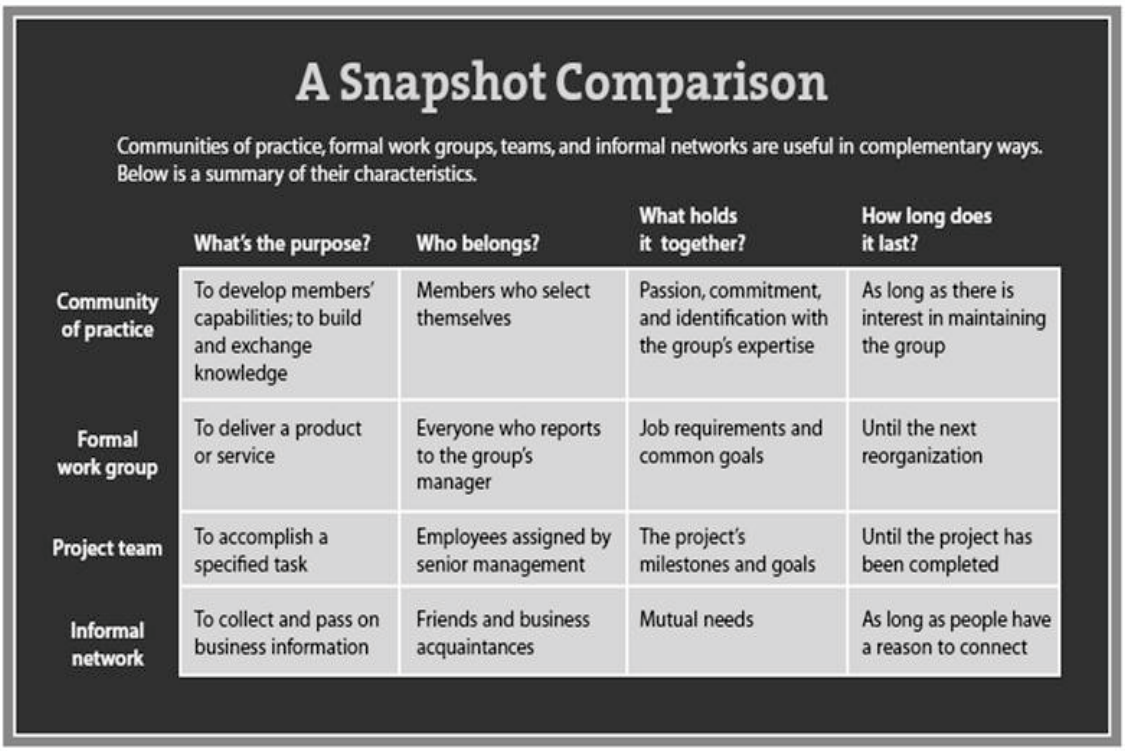
stress a practice-based standpoint, but view learning as a bridge between working and innovation, recognizing that organizations must close the gap between canonical and non-canonical practice and in doing so must reconceive of themselves as communities-of-communities (Brown and Duguid, 1991, p.53). Both Brown and Duguid's (1991) and Wenger's (1998) own later analysis suggest that, as well as facilitating effective learning, CoPs also contribute to innovation because their structure is flexible and they are constantly adapting to changing circumstances and membership (Assimakopoulos, 2007).

Wenger (2010) refers to CoPs as shared histories of learning, and whilst he clearly considers that CoPs spanning organizational boundaries might enhance innovation, he recognizes that this is not guaranteed. He suggests that shared repertoire, an essential element of CoPs, might be problematic in the construction of CoPs that span organizational boundaries because of 'irrelevance' or lack of defined 'competence'. This could be particularly applicable in science-based SMEs that are 'knowledge leaders' in their field (Pattinson and Preece, Forthcoming). The uniqueness of the knowledge base associated with a particular scientific innovation is likely to result in a lack of shared repertoire that could limit the construction of CoPs across organizational boundaries.

However, earlier interpretations of CoPs focused on apprenticeships (Lave and Wenger, 1991), where individuals work together in close proximity, and this is far removed from modern business relationships. Using this original definition, CoPs by their very nature are seen as informal, self governing groups. Figure 6 highlights the nature of CoPs in relation to other common organizational networks, such as formal work groups and project teams. CoPs differ from these other networks in that they are informal, self-selecting of both their members and leadership and self-organizing. CoPs last as long their members maintain a common interest and, perhaps more importantly, membership is held together by a shared passion, commitment, and expertise (Wenger and Snyder, 2000). For Wenger (1998), CoPs are both self perpetuating and knowledge generating as they continually reinforce and renew themselves. This feature raises the question of how, based on this later re-interpretation of the term, CoPs differs from other forms of organizational network.

Figure 6 CoPs and other networks

(Wenger and Snyder, 2000, p.142)



A Snapshot Comparison

Communities of practice, formal work groups, teams, and informal networks are useful in complementary ways. Below is a summary of their characteristics.

	What's the purpose?	Who belongs?	What holds it together?	How long does it last?
Community of practice	To develop members' capabilities; to build and exchange knowledge	Members who select themselves	Passion, commitment, and identification with the group's expertise	As long as there is interest in maintaining the group
Formal work group	To deliver a product or service	Everyone who reports to the group's manager	Job requirements and common goals	Until the next reorganization
Project team	To accomplish a specified task	Employees assigned by senior management	The project's milestones and goals	Until the project has been completed
Informal network	To collect and pass on business information	Friends and business acquaintances	Mutual needs	As long as people have a reason to connect

The challenge for management is to understand if and how CoPs can be cultivated, or managed, to the benefit of the organization. Wenger et al. (2002) suggest a broadening of the structural characteristics, suggesting that CoPs can be spontaneous or intentional, as well as formal or informal in structure. They suggest that many CoPs begin without any intervention or development from the organization. Individuals spontaneously come together, because of mutual need, ad meet as peers or learning partners. On the other hand, Wenger et al. (2002) also claim that organizations can intentionally develop specific CoPs and, whether they are spontaneous or intentional does not dictate the level of formality or activity.

They go on to suggest four types of CoP that an organization can cultivate for their strategic intent. 'Helping communities' are focused on solving everyday problems; 'best-practice communities' are focused on developing, validating and disseminating specific practices; 'knowledge-stewarding communities' are focused on organizing, upgrading and distributing knowledge that members use every day: 'innovation communities' are focused on fostering unexpected ideas and innovations (ibid, p.76).

In this study, innovation communities are of particular interest and, although similar to helping communities, they differ in that they intentionally cross boundaries and mix members who have different perspectives (Wenger et al. 2002).

For some, Wenger et al. (2002) present a simplification and commodification of the idea of CoPs, concentrating on their value as a management tool and abandoning the earlier apprenticeship learning model to refocus on innovation (Cox, 2005). They re-define the purpose of a CoP as relating to groups of people who share a concern, set of problems, or passion for a topic, and who deepen their knowledge and expertise by interacting on an ongoing basis. The re-designation of CoPs as a knowledge management tool highlights a fundamental issue regarding their nature; the amount of control an organization can, or should, exert over a CoP. The governance of CoPs is a disputed area within the literature, the main arguments revolving around whether they can be managed or cultivated, or whether they are a fundamentally emergent phenomenon. The issue of CoP governance is now discussed in depth.

3.5 CoP GOVERNANCE

In the original formulation (Lave and Wenger, 1991), CoPs were treated as an *emergent* form, not as a social institution formally and deliberately created by managers. More recent treatments (for example, McDermott and Archibald, 2010) have suggested that they can and should be managed with 'specific goals, explicit accountability, and clear executive oversight' (ibid, p.84). An alternative view is that CoPs should be cultivated rather than managed (Newell, Huang, Pan and Galliers, 2001; Hildreth and Kimble, 2002; Wenger et al. 2002; Saint-Onge and Wallace, 2003). *Management* implies control, which arguably stifles creativity, sharing and self-initiative (Andriessen and Verburg, 2004). *Cultivation* implies less control, allowing CoPs to retain much of their independence whilst still receiving appropriate organizational support (Wenger et al. 2002). Wenger et al. (2002) outline seven principles for cultivating CoPs (Table 4). They suggest that organizations focus on elements of 'design' that support the cultivation of CoPs.

Here the focus is on bringing in members from outside the organization as well as engaging with those on the periphery of a CoP in order to bring value to the organization through the relationships that develop. They suggest this process can be cultivated through networking events, such as conferences, workshops. This re-

definition represents a distinct move from Lave and Wenger's (1991) earlier conceptualizations of CoPs based on mutual engagement, joint enterprise, and shared repertoire, which focused on individual learning. This new perspective sees CoPs described, arguably more vaguely, (Cox, 2005; Li, Grimshaw, Nielsen, Judd, Coyte, and Graham, 2009) as a knowledge management tool for organizations to manage knowledge workers (Li et al. 2009) and raises the question of whether this re-interpretation is, in fact, really describing other, more formal work group structures, such as those described in Figure 6.

Table 4 Seven Principles for Cultivating CoPs

(Wenger et al. 2002, p.51)

1. Design for evolution – communities are dynamic and constantly changing;
2. Open dialogue between inside and outside perspectives - bridge the gap between CoP and external community;
3. Invite different levels of participation – engage peripheral as well as the core members;
4. Develop public and private community spaces – allow members to communicate with each other and external members;
5. Focus on value – the community domain should add value to the organization;
6. Combine familiarity and excitement – routine activities allow the development of relationships, whereas 'exciting events', such as conferences, fairs and workshops, (ibid, p.62) help keep the community alive;
7. Create a rhythm for the community – identify milestones to create a community tempo.

More recently, McDermott and Archibald (2010) discuss setting up CoPs as part of an organizations' overall business strategy. They support a management approach to CoP governance, claiming that CoPs require 'real' structure, rather than being independent and self organizing. They identify four principles for the design and integration of effective communities (Table 5). These principles stress that CoPs need to focus on 'real problems' identified by senior managers and to be focused on formal goals or deliverables. They further suggest that CoPs require strong, formal leadership and that managers should be expected to engage with CoPs in order to influence their design. For SMEs, with informal management structures, this

approach does not seem to offer a suitable approach to constructing CoPs. Far from being considered a marginal activity for the benefit the members, McDermott and Archibald (2010) view CoPs as: 'a valuable resource for coordinating work across organizational boundaries' (ibid, p.89).

Table 5 Four Principles for Designing Effective CoPs

(McDermott and Archibald, 2010, p.85)

1. Focus on issues important to the organization - sustainable CoPs tackle real problems defined by senior management;
2. Establish community goals and deliverables - formal goals/deliverables energize CoPs and provide focus;
3. Provide real governance - to be integrated into the organization CoPs need strong, formal relationships with top leadership;
4. Set high management expectations – management expectation have a strong influence on CoP success and senior management should therefore engage with CoPs.

McDermott and Archibald (2010, p.5) also suggest other ways to maximize the impact of CoPs. These include setting aside real time for CoP participation, giving CoP leaders and members time to participate, and training CoP leader in their role by providing CoP specific training. They also suggest holding face to face events that foster trust and build rapport between members, as well as stimulating the ad hoc encounters (discussed later by Hildreth , Kimble and Wright, 2000). They also suggest organizations make use of simple IT tools such as discussion forums, document libraries, expertise locators, on-demand teleconferencing, and online meeting spaces can support geographically dispersed CoPs. Again, these suggestions seem to offer little for SMEs who have limited time and resources available to divert away from core activities and reallocate to CoP construction activities.

The CoP governance issue is controversial and the distinction within the literature between the cultivation and management of CoPs is unclear, i.e. CoPs were originally viewed as both spontaneous and informal (Wenger, 1998), whilst in later work, Wenger et al. (2002) suggest that, although CoPs cannot be managed, they can be cultivated. On the other hand, more recent research (McDermott and Archibald, 2010) suggests that globalization has led to more complicated organizational

relationships, resulting in the need for CoPs to be actively managed and given targets and responsibilities. Imposing a formal structure and reducing independence will destroy many of the core features that make a CoP different from other formal groups. Lack of independence will surely stifle the spontaneous, emergent nature of CoPs, reducing levels of trust and discouraging voluntary membership, all essential elements for organizations that want to benefit from CoPs.

Cox (2005) puts forward three possible viewpoints regarding the manageability and control of CoPs. His most optimistic view sees CoPs as a tool to empower individuals, giving them greater freedom and engaging them in their own work, (Liedtka, 2000) which in turn generates benefit for the organization. His second, more critical view, challenges the proposition that CoPs 'create value by connecting the personal development and professional identities of practitioners to the strategy of the organization' (Wenger et al. 2002, p.17). Here Cox suggests it is unfeasible for an organization to align individuals' needs with the strategic aims of the organization. He considers this element to be the role of management, who represent all stakeholders, rather than CoPs which do not. A third, even more pessimistic view, is that CoPs are: 'a new and insidious form of control' (ibid, p.545).

By creating informality, organizations allow individuals to express more freedom and creativity (Misztal, 2003) and Cox (2005) suggests that this in itself might constitute a new set of rules, imposing an obligation on individuals to be overly positive about their work at all times. This third view also sees management ignoring the fact that relationships within CoPs are not always harmonious (Wenger, 1998). Cox's (2005) observations represent an interesting viewpoint and he suggests that if organizations are increasingly seen as 'communities of communities' (ibid, p.550) they might contain different types of communities, e.g. occupational communities, not just communities of practice. The ambiguity for Cox (2005) is whether managerial support for CoPs represents genuine empowerment or is really a new form of normative control.

Considerable effort has been made to explain the role of individual actors in building social networks. Cross and Prusak (2002) identify four common role-players in informal social networks: central connectors, boundary spanners, information brokers and peripheral specialists. However, informal networks are not usually part

of the official hierarchy of an organization (Krackhardt and Hanson, 1993) and most organizations are either unaware of these informal networks (Assimakopoulos, 2007) or do not understand how to govern them (Chan, 2006). Probst and Borzillo (2008) discuss the role of sponsors in relation to issues of CoP governance and view CoPs as a form of intra-organizational network suitable for the development and sharing of knowledge across organizational divisions.

Compared with McDermott and Archibald's (2010) approach, which focused on formalizing CoP design and integration into the organization, Probst and Borzillo (2008) claim to take a more supportive role for the organization, allowing CoPs to benefit from organizational support, whilst still retaining some level of independence. The difficulty with this argument is gauging the balance between the levels of organizational support provided and the amount of independence the CoP is allowed to exercise. Their first two commandments (see Table 6), for example, immediately restrict the activities of the CoP to strategic areas selected by the management making them sound more like project teams than CoPs.

Table 6 The Ten Commandments of CoP Governance

(Probst and Borzillo, 2008, P.339)

1. Stick to strategic objectives;
2. Divide objectives into sub-topics;
3. Form governance committees with sponsors and CoP Leaders;
4. Have a sponsor and a CoP leader who are best practice control agents;
5. Regularly feed the CoP with external expertise;
6. Promote access to other intra and inter organizational networks;
7. The CoP leader must have a driver and promoter role;
8. Overcome hierarchy-related pressures;
9. Provide the sponsor with measurable performance;
10. Illustrate results for CoP members.

Additionally, these commandments suggest that the use of committees, sponsors and leaders, together with the use of terms such as 'measurable performance' will, in Probst and Borzillo's (2008) view of CoPs, enable the organization to exert a high level of control over the construction of CoPs.

In more recent work, Borzillo (2009) expands on the theme of sponsorship, reflecting on the role of top management in supporting CoPs. Borzillo reiterates his opinion that, although some control is required, it is not possible for management to maintain total control. Borzillo (2009) investigated three governance mechanisms for guiding CoP development: (i) tight control over quality and performance in relation to CoP best practice, (ii) governance committees to assess CoP activities and (iii) multiplication agents to promote best practice across the organization. The level of control here is more in line with managing CoPs rather than cultivating them and is certainly describing a more formal group than early conceptualizations of CoPs suggest. In relation to control, Borzillo (2009) links CoPs and innovation when quoting the leader of the ‘‘power systems’’ CoP at Daimler Chrysler, who said:

> Our sponsor plays a crucial role in setting practice-related goals for our network. We have to design better performing power systems and the responsibility for this lies on his shoulders. As members, we basically spend our time discussing various technical combinations with which to reach this goal. Twice a year, we show the sponsor the most outstanding and innovative systems that our community has conceived.
>
> (Borzillo, 2009, p.65)

Borzillo (2009) also discusses the role of governance committees in assessing the overall activity of CoPs and deciding whether their activity makes strategic sense to the organization. Again he indicates that CoPs contribute to innovation, citing examples where the sponsors met with CoP leaders in quarterly roundtable committees. These allowed the sponsors to assess whether the knowledge and practices developed by a variety of CoPs, i.e. the assembly CoP, the car design CoP and the powertrains systems CoP, and whether such CoPs did increase innovation and efficiency in the vehicle manufacturing process. For Borzillo (2009), the sponsor can also play the role of a multiplication agent of best practices within both the CoP and the organization. Here the role of top management is to supervise the adoption of best practice by CoP members, providing adequate technology to support CoP exchanges and present quantifiable benefits to subsidiary companies’ top management.

Through regular reporting of the positive benefits of CoPs, Borzillo suggests that top management can promote the active sharing of best practice and encourage CoP membership amongst employees. Although limited to the role of top management as sponsors, Borzillo's (2009) research highlights ways in which organizations might bridge the gap between the organization and CoPs. One problem with Borzillo's approach is that, although he acknowledges that organizations cannot control CoPs, he suggests governance mechanisms which advocate the opposite of this. He also presents quotes from both Daimler Chrysler and Ford that suggest the term CoP might have been applied incorrectly to groups that might be more accurately described as formal project teams. Although the role of sponsors might provide a useful tool for organizations wanting to cultivate CoPs, Borzillo's (2009) approach, focused on top management teams in 21 large multi-national corporations, seems to offer little else for SMEs who want to cultivate CoPs.

Loyarte and Rivera (2007) have also attempted to develop a model for the cultivation of CoPs within organizations (Table 7). They consider the four components originally identified by Wenger (see Table 5) as: 'the key to evaluate whether companies are cultivating CoPs' (ibid, p.69).

Table 7 Four Phase CoP Cultivation Model

(Loyarte and Rivera, 2007, p.73)

1. Analysis for the detection of CoPs, i.e. do CoPs already exist?
2. CoP necessity, i.e. cost versus benefit?
3. CoP cultivation process, i.e. the best cultivation process to adopt?
4. Evaluation, i.e. has cultivation supported organizational objectives?

The model suggests that organizations should first assess whether CoPs already exist before then considering if there is a necessity for them in terms of the cost of cultivation versus the perceived benefit. Only then should organizations consider how best to cultivate them and evaluate their success in terms of meeting organizational objectives. Loyarte and Rivera's (2007) Four Phase Cultivation Model is based, in part, on Wenger's four structural components and also on McDermott's (1999) three key dimensions for the cultivation of CoPs, i.e. the kind of knowledge the community shares; the degree of connection and identity among

members; how closely integrated is the sharing knowledge with people's everyday work? Their results were analyzed in terms of four challenges for cultivating CoPs (McDermott, 2000, P.5). The 'management challenge' to create CoPs around topics central to the organization; The 'community challenge' which is that it is often difficult to maintain commonality and enthusiasm for the CoP; The 'technical challenge' related to developing technological tools that contribute to the community; Finally, the personal challenge, i.e. developing individuals' ability to discuss, share and think about CoP issues. This framework could be used by SMEs to raise awareness of CoPs and help select the most suitable cultivation process for implementing CoPs in science-based SMEs.

Loyarte and River (2007) also advocate that such a cultivation process, *inter alia*, can have a direct effect on the development of innovation. They speculate that, while organizations can benefit from cultivating CoPs, there is a downside: CoPs are composed of individuals and their success is closely linked to the personal intrinsic motivation of individual members, which is largely outside the control of the organization. Although this argument is a little vague, it is supported to some extent by their observations of the struggle between CoP control and independence. In one organization, where CoP membership was compulsory, the organization claimed it: 'got successful CoPs to achieve the pursued objectives' (ibid, p.72). However, in this instance it could be argued that the successful CoP was in fact more like a formal work group or project team. A second criticism of this model is that it is more like a tool to identify the presence of existing CoPs than a practical guide to the cultivation of CoPs. Nevertheless, this could still be useful for organizations in relation to identifying CoPs or other similar informal networks.

Scarso and Bolisani (2007) focus on CoPs that have developed within single multinational organizations. Their research is based on an examination of 200 studies of CoPs in large organizations. They view such organizations as networks of geographically dispersed and partly independent units, suggesting that they are not very different from a network of autonomous firms. Thus, they claim to: 'provide insights into the possible extension of the 'CoP approach' to the issue of knowledge sharing in industrial networks' (ibid, p.375). Their analysis discusses CoPs as a solution to overcoming the geographical, cultural and organizational barriers that often hinder the retrieval, transfer, and re-use of the knowledge essential to

successful innovation. Scarso and Bolisani (2007) consider that CoPs are highly diffused amongst many multinational organizations, the main purpose of such CoPs being to establish an environment that facilitates the sharing and diffusion of knowledge, thereby improving the innovative potential and the problem-solving capability of individuals.

After discussing five initial attempts at categorizing CoPs (Coakes and Clarke, 2006; Dubé, Bourhis and Jacob, 2006; Roberts, 2006; Pemberton et al. 2007; Verburg and Andriessen, 2009) they attempt to summarize the four major dimensions that they claim shape the existence and functioning of a CoP, which they refer to these dimensions as the 'four pillars' of a CoP. The first is the 'organizational dimension' concerning relationships and roles both between CoP members and between the CoP and the organization. The second is the 'cognitive dimension' regarding the specific knowledge domain and practice the CoP deals with. The third is the 'economic dimension' which considers the benefits and costs to the organization. The fourth is the 'technological dimension' regarding the role of enabling technologies. These dimensions mutually influence each other, raising some interesting issues regarding attempts to develop an effective CoP framework and which I now discuss.

The kind of knowledge exchanged within a CoP is affected by the organizational structure, which might result in conflicts with management, especially when organizational and CoP objectives diverge, and that require specialized roles for CoP management. When implementing support technologies, specific knowledge exchanges and the organizational features that shape the application of computer systems in CoPs need to be considered. Measuring the economic performance of a CoP is essential to its growth and sustainability, at least from the organization's perspective. However, this presents difficulties because of the informal nature of CoPs, and is dependent on the structure, management style and culture of the organization.

Scarso and Bolisani (2007) suggest two further factors that might affect CoP cultivation. The first is the 'business context', which includes elements such as the business environment, the corporate culture, the level of IT literacy, and the availability of resources. The second is the 'knowledge strategy' which is defined as: 'a plan for making the best use of the knowledge-based resources in the view of the

organization's competitive advantage' (ibid, p.385). These elements affect the dimensions and characteristics of a CoP in a variety of ways. For example, the nature of the hierarchical structure of an organization influences the type of 'knowledge islands' (ibid, p.375) that emerge. This aspect will influence the kind of knowledge exchanges a CoP is designed to facilitate.

They do touch on areas of potential conflict between CoPs and management, and acknowledge that there are power-political issues embedded within the social interaction process of CoPs (Pemberton, Mavin and Stalker, 2007). These areas of potential conflict are specifically concerned with, for example, the impact of timing on CoP development. They suggest organizations ask if it is an emergent CoP that has evolved because of a need, or has it been created intentionally, possibly as an offshoot of another formal organizational grouping? Scarso and Bolisani's (2007) cognitive dimension in particular presents an issue for science-based SMEs where managers are focused on specialized, science-based knowledge domains that can present a barrier to external knowledge sharing. Likewise, additional factors such as the 'business context' or knowledge strategy' are unhelpful for SMEs that are unlikely to have a formal KM strategy.

Pemberton et al. (2007) also suggest that the impact of CoP leaders and managers in 'managed' CoPs also needs to be considered, as well as the power-political interrelationship between emergent CoPs and the formal organization. They raise questions regarding the impact of dominant actors with positions of power as well as the power implications of novices and masters. Power could present a significant barrier to the construction of CoPs in SMEs where there is often an uneven distribution of power within knowledge based networks (Giuliani, 2005). They are also concerned about the emotional containment and emotion work that takes place within CoPs, and the implications on organizations when CoP practices diverge from organizational practices. They conclude there is no 'one size fits all' or 'best practice' approach to effective CoP construction or design, hence Pemberton et al. (2007) suggest high levels of transparency will be required in order to overcome difficulties related to the relationship between an emergent CoP and the formal organization.

Nevertheless, the work of Pemberton et al. (2007) does lack empirical evidence to support the assumptions made by the authors, especially with regard to power-political relationships embedded within the social interaction process. However, if organizations seek to cultivate CoPs, it suggests that they wish to ensure that the CoP sits comfortably with the values and culture of the organization (Nicholls and Cargill, 2008). Raz (2007) also takes a rather less positive view of CoPs, highlighting the potential for creating subversive cultures, rather than for fulfilling management's perceived role for them in the organization. This view is not necessarily suggesting that CoPs should mirror the formal organizational structure, according to Ackerman, Pipek and Wulf (2003), but rather that they should seek to side-step organizational power-politics and sit outside of that sphere of influence. Ackerman et al. (2003) posit an optimistic view of organizational politics and it could prove difficult for CoPs to maintain balance between supporting the organization and maintaining the independence of the CoPs. On the one hand, CoPs must be owned and driven by their members but, on the other, their legitimacy also needs to be acknowledged by management.

I have reviewed 60 publications that discuss the issue of CoP governance, in order to identify and categorize them, and a summary can be found in Table 8. My review found that descriptions of CoPs fall into three categories – emergent, managed and cultivated. Emergent CoPs are the closest to Lave and Wenger's (1991) description and focused on aspects of individual learning. On the other hand, proponents of managed CoPs suggest that they can be actively managed and aligned with organizational goals. Cultivated CoPs occupy the middle ground between these two views and suggests that, rather than manage CoPs, organizations can cultivate them by providing a suitable environment for them to flourish. Furthermore, the table highlights that I could find only 12 studies that discuss the governance of CoPs – whether by cultivation or management in SMEs. The summary confirms the variety of conflicting views related to the governance of CoPs, and whether they can be managed or cultivated remains a contentious issue.

Table 8 Summary of CoP categories

	Firm size undetermined	Large Organization	SME	Features
Emergent	Lave and Wenger (1991)	Wenger (1998), Wenger and Snyder (2000), Corso, et al. (2001), Allee (2000), Cross and Prusak (2002), Morgan (2004), Mørk, et al. (2006), Raz, (2007)		Informal and emergent structure based on mutual engagement, joint enterprise, and shared repertoire, which focused on individual learning (Lave and Wenger, 1991)
Managed		Swan, et al. (2002), Huang, et al. (2002), Coakes and Smith, (2007), Scarso and Bolisani (2007), Pemberton, et al. (2007), Garavan, et al. (2007), Pastoors (2007), Probst and Borzillo (2008), Autio, et al. (2008), Gertler (2008), Borzillo (2009), Corso, et al. (2009), Macpherson, et al. (2009), McDermott and Archibald (2010)	Handzic (2004), Tallman, et al. (2004), Wohlfart et al. (2006), Gausdal (2008), Akkerman, et al. (2008), Du Plessis (2007; 2008), Chanal and Kimble (2010), Knockaert and Spithoven (2009)	More complicated, modern organizational relationships result in the need for CoPs to be actively managed and given specific goals and responsibilities. Management implies high levels of control, which arguably stifles creativity, sharing and self-initiative (Andriessen and Verburg, 2004)
Cultivated	Amin and Roberts (2008), Moingeon, et al. (2006), Cox (2005), Roberts (2006), Li, et al.(2009)	Brown and Duguid (1991; 2001), Orr (1991), Lesser and Prusak (1999), McDermott (1999), Hildreth, et al. (2000), Wenger, et al. (2002), Ackerman, et al. (2003), Lesser and Stork (2004), Kimble and Hildreth, (2005), Loyarte and Rivera (2007), Juriado and Gustafsson (2007), Hildrum, (2007), Nicholls and Cargill (2008), Keil, et al. (2008), Scarso, et al. (2009), Zboralsk (2009)	Dewhurst and Cegarra Navarro (2004), Smedlund (2005), Hamburg (2008), Mason, et al. (2008)	Setting a strategic context and providing direction (see Table 2) rather than direct management allows CoPs to find a legitimate place within an organization. Cultivation implies less control, allowing CoPs to retain much of their independence whilst still receiving appropriate organizational support (Wenger, et al. 2002).

As SMEs possess fewer resources than larger firms (Tödtling, 2001), they might compensate for their lack of resources by utilizing networks (Partanen et al. 2008) such as CoPs, to support knowledge management and innovation and, therefore, benefit SMEs because both cost and risk are minimized and the value-added to the organization is high (Du Plessis, 2008). At the same time, there is a question regarding whether SMEs can spare the necessary resources required for cultivating CoPs (Roberts, 2006). Attempts to cultivate CoPs might not be feasible for SMEs because such activity diverts resources away from core business activities (Pattinson, Preece and Scott, 2011).

Research into CoPs that is focused across the boundaries of large, multi-national organizations, such as that of Scarso and Bolisani (2007), recognizes the paradox of using CoPs to support knowledge exchanges within single organizations as well as in inter-firm environments. They state that, although CoPs appear to be an important tool for exploiting knowledge islands inside organizations, their application is more difficult if the parties are too distant, or too independent, thus representing an emerging challenge for scholars and practitioners. The construction of CoPs across organizational boundaries also presents particular difficulties in science-based SMEs, not only because of lack of shared repertoire. Lack of trust, as well as limited resources, might also be issues preventing SMEs' participation in networks such as CoPs that tend to be formulated as informal rather than formal agreements (Braun, 2006). It is, therefore, important to consider the role of inter-organizational CoPs in supporting innovation.

3.6 INTER-ORGANIZATIONAL CoPs AND INNOVATION

Wenger's (1998) research focused on CoPs within individual organizations and failed to acknowledge that a lot of scientific research and technological development work is now done between organizations. The general criticism of this initial analysis is that CoP theory is amorphous, group-centric and inward looking (Assimakopoulos, 2007). In other words, the traditional view of CoPs is that members are closely connected and have few external linkages outside of their immediate organization. CoP theory therefore ignores the inter-organizational networks and relationships that are required in complex, technology-rich, innovation-driven, knowledge intensive organizations, where research and

development is organized at distributed locations and moreover CoP theory: 'seems to downplay the centrality and power of some actors and relevant social groups in the shaping of distributed complex technologies' (ibid, p.31)

The argument for the support and development of inter-organizational communities of practice (IOCoPs) is taken up and discussed by Moingeon et al. (2006, p.2) for whom CoPs 'have traditionally been... the gathering of colleagues from the same firm'. They go on to consider that CoPs can also bring together professionals who belong to different organizations, and that 'for the organization, IOCoPs indirectly represent a powerful monitoring and innovation force, making both knowledge production and distribution easier' (Moingeon et al. 2006, p.13). They acknowledge that innovation not only occurs within the boundaries of organizations but consider that most innovation occurs: 'in the interstices between firms, universities, research laboratories, suppliers and buyers' (ibid, p.13). Allee (2000) supports this view, stating that if CoPs emerge in the social space between project teams and knowledge networks, they could be beneficial in supporting learning communities that extend both inside and outside organizational boundaries. In the next section I discuss the role inter-organizational CoPs play in three key areas: supporting knowledge sharing and acquisition, building social capital and supporting innovation across organizational boundaries.

3.6.1 Knowledge sharing and acquisition across organizational boundaries

It is claimed that knowledge sharing leads to knowledge acquisition (Ngah and Jusoff, 2009) and, as the nature of knowledge in SMEs is almost entirely tacit (Cohen and Kaimenakis, 2007), it has been further suggested that CoPs provide a suitable vehicle for knowledge management in SMEs who have limited resources (Hamburg, 2008) and no formal strategy for developing, capturing, disseminating, sharing, or applying knowledge (Beijerse, 2000). Hildreth et al. (2000) discuss distributed, i.e. inter-organizational, CoPs and their importance in relation to moving organizations: 'beyond the established practices of capturing and codifying hard knowledge' (ibid, p.36). They view hard, or explicit, knowledge as knowledge that is easily articulated, captured and codified by the organization.

Soft or tacit knowledge, on the other hand, is less easily articulated or acquired. Each type of knowledge has different characteristics. Explicit knowledge, which can be codified (that is, expressed in numerical, textual or graphical terms) and, therefore, is more easily communicated and acquired by others, for example, the design of a product; Tacit or implicit knowledge, which is personal, experiential, context-specific and hard to formalize and communicate, for example, how to ride a bicycle (Tidd and Bessant, 2009, p.543). Hildreth et al. (2000) review hard and soft knowledge in relation to CoPs, identifying it as a dichotomy (Swan, Newell, Scarbrough and Hislop, 1999), or lying on a continuum (Leonard and Sensiper, 1998).

Nonaka (1991) advocates a similar view, seeing both types of knowledge as complimentary (Martin, Hatzakis and Lychett, 2004). Nonaka (1991) posits that tacit knowledge consists partly of technical skills gained through experience, whilst at the same time having an important cognitive dimension. This cognitive dimension consists of mental models, beliefs and perspectives that are so ingrained they are taken for granted and are, therefore, difficult to articulate. The stickiness of information or knowledge raises a number of issues related to innovation, including patterns in the diffusion of innovation, the specialization of firms, the locus of innovation, and the nature of problems selected by problem solvers.

Von Hippel (1994), for example, argues that firstly, when sticky knowledge or information required by problem solvers is held at one site only, the problem solving will be carried out at that locus, other things being equal. Secondly, when more than one locus of sticky information is required by problem solvers, the locus of problem solving may iterate among these multiple sites as problem solving proceeds. Thirdly, when the costs of the iteration are high problems that require multiple sites of sticky information will sometimes be 'task partitioned', i.e. divided into smaller, sub-problems, each of which will then draw on only one such locus. Fourthly, this will result in investments will be made to reduce the stickiness of information at some locations.

However, participation in intra-firm knowledge sharing activities is notoriously difficult because it is dependent on community members' willingness to share on a voluntary basis share their experiences and insights (Hildreth and Kimble, 2000;

Kogut and Zander, 1996; Von Hippel, 1998; Von Krogh, Ichijo and Nonaka, 2000; Wenger, 2000). In their work on user-led innovation, Franke and Shah (2002) studied patterns of user-led sharing of innovation in four communities of serious sports enthusiasts. Innovators in these user-led communities operated on the basis of 'generalized exchange' which they explain: 'is not conditional, [and] there is an expectation that if a community member provides assistance today, someone else will provide him with assistance when he needs it' (ibid, p.173). They observed that members shared their innovations freely within their respective community. Users rather than manufacturers were considered to be responsible for most innovations and that these users could be considered to be a metaphor for emergent inter-organizational CoPs.

Other examples cited by Von Hippel (2002) of organizations freely sharing knowledge with user-led communities include Von Hippel and Finkelstein (1979), who found this practice among users of clinical chemistry analyzer equipment produced by the Technicon Corporation; Allen (1983), who found furnace design information openly revealed by iron producers in the 19th century iron-making industry; Lim (2000), who reports that IBM freely revealed information on its copper interconnect semiconductor process and equipment innovations to equipment manufacturing firms and thereby to competing users and finally Morrison, Roberts and Von Hippel (2000), who found improvements to library information software freely revealed by libraries.

Although focused on large organizations rather than SMEs, these examples demonstrate that free sharing of knowledge and innovations is not a new concept and, certainly, the work of both Von Hippel (1994) and Franke and Shah (2003) highlights some of the issues related to sharing sticky knowledge as well as acknowledging the importance of collaboration and open innovation approaches to innovation. Allee (2000) suggests that inter-organizational CoPs might provide a mechanism to support knowledge sharing between organizations, but acknowledges that, because communities have looser bonds than other types of networks, organizations need to develop new techniques for constructing CoPs. Furthermore, Du Plessis (2008) suggests that CoPs in SMEs are used as learning entities where the transfer of tacit knowledge into explicit knowledge becomes a critical resource for innovation (Stephenson, 2006).

So, if webs of trust are built through social exchanges (Fukuyama, 1995; Putnam, 1993), then CoPs might help foster the interpersonal interactions necessary for knowledge sharing (Lesser and Prusak, 1999). CoPs have the potential to provide a safe enclave where members can share challenges, ask sensitive questions, test on-going ideas and expose their ignorance (Lesser and Storck, 2004; Wenger et al. 2002). Allee (2000) agrees that the culture and conditions for knowledge sharing must evolve in organizations that wish to successfully tap into the potential of CoPs.

In their conceptual paper, Coakes and Smith (2007) define 'Communities of Innovation' (CoIs) as a type of CoP dedicated to the support of innovation. They suggest that such CoIs can be cultivated through the efforts of 'innovation champions' leveraging their social networks, transforming them into CoIs, thus providing a safe haven for the creation and support of innovation. Innovation champions are considered to be people with: 'particular personality types and psychological profiles' (ibid, p.2). In order to successfully champion innovations in organizations, champions need procedural and resource support, as well as social and cognitive support. The influence of such innovation champions comes through social contacts, which is multiplied through the CoPs they participate in, and through the genuine respect in which they are held.

Innovation champions exhibit high levels of social presence, often associated with successful community building (Rovai, 2002). CoIs are considered by Coakes and Smith (2007) to transcend organizational boundaries and support collaboration with other communities, organizations, and also communities *in* other organizations. They also ensure that knowledge sharing becomes part of both the community's processes and cultural norms that often operate outside of the formal organization. SMEs might still benefit from cultivating innovation champions if they can identify individuals who exhibit high levels of social presence and encourage them to harness their existing networks. However, as previously noted, SMEs have limited time and resources and, therefore, might have difficulty providing prospective innovation champions with the necessary support to make them effective.

Brown and Duguid's (2001) work is also concerned with knowledge sharing, and they examine the paradoxical nature of 'sticky' and 'leaky' knowledge. Sticky knowledge refers to the internal knowledge of the organization that is often

considered difficult to disseminate internally. Leaky knowledge, on the other hand, is concerned with the flow of knowledge out of an organization, which is often considered to be undesirable. For Brown and Duguid (2001), an organization's knowledge base not only exists internally but also draws on its embeddedness in external structures. This embeddedness means that knowledge might flow out of an organization more easily than move productively within it. By focusing on practice within CoPs, it is possible to understand the flow of new knowledge in and out of an organization. They conclude that coordinating an organization around knowledge and practice, a demanding strategic task, is very different from coordinating an organization around more conventional routes, and has a direct impact on helping to uncover the innovative potential and challenge in all firms.

Whereas Allee (2000) suggests a new organizational culture for supporting CoP development, Brown and Duguid (2001) claim that focusing on the organization as a cultural unit: 'tends to over determine the contribution of often quite distant structures to groups of people with quite distinct practices' (ibid, p.201). In other words, there are factors, such as social context, that might exert influence on knowledge sharing between inter-organizational CoPs. Simm and Ferdinand (2006) discuss the importance of 'sticky' and 'leaky' knowledge in relation to inter-organizational relations and learning across organizational boundaries, where sticky knowledge is hard to move to other parts of an organization and leaky knowledge moves too easily outside of the organization.

Simm and Ferdinand (2006) see inter-organizational collaboration as one way to secure the complementary assets needed to turn innovations into commercial successes. They suggest that by focusing on social practice that is informed by social and cultural studies of knowledge and learning, the evident paradox of sticky and leaky knowledge is overcome. Thus, knowledge is re-positioned as closely related to actual practices within a CoP. The result is that knowledge circulates both internally and externally through networks of associations and is not a property of any particular firm.

Knowledge management plays an important role in the acquisition of new knowledge and innovation (Du Plessis, 2008), especially with regard to converting tacit into explicit knowledge. It provides a focus within the organization on the value

of tacit knowledge and helps in creating a suitable environment for tacit knowledge creation, sharing and leverage to occur. According to Du Plessis (2008), a good example would be through creation of communities of practice around areas of innovation that requires attention in the organization. This view can be likened to that of Cohen and Levinthal (1990), who discuss the importance of external knowledge to the innovation process. They see the 'ability to exploit external knowledge [as] ... a critical component of innovative capabilities' (ibid, p.128).

Cohen and Levinthal (1990) introduced the concept of absorptive capacity, which refers to an organization's ability to recognize the value of new, external information, assimilate it, and apply it to commercial advantage. They suggest that SMEs need to develop the dynamic capability of recognizing and acquiring new external knowledge from different sources, assimilate it, and apply it to develop innovation in terms of new products or services. The premise of absorptive capacity is that it requires prior related knowledge in order to assimilate and use new knowledge:

> At the most elemental level, this prior knowledge includes basic skills or even a shared language but may also include knowledge of the most recent scientific or technological developments in a given field. Thus, prior related knowledge confers an ability to recognize the value of new information, assimilate it, and apply it to commercial ends. These abilities collectively constitute what we call a firm's 'absorptive capacity'.
>
> (Cohen and Levinthal, p.128)

Tidd and Bessant (2009, p.257) see absorptive capacity as 'an important construct because it shifts our attention to how well firms are equipped to search out, select and implement knowledge'. The existence of CoPs within organizations facilitates knowledge sharing. This suggests that inter-organizational CoPs might play an important role in supporting knowledge management and innovation by supporting the transfer and sharing of tacit knowledge.

Inter-organizational networks, generally, play an important role in the development of innovation and, according to Chesbrough (2003), there has been an acceleration in the number of organizations moving towards systems of open innovation. The open innovation model is a paradigm that assumes that firms can and should use external

ideas as well as internal ideas, and internal and external paths to market, as they seek to innovate and advance their technology. Open innovation transforms internal and external ideas into architectures and systems whose requirements are defined by a business model. As Chesbrough (2003) explains:

> 'the business model utilizes both external and internal ideas to create value, while defining internal mechanisms to claim some portion of that value. Open innovation assumes that internal ideas can also be taken to market through external channels, outside the current businesses of the firm, to generate additional value' (ibid, p.24).

Open innovation allows organizations to manage the rich network of relationships, both internally and externally (Dahlander and Gann, 2008). In this situation, the challenge for organizations is to manage the flows of knowledge internally and externally. There are clear links between open innovation and absorptive capacity, particularly with reference to their focus on sourcing and the exchange of externally developed knowledge (Vanhaverbeke, Cloodt and Van de Vrande, 2007).

However, as previously noted, SMEs are often deficient in absorptive capacity because they lack a formal knowledge management strategy (Beijerse, 2000) and struggle to participate in open innovation, because of knowledge transfer problems caused by organizational and cultural differences (Van de Vrande et al. 2009). SMEs are often unreceptive to knowledge sharing because of lack of trust, internal conflicts, motivation issues and the lack of sharing mechanisms (Hamburg and Marin, 2010). It is also clear that open innovation and absorptive capacity are dependent on effective knowledge sharing and acquisition, and it is in these circumstances that CoPs add value to organizations because they contribute to the development of social capital which, in turn, is a necessary condition for knowledge sharing and acquisition (Lesser and Prusak, 2000).

In the next section I elaborate on the link between social capital, innovation and communities of practice.

3.6.2 Building social capital

Social capital describes the connections within and between social networks, including CoPs; the implication being that such networks have (and add) value to

society and organizations. In this sense, social capital is defined as both the resources that personal contacts hold, and as the structure of contacts within a personal network (Burt, 1992). Putnam (2000) cites Hanifan (1916) as coining the phrase to explain the importance of community involvement in sustaining democracy and economic development:

> The individual is helpless socially, if left to himself. If he comes into contact with his neighbor, and they with other neighbors, there will be an accumulation of social capital, which may immediately satisfy his social needs and which may bear a social potentiality sufficient to the substantial improvement of living conditions in the whole community. The community as a whole will benefit by the cooperation of all its parts, while the individual will find in his associations the advantages of the help, the sympathy, and the fellowship of his neighbours.
>
> (Hanifan, 1916, p.130)

Social capital theory has been criticized for being poorly designed and conceptualized. This criticism is mostly due to issues related to the multi-dimensional nature of social capital (Hean, Cowley, Forbes, Griffiths, Maben and Murrells, 2002). Bourdieu (1983:1984), Coleman (1994) and Putnam (2000) are the three main theorists cited in terms of developing the concept of social capital. Writing from within a broadly Marxist framework, Bourdieu (1983) distinguishes between three types of capital - economic capital, i.e. cash and other tangible assets; cultural capital, i.e. education, knowledge and skills and social capital, i.e. networks of relationships.

Bourdieu (1983) argues that social capital functions as the tool of an elite class who use it to maintain their superior class position in society. Coleman (1988), on the other hand, adopting an arguably over-optimistic view, describes social capital in terms of a public good that even marginalized communities and individuals can benefit from. In economics, a public good is a good that is non-rivalrous and non-excludable. Non-rivalry means that consumption of the good by one individual does not reduce availability of the good for consumption by others; and non-excludability that no one can be effectively excluded from using the good (Varian, 1992). Field (2008) contrasts these two views suggesting that Bourdieu's treatment of social

capital is somewhat circular and boils down to the thesis that: 'privileged individuals maintain their position by using their connections with other privileged people' (ibid, p.31). On the other hand, Field (2008) considers that Coleman's view is more nuanced in that he sees the value of connections for both individuals and the collective, whether they are privileged and disadvantaged.

Putnam (2000) also adopts a positive view of social capital, advocating it as a means to combat the many social disorders, such as crime, that are inherent in modern society. For Putnam, the networks that constitute social capital serve as conduits for the flow of knowledge. In 'Bowling Alone' (2000), Putnam considers that social capital refers to the connections among individuals – the social networks and the norms of reciprocity and trust that arise from such relationships. He links social capital closely to the notion of 'civic virtue'. The main difference here is that social capital reflects the fact that civic virtue is most powerful when it is embedded in a network of reciprocal social relations. In other words, a society of many virtuous but isolated individuals is not necessarily rich in social capital.

Social capital, therefore, relies on a social network of relationships and is summed up by Field (2008) in two words: 'relationships matter'. Connections, developed over time, enable individuals to work together to achieve things they could not achieve in isolation, or that could only be achieved alone with great difficulty or at an extra cost (Nahapiet and Ghoshal, 2000). These connections are made through a series of social networks, within which individuals tend to share common values. In essence such networks constitute a resource, a form of capital, which can be drawn on by its members. More recently, social capital has gained popularity amongst economists (Lesser and Prusak, 1999) as a term to describe intangible forms of capital, allowing researchers to tackle issues from a new perspective, such as the importance of maintaining a regional perspective in social capital analysis (Ferragina, 2010). In this sense, social capital is viewed as an organizational asset in the same way as other forms of capital.

However, this analogy can be misleading in that social capital is not depleted through use (Ostrom, 2000), rather it is likely to be depleted through *lack* of use (Mohan and Mohan, 2002). Social capital has been linked with an organization's ability to manage its knowledge resources and Nahapiet and Ghoshal (2000) suggest

that social capital encourages: ‘cooperative behaviour, thereby facilitating the development of new forms of association and innovative organization. The concept, therefore, is central to the understanding of institutional dynamics, innovation and value creation’, (ibid, p.245).

The importance of social capital as a contributor to innovation has been the focus of much theoretical discussion. Research in this area has linked the acquisition of knowledge not only with markets or hierarchy, but with ‘the social capital accumulated within regions through networks of interaction and learning’ (Landry et al. 2002, p.3). Indeed, supporters of social capital theory argue that it provides capabilities for creating and sharing knowledge that improves innovation capability. Putnam (2000) cites two types of social capital: bridging social capital and bonding social capital. Bonding social capital refers to the value assigned to social networks made up of homogeneous groups, whereas bridging social capital refers to the value assigned to networks made up of heterogeneous groups.

Lesser and Prusak (2000, p.256) describe structural, relational and cognitive dimensions of CoPs to explain how they support the development of social capital. The structural dimension emphasizes how CoPs encourage networks to grow among individuals with similar interests. Structurally, a community can serve as a means to link individuals, as a reference mechanism for evaluating the knowledge of other individuals without having to contact them directly. It also acts as a pipeline for connecting CoP members to people outside the immediate network. The relational dimension provides a way of testing the value and commitment of individual CoP members, and is linked to generating high levels of trust between the members. The cognitive dimension includes using shared artefacts’, stories and jargon within the CoP. These dimensions help to improve organizational performance by supporting CoP members in managing their own knowledge and in encouraging participation.

Lesser and Storck (2004) argue that the social capital resident in CoPs leads to behavioural change, resulting in greater knowledge sharing which, in turn, positively influences organizational performance. They suggest that a cohesive community, such as a CoP, might act as an engine for the development of social capital, and that social capital decreases the learning curve, increases responsiveness to customer experiences, reduces rework and prevents reinvention, and increases innovation. If

the social capital resident in CoPs positively influences knowledge sharing and innovation, then an important question is, why, theoretically, knowledge sharing and CoPs in science-based SMEs should be any different from in large firms?

Trust plays a significant part in providing the necessary conditions for knowledge sharing (Scarbrough et al. 1999). Trust and reciprocity facilitate organizational learning, thus lowering the transaction costs involved in knowledge exchanges (Dyer and Singh, 1998). It is also an essential element of social capital (Fukuyama, 1995; Granovetter, 1985; Putnam, 2000) and CoPs (Lesser and Prusak, 1999; Probst and Borzillo, 2008; Wenger, 1991; Wenger et al. 2002), as well as being fundamental for successful open innovation (Aylen, 2010; Chesbrough, 2003). Reciprocity is an important element of community participation and members of a CoP have a sense that making the community more valuable is to the benefit of everyone; they know that their contribution will come back to them (Wenger et al. 2002). Trust promotes cooperation, especially in large organizations (La Porta, Lopez-de-Silanes, Shleifer and Vishney, 1997), but presents particular difficulties for SMEs in that a lack of trust might be an issue in networks such as CoPs that tend to be formulated as informal rather than formal agreements (Braun, 2006).

Harding and Pawar (2000) posit that lack of trust manifests itself in fear, at both a personal and organizational level[3], and is a strong inhibiting factor for knowledge sharing in SME networks where individuals fear losing their 'expert status' (Wohlfart, Sturm, Wolf, Slagter and Emshanova, 2006) and organizations fear losing their competitiveness (Meeus and Oerlemans, 2000). Harding and Pawar (2001) studied 'know-how' transfer in 'heterogeneous' networks (i.e. different types of SME network) in the manufacturing sector, and examined the benefits networking brought in terms of competitiveness to the regional economy of the West Midlands. The main challenge for SMEs was building trust and developing strong personal relationships with other, often competing, organizations. Their research was based on a longitudinal study of twelve SME networks over a period of 18 months. It involved two types of network: the 'World Class Network' (WCN), a thematic (based on a particular business theme) network whose objective was to disseminate

[3] For the individual it is a fear of losing employment and for the organization it is a fear of losing business or going out of business (Harding and Pawar, 2000).

best manufacturing practice and the 'ADAPT Club', a horizontal (general interest) network seeking to build a general sense of place, allowing members to share their experiences.

Their preliminary findings were used to develop a network-based taxonomy of small manufacturing firms. Within the taxonomy vertical networks are based on associations of supplier firms. Horizontal networks are based on the 'industrial district' model where firms self-organize along horizontal lines. Thematic networks are, as the title implies, based on particular business themes. Heterogeneous networks contain different types of firms, whereas homogeneous networks are made up of firms from the same sector/industry.

An open horizontal network is, perhaps, the more appropriate for sharing tacit knowledge and can also be viewed as a form of CoP because of its flexible and open membership. Welter, Kautonen, Chepurenko, Malieva and Venesaar (2003), discussing the role of trust in SME networks within regional clusters, indicate that there are differences in SME approaches to collaborative practice across countries, regions and even within industrial sectors. This perspective suggests that SMEs often refrain from participating in innovation networks, particularly with new partners, because of the increased risk to their competitiveness (Mees and Oerlemans, 2003).

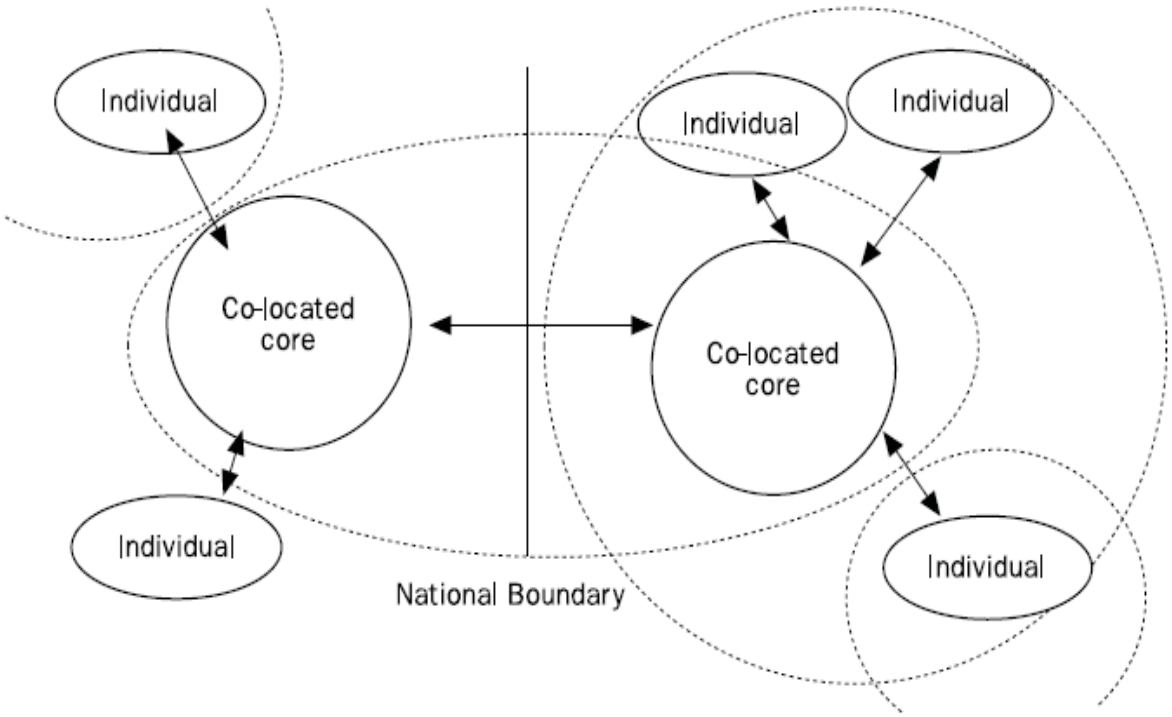
For SMEs participation in inter-firm networks, such as CoPs, is an issue because they fear opportunistic behaviour from competitors, which prevents reciprocal behaviour (Braun, 2006). For science-based SMEs, issues related to the appropriability of their innovations, e.g. enforcing intellectual property rights, suggests that a lack of trust, rather than resources, presents the most likely barrier to innovation through collaborating in CoPs. It has already been noted that social capital describes the links within and between social networks, including CoPs, and Hildreth et al. (2000) cite a variety of authors, including Brown and Duguid (1991), Manville and Foote (1996) and Brown and Solomon Gray (1998); all of whom have attempted to extend or redefine Wenger's original theory in relation to a distributed environment, i.e. CoPs that span geographical or organizational boundaries. In the next section I discuss the importance of inter-organizational CoPs for supporting innovation in a distributed environment.

3.6.3 CoPs and innovation in a distributed environment

The main justification for the re-definition of CoPs as a type of inter-organizational network comes from the pressures of globalization, which means that many organizations now function in a geographically distributed environment where regular face to face contact is reduced (Kimble et al. 2001). This view is consistent with the shift in perspective from Lave and Wenger's (1991) original view of CoPs as a theory of informal learning, to Wenger et al.'s (2002) re-alignment of CoP theory as a management tool for innovation and problem solving between groups that are often geographically distributed (Cox, 2005). Hildreth et al. (2000) raise two key issues in the evolution of the distributed CoP (Figure 7).

Figure 7 Evolution of the distributed CoP

(Hildreth et al. 2000, p.32)



Hildreth et al.'s (2000) framework identifies a number of key issues. The first key issue is that there appears to be a three stage evolutionary process to the development of distributed CoPs. Firstly, the distributed CoP can evolve from initial informal contact between its members or an official group that is formally recognized by the organization, because of the way the members interact. Secondly, the co-located CoP

might develop links with other CoPs or individuals at a different location. Thirdly, the developing CoP might make links to similar groups, possibly in different locations abroad. The second key issue was related to the degree of distribution. The 'national boundary' demonstrates that, in this case study, a distributed CoP existed, with members based in two different countries. In this instance, legitimate peripheral participation (LPP) was not necessarily a key aspect of distributed CoPs and only occurred in CoPs that were physically co-located.

The structure of the CoP in question showed that there was a physical co-located element, i.e. a co-located core with other CoP members situated elsewhere, as well as a social periphery, indicating that co-location was still an important aspect of the CoP. There were some individuals who were in a distant location but still felt themselves to be full members of the CoP. However, because of the distance they also felt they were on a physical periphery. This limited the number of ad hoc encounters they could have with their colleagues when compared to those CoP members who worked together in the co-located core and were able to benefit from impromptu meetings. Hildreth et al. (2000) suggest little can be done to support ad hoc encounters between CoP members that are not co-located. However, shared artefacts, such as documents, can act as boundary objects to generate discussion and participation across both time and distance. According to Hildreth et al. (2000), this aspect reduces the significance of both location and peripherality. It is interesting to note that neither of the two communities studied were truly distributed, and the authors acknowledge that each community did have a co-located core.

Discussion of the physical peripherality of one CoP member based many miles away, in Japan, indicates some level of uncertainty about the relative importance of both location and peripherality. The individual was accepted as a member of the group but did not feature so much in the meetings because of the time difference between Japan and the USA. She was kept informed of plans and progress but she was not able to play as full a part as other members were. If she wanted to take part in an electronic conference, she had to participate in the middle of the night. However, she was regarded as being a full member of the group, the other members had every confidence in her ability but the physical and temporal distance meant she was in some ways a peripheral member.

In contrast, Gertler (2001) questions whether organizational proximity can ever be a surrogate for geographical proximity. Torre and Gilly (1999) explain the distinction between these two types of proximity. Organizational proximity rests on two types of logic, a logic of similitude and a logic of belonging. According to the logic of belonging, individual actors are considered to be close when they belong to the same space of relations, for example to the same firm or network. According to the logic of similitude, actors are close when they are alike, for example when they possess the same space of reference and share the same knowledge, so that the institutional dimension is also important. In the first case, it is on the effectiveness of coordination that the belonging to the same space depends; in the second case, proximity is linked to a relation of 'resemblance' of representations and modes of functioning.

On the other hand, geographical proximity can be viewed from the perspective of the relations between agents, and this is considered to be the counterpart of organizational proximity. In these circumstances geographic separation and relations are dealt with in terms of distance. Referring to a great extent to the location of firms, it integrates the social dimension of economic mechanisms, or what is sometimes called functional distance. In other words, the reference to natural and physical constraints is an important aspect of geographical proximity but other aspects are equally important in its definition, for example, the aspect of social structures such as transport infrastructures that facilitate accessibility, or the financial mechanisms that allows the use of certain communication technologies.

Morgan (2004) takes particular issue with the argument that 'geography doesn't matter', positing that organizational proximity might be a partial substitute for geographical proximity, especially for CoP members. Morgan (2004) suggests that, rather than ask which form of proximity is better, one should ask how they will co-evolve at a time when learning and knowledge networks are becoming increasingly complex and organization spanning. There is certainly evidence that physical proximity enhances knowledge spillovers (Baum and Haveman, 1997), suggesting that knowledge available to organizations operating within regional clusters (which I discuss later) may also move, albeit slowly, beyond organizational boundaries (Tallman, Jenkins, Henry and Pinch, 2004).

Amin and Roberts (2008) also discuss the issue of co-location in relation to different types of innovation and they propose a CoP typology, based on a review of over 300 publications. They attempt to differentiate between the varieties of 'knowing in action' that have been traditionally assumed to be reliant on spatial proximity. Within their proposed typology they suggest four distinct groupings of CoPs suited to undertake different types of innovation. Although Amin and Roberts (2008) offer no clear definition of what they mean by radical and incremental innovation, but they do make a distinction between different types of innovation based on the characteristics of each CoP grouping: task-craft based CoPs associated with customized/incremental innovation; professional CoPs with radical or incremental innovation that are bound to institutional or professional rules where radical innovation is generated through use of multiple CoPs; epistemic/highly creative CoPs involved in high energy radical innovation; virtual CoPs that support both incremental and radical innovation.

For each CoP grouping, the level of co-location required varies. For the task or craft-based grouping a high level of co-location is important to support face to face communication and demonstration, e.g. apprenticeships. For the professional grouping, co-location is important in the beginning to promote the development of professional status through demonstration. For the epistemic or highly creative grouping, a combination of face to face and distanciated contact is suitable. Within the virtual grouping, technology is the predominant method used to mediate communication, i.e. virtual CoPs. Amin and Roberts (2008) challenge the view that the value of face to face, or localized, interactions are any different from those formed at a distance. They identify that: 'efforts to innovate involving interactions between CoPs give rise to greater diversity and, therefore, a wider range of possible outcomes than innovation within a single CoP' (ibid, p.360).

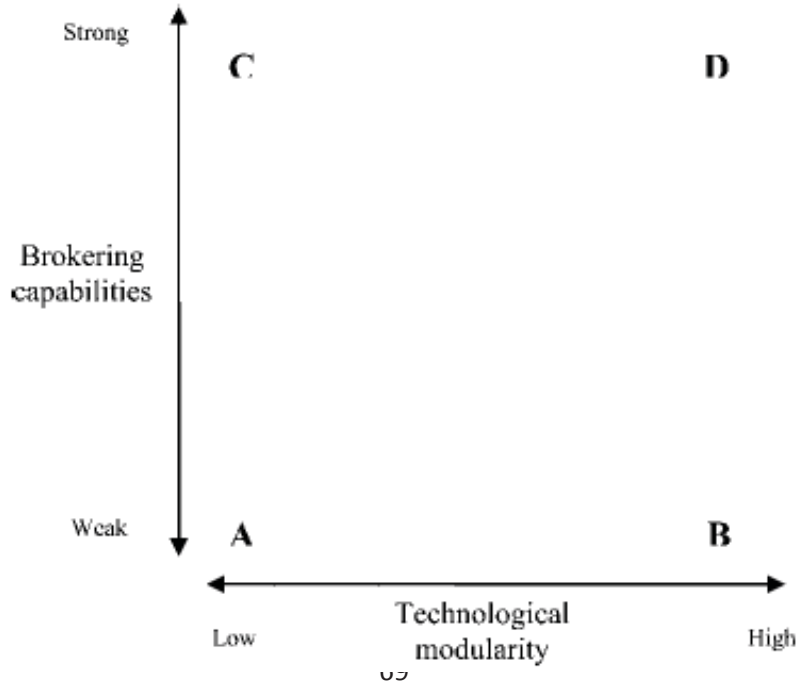
However, Amin and Roberts (2008) also propose that some differentiation is required between the varieties of 'knowing in action' that CoPs represent in relation to Wenger's original notion of situated learning. They suggest that the use of the term 'community of practice' has become imprecise within the extant literature and is now being applied to: 'social practices of all kinds in all sorts of collaborative setting and all manner of learning and knowledge outcomes are becoming folded together into one undifferentiated form' (ibid, p.355). Amin and Roberts (2008)

suggest that such homogenization of the term is unhelpful and glosses over the varieties of situated practice that exist. They propose that, if an umbrella term is to be retained, it should: 'capture the generic form of learning/ knowing in action or practice, but then stimulate effort to name its various forms with clarity and precision' (ibid, p.355). In other words, they ask whether CoPs support a specific mode of learning and knowing.

Hildrum (2007) also examines the role of face to face interactions between distributed CoPs that operate within specific innovation projects. Hildrum states that a: 'key feature of innovation projects is that they entail members from several distinct CoP[s]' (ibid, p.468). In other words, participants in an innovation project might also be members of multiple CoPs. Hildrum (2007) develops a theoretical model based on the concept of technological modularity, i.e. production systems that can be decomposed into a number of components that may be mixed and matched in a variety of configurations (Schilling, 2000), which he takes from the product-development literature and the concept of brokers from the literature related to CoPs. He uses this model to explain why some innovation project teams need regular face to face contact to efficiently co-create new technologies, whereas others do not. By combining the literature on brokers with the concept of technological modularity, Hildrum (2007) develops a Project Collaboration Space model (Figure 8).

Figure 8 A project collaboration space

(Hildrum, 2007, p.472)



Where projects display the characteristics of location A, frequent face-to-face interactions are likely to be crucial for project success. Being short of brokering capabilities such projects are prone to experience recurrent communication problems, and this requires concentrated face-to-face interactions. In addition, the projects' non-modular task structures are likely to translate single technical problems into multiple and interdependent problems, intensifying the need for face-to-face contact. Projects that display the characteristics of location B are also liable to require a high volume of face-to-face interactions, but less so than those at location A. The lack of brokering capabilities increases the likelihood of communication problems, but the modular task structure allows the project members to solve many of these problems locally without having to organize many face-to-face meetings.

Similarly, projects with the characteristics of location C are likely to need a moderate degree of face-to-face interactions. Here strong brokering capabilities reduce communication problems but the non-modular division of labour is likely to intensify the severity of any difficulties that do occur. This means that intensive face-to-face meetings are likely to be necessary at certain times during projects but not on a permanent basis as in location A. Finally, projects that display the characteristics of location D might be organized in entirely virtual settings, requiring few face-to-face interactions. The project's strong brokering capabilities reduce the potential for serious communication problems and allow the project group to co-operate efficiently via remote media. The modular task structure enables project members to solve many problems locally, without having to arrange many face-to-face meetings.

The model shows that the level of brokering capabilities combined with the level of technological modularity has a direct effect on the frequency of face to face contact that is required. Hildrum's (2007) model indicates that projects which develop high levels of technological modularity together with strong brokering capabilities are more likely to operate successfully in a distributed location. In an organizational context, modularization of a firm's structure can facilitate the coordination of innovation activities via an 'information structure' rather than managerial authority (Sanchez and Mahoney, 1996). In these circumstances, CoPs could effectively support both brokering capabilities and the modularization of organizational design.

Swan et al. (2002) focus on the construction of CoPs across both professional and organizational boundaries. Their study focuses on Medico, a large multinational company, and their radical innovation in the treatment of prostate cancer. Swan et al. (2002) attempt to contribute to the debate regarding the manageability of CoPs by examining the introduction of a new treatment for prostate cancer. This process entailed introducing significant changes to both medical and organizational practice within Medico, the organization studied. They argue that if organizations are comprised of multiple and a differentiated CoPs, the main organizational task becomes one of 'coherence finding'. In other words: 'finding the most productive local experiments and insight and turning them into broader systems of organizational innovation' (ibid, p.479). They consider the flow of organizational knowledge to be closely linked to the social relations that develop through shared practice that is, in turn, supported by CoPs.

In these circumstances, it is the task of the manager to nurture these social relations in order to promote the flow of knowledge. Swan et al. (2002) claim that the generally positive view of CoPs within the knowledge management literature exists, because most of the examples studied have been of incremental innovation. Radical innovation, on the other hand, requires the embedding of new knowledge and work practices as well as the disembedding of old ones. They support the view of Moingeon et al. (2006), in that innovation generally, and radical innovation in particular, often occurs at the interstices of CoPs, where they can also encompass the integration of new knowledge with embedded knowledge.

For organizations that wish to innovate, there are two clear imperatives; support the development and circulation of knowledge within communities and pursue alignments across communities. Aligning practice implies a critical shift for managers' roles towards that of facilitators who can construct and support CoPs. This shift could be through brokering roles as suggested in the work of both Hildrum (2007) and Swan et al. (2002), who view power as a relational characteristic implicit in the social practices of communities and see power as integral to managers' attempts to construct CoPs. This perspective also helps make sense of how managers' interact with other networks of practice or professional groups. It is worth noting that Swan et al. (2002) distinguish between networks of practice and CoPs,

claiming that networks of practice (NoPs) play a critical role in the innovation process by engendering shared identity.

However, they suggest that networks differ from CoPs because they are bound by formal institutions and governance which control certain elements, similar to professional bodies, such as membership of the network. Here they adopt Brown and Duguid's (2001) definition of a network of practice, which they describe as:

> …epistemic networks where practice creates the common substrate... [but] relations among networks members are significantly looser than those within a community of practice. Such networks are seen as critical to innovation because they allow the emerging local knowledge of particular groups to be accessible to others within the broader epistemic culture.
>
> (Swan et al. 2002, p.480)

The main problem with networks of practice is that they produce a different epistemic culture, linked to their social identities, which might encourage the flow of knowledge within networks but restrict the flow of knowledge between networks. From this position, Swan et al. (2002) posit that such networks can constrain innovation processes that rely on integrating knowledge across networks. It is also suggested by Swan et al. that professional groups involved in innovation are often resistant to change because of their vested interest in maintaining control over their particular domain of knowledge or because they wish to protect their professional standing. Radical innovation, in a professional context, therefore, presents a considerable challenge to managers. In this situation, Swan et al. (2002) argue that the struggle of professionals to maintain their power can prevent the mobilization of knowledge and the commitment required to drive innovation. In such circumstances, CoPs might be used as a rhetorical device for dealing with competing interests within the professional groups involved in radical innovation projects. Here, the rhetoric of 'community' is seen as a boundary object, as previously discussed by Hildreth et al. (2000). Medico, the organization studied by Swan et al. (2002), acted as a 'system builder', working in an improvised way across professional and organizational boundaries and transforming their business motivations in the process of community building. By acting in this way they were eventually able to achieve a

level of influence within the radical innovation process which might have been unattainable through more conventional means.

The traditional view of CoPs is that they are more suited to supporting incremental rather than radical innovation (Amin and Roberts, 2008). However, the work of Swan et al. (2002) demonstrates that CoPs can be used to mobilize external or inter-organizational networks by using them as a rhetorical device, focused, in this instance, on a disease. For Medico, this approach provided a rationale for cross-disciplinary working between CoPs in a multinational science-based organization and helped mitigate any inter-professional conflict. Swan et al. (2002) posit that, although NoPs share many features associated with Lave and Wenger's (1991) original CoP theory, they differ in that they are bounded by formal institutions and governance structures that control some elements, such as membership.

The gathering of external knowledge is vital for SMEs (Chen, Duan, Edwards and Lehaney, 2006) and, as I have shown in the previous sections, CoPs help support common interests and develop mutual trust that contribute to the creation of social capital within SMEs (Dewhurst and Cegarra Navarro, 2004). A study of SMEs in the Spanish optometry sector by Dewhurst and Cegarra Navarro (2004) found that the presence of inter-organizational CoPs improved organizational learning so there is evidence that inter-organizational CoPs provide benefits to SMEs. The same research also found that meetings and collaborations with customers to improve products and services and informal activities (e.g. dinners, lunches, and visits), helped to foster innovation in SMEs. The SMEs in Dewhurst and Cegarra Navarro's (2004) study focused on these more traditional aspects of CoPs, i.e. informal activities such as lunches and visits, whilst arguably undervaluing the innovation aspects. Although they do not provide a definition of SMEs in their paper, they do acknowledge that their conclusions might not be generalizable in SMEs in other industries outside of the Spanish optometry sector and concede that organizational learning might be different in other cultures. However, this research offers an interesting example of a successful inter-organizational CoP being constructed by an SME.

Nevertheless, the application of CoP theory in an inter-organizational context raises several difficulties (Soekijad and Huis in 't Veld, 2002) such as the fear of

opportunistic behaviour (Larsson, Bengtsson, Henriksson Sparks, 1998), lack of openness, and a lack of shared understanding (Soekijad et al. 2004). However, while much of the research on inter-organizational CoPs suggests that there are complex issues related to their manageability, there are also indications that it is possible to leverage innovation capability successfully through their careful cultivation. It has further been suggested (de la Mothe and Paquet, 1998) that the concept of regional systems of innovation might be built on the notion of CoPs and I explore this concept in greater depth in the following section.

3.7 CoPs AND REGIONAL CLUSTERS

The term regional cluster was popularized by Porter (1990) who claimed clusters have the potential to affect competition by increasing productivity, driving innovation and stimulating new business start ups. Porter (1990) also argues that knowledge spillovers within regional clusters stimulate economic growth and that localized competition enhances innovation. He cites, as examples, the Italian ceramics and jewelry industries, where hundreds of firms are co-located but still compete fiercely in their innovation activities, since the alternative to innovation is demise. The study is based in the Northeast of England where the Northeast of England Process Industry Cluster (NEPIC) supports a host of related science-based businesses, including biotechnology, pharmaceuticals and chemical processing. One of the cluster's aims is to promote collaborative approaches to innovation and this section examines how CoPs support knowledge sharing and innovation within regional clusters.

According to Cooke and Huggins (2002), regional clusters are groups of firms that are geographically proximate in vertical and horizontal relationships involving a localized enterprise support infrastructure. This infrastructure shares a vision for regional growth based on competition and cooperation in a specific market field. Cooke and Huggins (2002) see regional clusters as dynamic and displaying shared characteristics such shared identity and future vision that generates turbulence, as firms spin-off, spin-out and start up from other firms or institutions. They suggest clusters help develop dense and changing vertical input-output linkages, supply chains and horizontal inter-firm networks. Localized, third party representative governance associations develop that provide common services but also lobby

government for change. Cook and Huggins (2002) consider that over time, clusters can display features of emergence, dominance and decline.

Hendry, Brown, Ganter and Hilland (2003) assert that: 'the capacity for innovation in a national economy is both derived from and embedded within the structures that support it' (ibid, p.117). They cite Harding (1999) for examples of these structures, which include public and private funding arrangements, education-industry links and basic and applied research institutes. They also suggest that the geographical clustering of firms and related institutions is an important factor in terms of the economic development and competiveness of a region. For Hendry et al. (2003), clusters operate in: 'transaction-intensive regional economies that are linked in structures of interdependency stretching across the globe' (ibid, p.165). In other words, regionally based organizations should not be viewed as operating solely within the local economy; they might be part of a national or international economic network. In relation to innovation, regional clusters might even act as a substitute for expensive in-house research and development, if members can find a way to share tacit knowledge via CoPs.

Nooteboom (2006) distinguishes a cluster from other more general networks on the basis that clusters require localized embedding, He categorizes embedding as operating on three levels. Firstly, institutional embedding is concerned with the impact of regulation and norms of conduct, taxes, subsidies, legal system, infrastructure, schooling, research, labour market, etc. Secondly, structural embedding derives from the social network literature. Structural features of networks are size (number of participants), density (actual number of direct ties as a ratio of the maximum possible number), centrality (of which there are several forms), and stability of structure (rate of entry and exit). Thirdly, relational embedding appears in the social network literature in the notion of the 'strength of ties', but is developed in more detail in the literature on alliances or inter-organizational relations.

For Nooteboom (2006), innovation clusters require local embedding; although it is unclear how local embedding can be achieved. He does concede that embedding, in the sense of linkages between activities, does not have to be tied to location, and might also occur in communities that are: 'to some extent virtual, with communication at a distance' (ibid, p.2). This perspective is consistent with the view

of Moingeon et al. (2006) that inter-organizational CoPs indirectly represent a powerful monitoring and innovation force, and with the notion of the embedding of tacit knowledge within organizations as suggested by Hendry et al. (2003).

Roberts (2006) presents a tentative typology of CoPs (Figure 9) based on the nature of the practice in each category of CoP. In her typology 'communities of practice' focus on situated practice, involving mutual engagement, i.e. Lave and Wenger's (1991) original concept. Constellations of practice represent Wenger's (1998) later reinterpretation of CoPs as 'constellations of practice' where situated learning is achieved through brokers and boundary spanners in large organizations.

Figure 9 Roberts' CoP typology

(Roberts, 2006, p.12)

Nature of Practice	Type of CoPs	Examples
Situate Practice - Involving mutual engagement	Community of Practice	Yucatec midwives; Vai and Gola tailors; naval quartermasters; meat cutters; and non-drinking alcoholics (Lave and Wenger, 1991), Xerox repair technicians (Orr, 1996) Insurance claims processors (Wenger 1998)
Situated Practice - achieved through boundary spanners/brokers	Constellations of Practice	Insurance company (Wenger 1998)
Dislocated Practice*	Networks of Practice:	
	• Local	Urban creative industries (Conway et al. 2005).
	• Regional	Women's Internet design and development association (Benner, 2003);
	• National	National Health Service (www.nks.nhs/uk)
	• Global	World Bank (Wenger et al. 2002)
	• Virtual	Open Source Software (Edwards, 2001)

* Members to not practice together although they may be co-located. Their interactions will include knowledge exchanges relevant to practice, but they are not mutually engaged in practice. Dislocated practice may include membership of formal or informal associations.

Science-based SME are perhaps best represented by the third category, 'networks of practice', where the nature of the practice is often dislocated, i.e. members are separated in time and/or space. In these circumstances, CoP members do not necessarily have to be mutually engaged in the same practice, but might be involved in exchanges of knowledge or knowledge acquisition closely related to their relevant domain of knowledge. The success of CoPs as a tool for knowledge acquisition and innovation, within a regional cluster of science-based SMEs, is likely to be dependent on the strength of such networks and on the community spirit within the cluster.

Saxenian (2006), on the other hand, describes how 'glocalised' technological communities have strengthened economies in Silicon Valley, California and Hsinchu, Taiwan. Her research draws on evidence from an online survey of more than 2000 members of 17 professional associations in Silicon Valley. She talks of 'new Argonauts' - entrepreneurs who, although geographically dispersed, draw together both small and large firms, technology markets and global production networks in an increasingly unpredictable global economy. 'Glocalisation' refers to the twin process whereby, firstly, institutional/regulatory arrangements shift from the national scale both upwards to supra-national or global scales and downwards to the scale of the individual body or to local, urban or regional configurations and, secondly, economic activities and inter-firm networks are becoming simultaneously more localized/regionalized and transnational. Although entrepreneurial dynamism is to some extent a regional event (Feldman, 2001), entrepreneurs still require access to formal and informal international networks to overcome weaknesses in local conditions for innovation (Sternberg and Müller, 2007).

Assimakopoulos (2009) suggests that against a background of increasing globalization it is more important than ever to analyze the practice of a community adopting a network approach and to consider: 'personal 'glocalised' network communities where [the] emphasis is not only on individual actors but also on the set of relationships that connect these actors across all sorts of geographical and institutional boundaries' (ibid, p.17). In Saxenian's network of 'glocalised' communities, where firms both cooperate and compete, social networks can determine the speed and extent of innovation (Henton, 2000). It is when such networks are informal, involving personal links, that they are most effective,

especially for exchanging the tacit knowledge required for radical innovation (Assimakopoulos, 2007). Economic action, within and across organizational boundaries, is structurally embedded in these social networks of individuals and is largely built on trust (Granovetter, 1985).

Structural holes (Burt, 1992) and weak ties (Granovetter, 1973) are both ideas linked to this concept of embeddedness. Proponents of both theoretical positions argue that economic relations between individuals or firms are embedded in social networks, rather than existing in an abstract idealized market as originally posited by Polanyi (1944). Weak ties act as bridges between communities, forging links where none would otherwise exist. Structural hole theory (Burt, 1992) asserts that individuals with personal links to many networks can provide organizational advantage because they often enjoy a position of comparative advantage by occupying brokerage positions. Both of these theories are often linked to the concept of social capital discussed earlier in the chapter.

Returning to regional clusters, Tallman et al. (2004) examine knowledge sharing between organizations through the medium of 'untraded interdependencies', which Storper (1997) describes as those cumulative-causation prone externalities which: 'take the form of conventions, informal rules, and habits that coordinate economic actors under conditions of uncertainty' (ibid, p.5). Storper (1997) suggests that, although clusters are about geographical proximity, the success of some clusters can be linked to other factors. On the one hand, from a purely geographical viewpoint, clusters may just be about location and their associated exogenous forces, e.g. resource endowments, demand, competition, and infrastructure that can be put in place by government. On the other hand, the success of some clusters seems to be tied to endogenous factors, e.g. factors that evolve through the interaction of the member firms in some loosely defined manner, but that occurs without prior planning. In these circumstances, Tallman et al. (2004) suggest that CoPs demonstrate how independent individuals, working in a single context, can develop a social milieu and shared identity and, therefore, can support cooperation and knowledge generation within regional clusters. Such interactions produce advantage-generating, regional-level competencies that supersede firm-level competencies (Lawson, 1997). If regional clusters are to provide ongoing competitive advantage

within a knowledge driven framework, then a cluster specific architecture needs to be tied to the development of CoPs (Tallman et al. 2004).

Gausdal (2009) discusses the development of regional CoPs in the context of supporting management education. Her work focuses on a cluster of Norwegian high-tech SMEs who challenge their local university to develop a regional management education programme, aimed at improving management practices and co-operation within the cluster. The university introduced the concept of the 'network reflection' (Table 9), which they developed by combining inter-organizational networks of practice and CoPs with Mintzberg's (2004) 'experienced reflection' concept in management education.

Table 9 Network Interventions

(Gausdal, 2009 p.217)

(numbers in brackets represent the number of occurrences of each event)

Recruiting participants - recruiting participants from a cluster, practicing professions, open invitation to participate.
Seminars - participants meet face-to-face at several (8) seminars over several (9) months. Firm presentations, network news and joint meals at the seminars. Some (4) seminars including plant visits and one seminar (the 4th) with overnight stay at a retreat.
Lunch intervention - a planned ad-hoc intervention at the first seminar, on a safe project with a clearly defined target; preparing lunch, in small temporary inter-organizational groups arranged by the lecturer.
Reflection tasks - reflection tasks at each seminar alone or collectively, in small groups and during class, on experiences and challenges within the firms, and theoretical frameworks. Reflection tasks conducted in small temporary inter-organizational groups – different for each seminar and arranged by the lecturer.
Thesis groups - inter-organizational theses – dealing with practical challenges within the firms – as part of the exam, carried out in small inter-organizational groups arranged by the participants.
Content - provide participants with the same concepts, literature and lectures as mutual backdrops for communication, by participating in the same class. Tailor the content and study methods to the participants' expectations, which were discussed and mapped out at the first seminar. E-mails to follow up prepare and motivate for each seminar.

The ‘experienced reflection’ concept is based on facilitating several interventions and combining lectures, reflections and interactions. In addition to Mintzberg’s (2004) concept, ‘network reflection’ also includes other network activities such as inter-organizational interventions, firm presentations and plant visits. Gausdal’s analysis explores the proposition that ‘network reflection’ has the capacity to enhance regional cooperation, in a similar way to the concept of untraded interdependencies suggested by Tallman et al. (2004). The network reflection process (Table 9) consists of: ‘wondering, probing, analyzing, synthesizing and connecting’ (ibid, p.211); using the participants’ actual experiences in conjunction with organized reflection activities and inter-organizational tasks.

Gausdal poses three questions: does network reflection influence the development of regional co-operation and communities of practice? If increases in regional co-operation and communities of practice could be identified, did these influence regional collective learning? Does network reflection influence regional collective learning? According to Gausdal (2009), this process of network interventions (Table 9) enables the participants to create and share local explicit and tacit knowledge. Participants are seen as practitioners, and their experiences and actions are necessary in terms of the interventions planned. In practical terms, these ‘network interventions’ have similar features to conferences (Gustavsen and Engelstad, 1986), functioning as meeting places where participants can makes points, discuss in groups, and share experiences.

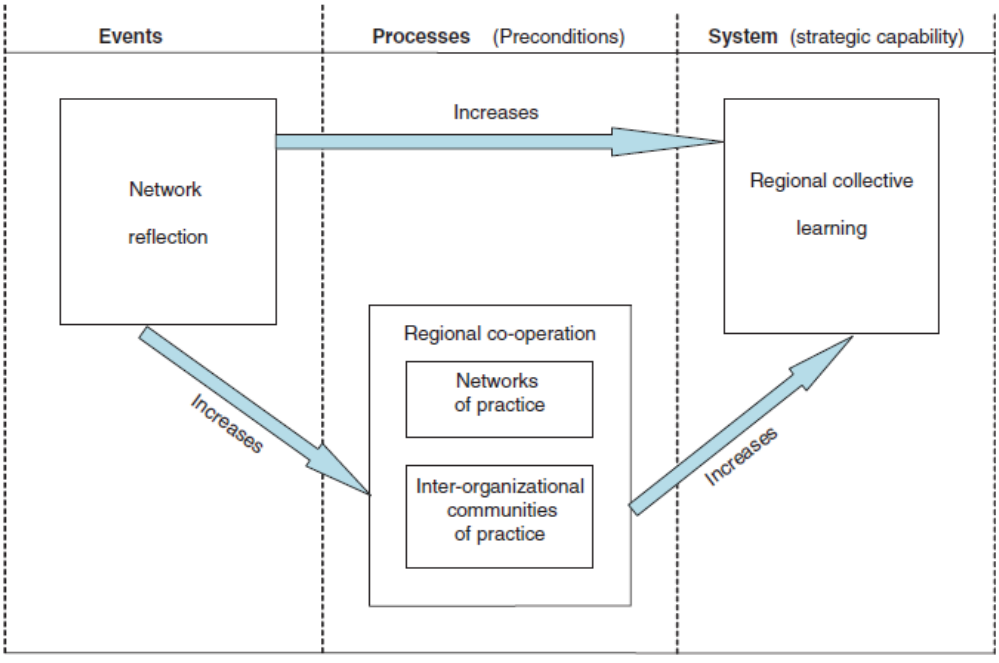
Gausdal (2009) studied a cluster association of high-technology SMEs, the Electronic Coast, located in the Norwegian county of Vestfold. Most firms are located within an 8 km circle around the city of Horten, with a few peripheral firms located up to 75 km away. The electronics industry in Vestfold consists of around 100 firms, mostly SMEs, and employs approximately 2500 people. The area is considered to be a high technology, export-intensive cluster, competitive in a global market. The Electronic Coast is committed to promoting growth and innovation through building inter-firm networks, which include local universities. In 2001 a Management Academy was set up to support improved management practices and increase regional participation. Network reflection is seen by Gausdal as an important spatial channel for making information available and for influencing

regional knowledge sharing. This approach is illustrated in Gausdal's preliminary model (Figure 10), which shows the influence of network reflection on both processes and strategic capability.

Gausdal found that 'network reflection' influenced cooperation between the development of regional CoPs, which in turn influenced regional learning. According to Gausdal (2009), the use of network reflection improved access to resources, saved time, augmented reflection activities and introduced elements of common language, all of which contributed to sharing knowledge and learning. If innovation policy in the UK should attempt to initiate and support inter-firm co-operation, as De Propris (2002) posits, then Gausdal's (2009) study of Norwegian clusters suggests that cultivating regional CoPs could be one way of providing support for such linkages and that CoP cultivation should be included in regional innovation policies. Gausdal notes that network reflections have the capability to increase regional cooperation, promote the construction of communities of practice, leading to enhanced regional collective learning, knowledge linkages and improving the density of regional knowledge networks.

Figure 10 Gausdal's preliminary conceptual model

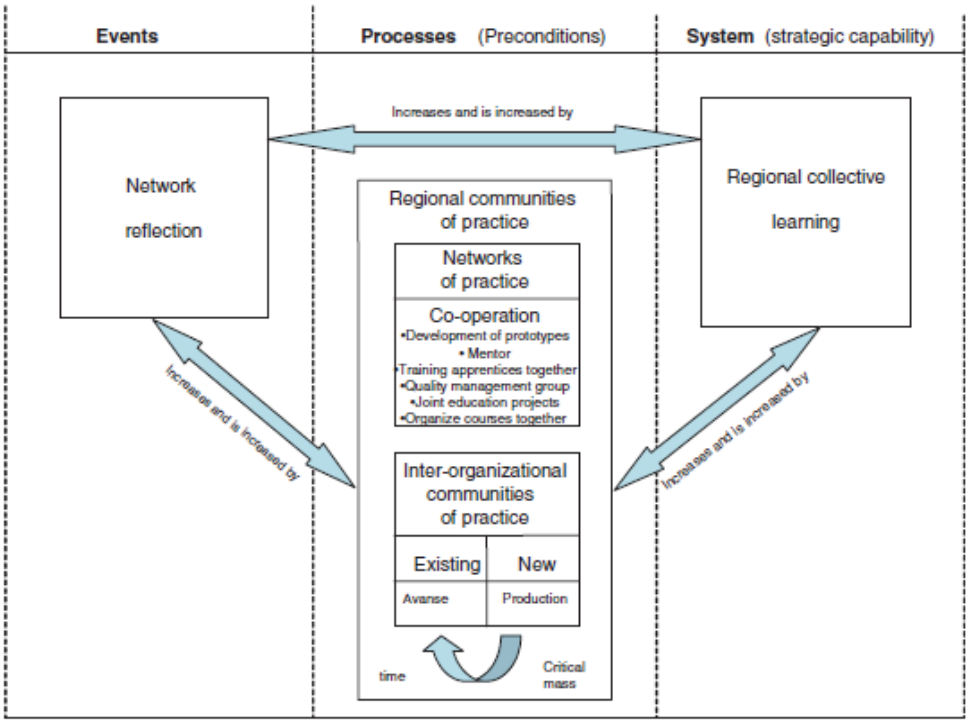
(Gausdal, 2009, p.220)



For Gausdal (2009) regional CoPs are seen as a combination of inter-organizational CoPs and networks of practice as shown in her revised conceptual model (Figure 11). There is the need for reflection on practice within regional CoPs if they are to increase regional collective learning, hopefully leading to economic development and enhanced competitive advantage. If clusters are 'glocalised', communities require local embedding, as Nooteboom (2006) claims, then the medium of untraded interdependencies (Tallman et al. 2004) and the development of concepts such as the network reflection (Gausdal, 2009) could be used to support the embedding process. CoPs might also provide a suitable framework for embedding initiatives related to supporting science-based SMEs operating within regional clusters.

Figure 11 Gausdal's revised conceptual model

(Gausdal, 2009, p.232)



Mason, et al. (2008) highlight the potential contribution of ICT networks, especially to SMEs, for sharing information within an industry cluster. They propose a modified version of the CoP, called the 'community of enterprise' (CoE) and its counterpart the 'virtual community of enterprise' (VCoE), which highlights 'the importance of participating SMEs and their relationships across industry boundaries' (ibid, p.6). According to Mason, et al. (2008) the VCoE concept addresses the unique

knowledge management requirements of SMEs, providing a way to engage and link together SMEs from different industries. On the other hand, Braun (2006) suggests that ICT adoption in SMEs is related to the size and nature of individual firms as well as being dependent on their perception of affordability and the business growth opportunities such investment presents.

According to Zhou et al. (2007), knowledge is managed differently in SMEs and is more likely to be created, shared, transferred and applied through people-based mechanisms rather than technology-based systems. Not all researchers take such a positive view of regional clusters. Some claim the term 'regional cluster' is ambiguous (Martin and Sunley, 2003) and difficult to define (Torre, 2006), leading to a concept so elastic that it cannot provide a useable model for regional economic growth. Even Porter (1990) acknowledges that the term 'cluster' could refer to city, state, country or even a group of countries, leading to confusing claims about its theoretical basis. For Taylor (2005), the 'mesmerizing mantra' of clusters is built on a few select success stories and the cluster concept neglects the imperatives of capitalism and ignores or downplays issues related to profits, prices and labour.

Taylor suggests cluster policy is blind to the role of the power inequalities between firms that shape their business relationships. Furthermore, Taylor claims it fails to incorporate issues related to time, change and path dependence into an understanding of local conditions and remains transfixed by the 'institutional instantaneous' (ibid, p.285). Whilst agreeing, to some extent, with Taylor (2005) about the difficulties in defining clusters, Torre (2006) argues that the successful concentration of firms in some geographical areas cannot be denied and connects this success to three main factors. The first is related to the embeddedness of economic relations into highly localized social networks. The second is that of the role played by institutions in the construction of geographical environments of economic interactions. The third is related to more traditional factors such as the attractiveness of some local areas in terms of land costs, tax or labour markets.

Torre (2006) sees clusters as a knowledge transfer tool, dependent on both geographical and organizational proximity, where localized social networks play a significant supporting role. In these circumstances CoPs might support the effective social relationships required to nurture the development of social capital as

previously discussed. Additionally, innovation is acknowledged as being an important mechanism that transforms social capital into economic growth (Akçomak and ter Weel, 2006) and, if this is true, then inter-organizational CoPs might become a valuable asset to science-based SMEs, helping them build collaborative networks with other firms.

3.8 CHAPTER SUMMARY

The systematic literature review revealed a lack of empirical research on CoPs and innovation in SMEs, thus prompting this broader review of the literature on CoPs and innovation. In this chapter I have outlined the origins of CoPs and their evolution from being a theory of situated learning, focused on the practices of apprentices working in close physical proximity, through a number of reinterpretations, eventually being viewed as an organizational tool for knowledge management, acquisition and innovation in an inter-organizational setting.

Research into CoPs has suggested a variety of cultivation and management methods (Pattinson et al. 2011). Cross and Prusak (2002), for example, focus on individual actors, identifying four common role-players in the cultivation process: central connectors, boundary spanners, information brokers and peripheral specialists. SMEs, however, may have a limited number of external linkages, or boundary-spanning opportunities available to them (Sawyerr, McGee and Peterson 2003) and, therefore, find it difficult to cultivate CoPs. Saint-Onge and Wallace (2003) suggest that organizations must develop a shared sense of purpose and ownership with the CoP based on mutual trust. Such approaches focus on CoPs in large organizations and might not be appropriate for science-based SMEs, which are often very secretive about their processes, and which operate within a culture of customer confidentiality (Bagchi, 2010), making sharing knowledge difficult because of lack of trust.

The literature also highlighted that SMEs have fewer resources than larger firms (Tödtling, 2001) and, it is suggested, might compensate their lack of resources by utilizing networks (Partanen et al. 2008), such as CoPs, to support innovation and knowledge management. On the other hand, there is an argument regarding whether SMEs can spare the necessary resources required to invest in CoP construction (Roberts, 2006). McDermott and Archibald (2010), for example, suggest

organizations must set aside time for CoP participation, provide training for CoP leaders and utilize simple IT tools to facilitate participation. Probst and Borzillo (2008) explore the use of governance committees to assess CoP activities, and management sponsors to guide their activities. Such approaches might not be seen as appropriate by SMEs because they divert vital resources away from core business activities.

The construction of CoPs presents only a partial KM solution for SMEs involved in innovation. CoPs are considered an introductory vehicle for knowledge management (Du Plessis, 2008), as well as an important way to boost technological learning and firms' ability to commercially exploit new innovations (Autio et al. 2008). However, for the reasons I have outlined in this literature review, CoPs are often problematic for SMEs. Research has tended to focus on large firms, with little empirical data relating to their existence or construction in SMEs. In the following chapter I describe the research methodology I used to explore this issue in greater depth.

CHAPTER 4: RESEARCH METHODOLOGY

4.1 INTRODUCTION

The purpose of this chapter is to present an overview of the research methodology adopted in the study to research CoPs and innovation in science-based SMEs. The chapter also provides an understanding of why I decided to undertake this study and why I chose a qualitative approach. I begin by restating my research questions before outlining my personal philosophical view as a social constructionist and qualitative researcher, explaining how these views shape both the ontological and epistemological approach used to conduct the empirical research. I then outline the research design, showing how and why I chose the research methods adopted as the most suitable to answer my research questions and fulfill my overall research aim. Finally, I consider the ethical issues associated with qualitative research and explain the measures taken, as a reflexive researcher, to reduce researcher bias.

4.2 RESEARCH QUESTIONS

The research questions guide the overall aim of the study which asks: 'to what extent are CoPs a 'privileged locus' for knowledge acquisition and innovation in science-based SMEs?' The purpose of this study is, therefore, to gain a deeper understanding of how science-based SMEs engage with CoPs to acquire new knowledge and what innovations, if any, are generated through such engagement. The study also considers whether CoPs help them to develop more focused innovation processes. This research, therefore, addresses a number of research questions:

1. Are CoPs to be found in science-based SMEs?
2. If so, how and why are CoPs constructed in science-based SMEs?
3. How is knowledge acquired in science-based CoPs?
4. What innovation is generated from collaborative activities in CoPs?

The systematic literature review on CoPs and innovation has demonstrated the paucity of empirical research relating to SMEs. The context of this research is science-based SMEs and, thus, the study contributes to our understanding of how CoPs are constructed, and how they enhance the innovation processes of SMEs. In

the next section I discuss my personal research journey and how my PhD studies helped me find my own place in the research landscape.

4.3 PERSONAL RESEARCH JOURNEY

Writing a PhD is not a linear process. The research journey is a story about how I came to my research topic, why I selected a qualitative approach as the most appropriate method to investigate this matter and how the process of conducting the research and writing the thesis has helped me develop as a researcher. In this section I provide the reader with a summary of my personal research journey.

My initial interest in 'situated learning' began in 2007 when I was studying for a Master's degree in Education at the University of Sunderland. The topic for my final year dissertation was 'Do computers support collaborative learning?' and, as the title suggests, this was a study of how ICT supports the learning of secondary school students. Through the process of writing the literature review for the dissertation I became particularly interested in the idea that learning is socially situated and the suggestion that 'communities of practice' (Lave and Wenger, 1991) can support this learning process. As a secondary school teacher, situated learning made perfect sense to me; in my work as a teacher had I observed how children seemed to be more engaged in learning that involved 'doing things' rather than simply listening to the teacher explaining things.

The primary research for my Master's dissertation was based on setting up and analyzing the findings from a student on- line forum. The intention of the forum was to provide a space for Year 10 Business Studies students to discuss course- related issues outside of the classroom. The students were invited to engage in the forum to post messages and replies, as well as hold discussions about subject related issues. The forum contained a variety of course- related topics, which students were encouraged used as a starting point for participation. However, the results of the study were inconclusive. Although there was some evidence of community building and collaboration, for a variety of reasons, students did not always want to engage with the forum. Nevertheless, the process of conducting the study inspired me to think about further opportunities for research in this area.

Having completed the Master's degree in 2008, I initially discussed further study options with my course tutor at Sunderland, who suggested I should register for a part time PhD. Although the idea of higher level study appealed to me, at the time I had a very demanding job as a teacher with additional management responsibilities, and felt that further part time study would be difficult. However, the idea of studying for a PhD did not go away and I began to investigate my options. I eventually decided that part time study was probably not for me because of the time scale for a part time PhD – up to 6 years – and also the cost of part time fees. At this point I was also considering registering for a Doctorate in Business Administration at Teesside University. By chance I saw an advert on their website offering a three year, full time PhD scholarship that covered all fees and a stipend to cover some living costs. In September 2009 I applied for the scholarship and was lucky enough to be accepted as a full time scholarship student.

I began my PhD studies in April 2010 and, as part of the scholarship arrangement, I was located in the *Science to Business Hub* (S2B Hub) project at Teesside University. At that time, Teesside University's engagement with science-based SMEs was conducted through the S2B Hub, an ERDF funded research project, which ran from February 2009 to October 2011. The project aimed to foster collaborative approaches to innovation in science-based SMEs and offered advice and support to develop their innovation strategies. The S2B Hub, in collaboration with One Northeast, the (then) Regional Development Agency, sponsored the first year of the scholarship, whilst Teesside University sponsored years two and three.

As a PhD student located within the S2B Hub project I came into contact with a range of individuals working in science-based SMEs. Through my conversations with these visitors I identified that science-based SMEs often lacked formal strategies for managing knowledge. I was initially tasked with conducting my research in the area of 'innovation in science-based SMEs', with a particular focus on the chemical industry. At this point it was suggested that my PhD could perhaps focus on the role of supply chains, or benchmarking in the innovation processes of SMEs in this sector. However, once I began to familiarize myself with the subject, I found I was more interested in the role of innovation networks and at this point discovered the connection between managing knowledge and communities of

practice. I therefore began to engage in more depth with the literature on CoPs and innovation and, after some discussion with my supervisors, began to formulate my research questions and the overall aim of my study in this area.

In the next section I focus on my philosophical framework and choice of an interpretive approach, before going on to discuss the research design.

4.4 PHILOSOPHICAL FRAMEWORK

All research is based on some philosophical assumptions about the nature of the world (ontology) and about how knowledge can be obtained (epistemology) (Myers, 2009). Ontology is concerned with questioning the nature of existence (Crotty, 1998) and reality (Denzin and Lincoln, 2005) and the assumptions that individuals make about the nature of reality (Easterby-Smith, Thorpe and Lowe, 2002). Epistemology refers to the set of assumptions made about knowledge and how it is obtained (Hirschhiem, 1992). These philosophical assumptions ultimately have an effect on the formulation of the research questions posed, as well as the selection of the methodology and methods with which to conduct the research (Easterby-Smith et al. 2002; Myers, 2009). Table 10 summarizes the main ontological positions in the social sciences, indicating the corresponding epistemological stance.

In Table 10 Easterby-Smith et al. (2008) capture the positivist, relativist and constructionist positions. The former two assume that there is a reality that exists independently of the researcher and the job of the researcher is, therefore, to identify the facts from this pre-existing reality. For the positivist, this identification is done through the use of experiments, whereas the relativist researcher, assuming there are multiple realities, uses triangulation methods to establish the 'facts'. The constructionist, on the other hand, does not assume that there is an independent reality, but rather tries to understand how people construct their own version of 'reality' to help them make sense of the world. This latter approach focuses on the use of language and conversations between people. It is not my intention to provide a detailed account of the differences between positivist, relativist and social constructionist viewpoints, and I highlight the differences here in order to emphasize my philosophical position as both a social constructionist and qualitative, interpretive researcher.

Table 10 Ontologies and Epistemologies in Social Science

(Easterby-Smith, Thorpe and Jackson, 2008, p.62)

Ontology of social science	**Representationalism**	**Relativism**	**Nominalism**
Truth	Requires verification of predictions	Is determined through consensus between different viewpoints	Depends on who establishes it
Facts	Are concrete but cannot be accessed directly	Depend on viewpoint of observer	Are all human creations
Epistemology of social science	**Positivism**	**Relativism**	**Social constructionism**

The view that knowledge is socially constructed has some resonance with Botha, Kourie and Snyman's (2008) view of the relationship between CoPs and social constructionist theory, which is summed up in their 'key elements' of CoPs: learning is viewed as a social phenomenon; knowledge is integrated into the culture, values, and language of the community; learning and community membership are inseparable; we learn by doing and, therefore, knowledge and practice are inseparable; empowerment is a key factor to learning, i.e. the most productive learning environments are created when there are real consequences to both the individual and their CoP. Understanding and learning are, therefore, *constructed* from a variety of sources, including the social and physical environment, and from the histories of the people involved (Brown and Duguid, 1991).

Daft and Weick (1984) refer to 'enacting' organizations, which: 'construct their own [learning] environments. They gather information by trying new behaviors and seeing what happens. They experiment, test, and stimulate, and they ignore precedent, rules, and traditional expectations' (ibid, p.288). In the present study I explore the idea that CoPs operate as 'enacting organizations' (Brown and Duguid, 1991; Daft and Weick, 1984) and, through a process of interpretive sense making and controlled change, innovation results. An interpretive methodology, therefore,

with its underlying social constructionist epistemology provides the basis for an appropriate and reflexive approach (discussed in greater depth later in this chapter), enabling me to explore the full complexity of human sense making (Kaplan and Maxwell, 1994), answer the study's research questions and, thus, address the overall research aim.

All research, regardless of being qualitative or quantitative, is based on an underlying philosophical assumption about what the researcher considers to be 'valid' research and what research methods are most appropriate (Myers, 2009). In essence, these philosophical assumptions represent the researcher's 'world view', i.e. a 'lens' through which we view the world and which shapes our choice of methodologies and methods. Qualitative researchers study things in their natural settings and attempt to make sense of, or interpret, phenomena in terms of the meanings people bring to them (Denzin, 1994). The qualitative researcher is viewed as a participant in their own research (Patton, 2002). Qualitative research is generally associated with an interpretive, naturalistic approach to the world (Denzin and Lincoln, 2000) that seeks to understand the values, beliefs, and meanings of social phenomena, achieving *verstehen* (Weber, 1864-1920) (a deep and sympathetic understanding) of human cultural activities and experiences (Smith and Heshusius, 1986).

Researchers who advocate interpretivism often question the positivist belief of the mind-independent reality (Kim, 2003). This is because qualitative researchers consider there to be no mind-independent reality to correspond with hypotheses to serve as an external referent point on their acceptability (Walker and Evers, 1999). Interpretive researchers should be open in their approach to understanding their research subjects and in the way they apply their conceptions to those being studied (Giorgi, 1997; Husen, 1999; Van Maanen, 1998). With interpretive research, the researcher's own subjectivity might impact their interpretation of data (Babbie, 2010), and a reflexive approach is required to acknowledge this bias. Interpretivists see facts as being value- laden and inscribed with meaning. Interpretive research is the study of social phenomena through the understanding of the social world that people live in (Beck, Bryman and Liao, 1993).

The aim of interpretive research is to examine the 'internal reality' of participants or the research subjects, i.e. to capture the lives of the participants in order to interpret and come to an understanding about their meaning (Henning, Van Rensburg and Smit, 2005). Interpretive research is subjective and assumes access to reality is only possible through social constructions, such as language (Myers, 2009). There is no need to define dependent and independent variables, as the focus of interpretive research is on the full complexity of human sense-making (Kaplan and Maxwell, 1994). Interpretive perspectives of qualitative research make different assumptions about the nature of social reality (Myers, 2009), assuming that all knowledge is socially constructed and that there is no objective reality that can be discovered by researchers and replicated by others (Walsham, 1993). As Orlikowski and Baroudi (1991) explain: 'interpretive studies assume that people create and associate their own subjective and inter-subjective meanings as they interact with the world around them' (ibid, p.5). For Orlikowski and Baroudi (1991), interpretivism rejects objective views of the world and seeks to find a shared understanding of social phenomena.

This study explores knowledge acquisition and innovation through a qualitative, interpretive approach, and this is necessary for a number of reasons. Firstly, it is the most appropriate way to address my research questions. A qualitative approach is necessary in order to understand the meanings and nuances associated with the experiences of the interviewees. Secondly, as I have already commented, a qualitative approach follows my own ontological view that knowledge is socially constructed. Thirdly, a qualitative approach provides a good 'fit' with CoP theory and the view that learning is socially situated. A qualitative approach is appropriate here because, combined with a social constructionist epistemology, it is an appropriate way to explore relationships and meanings, and to capture the different perspectives of the interviewees.

At this juncture it is worth noting that there is some debate over the use of the terms 'constructivist' and 'constructionist. Bryman and Bell (1991), for example, note that both terms are used interchangeably within the literature. In an attempt to clarify the issue, Papert and Harel (1991) explain that the term constructivist, with the 'v', expresses the theory that knowledge is built by the learner, not supplied by the

teacher. On the other hand, he considers that the term constructionist, with the 'n', expresses the further idea that this happens especially felicitously when the learner is engaged in the construction of something external, or at least sharable. It is useful to separate these two definitions, constructivism representing the view that meaning is constructed internally, through the mind, by reflecting on one's practice. Constructionism, on the other hand, represents the view that meaning is constructed through shared practices. I take an integrated view of these two approaches.

Having located the study in a social constructionist philosophy, I now discuss my research design, my choice of a case study approach, the data collection and data analysis methods, ethical issues, and the reflexive stance I adopted in conducting the study.

4.5 RESEARCH DESIGN

4.5.1 Case study research

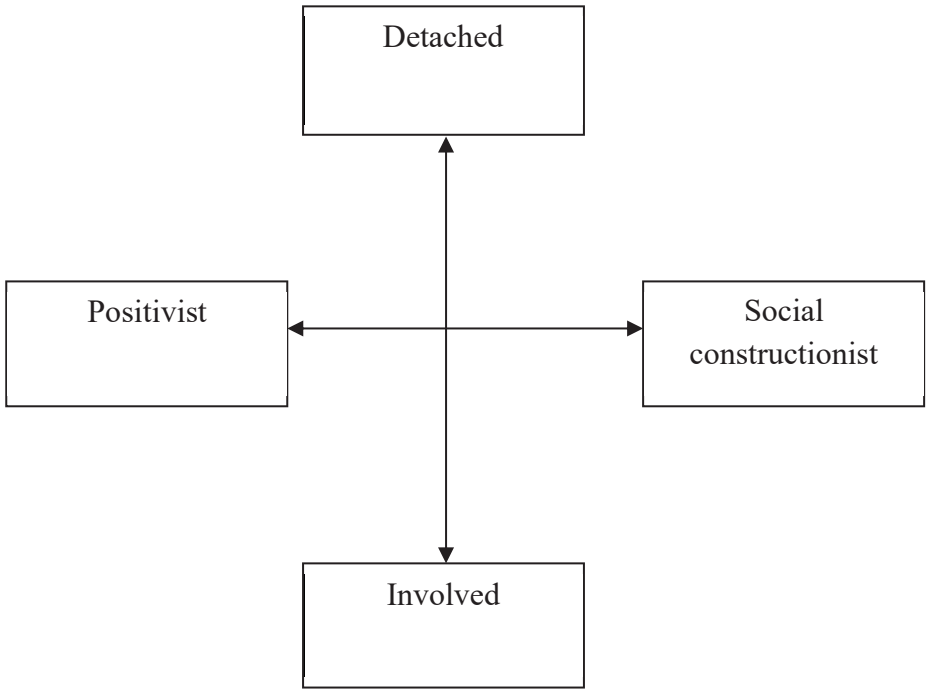
This research is a qualitative study of innovation and CoPs in science-based SMEs. The study draws upon 25 interviews conducted with a range of individuals from 7 science-based SMEs. A qualitative case study methodology was appropriate because it involved a study of complex phenomena with context (Baxter and Jack, 2008). According to Myers (2009, p.73) 'the purpose of case study research in business and management is to use empirical evidence from real people in real organizations to make an original contribution to knowledge'. The interpretive case study approach adopted in this study relied upon a social constructionist epistemology (Stake, 1995). Here, knowledge is viewed as being socially constructed (Myers, 2009) and, as with validity, quality is defined 'in terms of the plausibility of the story and the overall argument' (Myers, 2009, p.78).

Stake (2006) distinguishes between three types of case study – instrumental, intrinsic and collective. An instrumental case study is undertaken to gain an understanding of a larger issue. This involves looking at specific cases and developing general principles, and is suitable for gaining insight and understanding of a particular situation or phenomenon. An intrinsic case study involves looking at cases because of their unique features- the researcher has an interest in the subject and is aware that the results have limited transferability. The collective case study (Stake, 1995)

involves the combining of multiple cases into a single study, which is the same as the multiple-case study described by Yin (2003). Easterby-Smith et al. (2002) use a two-dimensional grid (Figure 12) to position two different social constructionist approaches to case study research.

Figure 12 Matrix of research philosophies

(Easterby-Smith et al. 2002, p.55)



In the top right quadrant is one view of social constructionism, where the researcher is viewed as independent, or detached, from the subject of the research (similar to Yin's, 2002) positivist position. In the lower right quadrant is a second view of social constructionism, where the researcher is involved as a participant in the research process (Stake's, 1995) interpretive viewpoint. Easterby-Smith et al. (2008) argue that the social constructionist approach is a self-reflective process, with particular relevance to considering power and cultural differences. This approach is useful when exploring CoP relationships in the context of science-based SMEs. Yin (2003) posits that case study research should be considered when the focus of the research is to answer 'how' and 'why' questions, when one cannot manipulate the behaviour of those involved in the study, when one wants to address contextual

conditions, or, when the boundaries are not clear between the phenomenon and the context.

I have adopted a case study approach as part of the overall research strategy of the study. The factors that influenced this choice over other possible research strategies are now outlined. According to Yin (2003), there are three conditions that must be met when deciding on an appropriate research strategy. First, the type of research questions posed; second, the extent of control the researcher has over actual behavioural events; third, the degree of focus on contemporary issues (ibid, p.5). The purpose of this study was to answer the questions:

1. Are CoPs to be found in science-based SMEs?
2. If so, how and why are CoPs constructed in science-based SMEs?
3. How is knowledge acquired in science-based CoPs?
4. What innovation is generated from collaborative activities in CoPs?

It is clear that these research questions consist of 'how' and 'why' questions that invite a case study approach. Yin's (2003) second condition is concerned with the degree of control the researcher has over actual behavioural events. In this study, I have no control over the behaviour of the interviewees in the science-based SMEs. As a researcher, I am 'outside to the case' of science-based SMEs as an observer rather than a participant. Regarding the third condition, the issues being investigated in this study are contemporary, thus satisfying this third condition for selecting a case study approach.

Perren and Ram (2004) note that the case study research is gaining greater acceptance in small business research. Furthermore, Chetty (1996) observed that using case study research in a SME context generates new insights that would not have emerged through adopting a more positivist strategy, such as a large survey. This is particularly important for this study because of the dearth of literature regarding a CoPs and innovation in SMEs. Proverbs and Gameson (2008) comment that case study research is highly relevant to science-based sectors that consist of different types of businesses and organizations.

The above demonstrates that a case study approach is appropriate to conduct research in science-based SMEs. A case study approach using in-depth, qualitative,

semi-structured interviews, suits the study of a heterogeneous data set to be found in science-based SMEs, where it is frequently difficult to make any generalizations.

Another important question when considering the adoption of a case study approach is whether it is compatible with the philosophical viewpoint of the researcher. I adopted a pragmatic approach (Saunders et al. 2009), based on the argument that 'the most important determinant of the epistemology, ontology, and axiology you adopt is the research question' (ibid, p.109). Whilst the study was approached from a pragmatic viewpoint, the nature of the research questions lead to the research methodology being based upon interpretivism in terms of epistemology and ontology.

I did not consider quantitative research strategies, in part because they manipulate independent variables to observe the behaviour of the dependent variables (Collis and Hussey, 2009), which was not possible in this research. A survey strategy is usually associated with a deductive approach (Saunders et al. 2009) and positivist philosophical positioning (Collis and Hussey, 2009), whereas my philosophical position as a social constructonist implied a more inductive approach. An ethnographic approach was rejected as it requires the researcher to be immersed in a setting, and become part of the subjects being observed in order to understand a particular phenomenon (Easterby-Smith et al. 2008). I was simply unable to devote the time needed to conduct such a study.

Grounded theory seeks to develop a well integrated set of concepts that provide a thorough theoretical explanation of the phenomena under study (Corbin and Strauss, 1990). In this approach theory is generated from the data being systematically gathered and analysed through an iterative process (Bryman, 2008). Grounded theory was, arguably, the most suitable alternative design for this research; however it was not simply attempting to generate theory, but rather was applying existing theory to innovation processes in science-based SMEs, and consequently was discounted.

The unit of analysis of a case study provides the basis of the research sample. This could be a country, culture, race, industrial sector organization, family, group individual, incident story, accident, innovation, etc, (Easterby-Smith et al. 2008). Given that the research project aim was to gain an understanding of how CoPs might

support innovation in science-based SMEs, and given the location of the researcher and a number of such SMEs in the NE of England, the boundary of the case study was determined to be science-based SMEs in the North East of England. Given also that there is a good deal of heterogeneity of SMEs in the region, the collective or multiple-case study model with individual SMEs as the unit of analysis was chosen as an appropriate method for exploring the differences and similarities between these organizations.

4.5.2 Data collection

Interviews are an important source of data and allow the researcher to gather rich data from individuals in various roles and situations (Myers, 2009). Qualitative interviews have been likened to night vision goggles because they permit the wearer 'to see that which is not ordinarily on view and examine that which is looked at but seldom seem' (Rubin and Rubin, 2005, p.vii). Interviews are useful for getting the story behind a participant's experiences and the interviewer can pursue detailed, in-depth information around the topic being investigated (Myers, 2009). The task of the interviewer is to understand the meaning of what the interviewee says (Kvale, 1996). For a number of reasons, which I now discuss, I decided to use semi-structured interviews as the most appropriate data collection method for the study.

4.5.2.1 Semi-structured interviews

Myers (2009, p.124) identifies three types of interview - structured, semi-structured and unstructured. Structured interviews use pre-formulated question that are strictly regulated with regard to the order of the questions, and sometimes regulated with regard to the time available. Semi-structured interviews use some pre-formulated questions but have no strict adherence to these questions and the interviewer can add new questions during the conversation. Unstructured interviews have few, if any, pre-formulated questions and interviewees have free rein to say what they want and there is often no set time limit. Each technique has its strengths and weaknesses, which I now discuss.

Structured interviews aim to ask the same questions to all respondents, ideally using the same wording and sequence of questions (Corbetta, 2003). Gray (2004) even suggests that the questions should be asked in the same tone of voice to prevent the

respondent being influenced by the interviewer. The main strength of structured interviews is that they ensure consistency, giving the interviewer control over topics discussed. However, the obvious disadvantage is that they minimize the role of the interviewee and may hinder the interviewer asking 'probing' questions (Myers, 2009). This research is an exploratory study and therefore asking the interviewees probing questions was an integral part of my research strategy. For this reason I did not use structured interviews.

Unstructured interviews, on the other hand, have the advantage of letting the interviewee speak freely about what they consider to be important and allow the researcher to explore or discard a particular line of enquiry (Easterby-Smith, 2008). The main disadvantage of unstructured interviews is that the outcome is dependent on how 'talkative' the interviewee is, i.e. if they are in a quiet mood then they might not say very much (Myers, 2009). I decided not to use unstructured interviews because, although I did want to let interviewees speak freely, I also wanted to focus on particular issues, for example innovation, and felt using unstructured interviews did not offer enough control over the interview process.

Semi-structured interviews attempt to create a balance between structured and unstructured interviews (Myers, 2009). They are best used when it is unlikely that the researcher will get a second chance to interview someone (Bernard, 1988) and should be viewed as a guided open interview (Easterby-Smith et al. 2008). The interviewer in a semi-structured interview generally has a basic framework of themes or questions to be explored but this structure allows new questions to be brought up during an interview as a result of what the interviewee says (Lindlof and Taylor, 2002).

Semi-structured interviews offered the most appropriate interview technique for this study for a number of reasons. First, because of time constraints, it was unlikely that I would get a 'second chance' to interview some of the people. Second, having a basic structure allowed me to explore issues relevant to my research questions and overall aim, whilst also providing a degree of flexibility that allowed me to explore any unexpected issues that might arise. Using in-depth, semi-structured interviews allowed the opportunity to probe deeply in order to follow up certain comments, open up a new dimension of an issue, and to secure, as far as possible, authentic

accounts that were based upon the personal experiences and reflections/ understandings of the interviewees. In the next section I explain the sampling technique used in the study.

4.5.2.2 Sample

Unlike quantitative research, which adopts random sampling techniques in order to generalize to a larger population, qualitative, interpretive research uses purposive sampling which involves selecting informants based upon an important characteristic or set of characteristics (Myers, 2009). The study used critical case sampling, a sub-set of purposive sampling techniques, the intention being to select a small number of important cases that were likely to 'yield the most information and have the greatest impact on the development of knowledge' (Patton, 2002, p.236). Critical case sampling focuses on selecting cases on the basis that they make a point dramatically or, as in this case, because they are important in relation to the research questions. This sampling technique is particularly useful for exploratory, qualitative research, where resources are limited and, although it may not yield findings that are broadly generalizable, it allows the researcher to develop logical generalizations from the rich evidence produced when studying a few cases in depth (Patton, 2002).

Other purposive sampling strategies were considered (See Given, 2008) and rejected for a variety of reasons. Maximum variation sampling, for example, involves purposefully selecting a wide range of cases in order to obtain variation on issues of interest, with a view to documenting the uniqueness or variation in a phenomenon. In this study, rather than looking for variation *per se*, I sought to explore both variation and similarities. Extreme, or deviant, case sampling selects outstanding successes or notable failures, exotic events, or crises, but was rejected because I was not seeking examples of such extreme behaviour. Homogeneous sampling is a technique that is used to reduce variation and simplify analysis or to facilitate group interviewing, but was rejected because within the sample there was a wide range of different businesses, thus not representing a homogeneous data set. The final technique I considered was *snowballing*, which involves recruiting potential interviewees from the acquaintances of existing interviewees. However, I rejected this technique because it is utilized primarily as a response to overcome the sampling problems associated with understanding and sampling concealed populations such as the

deviant and the socially isolated (Faugier and Sargeant, 1997) which does not describe my sample.

The use of semi-structured interviews allowed the gathering of data from a broad range of people in various roles within each of the organizations being studied (Myers, 2009). It enabled a nuanced, deep understanding of the main issues related to innovation in science-based SMEs in the Northeast of England. The individuals selected were employed in both technical roles, i.e. scientists and engineers, and commercial roles, i.e. operations, finance and purchasing. Challenges were encountered in gaining access to interviewees; on most occasions on my initial contact with an organization, I was directed to a 'gatekeeper', i.e. the person who decided who I could have access to, and this restricted my choice of interviewees. With respect to Company F, it emerged during the interviews that they it was not engaged in any science-based innovation relevant to this study, and therefore the data from the transcripts of the three interviews in Company F were not included in the final data analysis and discussion. Although it was a science-based business, in the sense that it provided lab-based fuel testing services to commercial ship owners, it employed standard (non-innovative) testing procedures used throughout the marine fuel testing industry.

When considering the question of 'how many interviews?', Guest, Bunce and Johnson (2006) consider that 12 interviews are usually sufficient for purposive sampling amongst relatively homogeneous groups of individuals. However, purposive sampling requires careful selection, and twelve interviews is unlikely to be enough if the group 'is relatively heterogeneous, the data quality poor, and the domain of inquiry diffuse and/or vague' (Guest et al. 2006, p.79). With this caveat in mind, a total of 25 interviews took place between March 2011 and November 2012. Analysis of the data began almost as soon as the first interview was transcribed and was an on-going, emergent process. Each interview lasted between 40-80 minutes and was based around a protocol and interview guide (Appendix 1).

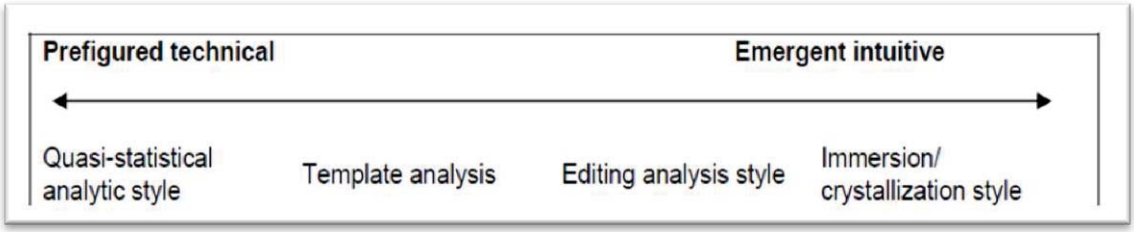
The interview protocol included 13 questions. Each interviewee was provided with a copy of the interview protocol and questions before they were interviewed. Although these initial questions provided a starting point for each interview, adopting a flexible, semi-structured approach enabled the interviewer to deviate from the

'script' and pursue other interesting responses made by the interviewees. All of the interviews were recorded, with the exception of one (where the digital voice recorder failed to record – although detailed handwritten notes had been taken). In each case, the permission of the participant was sought and obtained. Each recording was then transcribed, and imported as a Word document into Nvivo 9, a qualitative data analysis software tool.

A parallel consideration when planning the gathering of interview data and its input into Nvivo was *how* I would use that data. How would I analyze and interpret the interviews? As Symon and Cassell (1998, p.5) point out: 'despite the increased popularity and use of qualitative methods there is relatively less information available about how to conduct qualitative data analysis'. They do, however, mention the work of some exceptions to this general point, such as Dey (1993); Miles and Huberman (1994); Silverman (2001) and Strauss and Corbin (1990). Marshall and Rossman (2011) describe data analysis as the messy, time-consuming and creative process of bringing order, structure and interpretation to the data collected. They present a continuum of ideal-type analysis strategies (Figure 13).

Figure 13 A continuum of analysis strategies

(Marshall and Rossman, 2011, p.209)



At one end of this continuum are the pre-figured technical, quasi-statistical, scientific strategies of the researcher who adopts an objectivist/positivist stance relative to the inquiry and who has stipulated categories in advance. At the other end are the immersion/crystallization strategies which do not anticipate categories and rely on the researcher's intuitive and interpretive capacity. Between these two extremes lies both 'template' and 'editing' strategies. Template strategies are reliant on sets of codes that are developed and applied to the data, whereas editing strategies are less prefigured and the researcher 'engages the text naively, without a template'

(Crabtree and Miller, 1992, p.20), searching each text to generate codes and themes to illustrate categories of meaning.

King (2004) notes that *thematic* template analysis is often referred to by other terms such as 'codebook analysis' or 'thematic coding', but the essence of the approach is that the researcher produces a list of codes, i.e. the template, representing themes they have identified from their data. Some of these themes will usually be defined *a priori*, but these will be modified, added to, or removed as the researcher conducts the iterative process of reading and interpreting the text. The template approach can thus be seen as occupying a position between content analysis (Weber, 1985), where codes are all predetermined and their distribution is analysed statistically, and grounded theory (Glaser and Strauss, 1967), where there is no *a priori* definition of codes. I chose thematic template analysis because it allowed me to combine the *a priori* codes I identified from the literature and my research questions with an iterative, inductive approach that was consistent with my social constructionist position. Having outlined my sampling strategy and linked this with the data analysis approach, I now go on to explain the latter in more detail.

4.5.3 Data analysis approach

My research strategy incorporated plans for the analysis of the interview data that combined the *a priori* themes identified from the literature review with the codes and themes that emerged from the analysis of the data that I collected. While Marshall and Rossman's (1992) continuum (Figure 13) places template analysis towards the quasi-statistical end of their spectrum of analysis approaches, Crabtree and Miller (1999) suggest that template analysis offers an intermediate approach, allowing the researcher to combine some initial *a priori* codes with an immersion/crystallization style of analysis (discussed in more detail later in this chapter). King (2004) argues that template analysis is a useful tool for conducting a thematic analysis of qualitative data. It provides the best fit with my research design and the type of data I am collecting. It is helpful at this point to discuss my reasons for adopting a thematic approach, before placing this approach within the framework of template analysis.

4.5.3.1 Adopting a thematic approach

Thematic analysis provides a suitable method for analyzing the interview data in this research because it useful in:

> identifying, analyzing and reporting patterns (themes) within data. It minimally organizes and describes your data set in (rich) detail. However, frequently it goes further than this, and interprets various aspects of the research topic' (Braun and Clarke, 2006, p.79).

Thematic analysis seeks to unearth relevant themes in a text at different levels, and facilitate the structuring and representation of these themes (Attride-Sterling, 2001). It does not rely on a pre-existing theoretical framework and, as it can be used to report meanings and experiences of participants, it can support a social constructionist perspective (Braun and Clarke, 2006). The advantages of using a thematic approach are summarized by Braun and Clarke (2006, p.27), who claim it is: flexible, can summarize key features of a large body of data, highlight similarities and differences in a data set, generate unanticipated insights, and allow for social as well as psychological interpretations of data.

There are differing views about when in the data analysis process a researcher should engage with the literature. In summary, some argue that a more inductive approach would be enhanced by not engaging with literature in the early stages of analysis, whereas a theoretical approach requires engagement with the literature prior to analysis (Braun and Clarke, 2006). On the other hand, Tuckett (2005) argues that engaging with the literature in both approaches at an early stage sensitizes the researcher to the more subtle features of the data.

My literature review has provided an indication of the potential issues that might emerge, as well as informing the development of the *a priori* codes and themes in the final template (see Table 23). However, by adopting a reflexive approach, I would argue that I can still maintain an inductive, theory generating analysis of the data that is consistent with my social constructionist viewpoint.

Braun and Clarke (2006) outline the phases involved in data coding when conducting a thematic analysis-see Table 11. This begins with familiarizing oneself with the data, followed by generating some initial codes, searching for and reviewing themes,

defining and naming the themes, and, finally, conducting the final analysis and producing a report of the findings. Braun and Clarke (2006) stress that these are guidelines rather than rules, and any data analysis method needs to allow for flexibility in the way it is applied. They also provide some guidance regarding potential pitfalls to be avoided when using thematic analysis. Their first point is that there is sometimes a failure to actually analyze the data at all. Thematic analysis is not just a collection of extracts strung together with little or no analytic narrative. Nor is it a selection of extracts with analytic comment that simply or primarily paraphrases their content.

Table 11 Phases of thematic analysis

(Braun and Clarke, 2006, p.16)

Phase	Description of the process
1. Familiarizing yourself with your data:	Transcribing data (if necessary), reading and re-reading the data, noting down initial ideas.
2. Generating initial codes:	Coding interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code.
3. Searching for themes:	Collating codes into potential themes, gathering all data relevant to each potential theme.
4. Reviewing themes:	Checking in the themes work in relation to the coded extracts (Level 1) and the entire data set (Level 2), generating a thematic 'map' of the analysis.
5. Defining and naming themes:	Ongoing analysis to refine the specifics of each theme, and the overall story the analysis tells; generating clear definitions and names for each theme.
6. Producing the report:	The final opportunity for analysis. Selection of vivid, compelling extract examples, final analysis of selected extracts, relating back the analysis to the research question and literature, producing a scholarly report of the analysis.

Another pitfall to avoid is using the research interview questions as the 'themes' that are reported. In such a case, no analytic work has been done to identify themes across the data set, or to make sense of the patterning of responses. They also point to a weak or unconvincing analysis, where the themes do not appear to work, where there is too much overlap between themes, or where the themes are not internally

coherent and consistent. All aspects of the theme should cohere around a central idea or concept. They suggest there can be a mismatch between the data and the analytic claims that are made about it. In such an (unfounded) analysis, the claims cannot be supported by the data, or, in the worst case, the data extracts presented suggest another analysis or even contradict the claims. A mismatch can also occur between theory and analytic claims, or between the research questions and the form of thematic analysis used.

A good thematic analysis, therefore, needs to make sure that the interpretations of the data are consistent with the theoretical framework that is adopted, in this case a social constructionist view. Even a good and interesting analysis which fails to spell out its theoretical assumptions, or clarify how it was undertaken, and for what purpose, is lacking crucial information (Holloway and Todres, 2003), and thus fails in its purpose (ibid, p.266). With these caveats in mind I decided to use template analysis as a suitable framework to thematically analyze my interview data and I discuss this in the following section.

4.5.3.2 Template analysis

Template analysis (Crabtree and Miller, 1999; King, 2004) is one method of thematically analyzing qualitative data. This approach involves developing an initial coding 'template' summarizing the themes identified by the researcher and organizing them in a meaningful and useful way. Template analysis emphasizes hierarchical coding, i.e. beginning with broad themes and then encompassing sequentially narrower, more defined themes as the analysis progresses. Template analysis often begins by the researcher identifying some *a priori* codes related to the main research question and Crabtree and Miller (1999) suggest that researchers can develop codes: 'only after some initial exploration of the data has taken place, using an immersion/crystallization or editing organizing style. A common intermediate approach is when some initial codes are refined and modified during the analysis process (ibid, p.167).

These *a priori* codes often develop because a researcher has started with the assumption that certain aspects of the phenomena being investigated should be a particular focus of the investigation (King, Bell, Martin and Farrell, 2003) and King (2004) support three positions when generating *a priori* codes. Firstly, have some *a*

priori codes based on the theoretical position of the research; secondly, develop codes after some initial coding of a sub-set of data; thirdly, use a combination of these two approached - start with some pre-defined codes and refine these after some initial exploration of the data. *A priori* codes are, therefore, often identified before the full data set has been analyzed and can emerge from initial coding of a sub-set of the data, or be drawn from the literature review, or emerge from recommendations in earlier research. However, *a priori* codes or themes should be treated as provisional (King, Carroll, Newton and Dornan, 2002) and may be adapted or removed if they do not prove to be useful or appropriate in terms of the data being examined or the research question posed.

Once any *a priori* themes are defined, the next stage is to begin reading through the interview transcripts, marking in some way, either manually or using a computer programme, any sections that appear to the researcher to have some relevance to the research question. These codes are then organized into an initial template, usually based on the coding of a sub-set of the interview transcripts. The exact number of interviews used for the sub-set will depend on the total number of interviews conducted. King (2004) gives, as an example: a sub-set of the first six interview transcripts from a total set of twenty one transcripts. The initial template is then applied to the whole data set, i.e. all the interview transcripts and modifications are made based on any new themes that emerge. Once the final template has been defined, it is then used to code all the interview transcripts, providing a basis for the researcher's interpretation.

The main advantage of template analysis as an analytical technique is that it offers a flexible, iterative approach that does not tie itself to any one particular philosophical position. Template analysis enables the researcher to adopt a systematic approach to data analysis while maintaining a reflexive approach (King, 2006). Crabtree and Miller (1999) note that template analysis allows the researcher to focus his or her initial effort on text that is relevant to his or her research aims, whilst allowing him or her to identify additional themes later through engaging with the data in a more nuanced 'line-by-line' scrutiny (ibid, p.164).

Such analysis enables the researcher to move away from the often descriptive initial themes to make connections to more interpretive themes, making template analysis a

useful tool for exploratory qualitative research. In terms of reliability and validity, King (2004) suggests a variety of quality checks that can be made when conducting template analysis. These include independent scrutiny, respondent feedback, creating an audit trail and reflexivity. At one or more of these coding stages, King (2004) posits that the researcher should carry out some kind of quality check to ensure that the data analysis is not being distorted by the researcher's own preconceptions and assumptions. He suggests a variety of approaches including using independent scrutiny by the members of a research team, or even an 'outside expert' coding samples separately then comparing similarities and differences and agreeing any changes required to the initial codes/themes.

He also suggests using respondent feedback, i.e. asking research participants to comment critically on the template (in the early stages of development) and on the data analysis (in the later stages of development) as well as creating an audit trail by displaying successive versions of the template, accompanied by commentary on what changes were made at each stage and why, include at least one coded transcript, or a series of extracts, or other materials such as your memos, notes, or case summaries. Finally, he considers reflexivity can be built in to the process by documenting presuppositions at the start of the research, discussing and reflecting on research with others, reflecting on one's performance in research interviews by listening to interview recordings and keeping a diary of one's feelings about the data analysis process.

King (2004) suggests a variety of methods of writing up the data. The first method is individual case-studies, followed by a discussion of the differences and similarities between the cases. The main advantages are that this approach gives the reader a good grasp of the perspectives of individual participants and ensures that the analysis does not become too abstracted from interviewees' accounts. The main disadvantages are that this approach tends to take up a considerable amount of word up and so it can be problematic where word limits are tight. The reader can get caught up in too much individual detail and find it difficult to see the 'big picture'.

The second approach is to present an account structured around the main themes, drawing illustrative quotations from each interview transcript to highlight particular points. The advantage of this approach is that it produces a clear and concise

summary of the most significant findings and is useful where the words limit is tight. However, this approach can promote over-generalization and the reader can lose sight of the individual experiences. The final approach is a thematic presentation of the findings, using a small number of full case-studies to illustrate key themes – thus providing a useful fusion of the previous two approaches but it can be difficult to decide on suitable selection for choosing the cases to use.

Using King's (2004) template analysis approach, I created a thematic template that enabled me to think about the relationship between the *a priori* and emerging codes, between themes, and between different levels of themes, i.e. main themes and sub-themes. Some of these codes I have identified as major themes in my analysis, some form sub-themes, and others I discarded as the analysis progresses. By combining a 'deductive-inductive' approach to coding the data I have also extended King's original technique. I incorporated *a priori* coding of the data *across* the hierarchy of the three levels of codes in my final template (see Table 23), rather than just using *a priori* coding at the first level.

Having outlined the research design of my study, I now go on to discuss the associated ethical issues and how I dealt with the challenge of being a reflexive researcher.

4.6 ETHICAL CONSIDERATIONS

Ethical practice is defined as a moral stance (Myers, 2009), involving: 'respect and protection for the people actively consenting to be studied' (Payne and Payne, 2004, p.66). Whilst there is a question regarding the balance of responsibility between the research participants and the wider public (Westmarland, 2005), McNabb (2002) considers that the four guiding principles guide ethical research. The first is truthfulness. It is unethical for researchers to lie, be deceitful or purposely mislead. The second is thoroughness. Researchers should be methodical and not cut corners. The third is objectivity. Researchers should not allow their values or bias to affect their research. The fourth is relevance. Research should not be done for frivolous, wasteful or irrelevant reasons. The 'golden rule' of research ethics states that 'you should do unto others as you would have them do unto you' (Myers, 2009, p.46). In other words, if you are unsure about the ethics of your research, it is a good idea to

put yourself in the other person's shoes and consider how they might feel about how they are portrayed (Jackson, 1987).

Whilst there is an on-going debate in the field of management regarding the provision of ethical codes (Easterby-Smith, 2008), management researchers and their associated professional organizations are fairly relaxed about such provision. Based on an examination of the ethical principles of nine professional bodies in the social sciences, Bell and Bryman (2007) identify and list ten principles for conducting ethical research and these are summarized by Easterby-Smith et al. (2008, p.134):

1. Ensure no harm comes to participants
2. Respect the dignity of research participants
3. Ensure the fully informed consent of participants
4. Protect the privacy of research subjects
5. Ensure the confidentiality of research data
6. Protect then anonymity of individuals and organizations
7. Avoid deception about the nature or aims of the research
8. Declare all affiliations, funding sources and any other conflicts of interest
9. Maintain honesty and transparency in communicating about the research
10. Avoid any misleading or false reporting of research findings

The first seven of these principles relate to protecting the interests of the research subjects, whereas the last three are concerned with ensuring accuracy of data and lack of bias in the research results. By understanding the implications of straying from these principles, researchers are better placed to recognize any ethical dilemmas that might arise in the course of their research (Myers, 2009). In relation to ethics, Easterby-Smith (2008, p.138) also identify a number of implications for the researcher. First, it is important to recognize that power and political issues will be significant, even when they are not obviously present. Second, there are no easy answers, or solutions, to the political web, which exists in the form of ideologies, of personal interests (including those of researchers), of power differences and of ethical dilemmas. Third, the researcher needs both clarity of purpose, and much flexibility in tackling problems. Fourth, clarity of purpose can come from self-awareness of one's own interests and assumptions about the world, and these can be incorporated into reflexive accounts.

With these considerations in mind I was concerned about protecting the identities of both the interviewees and the SME organizations and for this reason all of the data in this study has been anonymized. At the same time, I recognize there is a need to be reflexive, and it is to this key matter that I now turn.

4.7 VALIDITY, RELIABILITY AND REFLEXIVITY

Whereas quantitative research defines quality in terms of the validity and reliability of data (Myers, 2009), an interpretive approach relies on the authenticity, plausibility and criticality of the 'story' and the quality of the overall argument (Walsham and Sahay, 1999). Adopting an interpretive approach provides: 'a new means of investigating previously unexplored questions, thus enabling management researchers to conduct research that [leads] to new forms of knowledge about management and organization'(Sandberg, 2005, p.45). Golafshani (2003) presents a variety of definitions of validity and reliability in qualitative research and suggests that if testing is: 'a way of information elicitation, then the most important test of any qualitative study is its quality' (ibid, p.601).

For Golafshani (2003), a good quality qualitative study, i.e. one that is able to generate understanding, can help us 'understand a situation that would otherwise be enigmatic or confusing' (Eisner, 1991, p.58) where other, i.e. quantitative, research methods were employed. Golafshani (2003) considers reliability to be irrelevant and even misleading (Stenbacka, 2001) for qualitative researchers and concludes that reliability and validity in qualitative research are conceptualized as trustworthiness, rigour and quality. Golafshani (2003) suggests that reliability is a consequence of validity and it is, therefore, sufficient to demonstrate that qualitative research is valid.

Golden-Biddle and Locke (1993) identify three criteria for establishing validity in qualitative research that adopts a constructionist design. First is authenticity, i.e. convincing the reader that the researcher has a deep understanding of the phenomenon being studied in the organization. Second is plausibility, i.e. the research should be linked to some ongoing area of interest amongst other researchers. Third is criticality, i.e. the research should challenge existing assumptions and offer something novel.

Reflexivity is the process of the researcher being aware of his or her effect on the process of conducting research as well as on the outcomes of research, and is based on the premise that knowledge is not separated from the knower (Steedman, 1991). In conducting qualitative research, the researcher is not able to remain 'outside' of the subject matter and their presence will have some kind of impact on the outcomes. The concept of reflexivity has been defined by Alvesson and Sköldberg (2000) as 'the interpretation of interpretation', in other words, as another layer of analysis in addition to the original interpretation of the data. Borkan (1999) views 'immersion/crystallization' as a suitable reflexive technique to demonstrate the validity of qualitative data. Immersion is the process whereby researchers *immerse* themselves in the data they collect by reading or examining some portion of the data in detail. Crystallization (Richardson, 1994) is the process of temporarily suspending the process of examining or reading the data (immersion) in order to reflect on the analysis experience and attempt to identify and articulate patterns or themes noticed during the immersion process (ibid, p.182). These complimentary processes continue until all the data have been examined and patterns and claims emerge from the data that are meaningful and can be well articulated and substantiated. I adopted this immersion/crystallization approach in an attempt to ensure I was reflexive in both the collection and the analysis of the data I gathered for this study. I adopted a number of reflexive 'immersion/crystallization' techniques, which I now discuss.

As part of the on-going iterative process of analysis, I immersed myself in the data. I produced verbatim transcriptions of all the interviews myself, thus enabling me to spend a great deal of time listening to each interview and 'getting to know' the data. On average, transcribing one hour's worth of recorded interview took me approximately 6 hours to type up verbatim. During this process I constantly reviewed the interview recordings and returned to my interview notes. I also shared and discussed my findings with other qualitative researchers, including my supervisors. This was very useful in gaining different perspectives to my initial interpretations and this helped me when (re)examining at my data. I also shared my research in a number of other forums; for example, I presented my preliminary findings at the Teesside University Graduate Research Conference in 2011and at the Business School's own research forum - the Centre for Leadership and Organizational Change - in 2012, and via conference papers at the Institute for Small

Business and Entrepreneurship Conference, 2011 and the European Group for Organizational Studies Conference, 2011.

4.8 CHAPTER SUMMARY

In this chapter I have reviewed the research questions and overall aim of the study and recounted my personal research journey. The chapter has outlined the philosophical framework of the research, placing it firmly in the epistemological and ontological stance of social constructionism. The chapter has outlined and discussed the research design, justifying the choice of a case study approach, explained how the data was collected and analyzed, and discussed the associated ethical and reflexivity issues. In the next chapter I present the findings of the primary data analysis before going on to discuss my interpretation of these findings in the discussion chapter.

CHAPTER 5: FINDINGS AND ANALYSIS

5.1 INTRODUCTION

The purpose of this study is to gain a deeper understanding of how science-based SMEs engage with CoPs to acquire new knowledge and what innovations are generated through such engagement. The study considers whether CoPs help develop more focused innovation processes in science-based SMEs. In order to explore this issue, and according to the research design described in the previous chapter, a case study of participants in science-based SMEs is conducted. This chapter is divided into four sections, the first section introduces the case study organizations and identifies the interviewees involved, the second section explains the data analysis process, the third section presents the findings of the primary data analysis, and the final section offers a conclusion.

5.2 THE RESEARCH PARTICIPANTS

Company A

Company A is a contract chemical processing company operating from three sites in the Northeast of England. The company offers bespoke outsourcing solutions to the speciality chemicals industry, producing a variety of products, including flame retardants, agrochemicals, biocides, herbicides and animal feed additives. They have specialist knowledge in a variety of chemical processing methods such as granulation, extrusion, roller compacting, impregnation and coating. They also specialize in the size reduction of solids by crushing, milling and micronising as well as offering support facilities, packing services, quality systems and expert technical management back-up. The company was established in 1992 and in 2006 merged with another chemical processing firm in the south of England. The merger enabled the company to increase its size as well as its portfolio of contract processing services. The company conducts a small amount of business with UK customers, but most of their business is with customers based in Europe and more recently in America. They currently employ around 65 staff and have a management team of four consisting of the Managing Director, Operations Director, Finance Director and Commercial Director. Current turnover for the company is around £5 million (2011).

Interviews were conducted with 4 employees: the Operations Director, the Purchasing Manager, the Commercial Director and the Finance Director.

Company B

Company B is a biotechnology company manufacturing a range of 'in-vitro' diagnostic products for use in the detection, prevention, and monitoring of a number of medical conditions related to haemostasis and platelet function. Used in combination with an electronic instrument the company's products can determine how quickly or slowly blood clots for patients being treated with warfarin. The company was founded in 2002 and originally started in a small incubator unit with three staff. The company was initially a one product business, manufacturing a 'reagent' product required for the management of warfarin. Warfarin has a wide range of applications, including treating patients who have had a heart valve replacement, deep vein thrombosis, and sufferers of atrial fibrillation (irregular heart beat). In August 2009, the company moved to purpose built premises and installed a new fully automated bespoke freeze dryer which allows the company's scientists to control the development and production process with greater precision. They now employ 12 staff and are currently involved in all areas of coagulation and platelet aggregation. The company supply products to hospitals and GP surgeries throughout the UK as well as having established an extensive global network of distributors from South America to Asia. The company turnover has risen from £100,000 in 2003 to £1.2 million in 2011.

Interviews were conducted with 5 employees: the Managing Director, the Technical Manager, the R&D Manager, R&D Scientist and R&D Technician.

Company C

Company C, founded in 2008, is a spin-out company from the Centre for Process Innovation (CPI) at the Wilton Centre, Redcar. Company C produces customized nanoparticulate dispersions and ultra-stable emulsions for use in a wide range of industries. The novel technology developed by Company C allows hard particles to be processed via mechanical compressive stresses and fluid extensional stresses, producing stable dispersions of nanoscale particles at a rate which is industrially significant. Their equipment allows for a wide range of materials such as Zinc

Oxide, Titanium Oxide, Silicon Oxide, Aluminum Oxide, Zirconium Silicate, metals such as silver, gold and copper, nanopigments (organic and inorganic), nanoclays and nanotubes to be processed within a wide range of carrier fluids (including flammables). Efficient heat extraction from the carrier fluid allows heat sensitive materials such as foodstuffs to be processed without the problem of denaturing. This technology is also particularly effective at creating emulsions with nanoscale droplets at a very wide range of viscosities. The company currently employs four staff. Two are full time staff, a scientist who is the Technical Director and founder of the company and the other who is a scientific instrument technician. They also employ two part time lab technicians. The company does not at this time have an established customer base. Details of the company's turnover were not available.

Interviews were conducted with two employees: the Managing Director and the Technical Director.

Company D[4]

Company D specialises in a novel class of water treatment systems that use a process called 'photocatalysis' to destroy a broad spectrum of organic contaminants in water. Unlike traditional industrial water treatment methods such as filters, granular activated carbon (GAC), or membranes that work by concentrating contaminants for later disposal, the Company D range of systems efficiently destroys organics with little or no extra disposal costs. Industrial pollutants such as surfactants, BTEX compounds (Benzene, Toluene, Ethylbenzene, and Xylenes), estrogenic compounds, pesticides, dyes, bacteria - plus a spectrum of other contaminants - are simultaneously reduced or removed to stringent limits, leaving only water, and trace amounts of carbon dioxide. Company D was founded in 2009 and was originally based in Aberdeen. They moved to the Wilton Centre in 2011in order to take advantage of the support offered by CPI. The company employs 2 full time staff; the

[4] Companies C and D are both new business start-ups located in the Centre for Process Innovation (CPI), a science and technology park based at the Wilton Centre, Redcar. The CPI is dedicated to nurturing innovative businesses within the science, technology, engineering and life sciences. Established in 2004, the Centre helps companies develop and scale up their innovations and take new products and processes to market. They provide support for a range of industrial sectors including the pharmaceutical, food, chemical, energy, transportation and printable electronics markets.

Technical Director and the Managing Director, the co-founders of the company, and a part time Sales Development Manager. Details of the company's turnover were not available.

Interviews were conducted with two employees: the Managing Director and the Technical Director.

Company E

Company E, incorporated in 2003, manufactures semi-conductor materials within the Cadmium Telluride family, which have a variety of applications in the areas of medical imaging, security screening, industrial inspection and space exploration. The company is a spin out company from the University of Durham and began in a small way, with a team of three staff operating out of an incubator unit within the university. The company soon outgrew the incubator space and in 2005 moved to a local science park. Although originally set up to commercialize the production of single crystals, the Company's business model evolved to move up the value chain to produce sub-assemblies and end user products in the x-ray market. The result is a series of products that are being launched to deal with liquid based threats in aviation security and border control. The Company has over 60 employees and its current product range now includes high quality single crystal material through detector assemblies to complete system designs. The company recently received its first order for a treatment system from a UK-based petrochemical company but has yet to establish itself in the market place. The company's current turnover was unavailable.

Interviews were conducted with 5 employees: the Chief Technical Officer, the New Technology Manager, and the Materials Manager, the Technical Manager and Senior Scientist.

Company F

Company F, incorporated in 2003, is a marine fuel testing company. Its main business activity is to provide an integrated fuel testing service for ship owners, managers or anyone involved in the purchasing or use of marine fuels. The company provides laboratory analysis and commentary on the quality of marine fuels used by all types of seagoing vessels. Its range of industry standard services includes fuel

testing, bunker quantity surveys to ensure that the quantity of fuel paid for is actually delivered to a vessel, pre-bunker analysis to assess the quality of fuel prior to delivery, ship fuel sampling audits to ensure representative samples are obtained for testing purposes, and purifier efficiency monitoring, which gives an indication of how well the entire fuel pre-treatment system is operating. In addition to these field and laboratory based services the company also offers full investigative analysis to examine any damage caused to ships' operation by fuel contaminants which are non-naturally occurring components of the residual/distillate bunker fuel. The company currently employs around 40 staff and recently announced the formation of a strategic alliance with another company who has taken a non-controlling stake in Company F. This company has an annual turnover of £6 million.

Interviews were conducted with 3 employees: the Technical Director, the Operations Director and the Customer Services Manager.

Company G

Company G specializes in the design and manufacture of gas sensors and analyzers, and provides innovative solutions to gas monitoring in a variety of environments. The company offer a diverse range of products and services in areas that including sports diving, where they manufacture a wide range of Nitrox and Trimix analyzers; commercial diving, where they produce a selection of portable and fixed diving analyzers providing comprehensive life support for divers in diving bells and chambers working offshore; military systems, where they offer life support solutions for naval diving and routine submarine atmosphere monitoring; industrial and laboratory safety, such as industrial safety equipment for toxic, flammable and inert gases; and in hospitality, pubs and breweries, where they manufacture carbon dioxide sensors. Established in 1981, the company currently employs around 40 staff. In 2012 it was shortlisted for a prestigious North East innovation award. This company has an annual turnover for 2011 was £5 million.

Interviews were conducted with 4 employees: the Managing Director, the Service Manager, a Design Engineer and an R&D Engineer.

5.3 THE DATA ANALYSIS PROCESS

As discussed in Chapter 4, template analysis provides a specific method of thematically analyzing qualitative data by developing a coding 'template' that can be used to identify and organize themes in a meaningful way (King, 2004). According to King (2004), in template analysis it is common to develop some a priori themes in advance of initial coding that are related to the research aims. Based on the theoretical position of this research, its aims and objectives, and the results of the systematic literature review (see Chapter 3), a number of themes were identified that were expected to be relevant to the research questions. This approach resulted in three a priori themes being identified from the systematic literature review of 'communities of practice and innovation' and Table 12 provides a definition and description of each theme.

Table 12 Coding descriptions for the Level 1 *a priori* themes

Code 1	**Community of Practice**
Definition	A group of people, who share a concern, set of problems, or passion for a topic, and who deepen their knowledge and expertise by interacting on an ongoing basis (Wenger et al. 2002).
Description	The structure of a CoP consists of three interrelated elements: mutual engagement, joint enterprise and shared repertoire (Wenger et al. 2002).
Code 2	**Knowledge acquisition**
Definition	The knowledge that a firm obtains from internal knowledge sharing (Zheng Zhou and Bingxin Li, 2012) and external sources (Gamble and Blackwell, 2001).
Description	Knowledge from external sources including suppliers, competitors, partners/alliances, customers, and external experts and networks (including CoPs) which can extend well outside the organization.
Code 3	**Innovation**
Definition	The development and implementation of new ideas by individuals who, over time, engage in transactions with others in an institutional context (Van de Ven, 1986).
Description	Current models of innovation focus on collaboration, external networking and speed to market for determining firms' competitiveness, particularly in knowledge-intensive areas of innovation (Assimakopoulos, 2007).

The codes identified in Table 12 appear as Level 1 themes in the initial template (Table 13) and represent *a priori* themes generated from the research aims. The majority of the Level 2 and 3 sub-themes in Table 13 were then generated through a more iterative process involving initial analysis of a sub-set of six of the total sample of interview transcripts.

Table 13 The Initial Template

Level 1 Themes	Level 2 sub-themes	Level 3 sub-themes
1. Communities of Practice	1.1 Identifying CoPs	1.1.1 Community - mutual engagement 1.1.2 Domain - joint enterprise 1.1.3 Practice - shared repertoire
	1.2 Types of CoPs	
	1.3 Building social capital	1.3.1 Trust 1.3.2 Reciprocity
2. Knowledge acquisition	2.1 External sources	
	2.2 Absorptive capacity	
	2.3 Individual learning	
	2.4 Collaboration	2.4.1 Informal
		2.4.2 Formal
3. Innovation	4.1 Novelty of the innovation	
	4.2 Innovation as problem solving	

However, as outlined in the methodological contribution of the study (p.3), in an adaptation of King's (2004) approach, there are some exceptions to note:

- The Level 3 sub-themes listed under 'Identifying CoPs' are based on Wenger et al.'s (2002) description of the structure of a CoP, i.e. mutual engagement, joint venture and shared repertoire, rather than from analysis of the initial sub-set of data;
- 'Absorptive capacity' was initially included as a sub-theme of 'knowledge acquisition' based on its close association with Gamble and Blackwell's (2001) definition which links the two concepts;
- 'Building social capital' was included as a sub-theme of 'Communities of Practice' based on its relevance to the research aims.

Development of the final template followed these stages:

1. Identification of potential *a priori* themes (and some of the sub-themes as previously noted) from a systematic literature review of 'communities of practice and innovation in science-based SMEs' based on their relevance to the main research aims and theoretical position of the research.

2. Transcription and review of an initial sub-set of 6 research interviews (3 in Company A, 2 in Company B and 1 in Company D) to identify key issues and themes. Transcribing the interviews was a lengthy and on-going process and analysis of the initial sub-set interviews began well before all the interview data had been gathered.

3. Initial coding of the sub-set of interview transcripts identified 16 additional sub-themes relevant to the *a priori* codes already identified and the main research aims. This initial coding was conducted by hand, marking the printed transcripts with a pen, before inputting the data into Nvivo to create the initial template (Table 13). Themes that already encompassed one of the *a priori* codes already identified were coded as such, if not an existing code was modified or a new code created that fitted the new theme.

4. The initial template was then further developed by applying it to all of the interview transcripts. A total of 38 new themes were identified that did not fit with existing codes. From the initial template (Table 13), 2 codes were subsequently discarded ('external sources' and 'formal') and 3 were assigned more appropriate labels ('novelty of the innovation' became 'novelty', 'innovation as problem solving' became 'problem solving' and 'informal' became 'informal relationships'). One code ('absorptive capacity') was moved from Level 2 sub-themes to Level 3 sub-themes.

Development of the final template was, therefore, an iterative process and earlier versions of the template (see Appendix 2 for an example of an earlier version of the template which demonstrates that this was a reflexive process) underwent 17 changes in total before the final template (Table 14) was achieved. Interpreting the data and deciding which themes to discard and which to keep involved making judgments about their salience in relation to the research questions and the

phenomena being investigated. In order to prioritize the themes, I looked at each one in the context of each individual interviewee's accounts, as well as examining and comparing the transcriptions from the different participants. .

Table 14 The Final Template

Level 1 Themes	Level 2 sub-themes	Level 3 sub-themes
1. Communities of Practice	1.1 Identifying CoPs	1.1.1 Community - mutual engagement 1.1.2 Domain - joint enterprise 1.1.3 Practice - shared repertoire
	1.2 Types of CoPs	1.2.1 Apprentice-based 1.2.2 Intra-organizational 1.2.3 Inter-organizational 1.2.4 Nascent
	1.3 Building social capital	1.3.1 Credibility 1.3.2 Passing on business 1.3.3 Social presence 1.3.4 Personal relations 1.3.5 Lack of 'band width' 1.3.6 Trust 1.3.7 Reciprocity
2. Knowledge acquisition	2.1 Individual learning	2.1.1 Canonical practices 2.1.2 None-canonical practices
	2.2 Knowledge sharing	2.2.1 Internally 2.2.2 Externally 2.2.3 Journey versus destination 2.2.4 Balancing R&D with 'productionization' 2.2.5 'Low hanging fruit'
	2.3 Collaboration	2.3.1 As a route to market 2.3.2 As a source of funding 2.3.3 Boundary spanners 2.3.4 Acquiring 'key experts' 2.3.5 Informal relationships 2.3.6 Open innovation 2.3.7 Absorptive capacity 2.3.8 Spin outs
3. Innovation	3.1 Novelty	3.1.1 Uniqueness 3.1.2 Directed creativity 3.1.3 Occupying niche markets 3.1.4 Novelty limiting knowledge sharing 3.1.5 Providing competitive advantage
	3.2 Problem solving	3.2.1 Designing solutions for customers 3.2.2 Customer reliance on expertise 3.2.3 Incremental innovation 3.2.4 Radical innovation

5.4 KEY FINDINGS

Section 5.4 is devoted to presenting the key findings with excerpts from the interview data being used to illustrate key points. The rest of the section is then

organized according to each of the three Level 1 themes identified in Table 14 - communities of practice, knowledge acquisition and innovation.

- Theme 1 – 'Communities of practice' examines whether CoPs are present in science-based SMEs and, if so, how they are constructed and their contribution to building social capital;
- Theme 2 – 'Knowledge acquisition' explores how knowledge is acquired through individual learning, knowledge sharing and collaboration;
- Theme 3 – 'Innovation' explores innovation as both 'novelty', i.e. radical innovation, and as 'problem solving', i.e. incremental innovation, and identifies how CoPs contribute to innovation in science-based SMEs.

Table 15 summarizes the categories of CoPs and the types of innovation found in each of the SMEs. It is based on the definitions of CoPs and innovation identified and discussed in the literature.

Table 15 Categories of CoPs and Innovation

Categories of CoP:

- Apprentice-based CoPs are most closely related to Lave and Wenger's original conceptualization of CoPs as a locus for practice-based learning;

Organization	CoPs	Innovation
Company A	Intra-organizational Inter-organizational	Incremental
Company B	Apprentice-based Inter-organizational	Incremental
Company C	Inter-organizational	Radical/Disruptive
Company D	Inter-organizational	Radical/Disruptive
Company E	Inter-organizational Intra-organizational	Radical/Disruptive Incremental
Company F	n/a	n/a
Company G	Intra-organizational	Incremental

- Intra-organizational CoPs are, perhaps, best viewed as informal networks suitable for supporting individual learning, knowledge acquisition and knowledge sharing between professional groups within the SMEs;
- Inter-organizational CoPs, on the other hand, represent informal groups that include members external to the organization, e.g. customers, suppliers and even ex-colleagues.

Types of innovation:

- Radical innovation refers to the commercialization of 'new to the world' inventions;
- Incremental innovation involves making regular on-going improvements to existing products and services.

There was no evidence of the explicitly managed CoPs identified in the literature review, nor was there any suggestion that participants were aware of the concept of CoPs, or their implementation or even presence in their organizations. However, participation in a variety of informal CoPs, both emergent and to a lesser extent cultivated was confirmed through analysis of the interview data. Each theme is now discussed in detail.

5.4.1 Theme 1 - Communities of Practice

This research found evidence of three specific types of CoPs – apprentice-based CoPs, intra-organizational CoPs and inter-organizational CoPs – which the science-based SMEs leveraged to varying degrees, in order to improve their knowledge acquisition and thus enhance their innovation capacity. Research has tended to focus on CoPs in large organizations (Loyarte and Rivera, 2007; Probst and Borzillo, 2008; Swan et al. 2002; Wenger et al. 2002) and this important finding confirms their presence in science-based SMEs, thus addressing my first research question – 'Are CoPs to be found in science-based SMEs?' This finding also supports the widely held view that CoPs exists in all types of organizations (Brown and Duguid, 1991; Hildreth et al. 2000; Lesser and Prusak, 1999; Wenger, 1998; Wenger et al. 2002). The relative importance of each of these types of CoPs in the innovation processes of the science-based SMEs is now explored in greater detail.

5.4.1.1 Apprentice-based CoPs

In the science-based SMEs there was limited evidence of the 'traditional' *apprentice-based* CoPs described by Lave and Wenger (1991), with the exception of Company B. In Company B, although ostensibly working as part of a team, the less experienced junior scientist and two technicians often worked in isolation, seeking advice and support from the R&D Manager as and when they required it. As the R&D Scientist confirmed: 'You're part of a team but you work alone a lot of the time and so when I want to find something out I can go to [R&D Manager] for advice…', the R&D Manager could be viewed as the 'master', passing on his know how by engaging in knowledge exchanges closely related to the 'novice's' area of practice. In this instance, the apprentice-based CoP emerged through a process of community building, i.e. mutual engagement, centered round a specific domain of scientific knowledge, i.e. joint enterprise, out of which came a sense of shared repertoire. The R&D Manager was, in turn, mentored by the Managing Director, who, through his personal network of contacts, brought the R&D Manager, and to a lesser extent the more junior scientists and technicians, into contact with people outside of the organization, enabling them to access external knowledge in addition to calling on members of their internal community:

> [Name omitted], our R&D Manager, he, and our other less experienced scientists, through [the MD's] mentoring really, is getting in touch with this and that group of people and the knowledge is transferring to [R&D Manager] so he is getting more confident in passing this on to colleagues. (Technical Manager, Company B).

However, Lesser and Prusak (1999) observe that shared language is an important element in building the trust and social capital associated with successful CoPs. Lack of shared language in science-based SMEs could prevent apprentices moving from a position of legitimate peripheral participation, as a 'newcomer' to becoming a full participant as an 'old timer' and taking a position of full participation in a CoP. One participant in Company E used the following anecdote to highlight the potential value of apprentice-based approaches in adding value to an individual's learning experience, whilst highlighting the difficulty in developing shared language in science-based innovation:

> It makes it very difficult for there to be a shared language and, you know, there is this well worn thing about... old doddery gits telling them that, for no fathomable reason, that what seems like a perfectly sensible plan that they have isn't going to work and then having to deal with the acute embarrassment of finding that it didn't [laughs] and that problem is for us is actually kind of awful because… the way a lot of people get though that learning curve is that the doddery old gits give them someone something they can fall over a little bit on and it doesn't have really a whole lot of impact on the organization… but for us there isn't much latitude. (Chief Technical Officer, Company E).

The theory of absorptive capacity (Cohen and Levinthal, 1991) also suggests that shared language is important in helping firms assimilate and use new external knowledge, including knowledge of the most recent scientific or technological developments in a given field. The lack of shared language, which is closely associated with shared repertoire, might hinder science-based SMEs' ability to recognize and acquire new knowledge, assimilate it, and apply it to develop their innovation. There is also a further implication that shared repertoire, fundamental to sharing meaning within a CoP, is difficult to cultivate in science-based SMEs in relation to the level of 'novelty' of the innovation. This sentiment was echoed by other participants:

> … a lot of the stuff we do, we… is… no-one knows how to do. Very little of what we do is 'building the house', where building… where you put the bricks in, you build the floors, you build, you put all the wiring in. Very little of that is what we do. It's a lot of unknowns, so you have to innovate at most steps along the way. (New Technology Manager, Company E).

Within the SMEs dealing predominantly with R&D customers, focused on radical innovation, this shared language and repertoire was strongly linked to generating radical innovation:

> Somebody from outside looking in has, for example, no idea why a person is doing something that, that, you know, and you… and I think one of the things that we find most difficult with things that aren't… you know, it's not…

> we're not doing projects here that are digging ditches or building walls. There's no-one even knows how to do what we're doing so… (Materials Manager, Company E).

Apprentice-based CoPs seem, therefore, more appropriate for supporting individual learning in SMEs involved in incremental innovation, i.e. Company B, where there is a high level of reliance on using shared language and building a shared repertoire to facilitate passing on *existing* knowledge between scientific staff internally. On the other hand, if firms are involved in radical innovation, such as Company E, CoP development and deployment is inhibited by the absence of shared language and shared repertoire related partly to a lack of existing knowledge and the uniqueness or 'novelty' of the innovation. This aspect frustrates both the development of shared language and shared repertoire associated with community building. Although evidence of apprentice-based CoPs was scant, and their applicability to supporting innovation unclear, there was confirmation of the presence of other types of CoPs - both *intra- and inter-organizational* – focused on specific domains of scientific and engineering expertise and collaborative approaches to innovation.

5.4.1.2 Intra-organizational CoPs

Intra-organizational CoPs, - i.e. informal networks suitable for the development and sharing of knowledge within organizations (Probst and Borzillo, 2008) - often emerged unplanned, beginning on some occasions with 'corridor meetings' between individuals, who met in passing and held impromptu meetings to discuss particular issues. Although individuals often worked in formal teams, the importance of these informal encounters was closely allied with developing innovative solutions. As one participant commented: 'people work in teams generally, but often the most productive solutions happen by accident. Like when we chat at lunch about formulations... it sometimes solves the... we discuss possibilities' (Operations Director, Company A). There was confirmation of both mutual engagement and joint enterprise between different professional groups within the SMEs, i.e. between scientists and engineers. In this excerpt, for example, the Materials Manager refers to 'informal networks' and 'corridor meetings' where colleagues exchange knowledge informally, and which have some resonance with the 'war stories' told by photocopier repair men in Orr's (1990) book *Talking about Machines*:

> Internally there is a network which is probably the four people who I talked about, you know, the IT guy, the detector guy, myself and Ben, and that's an informal network, you know, but we're… we tend to do corridor meetings, you know, how's that - because we have the … our Venn diagrams of influence cross over so regularly that, you know, that you end up like, if I don't, if I didn't make a crystal, [Name omitted]'s probably sitting tapping his fingers waiting for that crystal to come through 'cause he want to do some testing… or the detector guy wants to do something… (Materials Manager, Company E).

Here, it seems to me, the Materials Manager is describing an intra-organizational CoP where members share internal knowledge. This finding supports Conway's (1995) view that informal networks, such as CoPs, play a crucial role in enabling firms to access internal knowledge and develop new innovations. On the other hand, there was also an implication that for staff operating at a strategic level participation in intra-organizational CoPs is more difficult because they came into contact with fewer people as they reached senior positions. This aspect could also represent a significant barrier to leveraging the social capital inherent in the relationships forged out of CoPs. One interviewee, who began his career as a physicist before moving into management, referred to this phenomenon as lack of 'band width':

> These days I tend more to work with a limited set of people… but... that's because I don't have the 'band width' to get involved at… at a level for everyone in the organization, I mean the organization has grown and my role's changed so I don't have the band width. (Chief Technical Officer, Company E).

This finding provides insight regarding the governance of CoPs in science-based SMEs. Probst and Borzillo (2008), for example, claim that managers act as 'control agents' in organizations and play a key role in CoP construction. However, their research is based on a study of CoPs in large organizations where managers actively promote CoP membership amongst employees. This finding suggests that, in science-based SMEs, scientists occupying management roles are aware that their ability to participate in internal networks and, therefore, their ability to act as 'control agents', encouraging other employees, becomes limited as they take on

more strategic roles. The evidence suggests that, although intra-organizational CoPs fulfil an important function in supporting individual learning and internal knowledge sharing, it is sometimes difficult for staff working at a strategic level to access them because of their lack of 'band width'.

Although there was no evidence of intentionally managed CoPs, there was confirmation in one SME of efforts to cultivate intra-organizational CoPs. Company G had introduced the idea of an 'Imagineering Wall' (Figure 15) in an effort to encourage employees to generate innovative ideas: 'It allows for anybody and everybody in the company to contribute and comment in a very free and open way' (Service Manager, Company G).

Figure 14 The 'Imagineering Wall', Company G

The ‘Imagineering Wall’, a portmanteau referring to a large tri-divided whiteboard mounted on an office wall, was an area where employees could post innovative ideas for new products or improvements to existing products. The purpose of the wall was seen by the MD as an informal way to generate ideas. Employees were encouraged to post ideas on the wall, no matter how bizarre they might appear, in order to encourage sharing and creativity and an open approach to innovation:

> It was the idea of open sharing of ideas within the company, sort of, that anybody, where ever they work in the company, can submit any idea they have and it can go on the wall… and everyone else can see it… and everyone else can contribute. (Design Engineer, Company G).

However, setting up the wall was seen as a challenge to such a process driven firm, where the focus was very much on formal procedures for product development, as the Service manager explained:

> It’s been a challenge for us to set up the ideas wall… because… we’ve had to get around the fact that we don’t want to put any process I place, because if we do we formalize the innovation process too much and we won’t get the creativity which we’re wanting from the ideas wall in the first place. (Service Manager, Company G).

The caption above the wall explained its purpose: ‘To grow the business by identifying unique problems and using our skills and knowledge to produce profitable solutions.’ As the Service Manager explained:

> …it is an informal way for us to gather and radiate information about ideas that come up in our day to day work from anybody in the company… so … if somebody from the sales department gets a call from a customer, they ask for something we don’t necessarily have a product offering for, that can be identified as a problem that we, at least, don’t have a solution to. So we put that up [on the ideas wall] and develop that and try and see if there is a product or service we could develop to offer that customers? Is there a market? Is there a technical solution to the problem they are asking? (Service Manager, Company G).

Employees who chose to participate could comment on ideas that had been posted, or add their initials to an idea as a form of endorsement, or to show an expression of interest. The system was self-selecting; if an idea reached a 'critical mass', in terms of employee interest, those who had endorsed the idea were encouraged to get together informally and work on the innovation. Individuals found their own partners to work with:

> The research that we've done into this area would suggest that the most successful ideas are those that start from the individual and then… they successfully persuade other to share that motivation, that idea, that concept, and then get some momentum behind it. (Managing Director, Company G).

Although all employees were encouraged to participate in using the wall, it was R&D staff who posted most ideas. This action was partly because of their status as 'experts' and partly because of the added incentive of a 10% time allowance which allowed them to pursue their own ideas, or those they selected from the wall. The wall provided a focal point for individuals to share ideas they were interested in developing and to seek other members with similar interests:

> … and it doesn't necessarily have to be stuff that's off the ideas wall either, they could be thinking of stuff they eventually want to put on the ideas wall… again there's a lot of motivation there… if it's not something that interests the individual then they're not going to give their all, they're not going to give their best… (Service Manager, Company G).

All participation was voluntary and, in effect, employees formed intra-organizational CoPs centred round their chosen innovation idea:

> … [employees] can do it on their own terms… there's not sort of a rule that at 9 a.m. on a Monday morning you go and look at the ideas wall [laughs]… it's a case of when you feel you want to… or, you know, as part of taking time out of your day… you can spend [that time] on problems and ideas that interest them. (Managing Director, Company G).

The wall was divided into three sections. Section one was where people posted their initial ideas. If an idea gathered enough momentum, it was moved to the second

section. Here the idea could be developed further by those employees who want to work on it. At this stage, the purpose is to find out if the idea is feasible and whether they have the expertise to develop it further: 'at that stage we have much more idea, you know… there is a market, there is a technology… there is a potential there for us to make something of this… it's something we're capable of doing, things like that…' (Service Manager, Company G). If an idea reaches the third stage of the wall, it is formalized and a business case is developed for continuing with the project in terms of development cost versus potential benefit to the company:

> … ultimately we can then hang number and fact on to that idea and eventually get to the point here we do have a very formal form, a business case… which is still very loose… in terms of how much is it going to cost and how much we can potentially make as a return… (Service Manager, Company G).

The Imagineering Wall had been successful in generating a number of small incremental innovations to existing products. In total, the CoPs that emerged from employees engaging in 'wall activities' had produced 6 'new and improved' versions of products that were on the market and a further 4 projects that were in the early stages of development (as at July 2013). However, quantifying the number of CoPs that emerged was difficult. The company did not keep accurate records of each employee's informal 'wall activities' until these became formal projects. This approach meant that an employee could move from one project to another without having to inform anyone and, therefore, might be engaged in multiple CoPs at any one time. This aspect made it difficult to track the number of CoPs they were members of as well as the depth of their involvement.

Not all interviewees expressed such positive views of the Imagineering Wall and some employees were skeptical about employing the wall to generate new ideas:

> It's a good idea… I'm not convinced it works… in the guise it's in at the moment. I think how it's supposed to work has been constantly shifting since it's been set up... it's tried to be many things, but the general gist of it is that people in here will pop an idea, put it on the wall and they'll all come and contribute to it…. and drive forward… pick it up and see if it is commercially

> viable, or not. That was great when it was first developed because everyone had been sitting for a few years saying "why didn't we do this", "why didn't we do that"… and when the wall was put there everyone just jumped on it… and everything is discussed and bashed out… and then, after the novelty is worn off everybody's sort of got rid of their ideas and it is now sort of sat… we don't really have enough external stimulation to keep it going… (R&D Engineer, Company G).

This response implies that the wall initially provided an outlet for employees to share their unrealized ideas. However, once they had posted their ideas on the wall, their initial spurt of creativity was over. To maintain the wall's creative momentum, the interviewee suggests that it requires external stimulus. Macpherson et al. (2009) suggest that artefacts are important in supporting the construction of CoPs and Lesser and Prusak (2001) support this view, explaining that the cognitive dimension of CoPs, which includes the development of shared artefacts within the community, improves organizational performance and the development of social capital, both of which are essential for innovation. This finding helps shed light on how science-based SMEs can use artefacts to encourage the construction of CoPs and goes some way to answering my second research question – 'how and why are CoPs constructed in science-based SMEs?'. In effect, the 'Imagineering Wall' acted as a shared artefact, a boundary object, encouraging the practice-based discussion and participation that is indicative of the cultivation of intra-organizational CoPs. As on participant observed: 'we want to use the wall to capture their skills and expertise and creativity to the benefit of the company' (Managing Director, Company G). The long term success of the wall might depend on how it is used and on the ability of the company to engage external partners.

5.4.1.3 Inter-organizational CoPs

There was evidence of inter-organizational CoPs that emerged through mutual engagement and collaborative relationship building centred round two distinct sets of customers: commercial organizations and R&D organizations. The commercial organizations represented a variety of customers from a range of 'for profit' businesses, including larger organizations, whose main aim is to generate profits through commercial activity. The commercial organizations tended to be seeking

solutions to specific problems, for example, commercializing new science-based products, or scaling up production of a new chemical process. The R&D organizations are represented by universities and other research institutions, whose main activity is research and development but who also want to generate new revenue streams through filing patents for new products and process and commercializing their inventions by forming spin-out companies.

Successful mutual relationships with both the commercial and R&D organizations was established through regular engagement between individuals in both organizations, often on an informal basis, thus developing the initial ties that Wenger (1998) suggests bind informal groups, such as CoPs, together. One Managing Director stressed the importance of regular contact for building and maintaining relationships with customers and building strong relationships with customers through regular, informal contact was very much a feature in all of the participant organizations: 'We very much have to work with these customers and build relationships and that can only be achieved through regular contact' (Managing Director, Company B). Regular interaction with customers produced a sense of shared understanding; by working together towards a mutual goal and engaging in joint enterprise, inter-organizational CoPs emerged, where the participants sought to develop solutions in partnership with customers:

> We work together with the customer to provide solutions in a way we both understand. Someone may call, a chemist or engineer for example, or someone else... call to discuss progress and that's significant in terms of maintaining good relations and meeting their demands for a solution. (Operations Director, Company A).

Whilst relationship building through mutual engagement often took place informally, it was nonetheless considered important in terms of developing solutions for customers. Luecke and Katz (2003) stress the importance of such processual approaches that emphasize relationships and knowledge exchanges, suggesting that these have greater purchase in terms of understanding where CoPs link to innovation. In the following excerpt, the MD of Company B highlights this processual approach, explaining how once he had identified a company he wanted to work with he would first initiate and then attempt to maintain mutual engagement by

building a relationship with the potential customer. Although initial contact with this potential customer occurred in 2005, Company B did not receive an order from them until two years later. The MD highlighted one example where, from the initial point of contact, he had established a strong relationship, in effect the foundations of a nascent CoP, with one of the executives at the firm by sharing expertise:

> When the 'exec' of the company came over to see his distributor in Stockton he'd come into Hartlepool and have a meal and chew the fat... discuss how we can help them - and through that relationship building we help them develop solutions. (Managing Director, Company B).

Strong personal relationships were closely linked to trust, discussed in more depth later, and as one interviewee explained: '… once the personal relation[ship] is fairly strong, trust is then quite difficult to break' (Purchasing Manager, Company A). Trust was also linked to whether an individual could be relied on to 'perform', especially where they were involved in radical innovation projects:

> I think [personal relationships] more important than you'd hope. I think… I think it still is you go with someone you… it's much easier to go with someone who you know and you know how they're going to perform and how they're… like whether you can rely on them or not. Going into the unknown with someone new is much more difficult I think. (New Technology Manager, Company E).

In one SME, the Managing Director, a prolific networker, regularly visited customers providing advice and sharing his expertise in the area of Warfarin management, an anti-blood clotting agent:

> …because, I mean, [the MD's] helped out Hospitals. They're not a customer but they couldn't get the support from their current supplier. So because of his networking, because he's known to have the knowledge in this sort of field, the contact [form the hospital] says "look, I'm using this reagent, although it's not yours, this is happening to my patients, or these are the results" – and it is not good. So he basically takes the data, has a look at it and says "you can do this, this, this or this. He hasn't tried to force them to

> buy our reagent or anything. He's just helped them out. (Technical Manager, Company B).

The MD was willing to provide advice on the use of competitors' products and used these visits as opportunities to build personal relationships with existing and potential customers and, as the Technical Manager explained: 'He was willing to provide advice on the use of competitors' products and used these visits as opportunities to build personal relationships with existing and potential customers'. The ability to leverage personal relationships helped bring individuals together, including customers, competitors and suppliers, forming the basis for CoPs to develop. For example, in Company B, the MD had built an extensive inter-organizational CoP consisting of diverse members, including hospital doctors, nurses, GPs, Practice Managers, hospital technicians and academics. However, the success of such CoPs was entirely dependent on the strength of social presence exhibited by the individual, in this case the MD of Company B., This is often associated with successful community building (Rovai, 2002) and has some resonance with Coakes and Smith's (2007) notion of 'innovation champions' who transcend organizational boundaries and support collaboration with other communities and organizations.

Some SMEs held events to bring together customers and suppliers and showcase their expertise, thus encouraging the informal interactions that are often the basis for CoP formation:

> One of the things [name omitted] does, as Head of Technical Support, we invite major suppliers here who we get, sort of raw materials from but who sell to the industry, and potential and existing customers… and we will give them, if you like, seminars on different sort of process techniques which sort of can help them go and find more businesses… business, and has a reciprocal effect in that they put us in touch with businesses who want help… sort our of knowledge [sharing] (Managing Director, Company A).

To a great extent, this finding demonstrates that science-based businesses are reliant on the strength of the personal relationships that entrepreneurs form with external partners, such as universities, research laboratories and even other science-based

firms (Lee et al. 2001; Andersen and Jack, 2002). This finding confirms the point made by Lechner and Dowling (2003) that personal relationships are the 'basic building blocks' of firms' knowledge, innovation and technology relationships, which play an important part in their commercial success. This aspect raises an interesting question – how do SMEs lacking individuals with high levels of social presence build the relationships necessary for CoPs to develop?

For the two start-up organizations (Company C and D) based at the Wilton Centre, support was provided by the Manager of the CPI who, acting as a boundary spanner, brought companies together to engage in open innovation activities:

> ... [the CPI Manager] is looking at… we had our first sort of get-together of water treatments… water monitoring company conference rather, where… he contacted a few companies in the area, mostly companies that didn't directly compete with each other. And we all gave a little presentation on our own companies and had a network event after that. And we have some meetings with some of those companies next week, actually. (Technical Director, Company D).

Cross and Prusak (2002) identify boundary spanners as an essential element for building effective CoPs, and this finding suggests that they provide an alternative method for building the informal relationships that the construction of CoPs relies upon. Networking events enabled the SMEs at the Wilton Centre to meet with competitors in an open innovation forum where they could engage in knowledge sharing activities, exchange ideas and build the informal relationships that are the basis of networks such as inter-organizational CoPs:

> It is quite informal and I think the idea is that, and I think it's a good one, that… companies know what other companies are capable of. So if they come across something that they can't manage with one of their clients they say 'ah!', and then we can start talking, potentially either swopping ideas… or working together… to provide a solution, because at the end of the day the customer doesn't care who's doing the work, as long as it's done. (Technical Director, Company D).

The inter-organizational CoPs that flourished in the aftermath of such events frequently led to more formal partnerships being established between firms' based on their mutual need for expertise they did not possess internally:

> We'd worked with [Company X] when they developed some technology in conjunction with [Company U] at the University of [L]. So we knew technology-wise that [Company X] were very, very good at… the world-leading, mixing… they're a family-run firm down in Glossop near Manchester, brilliant reputation as engineers. What they don't have, and they recognize this as well, is the market-facing side of things. So as a team we were able to develop the algorithms and models to say "we need 'x' amount of energy to split these particles up". So now you can actually say "I need 'x' amount of energy", and they're perfect as a partner to go along and say "build me something that'll give me 'x' amount of energy". (Technical Director, Company C).

Engagement in activities that led to such joint enterprise also enabled the SMEs to develop customers' inventions and turn their ideas into a commercial product:

> Well, it's more, it's their ideas but they want us to develop the idea into a practical application for their machines, yeah they, I think the MD of that company or the scientific team have come up with the actual idea and they pass it on to us to develop further. Of course we keep in regular contact with certain people in the company to ensure things go well. (R&D Manager, Company B).

Inter-organizational CoPs emerged between the science-based SMEs and their suppliers. For example, a CoP emerged between Company B and the firm supplying them with the freeze-drying equipment used to manufacture their products. The Technical Manager had built a strong personal relationship with the suppliers, to the point where they allowed him to service and repair the equipment himself:

> Yes, but what they're left me with basically now, because I don't like [travelling] – because it's an hour's drive, what they've left me is the fridge gas, they've left me bits and bobs, but if every there's a problem I can be on the phone but I can also be doing [repairs]. It's a good situation – and I

> suppose it helps them iron out any glitches in their systems and we find out quite a bit on the software side as well so that helps us perfect our programs. We've been optimizing the drive and sharing the data with their staff. (Technical Manager, Company B).

The supplier also sought the technical expertise of Company B's Technical Manager to improve the performance of their equipment on behalf of other customers who had issues using the equipment. An inter-organizational CoP emerged from a sharing of knowledge and expertise related to optimizing the reliability and performance of the freeze drying equipment and this, in effect, created new knowledge within the CoP that all the members benefitted from:

> … this company has been having trouble perfecting the program, where me and [name omitted], I'm using my engineering mind and he's using his scientific mind and we've matched together… we've tailored our freeze drying programs to suit the materials we're drying. They've been having difficulty drying an enzyme over there, and with it being the same machine I just asked them to send me the graphs, send me the data and a picture of what's happening and within seconds I could see what was wrong. (Technical Manager, Company B).

Inter-organizational CoPs provided a fruitful environment for bringing together individuals from different organizations and their development was crucial in generating knowledge exchanges between the science-based SMEs and their external partners. Innovation is acknowledged as an important mechanism for transforming social capital into economic growth (Akçomak and ter Weel, 2006) and CoPs might be considered a valuable asset for building the requisite connections both within and between social networks. In the next section, I explore the importance of trust and reciprocity in building social capital and how this is linked to the construction of CoPs in science-based SMEs.

5.4.1.4 Building Social capital

Field (2006) summed up social capital in two words: relationships matter. This perspective was echoed by one interviewee who linked success with building good relationships: 'business is about relationships, it really is, you know? I have

extremely good relationships with everyone I work, with that's why we're successful' (Managing Director, Company B). Social capital has been described as a contributor to innovation by providing capabilities for creating and sharing knowledge (Landry, 2002). Analysis of the data revealed a strong link between the CoPs identified and the development of social capital in trust-based relationships. Trust was considered an important way to build credibility, as one interviewee explained: 'You've got to build up credibility… people need to trust you'. It was seen as important to build trust in the process of developing and maintaining these relationships, which takes time, especially when dealing with firms outside the region. For Company A:

> … [customer X] are very, very particular and everything takes a very long time and, and they have to go through this trust building exercise which… involves quite a few visits, before the point they get to when they say 'Right, okay we're now going to go with [Company Y]'. (Operations Director, Company A).

Trust was also linked to building the success of the SMEs; to becoming more established through recognition of their knowledge base: 'We're getting more established, our name is getting more well [sic] known. I think we're, sort of, being trusted in some respects, it takes time, but our knowledge base is gradually being recognized' (Technical Manager, Company B). Building trust-based personal relationships helped SMEs gain access to new markets: 'It does make life an awful lot easier when you have a better personal arrangement in there. Rather than going in there totally cold, it gets you so much further down the line; the trust is already there' (Managing Director, Company C). This has some resonance with the notion that the social capital present in CoPs can be leveraged to promote trust and reciprocity, leading to greater knowledge sharing. Although trust can promote collaboration, it could be a problematic matter, however, for some SMEs. Whilst acknowledging the importance of trust-based relationships, some interviewees commented that it was prudent to also have formal contractual agreements and the use of non-disclosure agreements (NDA) was common:

> We will set up secrecy agreements, confidentiality agreements, call it what you will, to... ensure that our customers are happy with what we're doing. So,

> there's trust, but it's backed up with sort of… contractual agreements. (Commercial Director, Company A).

> Well, I think, you know, trust is pretty important, and obviously as I said collaborations have to be under NDA's from our point of view. (Technical Manager, Company E).

Trust was a particular issue for the two smallest firms, companies C and D, both recent start-ups which still had patents on inventions they were in the process of commercializing. They felt that they were vulnerable because of their lack of business experience and this was a barrier in building trust-based relationships: 'everybody's out to protect their own business… so you just have to keep part of yourself back. And that's one thing that you just learn. My background isn't in business, it's in the technical part of the thing, so I'm just getting used to… it' (Technical Director, Company C). Lack of trust, therefore, often presented a barrier to community building, i.e. achieving mutual engagement, even when the other relevant conditions for CoP cultivation existed, i.e. when there was evidence of joint enterprise and shared repertoire. This finding supports Harding and Pawar's (2000) view that lack of trust inhibits knowledge sharing in SMEs. When such conditions exist, 'nascent' CoPs fail to develop into fully developed CoPs. Nascent CoPs are considered to be groups of people with a shared concern, who for various reasons, do not take the necessary action to build a community, or, are prevented from doing, thus failing to become fully developed CoPs.

Building trust was not always easy, even for the larger SMEs. In the following extract, the interviewee suggests that when sourcing external expertise for developing 'something completely new', i.e. radical innovation, trust building is sometimes a secondary consideration, coming after getting someone with the necessary expertise, particularly if the person is not within their existing external network:

> I think trust is important… I'm not sure how well we measure it. I mean if you've got someone from an existing network then that's easier to measure. I would say most of the things I've done I would not be able to bring people in who… 'cause for… for [name omitted], he's maybe a little… he's close to

> having to execute what he did before. For me, I'm executing stuff I've never done before, I mean, I might have done scientific instrumentation but I'm looking for a solution to an area that I've never dealt in before, so then I've got to find someone completely new and… then, you know, probably in a very unscientific way… it's just whether you get on with them or not. A lot is talked about whether… in 30 seconds you form your view on whether you will have a relationship with that person regardless of any other analytical information you later obtain through any interview process or… looking at references, or anything else, and I guess realistically I probably realize that most of it is those 30 seconds of relationship. Could you imagine this person as part of your friends set probably governs whether… you're prepared to have a relationship with them, and I mean there is an inevitability… at work that you hire people that probably don't fit in that… 'cause if you're scouring for a particular skill and it's a rare skill then I think you do end up with people who don't fit the 30 second assessment criterion. (Chief Technical Officer, Company E).

Many of the interviewees recognized the importance of building trust-based relationships and understanding (potential and actual) customer needs through regular engagement and the sharing of expertise, both internally with colleagues and externally with customers and other organizations:

> You need to develop expertise and be equipped, it's open ended, but you, commercially, you've got to think 'I need a product I can sell', and to a great extent that relies on my team working together and understanding each other's contribution....as well as working with the customer… so that we understand their needs. (Managing Director, Company B).

Generally, the SMEs were open to the idea of collaboration, but wary about choosing suitable collaboration partners, basing their decisions on an assessment of the motivation of potential partners: 'For me it comes down to what is the motivation of the individuals being involved… because there's a… the success of the work we have done with other companies is down to clarity and what we're expecting to be delivered' (Service Manager, Company G). Building trust-based collaborative relationships through mutual engagement was compared by one participant as a

journey where he acts as a guide, conducting his customer on a voyage to find a solution: 'I see that I'm taking them on this journey... interestingly… my job is to take… is to bring him [the customer] on this journey, this voyage… and explain to him why my vision is the right one to do' (Technical Manager, Company E).

Through regular mutual engagement, sharing expertise internally with colleagues and externally with customers, the science-based SMEs were often able to build effective trust-based inter-organizational CoPs, develop their capabilities, and work with their customers and understand their needs. As one scientist commented: '… they trust us to work with them and put our best efforts into finding their solution'. Passing on work to competitors in this way was often considered to be good way to build trust and reciprocity with both customers and with competitors, as well as being a reciprocal arrangement that was to everyone's benefit:

> … we know a number of people, and we meet up with our competitors, if you like on a friendly basis. So there are areas, as I mentioned, there is one particular company down Cambridge, who specialize in liquid work. So if a company comes to use with a query, sorry with a possible opportunity, and let's say it involves solvents, flammable solvents. We just don't have that facility here; unless it's a very, very big project we are most unlikely to install that facility so we will pass them on to a company that we know ,that we know are reputable and provide a good service. (Operations Director, Company A).

Reciprocity was an important part of this process and was considered to be to everyone's benefit: 'Yes, it's reciprocal and it's handy. Now, I'm not going to pretend there are huge amounts of work going backwards and forwards, but occasionally it crops up and it's to everyone's benefit when it does' (Operations Director, Company A). Some SMEs offered to provide some services free to universities for which they had previously worked, and who are involved in research projects, in exchange for the university providing them with an 'external validation' service for their new innovations:

> … in the past the university's got a grant to do this research, then we say 'well, we'll do this', but then that's how we got the contacts, so 'cause we've

> done this, or that for them, if we want something to be externally validated, we can say, you, 'Do you mind doing this?' (R&D Scientist, Company B).

This type of reciprocal arrangement was a way to make contact with new customers, or maintain contact with existing ones through exchanges of knowledge and expertise between the parties. As one interviewee observed: 'if we need some help or advice regarding actual platelet function then [the university are] more than happy to help us. It's mostly [the MD] building connections, connections that way' (R&D Manager, Company B). The ability to communicate effectively, in a CoP, particularly in an inter-organizational CoP, involves creating an effective social presence in order to build personal connections, and the MD in Company B recognized its importance:

> I have extremely good relationships with everyone I work with that's why we're successful. And I'm carrying over that good relationship to everybody in here. Now when people come and visit us it's not just 'you and me'. I make sure they meet everybody; more people are involved in the meetings. They start to build their own relationship with them. (Managing Director, Company B).

Trust and reciprocity are an essential element in building social capital (Fukuyama, 1995; Granovetter, 1985; Putnam, 2000) and constructing CoPs (Lesser and Prusak, 1999; Probst and Borzillo, 2008; Wenger, 1991; Wenger et al. 2002) and the ability to be 'out there', making connections was an important factor in relationship building and trust. Company B had been particularly successful at building connections and, as the R&D Scientist acknowledged: 'Well I suppose it's 'who you know' - especially who [the MD] knows as he's worked in the industry a long time'. The MD in this instance exhibited a particularly high level of saliency in both his networking and relationship building:

> Well really, I mean, relationships I really think are very important. Our customers… we inherited a customer base from the hospital in Manchester. The first thing I did was go around and meet every one of them. They didn't know me, they didn't know [the company], so we had to go and shake hands, sit down tell them who we were, tell them what we planned to do and, you

> know, reinforce to them that the service they would get would be improved over what they previously got… (Managing Director, Company B).

Successful business relationships were often developed out of the MD's ability to build strong trust-based personal relationships with customers:

> …myself and the CEO hit it off on a personal level. And his son now comes and works here during the summer. He's a German biochemistry student but when he finishes his degree he'll be coming to work here. He likes Hartlepool… he's a bizarre kid [laughs]. So... but that relationship took off but, on the back of that, the professional relationship we have is extremely good. I mean now all of his staff trust us enormously and it's building that sort of relationship that's really good. (Managing Director, Company B).

Sharing knowledge and expertise, in both intra and inter-organizational terms was recognized as being of the utmost importance in most of the science-based SMEs. There was much evidence of shared repertoires and of mutual engagement via the sharing of expertise in sustained, medium to-long term collaborative relationships through the building of communities of experts across two or more organizations. Through a variety of CoPs, social capital was leveraged to generate trust and reciprocity between SMEs and the organizations they worked with, enhancing knowledge-sharing and innovative potential. However, there were also instances of low levels of trust, especially in the early days of attempting to establish collaboration ('Can we trust organization X?'), and hence some of the SMEs used formal confidentiality agreements relating to their present or potential future innovations. The sharing of knowledge and expertise, in both intra and inter-organizational terms, was recognized as being of the utmost importance, and was sometimes used by an SME as a means of binding the external organization to the company.

5.4.2 Theme 2 - Knowledge acquisition

Knowledge acquisition was considered a key factor for successful innovation in the science-based SMEs. A variety of approaches to internal and external knowledge acquisition were adopted by the SMEs, converging around the themes of

collaboration, knowledge sharing and, to a lesser extent, individual learning. These are now discussed in detail.

5.4.2.1 Individual learning

For some of the SMEs, particularly Companies A, B and E, individual learning was a way for employees to acquire skills through a combination of formal and informal training, where formal qualifications were supported alongside informal 'on-the-job', training. One interviewee referred to this as 'internal training':

> There's certainly training for some of the workers, definitely, we've done some stuff like 'skills for life' I think it's called, and also there's a lot of internal training going on. So there is a move in that direction as far as management goes. It's just not that formalized. (Commercial Director, Company A).

An informal approach to individual learning was particularly evident in Company A, where, in the main, employee's work was focused less on science-based R&D activity and more on established chemical processing operations to solve their customers' problems, i.e. aligned with incremental innovation:

> [Learning is] certainly not formal. Given the opportunity, if you push yourself forward, the company is always absolutely cooperative and willing to help you gain certificates. As far as training you on courses go, it's not quite so formal… obviously with bigger companies and things people… have the time… here there is no formal, that I'm aware of, any formal scheme for getting everybody trained up.(Purchasing Manager, Company A).

Company A, based in the north east of England, had merged with another firm based in the south of England in 2010. On relocating the entire business to the north east site, the company had then found it difficult to find process operatives with suitable skills and expertise:

> … when we merged and moved the business 300 miles north… and went into… these problems; that we didn't have trained operators, we were taking people off the street. And whereas in the south I'd had people working for 25 years and you could say to them, "Here's an operation, there's the

> paperwork, off you go!" People here will say "Well, where's the switch to turn the thing on! (Finance Director, Company A).

Company A made a range of products with a seasonal demand – such as airport runway de-icer and agrochemicals – and, therefore, employed a lot of temporary staff during busy periods. Although the company provided a lot of support, both for permanent and temporary staff, in order to develop their skills, learning was mostly informal and focused on passing on existing practices. However, there was no evidence of apprentice-based CoPs in Company A, and this deficiency occurred due to a combination of the transient/seasonal nature of the workforce and the low level of scientific knowledge required for process operators, who represented the bulk of the workforce. The company's main focus was on providing staff with enough skills to be productive through skills training:

> … and people working here really are doing one qualification or another. But they're lively, because you get them into the business and usually when you take them on you can get them into a position where they do actually use some of their skills. (Purchasing Manager, Company A).

In other organizations, most notably Company B and Company E, most employees had a scientific or engineering background and there was a greater focus on scientific R&D to produce innovative new products and processes. Here, there was also an expectation that scientific staff in particular would already have a level of pre-requisite knowledge from their formal education that could provide a starting point for acquiring the more specific knowledge required to generate innovation through their work:

> I'll learn new things every day… there's obviously initial training, 'cause the main thing is… what you learn, you know from you're 'A' levels like Biology, then it's obviously very specialized for this…for haemostasis… so then it's training and then obviously [you do] your own research when you're doing a specific project. (R&D Technician, Company B).

In Company B, where scientists often worked in isolation, a CoP emerged in response to members' individual learning needs. This apprentice-based CoP, much in line with Lave and Wenger's (1991) original notion of how CoPs support situated

learning, enabled scientific staff to support each other's learning through knowledge exchanges occurring between members, and provided a place where members could seek advice from more experienced scientists. Tacit knowledge within the organization was passed on, through what Orr (1991) calls 'non-canonical practices' within the CoP, from more experienced scientists, such as the R&D Manager (the 'master') passing on his knowledge and expertise to the less experienced scientists and technicians (the 'novices'):

> Well at the moment it's primarily… [name omitted]'s Research and Development Manager, then I'm the Research and Development Scientist and then [name omitted] and [name omitted], they're Research and Development Technicians, but we're learning as we're going on and if there's any relevant training that we think we need, we ask, you know, can we do this or that. But at the moment it's working well by the [R&D Manager] leading us to help us learn new stuff we need to do the job... and we support each other… as we go along sort of thing. (R&D Scientist, Company B).

Members of the apprentice-based CoP were generally educated in science subjects at a level commensurate with their job, i.e. the scientists had a university degree in a science, or related subject, whereas the technicians tended to have, or be working towards, a higher national certificate (HNC)/diploma (HND) level of qualification:

> … we have [R&D Scientist 1], who's a graduate, and there's [R&D Scientist 2] who's studying with the Open University… they're the two scientists in the department. Then we have [Technician 1] who's an apprentice - who's at college at the moment… and it tends to be [R&D Scientist 1] and [R&D Scientist 2] who will do the 'lion's share' and then [Technician 1], who will help them out. (R&D Manager, Company B).

In this instance, the CoP emerged from a need to support members' existing scientific knowledge alongside more formal, individually tailored 'on the job' training and qualifications. This finding reinforces Nonaka's (1991) suggestion that tacit knowledge consists partly of technical skills gained through experience, whilst at the same time having an important cognitive dimension consisting of mental

models, beliefs and perspectives that are taken for granted and, therefore, difficult to articulate. The CoP supported individual learning focused on tacit knowledge acquisition through non-canonical practices, i.e. passing on specific scientific 'know-how' regarding the company's specialist area of operation (haemostasis) that had not been captured and codified by the organization and was not, therefore, part of its canonical practices. Company B's R&D Scientist commented: 'I was already a graduate. I already had the background knowledge, so then obviously you have to do your training in-house to specialize [in haemostasis]'. Company B presents an example of individuals in a science-based SME acquiring and sharing internal knowledge via an emergent, apprentice-based CoP.

However, not all SMEs involved with scientific R&D activity had the same approach to learning. In Company E, for example, there was awareness that, although individual learning was an important part of the innovation process, there was a need to align that with the commercial goals of the organization:

> We might have to do bits of research, but the learning for learning's sake… or because of what's interesting, isn't really what we do. We are a commercial company and we need to make products, we need to make money. That's what we're in it for. We're not in to widen everyone's understandings… (New Technology Manager, Company E).

Scientists were expected to have the pre-requisite scientific expertise and skills to perform their job and individual learning was considered an individual responsibility. Here, the expectation is that individual learning was the *individual's* responsibility, thus restricting the emergence of apprentice-based or intra-organizational CoPs to support learning in Company E. This finding goes some way to answering my third research question – 'How is knowledge acquired in science-based SMEs?' – by providing some evidence that apprentice-based CoPs can support the acquisition of *existing* knowledge within science-based SMEs. In the next part of this chapter I focus on knowledge sharing.

5.4.2.2 Knowledge sharing

In many science-based firms, knowledge acquisition and knowledge sharing was observed to occur through the construction of apprentice-based, intra and inter-

organizational CoPs already identified. Some of these CoPs emerged unplanned and some were cultivated by the SMEs. Intra-organizational CoPs focused on specific domains of scientific and engineering expertise. Scientists and engineers in these CoPs pooled their internal knowledge and shared expertise to solve problems and/or generate innovative solutions on behalf of external customers:

> Obviously there are two or three people in the company with the experience and knowledge to [solve problems]. Which I think, many of our large contracts that we've got out are developed that combined expertise. These few people are linked by what they know about the industry and can get together and share what they know with customers to solve problems.... sometimes it's one or two... and sometimes more... depends on the problem and what is required... (Purchasing Manager, Company A).

Collaboration and problem solving on behalf of customers often created an internal tension in relation to internal knowledge acquisition and sharing, because of a lack of resource required to develop new products or tight deadlines from customers. As one interviewee explained: 'I think it is true to say that there is a tension… I know we talked about collaborations with customers… there's always a tension between the cost of developing things and getting products out the door'. High levels of uncertainty added further tension to collaborative relationships with customers:

> Collaborations with customers are, you know, they are developmental for us at this time, they are about development, but at the end of the day somebody's read the specification and they've… written a plan… when things are going to be delivered… and that plan was written, of course, without having done the work that you need to do to understand the things you need to understand… to do the development, if you see what I mean? So there's a tension there. You're going to find things out that you didn't know when you made the plan, by definition, in the development… or the research and development environment (Technical Manager, Company E).

As discussed in the literature review, SMEs have access to fewer resources than large organizations (Tödtling, 2001) and might compensate for this deficiency by utilizing networks (Partanen et al. 2008) such as CoPs to achieve collaborative

approaches to innovation. Conversely, there is an argument regarding whether SMEs can spare the necessary resources required for cultivating CoPs (Roberts, 2006). Rather, CoPs were found to emerge because of commercial pressures. Pressures from customers sometimes acted as a catalyst, encouraging individual scientists and engineers to pool internal knowledge and expertise in order to provide solutions. In these circumstances, intra-organizational CoPs could form quickly in response to the need to find a solution quickly:

> I mean, there's often an internal tension. It's more a problem because you're going to discover you've got a problem, something you realize isn't working and what you really need to do is to undertake some actions to investigate that problem first of all and try a solution, but if you've got to get some samples out by a certain date and the resource is tied up… what you end up doing is guessing the solution in order to help them out, and typically the guess is wrong… [laughs]… this is when we really need to pool our knowledge. (Materials Manager, Company E).

Scientists and engineers in these intra-organizational CoPs shared their existing knowledge, the 'obvious stuff', as well as generating new knowledge, the stuff they 'don't yet understand'. As one manager stated: '… we can share stuff that, you know, like obvious stuff, and we share some stuff that's like, "well we don't yet understand that"…' (Material Manager, Company E). In some firms, there was an acknowledged disparity between large numbers of scientific and too few engineering staff, and that to commercialize their innovations, the 'scientific' expertise, usually more aligned with the firms R&D activities, needed to be combined with 'engineering' expertise in order to scale up products and processes and make their innovations robust enough for commercial production:

> I think one of the things we… we've got a lot of scientific and not enough engineering [staff] if we're looking back. I think we're too much… physics… technical, scientific knowledge-based, as opposed to the engineering… for things like cutting and polishing the materials, standardizing processes, things like that. Whereas the scientific mind set is more 'we've tried it once let's make it better, make it better'. So we were still very 'scientific' in those

> [early] days. We had to bring people in to share knowledge... with different science and engineering skills… (New Technology Manager, Company E).

Although it was generally recognized that there was a need to combine scientific and engineering expertise in order to commercialize their innovations, scientists generally viewed their role as one of research and development, considering the role of commercialization to be separate and the domain of engineers and other technical staff: 'So [scientists] tend to be building, developing crystal growth kits as opposed to commercial production of crystal growth kits. The mind set was still development' (New Technology Manager, Company E). Another interviewee, in explaining his role as an engineer, highlighted what he perceived to be the difference between scientists and engineers in the way they think about innovation:

> … again this is the scientist and engineer, a scientist would see pure innovation as doing something that hadn't been done before, but an engineer will almost be happy that innovation is making something happen every time. It is that big difference, you know, and [pauses] to some extent I know, myself included, there is a big thing that I'm loathed to re-invent a wheel, I just want… I will pick the best thing that I have seen or I have available in my network, or whatever, or my knowledge, or my past knowledge. I'll pick that and I'll go with that as my route, you know, and… whereas a scientist will go 'oh, but I could do something different' 'cause doing something different would be more interesting, you know? (Materials Manager, Company E).

The conflicting views of scientists and engineers represented a recurring theme and were summed up by one interviewee who explained: 'I would say scientists are in this for the journey and engineers in it for the goal'. In a similar vein, Harris and Sheswell (2005) note that 'legitimate conflicts' can have both a negative and a positive impact on the construction of a CoP. Legitimate conflict occurs when the legitimacy of one participant is brought into question by other members of a CoP, in this case scientists and engineers, and can marginalize the participant involved and can sometimes result in withdrawal from the CoP. Such conflict between 'journey' and 'destination' was reiterated by some engineers, who considered scientists to be too focused on 'experimenting' without any consideration for the commercial

aspects of their research:

> An engineer wants to get somewhere. In fact an engineer's happy if something never happens again, you know I think that's the thing that… a scientist likes to do a thing over and over and over, you know, 'we'll try that', 'I'll do that experiment'. An engineer would be… an engineer's target, I would say, is to make it to have nothing to do in a day. (Technical Manager, Company E).

Knowledge sharing between scientists and engineers often created issues related to how quickly innovations could be commercialized:

> Well, the scientist tended to build but from a…not from an engineering point of view. Not from a 'how often is this going to fail'… 'is this going to be repeatable'… more just… [pauses] well it's kind of a slow process and you've almost got to take, you've got to drag some of these scientists kicking and screaming sometimes because it's their baby, it's their toy. They've developed it… but it isn't a fast process. (New Technology Manager, Company E).

However, scientists also recognized the conflict between the extended timescales that some R&D activity requires and the need to match this with customers' needs. One interviewee posited that, for scientists working in academia, timescales were simply not important because there was no commercial pressure to fulfil customer needs:

> I guess what happens for a lot of academics is that no one other than themselves relies on the outcome of the work and hence the outcome can always be fine because it's… you generated what you needed in order to do the next thing but if someone else needs that you've got to generate what someone else needs, not what you need. (Chief Technical Officer, Company E).

This fundamental difference between scientists' and engineers' perceptions of timescales created further areas of internal tension, representing a potential barrier to knowledge sharing and acquisition:

> There's definitely a language difference, and actually, and one of the things [laughs] is, you know, I can… I get a lot of, you know, when I push as I… 'cause my job is to push and try and drive things along, especially as we have finite time lines on these sort of projects, you know? We have deliverables, we have milestones, things like that to meet, and you know… and some of the scientists… the deep science is just like, oh hey, I just… it's just going to take as long as it takes, really you know, and it is really difficult because how do you put a time frame on doing something you've never done before? You know, if I asked you to go out and learn how to fly a micro-light, how long would that take to do, you know? It's impossible to know, isn't it? (Technical Manager, Company E).

Whilst engineers recognized themselves as the people who 'productionized' innovation, i.e. transformed inventions into commercial products, scientists considered their role to be more closely aligned with R&D activities, i.e. radical innovation:

> … these guys [scientists] needed someone to help them sort of 'productionize' I suppose it one of the terms for it, which is basically making some of the processes more robust, putting in some of the documentation for the systems, being able to make things more than once is the obvious thing… (Materials Manager, Company E).

Scientific staff did recognized that a tension existed between the views of innovation as a journey or a destination, as this excerpt from the Chief Technical Officer in Company E, himself a physicist, confirms:

> [the Materials Manager – an engineer] has some particular expectations because of his background and probably he finds it a little bit more difficult than people with a physics background to work with… pure physicists, but you know, he has a demand for very focused… people and… and in general he'll find a job is never finished for a physicist, whereas for an engineer it always has to be finished. (Chief Technical Officer, Company E).

Involving scientific staff in the commercial aspects of science-based business was an issue, because it often created additional tension, and took scientists far outside of

their comfort zone. In Company B, for example, the MD had considered involving his R&D Manager in the commercial aspects of the business in order to deal with the company's expanding customer base:

> There's my development scientist, [name omitted]. He'd be really freaked out by the idea; he wouldn't be comfortable in that role. But he'd feel comfortable on the technical side of the products. But the business negotiations I still don't feel 100% comfortable with and, I'm a biochemist, and I've learnt business (Managing Director, Company B).

This tension between scientists and engineers had a profound effect on approaches to commercializing innovations, especially with regard to timescales. As one engineer observed:

> … the R&D Manager was very much 'do the science bit' playing with the tools, doing experiments, things like that… and then I think the bias has changed over a few years and the realization was that the science was necessary but it needed to be done in parallel with the actual running of the equipment and the delivery of things to a timescale (Materials Manager, Company E).

Engineers were generally more aware of the commercial deadlines involved in meeting customer needs, solving problems and getting a product to market:

> … the majority of this breaks down when we realize that the goal isn't the same and that's the problem If you… fix the goal… that doesn't become an issue… because we're finding that people are drifting off from the path and the reason they they're often drifting off from the path is they have a totally different goal to you, and actually a lot of this is because they're on the journey and not at the goal. (Technical Manager, Company E).

Engineers generally considered scientists to lack a real world perspective in regards to commercializing innovation:

> … it's sometimes hard for [scientists] to take on the requirements of the real word and the frailty of actually achieving something in terms of all of the

> things that can go wrong. So, you know, they end up with very idealistic views of what can be achieved in what time and then, you know, if you add people who are desperate to get revenue so that they take those time scales and then say 'well let's squeeze that a little bit harder' [laughs].. .you… so I spend a lot of time trying to put some real world perspective on things. (Chief Technical Officer, Company E).

The accusation that scientists lack a 'real world perspective' suggests a degree of disconnect, not just between the way scientists and engineers view their respective roles, but in terms of how scientists perceive their own role in commercializing innovations. Lack of shared identity and the separation of knowledge domains amongst scientists and engineers present a significant barrier to the potential for enhancing both individual learning and internal knowledge acquisition within intra-organizational CoPs. This finding seems to contradict Swan et al.'s (2002) observation that CoPs can be used as a rhetorical device by science-based organizations in order to mobilize external networks and mitigate inter-professional conflict. One reason for this could be that Swan et al. (2002) distinguish their study of 'networks of practice' in a large organization from CoPs in that the former's membership is bounded by formal institutions and governance structures that are less likely to be found in SMEs.

In comparison, inter-organizational CoPs often developed out of personal relationships that had been maintained with ex-colleagues. In terms of social capital, ties with former colleagues were often considered easy to leverage because the connection already existed, and one participant described these ties as 'low hanging fruit', meaning that they were an easy to reach source of external knowledge: 'I hate to use the word 'low-hanging fruit', but… [laughs]… we had personal contacts even from previous lives with [other] companies. So it does make life an awful lot easier when you have a better personal arrangement in there' (Technical Director, Company C). Interviewees confirmed they often turned to 'old networks' first when seeking external knowledge through a form of inter-organizational CoP that emerged from connections with individuals they already knew, and who could provide the expertise or knowledge they required:

> Old networks invariably. I would say old networks from lots of different places… but certainly it's somebody knew somebody, knew somebody… you know, and it tends only to be two degrees of separation, you know I think if you looked at these people, they would be on my LinkedIn for example, you know… that's, if you know LinkedIn, the social network… or sometimes even competitors! (Material Manager, Company E).

In one example, personal networks of ex-colleagues were accessed to help an individual update his knowledge in a scientific area he had not worked in for some time, but which was pertinent to the success of his new science-based SME:

> I kept in touch with some colleagues of mine at university and this opportunity or idea came up. The original concept didn't work out, but the idea was still there, strong enough that I managed to get together with my other co-founder, an ex-colleague, and we developed [Company D] from that, and as I say it's been going for three years now, and I've been having to quickly re-learn a lot of old Chemistry and Physics now that I need to use it and its been useful to pick my old colleagues brains a bit. (Technical Director, Company D).

In the following excerpt, one interviewee explains how he uses his personal network as an inter-organizational CoP, sourcing external knowledge as and when he required it:

> I think quite a lot of us also have a personal network, which is people we've worked for in the past where we don't get them in for… jobs, you know… but I've got two guys, who are my ex-colleagues from NEC up in Scotland, and three of use bought a racing car together, which was just an old wreck and we use to race it at Knock Hill. We bought it the day before we were made redundant, which was kind of good timing [laughs]… and so we've always stuck together, you know, girlfriend and wives are friends and we meet up, they live up in Scotland, one in Edinburgh one Glasgow, but they're a network of people… they both work in high-tech industries so, you know, we get… I might get a question one day saying 'you ever etched this?', or 'have you ever done that?', or 'you ever worked with that chemical?', see,

> you get that kind of discussion goes on and that's just, you know informal, 'emaily' type thing, but it's still a network community. (Materials Manager, Company E).

Although these types of personal networks display characteristics that seem to have more in common with Möller et al.'s (2007) notion of 'parity-based' personal networks, they can be considered as a form of inter-organizational CoP. This approach to sourcing external knowledge was particularly evident in Companies B, D and E, where the work was more aligned with radical innovation, and one participant described his personal network in terms of keeping in touch with 'old friends', which enabled him to gain access to external sources of knowledge:

> I spend a lot of time reading about technologies outside of what we do… spend a lot of, I mean I've got a lot of old friends in different business so I spend a lot of time talking to people about technologies in other areas. (Chief Technical Officer, Company E).

Stremersch and Van Dyck, 2009 have suggested that radical innovations are more likely to be found in the area of informal social networks, such as CoPs, and to be balanced between internal and external innovation Maintaining personal networks and, thus, constructing inter-organizational CoPs with a range of external partners (including ex-colleagues, suppliers, competitors, partners and customers) provides an important source of internal and external knowledge acquisition for these three firms, helping shed light on how knowledge is both shared and acquired and helping answer my third research question. In the next section I discuss how CoPs support collaboration in the innovation processes of science-based SMEs.

5.4.2.3 Collaboration

Innovation has traditionally been viewed as an activity that is managed within organizational boundaries; more recent views of science-based innovation, however, have concentrated on the role of collaboration (Pisano, 2010). The importance of inter-firm collaboration was recognized in all of the SMEs, and Companies A, B, C and G were all actively seeking collaboration opportunities with other organizations in order to generate new radical innovations. Company E, however, was more focused on external collaboration with respect to problem solving on behalf of their

customers and suppliers. Company D, on the other hand, was only interested in collaboration partners who would help them commercialize their innovation. One interviewee remarked: '… we're looking into areas, sort of working in collaboration with a German company… we're looking at some new areas with them' (R&D Manager, Company B). Other interviewees recognized that, although they had not been involved in a lot of collaboration in the past, it was an important area of future development and growth for their company: '[collaboration is] not something we've done a huge amount of in the past, but it is something that we're actively trying to encourage and establish with our design effort… our creative efforts' (Managing Director, Company G).

However, efforts to collaborate produced mixed results. Customers of Companies A, B and G, for example, often sought collaboration with these science-based SMEs in order to acquire knowledge that they did not already possess. The SMEs then used this sharing of expertise as a means of binding the customer to them, in effect cultivating an inter-organizational CoP: 'We were able to reinforce our technical capabilities… because the guy we met is an instrument technician. So the chemistry side… he wasn't very capable on. So he really had to depend on us to give him the right information' (Managing Director, Company B). SMEs often provided support and advice to customers as a way to reinforce their capabilities and expertise and build collaborative relationships:

> Certainly in the last year or so we've started to try and do more in terms of getting out to visit customers. We certainly tag along to sales calls now… and we do pop out and see people when we feel there might be something we can chat to customers about in… a more sort of technical way really. (Design Engineer, Company G).

At the same time, in seeking expertise to help them commercialize customers' inventions, the science-based SMEs both pooled expertise internally or sought external expertise. Emergent intra- and inter-organizational CoPs contributed to this process via collaborations that resulted in knowledge sharing and the exchange of tacit knowledge with the SMEs acting as 'key experts'. The capability to access internal and external pools of knowledge suggests that although these SMEs may have no *formal* strategy for knowledge acquisition, they did possess some absorptive

capacity based upon the collaborative relationships that develop through emergent CoPs (see also Beijerse, 2000):

> Right at the outset they'll [customers] come to us and say, 'Look, we've got a particular problem. Do you think you can solve it?' And, coming back then to the pool of knowledge and experience we have within the business, then we can apply ourselves and we can usually come up with solutions, or recommend alternative solutions which we might not have, but you know, we can either develop... bring in outside expertise, or pass, perhaps potential enquiries on to other people that we know or source solutions from people in our network. (Operations Director, Company A).

Collaboration also occurred through the outsourcing or sharing of R&D activities by larger firms, or from larger firms' purchasing of innovation 'solutions' from science-based SMEs, in other words through adopting open innovation approaches to R&D, as one interviewee observed: 'The market is moving more and more towards collaborative work; a lot of large organizations are dissipating some of their research. Organizations internally are looking at outside to do a lot more of the research' (Technical Director, Company C). SMEs involved in R&D based innovation generally valued collaboration opportunities as a means of growing their businesses, or as a way of saving on R&D costs through joint development:

> We've already talked about [collaboration]. We have technologies in here, like freeze drying and liquid filling capabilities, that if they go the way they've talked to me about going, into the drug diagnostics business, they might need access to that. Then instead of them investing shed-loads of money in doing it themselves, if you like, we collaborate on it. If it really takes off we either continue to manufacture for them or they do it themselves. Either way we've helped each other save money through that joint development. (Technical Manager, Company B).

However, those SMEs less involved in R&D activities, such as Company A, did not see the value in growing their business collaboration with other firms. Rather, they favoured other approaches to business growth, for example, via mergers and acquisitions, or through organic growth:

> I mean, we set out with the prospect of looking at all forms of growth, organic growth, acquisitions, etc. The acquisitions side hasn't proved to be successful, as of yet, but we still have that in the background that if there is a company that it would be sensible either to acquire or merge with, then we would do that. The organic growth is, at the moment, where these big projects are coming through, which could be anywhere between 25 and 50% of turnover to the business. So that's sort of quite a significant increase. Other than that, collaborations… apart from sub-contract ones I can't that there are, that there's much to be gained through that process other than the fact that you know a company and you know how they operate and it maybe there's synergy by combining the two? (Finance Director, Company E).

For Company A, collaboration tended to be with suppliers, sub-contractors and sometimes competitors, and was often initiated because they needed to pass on work they were unable to do at that moment in time. As the Operations Director explained: 'Yes, generally it will be work we could do ourselves but we don't have the capacity for the particular time'. Other than passing on work, there was little desire to engage in collaboration which was due to a combination of issues: Firstly, the firm's work was aligned to incremental innovation, using old process industry-based technology to manufacture a range of products for customers – which meant there was no motivation for seeking new knowledge through collaboration with other firms. Secondly, a lot of work involved the use of non-disclosure agreements before handling customers' 'secret formulae', making collaboration and knowledge sharing outside the organization:

> We all get involved with secrecy or none disclosure agreements because people's formulations are their intellectual property. Clearly, if we simply give the formulation to another company who is sub-contracted to us, if it was a disreputable company, they could go off and start producing that particular product. (Operations Director, Company A).

All of the SMEs recognized that they had to be wary when collaborating with other organizations. Companies A, C, D and E, for example all used NDAs, but even those firms who did not were aware that they had to be careful when collaborating. As one interviewee confessed: '... you can talk to them but not give them too much

information. [laughs]…' (R&D Manager, Company B). Pavitt (1984) points out that science-based firms that develop new innovations have a high degree of appropriability from patents, secrecy, and tacit know-how which they need to protect. The need for secrecy, in particular, made it difficult to build collaborative relationships based on mutual engagement and shared repertoire, thus restricting the emergence of inter-organizational CoPs. However, other SMEs, notably Company E, did become involved in collaboration with competitors that was more knowledge-based. One of their major investors, the US Government, was funding research by a number of firms involved in growing Zinc Cadmium Telluride (ZCT) crystals and they organized a forum to bring together competitors to discuss research in this area. In effect, the US Government, acting as a boundary spanner or broker, attempted to influence knowledge sharing and collaboration between firms, thus providing opportunities for the emergence of CoPs:

> I think the competitors' one is very interesting for… the crystal growing industry because it is such a small industry. There is probably only four people in the world who grow these crystals, four companies in effect, and because there is such a want for these crystals by the likes of the US Government, then something very unusual happened in that the US Government will organize a forum for people, representatives from the different companies to come together and discuss technology innovation. Which is kind of unusual in, I don't know of many other industries where you would invite, you know [competitors]… I think that may happen in some safety elements of the auto industry, but even then not much. I think they keep it highly under wraps. (Materials Manager, Company E).

Company E saw collaboration with the US Government as a source of funding for their R&D activity into growing ZCT crystals. However, even with the intervention of such an influential 'broker' as the US Government, the interviewee felt a need to be guarded about what knowledge he could share with competitors in such a 'small industry': 'it'll be the game of chess that we play often, when you're working with these people, you know, you're letting sufficient out but keeping certain, you know… it's like telling people *what* you're going to do but not *how* isn't it? That's the trick!' (Materials Manager, Company E).

Two of the SMEs, Company B and Company E, formed collaborative relationships with universities as well as with commercial customers. Company B, for example, was predominantly focused on developing products for commercial markets but was still involved to some extent in university collaborations:

> The main collaboration really is with this company in Germany. It's taking about 80% of our resources. Were on really tight deadlines as well and that, so it's all hands on deck. Aside from that we have, as I say, a collaboration with [N] University, and we also we are doing some collaboration with [T] University on a small project there. (R&D Manager, Company B).

Company E, a university spin-out company, was very R&D focused and continued to have a sustained period of mutual engagement with its original university, and the two organizations continue to work closely together, as the Technical Manager commented:

> We still collaborate with the university… in fact we built a system… one of the four systems is at the university, you know, so we have a fairly strong collaboration with [D] University. We work with their scientists on a variety of crystal growth development... issues... we can dip in and out of each other's research quite often, almost by accident. (Technical Manager, Company E).

Here, knowledge sharing was a collaborative process between Company E, and its university partner. Company E helped the university to commercialize its basic R&D and in the process the company gained access to the university's R&D results: '[The university] had other separately funded programmes, a programme to work on the growth, and we obviously help them… and I mean [long pause] we have access to their information, results and things' (New Technology Manager, Company E). They also gained access to [D] University's network of partner organizations, a type of inter-organizational CoP, some of whom it collaborated with:

> … we spent the first year or so still using the [D] University facilities and were very much part of their physics department so we'd used, we'd use the mechanical workshop there to get parts made up that we required and we still

> use the network there quite a lot to source expertise. (Chief Technical officer, Company E).

For Company E, mutual engagement and shared practice also provided the means to exchange its expertise with customers in a two-way collaborative process. The Technical Manager also referred to the company's involvement in the wider semi-conductor R&D community, where it is working with several other universities researching into semi-conductor materials, which suggests that much larger inter-organizational CoPs exist outside of those emerging from purely commercial relationships:

> We're involved in a project with more than [D] University, there are other universities involved in various projects… there's a certain amount… there's a certain scientific community looking at this… semiconductor materials are, you know, the subject of considerable R&D... research and effort, and universities all over the world, you know… I mean it's… something we are involved in, in the wider research community. (Chief Technical Officer, Company E).

In the following extract from Company B, another university was seeking help to scale up the results of their R&D activity and to develop a commercial product for a spin-out company. To do so, the university sought assistance from Company B, which could provide manufacturing expertise to help commercialize the innovation:

> We've built a close relationship with [N] University, in the cardio-vascular medicine department, who are probably one of the world leaders in platelet function and knowledge there. They came to us, they had… ideas, and they came to us because they wanted us to manufacture a product for a spin out company they've developed and they needed the manufacturing side of things and our knowledge to help them and, sort of, preservation of certain chemicals and freeze drying. We pooled our expertise to help them scale up the development. (R&D Manager, Company B).

This arrangement was an informal one, where Company B provided its manufacturing expertise on an informal basis, in the hope that it would become the preferred manufacturer and eventually supplier to the university's spin-out company.

The university scientists called on Company B's expertise as and when they needed it. This informal approach was, in effect, an inter-organizational CoP:

> We're actually helping develop some products for [N] University. They had some ideas and that needed someone to follow on up through it with the projects, you know? Again, it's to do with testing the blood, again, that sort of… sort of, more of a science study, doctors doing it, but not students - its research we're working on with the university. They just call on us when they need us. (Technical Manager, Company B).

Company G, in their attempts to cultivate collaborative relationships, were interested in partnerships with universities that would generate new commercial products that they could sell. However, as previously noted, there was often conflict between the SME's need to commercialize new products and the academics who were more interested in discovery and motivated by their efforts to publish academic papers:

> Academics are not necessarily interested in the commercialization of the technology because actually they're just interested in the discovery and the… and to a certain extent, you know, publishing the papers… because that's what they're measured on ultimately. They want to get published in a journal… so that's their driver… (Technical Manager, Company G).

The Triple Helix model (Etzkowitz and Leydesdorff, 2000) posits an integrated, networked approach to innovation that focuses on collaboration between university, industry and government. However, the findings of the present research demonstrate that, although the SMEs did collaborate with universities, there was no evidence of government involvement, illustrating the government's current non-interventionist stance in SME collaboration. Some science-based SMEs saw collaboration as a route to market for their innovations and building collaborative relationships took a variety of forms. One firm, in considering a formal approach to collaboration, was seeking an alliance with another firm where both companies could share development costs and develop joint intellectual property rights on their innovations:

> We're looking for somebody that would be interested to develop joint IP, either in the actual format, the physical form of the catalyst material, or in the chemical composition because of certain doping you might get quite

> radically-improved performance, so we'd be looking at all of that. (Technical Director, Company D).

Company C, on the other hand viewed its innovation, in the field of nanotechnology, as an enabler for improving customers' existing products and sought a single route to market through collaboration with manufacturers, adopting an 'open innovation' approach:

> … what we've actually developed is something which is an enabler to other people. It allows their product to reach its full potential so in some ways it's a little bit different. We're looking at sort of pushing this technology out to companies, to realize the potential of the materials, which will fit in, on some cases, with what's going on in you know open innovation marketplace. (Technical Director, Company C).

Other firms chose to collaborate through multiple routes, for example, Company B sought to license its innovations to other firms to manufacture, in addition to being an OEM (Original Equipment Manufacturer) manufacturer of its own branded products. Company B had originally planned on manufacturing and selling its own branded products rather than manufacturing products on behalf of other firms:

> I didn't set out to be a contracting manufacturer. We really did set out to try and sell a range of products that would sell as [Company B], for us to work through a range of distributors, and we would have been very happy with that. When people started to knock on our door asking to use our scientific expertise, and having seen how aggressively that has grown over the last few years, then that was certainly a business changing event for sure. (Managing Director, Company B).

However, the company had been surprised to find that it had greater commercial success through collaborations with other firms, in effect by selling its 'capabilities' or 'clinical ability' as a contract manufacturer, developing products on behalf of its customers. For Company B, the success of this collaborative approach can be linked to the high level of social presence displayed by the Managing Director, whose ability to communicate effectively and build strong social relationships, was instrumental in providing the basis for thriving inter-organizational CoPs to form. In

this sense, the MD acted as an 'innovation champion' (Coakes and Smith, 2007), transcending organizational boundaries and supporting inter-organizational collaboration. The MD recognized the importance of involving all his staff in building collaborative relationships, creating the conditions for CoPs to emerge: 'Now when people come and visit us it's not just 'you and me'. I make sure they meet everybody; more people are involved in the meetings. They start to build their own relationship with them' (Managing Director, Company B).

The Managing Director's ability to be 'out there', making connections, was equally important in building the trust-based relationships essential for successful CoPs. Company B had been particularly successful at building collaborations with other firms as the R&D Scientist acknowledged: 'Well I suppose it's 'who you know' - especially who [the Managing Director] knows as he's worked in the industry a long time'. When employees from 'Company T' came to view the business unit next door, the Managing Director of Company B took the opportunity to meet them and show them around his own unit. They soon realized the two firms had complimentary areas of expertise and potential area in which they could collaborate:

> … the ladies from [Company T] came here to visit for 10 minutes because they're thinking about moving next door and three hours later I had to kick them out because I had to go to a meeting. We just got on really well and we realized that there's potential areas of collaboration, because we're from the same area but different products. (Managing Director, Company B).

Rovai (2002) observes that social presence is often associated with successful community building and the Managing Director used his social presence to build on the initial impromptu meeting, drawing together individuals, in essence, cultivating an inter-organizational CoP. Through his existing network of personal contacts, he brought together 'Company T' and [C] University in order to solve a problem that he was aware the university were having in scaling up on one of its innovations:

> [Company T] produce novel research entities for pharmaceutical research based on peptides. It's a very good business. I just didn't know it was in Billingham that's all. We now keep very much in touch. I mean, I have a link with [C] University Department of Biochemistry and a researcher down there

> is struggling to scale up his peptide synthesis, so we arranged a meeting with [Company T] because they can do it. (Managing Director, Company B).

It is, perhaps, not surprising that the two smallest firms (Company C and Company D) displayed no evidence of pooling knowledge and expertise internally due to the limited numbers of staff in each organization. However, there was some indication of inter-organizational CoPs emerging through mutual engagement and external collaboration with customers, often through providing advice and scientific expertise, which was strongly linked to 'problem solving' activities:

> Now, the marketplace is now sort of saying 'don't come to me with bits of technology, don't expect me to pay for that development, ask me what my problems are and show me how you can solve them'. So we've been working on that sort of principle, trying not to promise the earth to the customers but actually… it's down to what we were saying before about collaboration. (Technical Director, Company C).

The success of these relationships was, again, based on building strong personal relationships with customers, based on mutual engagement and shared expertise:

> I think a lot of it is based on very personal… on personality. I'm finding that's what works for me, if I can build up a good rapport with the company. Even with the clients, I find if that I can do that, they seem to come to you for advice rather than just as a supplier. And if you're in that position then I think you're in a strong position for building on the future with them. Same with suppliers, I think with all my suppliers I think I'm on a fairly good personal footing with them, just how I do business. (Technical Director, Company D).

Most of Company C's innovations had been generated through collaborations with customers. For example, a sun screen manufacturer had asked for help to improve the distribution of their product. As part of the innovation process, the sunscreen manufacturer shared their test data about the product with Company C. Through the process of mutual engagement both parties were able to enhance the innovation process by sharing their knowledge:

> Most of the work we do…we do one or two pieces internally, but pretty much all of what we do is in collaboration with an end, an end-user. Whether that's right down to basically testing the technology, we've developed this technology but what we don't have, as a small company, is the ability to test various applications. So we've done some work with some [sun] screen manufacturers to… well we did a very small piece of work to show we could improve, or should improve, the distribution of particles for [their] sunscreen. (Technical Director, Company C).

Company C had developed one particular innovation in collaboration with another firm which was one of its main competitors:

> One of our main competitors was actually torn about collaborating with us. I should have mentioned that earlier. We basically developed the [innovation] in conjunction with [a firm] who would potentially become our main competitor…they're hot on developing the technology while we're really hot on the marketplace and what's out there. It's an excellent fit together. The IP is going to be shared, we're moving forward as a partnership - collaborating on it. (Technical Director, Company C).

The collaboration developed from what was originally an informal network, i.e. an inter-organizational CoP, where members had a sense of shared repertoire based on their experience in a particular area of nanotechnology and as the Technical Director explains: 'we've all got backgrounds in processing of some form… I've got twenty years in that background and my colleagues a little bit longer. So we've got quite a history in the industry…' (Technical Director, company D).

Choosing partners to collaborate with was often based on developing strong personal relationships that developed by building a share repertoire. As one MD explained: 'Good personal relationships are critical' when choosing suitable collaboration partners. In the following excerpt, an interviewee discusses the importance of providing 'free', informal advice and guidance on how to use their products, reinforcing that sharing expertise with customers, and potential customers, is necessary in order to deliver solutions. Again, this approach is one that could be viewed as an inter-organizational CoP: 'We're now dealing much more and more

with GP's and pharmacy driven units... these customers require a lot of support to use our products... we meet up or visit them regularly with people to chat about their needs... share our expertise' (Managing Director, Company B).

In one case, advice was backed up with other 'free' services such as testing, validation and reporting services, in the hope that sharing the company's expertise would build up a shared repertoire and strengthen its chances of gaining paid contracts in the future:

> … in certain cases what we might do is offer a kind of validation that our system might work by a sort of a… my co-founder hates this word, but a 'free test'. She doesn't like the word free [laughs] complimentary test. But it's just to prove that the system at least has some effect on their particular effluence stream. And then after that I would probably go with a brief report presentation and then meet them at that point. That seems to work quite well. (Technical Director, Company D).

Shared repertoire was also a significant component in terms of the understanding of how CoPs developed for collaboration in science-based SMEs. Shared repertoire was evidenced internally, between colleagues, and externally, with customers from both commercial and R&D organizations. In their 'Ten Commandments of CoP Governance', Probst and Borzillo (2008) state that effective CoPs need to be regularly fed with external expertise. Some firms brought in external expertise for collaboration purposes, thus enhancing their absorptive capacity. Sometimes this approach simply involved outsourcing certain aspects of work where they lacked expertise, for example, in Company G a lot of electronic design work was outsourced to another firm and this began as a straightforward contractual arrangement:

> One area where we have outsourced in order to bring in skills that we don't have is… working recently with [Company Q], who do various industrial design really… and we're sort of… an area where we don't really have the skills is in terms of how we package and present out products… in terms of producing ascetically appropriate products we're lacking… (Design Engineer, Company G).

Their relationship with The Product Group, a company specializing in industrial design and product development, soon developed into a more collaborative relationship, thus generating a strong sense of shared repertoire: 'The guy who works for [Company Q]… he's got a lot of good experience in product development so we try and get something back a little bit … in terms of how we can develop our products… sort of innovating through ideas generation. (Design Engineer, Company G). Mutual engagement with customers from R&D organizations was generally considered to build stronger collaborative relationships than those developed with commercial organizations. This finding suggests that the level of mutual engagement is more intense where the focus of the joint enterprise is on providing solutions to the 'unknown', i.e. where it is more clearly aligned with radical innovation:

> I'd say the R&D ones are tight… because they're the ones that we're - it's almost like going into the unknown with the R&D ones - with commercial ones you almost know what you're trying to do; it's almost 'painting by numbers' yeah, when you need to do this, this, this and this? Whereas the ones with the universities are more… you're on a quest and you know roughly where you want to get to, but haven't got an idea how to get there. They've got some expertise to try and help us get there. (New Technology Manager, Company E).

Not surprisingly, then, in the SMEs with a stronger R&D focus there was a stronger sense of shared repertoire, developed through interactions centred around their particular domain of knowledge, i.e. an area of scientific and/or technical expertise. As one of these scientists observed: 'I think everyone has a physics PhD. So yeah… [laughs]… if you want to put it in those terms [that they were all scientists]' (Senior Scientist, Company E). However, shared repertoire was equally as important in more commercially focused organizations, where providing industry specific expertise was considered an effective way to build reciprocity and secure future business. Experts pooled their knowledge, sharing their expertise with customers, collaborating to help them find solutions to their problems, i.e. generating incremental innovation through the construction of inter-organizational CoPs:

> … if we're talking about a potential new business, the various aspects. We've got the commercial expertise, we have the technical expertise, we have the,

> sort of, support services, like the laboratory, the compliance side and it is a very strong management team. And because of the time… the experience, I think this is something people doing innovation value. (Operations Director, Company A).

Autio et al. (2008) suggest that firms involved in collaborative innovation should seek to foster the development of CoPs. Data analysis has revealed that science-based SMEs adopt a range of collaborative behaviours, including participation in intra and inter-organizational CoPs, in order to try and improve their knowledge acquisition and innovation capabilities. This section has clarified the role of collaboration as a contributor to knowledge acquisition in science-based SMEs and helped address my third research question. In the next section, I discuss the participants' views of innovation in science-based SMEs.

5.4.3 Theme 3 - Innovation

Three types of CoPs – apprentice-based, intra-organizational and inter-organizational – were leveraged by science-based SMEs for a variety of purposes, including facilitating individual learning, knowledge acquisition and sharing, and collaboration, all of which are linked to improving firms' ability to generate innovations. Interviewees expressed both radical and incremental views of innovation. For example, interviewees from Companies C and D described innovation in terms of novelty or uniqueness, i.e. aligned with ideas of radical/disruptive innovation represented by 'new to the world' products and processes. Here their descriptions were more aligned with disruptive (Christensen, 1997) or discontinuous innovation (Tidd and Bessant, 2009). Other interviewees, in Companies A, B and G, considered innovation more in terms of their organization's 'problem solving' activities, i.e. the incremental innovation described by Bessant and Tidd (2007). Here, the science-based SMEs acted as problem-solvers for their customers. Interviewees in Company E described both radical/disruptive and incremental views of innovation.

5.4.3.1 Novelty

A total of eight interviewees described their firm's innovation in terms of novelty or uniqueness. Company E, for example, had developed a novel process for growing

ZCT crystals and claimed that it was the only company able to produce crystals in this way, as one interviewee explained: '… we're not making a BMW and someone else is making a Volkswagen, this is, you know, we are the only company making this in the world, you know, *like* this' (Materials Manager, Company E). The novel element of its innovation was a new chemical vaporization technique, enabling the production of larger, better quality ZCT crystals than its competitors and which, therefore, had a wider range of uses and subsequently appealed to a larger market, or even to previously untapped new markets. The company saw its process as disruptive innovation, providing a commercial advantage by enabling them to provide a 'better' solution than its competitors in a way that could not be replicated, as one interviewee explained:

> Most of the previously commercial techniques were liquid methods, so you'd heat up a pool of material, let it melt and then let it condense and [there are] a number of disadvantages to this, but it's easy to control. The method that [D] university worked on was a vapour growth technique. So what you do is heat up a sample under a vacuum and its sublime, so it goes straight from a solid to a vapour and then, if you can control, the vapour flow, then you can grow your crystals with a lot fewer defects, which I think is the main thing, so you get a much higher yield and it's inherently scalable, whereas the liquid growth techniques are not scalable. So [there are] some major advantages to [this] technique. (New Technology Manager, Company E).

Initially, the company had intended to grow the crystals and sell them to other manufacturers to use in their products. However, the company quickly realized it could manufacture its own products, as one interviewee noted: '… it had to be adaptive, because in proper innovation there isn't anybody who has ever done this before [laughs] you know… but we realized we wanted to do more than just grow crystals', (Technical Manager, Company E). It also acknowledged that this new approach meant having to adopt a broader, incremental definition of innovation, (Bessant and Tidd, 2007), encompassing it as a problem solving tool:

> [Innovation means] new ways to solve problems, I think… is where we are. So we have a technology that no-one else can use… and either finding new

> products for that technology… or using that to… enhance existing products I think is where the innovation is. (New Technology Manager, Company E)

So, by adding additional functionality to the crystals, or incorporating them into their own products, the company could improve on its original business model:

> … really it was the 'roast chicken' model… it was the fact if you sell a raw chicken you get certain value. If you cook it you get more. You add value. Make it into sandwiches you get even more… and that's exactly what we realized we can do. We can sell ZCT as a little square and get a certain value for it. We can put electrodes on it and get more money. We can put it in some electronics and get even more money, or we can out it into a device that can be bought by someone who's completely none-technical and get even more money. And that's still the model now… (Materials Manager, Company E).

Its new business model combined its original idea of selling ZCT crystals to other manufacturers who had plans to develop and manufacture their own range of products (called 'systems') incorporating ZCT crystals, e.g. radiation detectors, airport security scanners and medical x-ray devices:

> I think in terms of the materials we are trying to develop… [we're trying to] make a more reliable, high yield process to produce an existing material basically… but the 'systems' are trying to address a new market, for example security and liquid, bottle scanners through airports, I mean that's a new market. Even the radiation detectors …. mind you…. I suppose the radiation detectors… the hand held radiation detectors, are aimed at giving somebody, giving the customer… a performance in a simple hand held device that might have required a much more, which can be possible, you can do, but which might have required a much bulkier, more complex, more expensive piece of equipment. (Technical Manager, Company E).

Companies C and D, both recent start-ups in the early stages of commercialization, expressed similar views about innovation. Both of these firms saw their processes as 'new to the world' innovations, with one interviewee describing his company's water treatment process as a disruptive technology, the new science pushing out the old and replacing it with its own science-based innovation: 'Innovation to me means

something that is absolutely brand new rather than just a step change. It's a disruptive technology I think… I don't know if I like the phrase or not because to me the phrase 'disruptive technology' has negative connotations. But it's what is used…' (Technical Director, Company D). The interviewee was also aware that incremental changes played an essential role in the development of new products and processes, and was frustrated that his 'scientific' perspective meant he sometimes failed to recognize their importance:

> '… sometimes I get annoyed that I don't see the incremental shifts being as important as the big ones. I think [of them] as developmental processes rather than something innovated. I mean it's a different… probably the scientist in me… it's got to be 'new'… (Technical Director, Company D).

As a science-based start-up, Company C had received some funding to carry out 'proof of concept' testing in order to demonstrate the feasibility of its innovation, i.e. that it worked correctly and could be developed into a commercial product:

> … we received some money for basically' proof of concept'. So some of that money was used to, you know, see whether the machine works or not. We wanted to do that on live projects rather than just little bits of material, we wanted to get straight into the marketplace and work with people we know who could provide us with a testing service and offer feedback. So we have spent 6-7 k on running the trials. Yet we spent double that on doing the applications, testing and that generated data for us to move forward with IP, you know, had arrangements for…they, they get first into marketplace (Managing Director, Company C).

When explaining the nature of his firm's innovation, one interviewee in Company C noted its distinctiveness, or uniqueness being what the market place was looking for:

> Nanotechnology is when you make the particles stick together, and they're very hard to get apart. Huge forces needed to be able to get them apart. And the marketplace has been looking for a technology that puts enough energy in to split them apart. They're only useful when they're split apart, in single particles. So this is a distinctive technology, our [method] is based around a

> technology that we've developed that puts energy into these systems to separate the particles out. (Technical Director, Company C)

Although Company C viewed its innovation as unique, it acknowledged that it had used the innovation to improve an existing process. The company had improved the existing technology for a process called 'bead milling', used to grind various types of particles to very specific sizes for uses in a wide range of industries. It had realized that, rather than try to usurp the incumbent technology, the company could use its science-based process of customized nanoparticulate dispersions to improve the existing technology:

> … we originally pushed this technology to replace the incumbent technology in the marketplace which is called a… something called a 'bead mill' which is a tube, a couple of feet along, full of tiny beads that are no less than a millimetre and basically a massive big gearbox spins them all very quickly and that crushes particles down. Originally we looked at possibly replacing that technology, but through some of the work we've done we're now looking at adding things onto the end of that to improve it. (Technical Director, Company C).

These SMEs generally considered the novelty or uniqueness of their innovation provided a competitive advantage over their competitors because they could provide a 'better' solution to customer's problems, which, as one interviewee explained, could not be replicated:

> … we're kind of unusual in that we're the only people who are growing [crystals] by what's called 'vapour phase'. So everybody else takes a big pot of metal, melts it and it goes from a solid to a liquid, then back to a solid. We actually go from a solid to a vapour and back to a solid. So we do have some inherent differences so we could discuss stuff and [our competitors] wouldn't be able to make a lot of use of it, you know. (Senior Scientist, Company E).

Although uniqueness provided capability advantages, some interviewees considered it a barrier to innovation because uniqueness restricted the ability to build shared repertoire with external organizations, thus limiting collaboration opportunities:

> I think [uniqueness] should be an advantage in as far as the capability goes. I think it's a disadvantage 'cause we are the only people in the world doing this so it's that… innovation is quite difficult 'cause it can only come from ourselves. If we're doing innovation via reading scientific papers then there aren't that many that, you know, well they're either not quite the same so we would have to change and alter stuff, or we have to go back to far more fundamentals and take it from 'well, what's that atom actually doing', rather than 'oh, when you heat this, this happens' type of thing. (Material Manager, Company E).

This finding seems to contradict Allee's (2000) claim that inter-organizational CoPs provide a mechanism for knowledge sharing between organizations. It suggests that, for science-based SMEs involved in radical innovation, the uniqueness of their products is a barrier to knowledge sharing, restricting the ability to build the shared repertoire which is essential in constructing successful CoPs. Novelty was closely associated with these interviewees' descriptions of their firms' unique inventions, which sometimes represented the basis for the further incremental innovation in the production of new products, processes and in the development of new markets. However, the uniqueness associated with novel innovations also presented a barrier to knowledge sharing and knowledge acquisition because of a lack of shared repertoire. As well as expressing views of innovation as 'novelty', interviewees also described innovation in terms of 'problem solving'. This is discussed in the next section.

5.4.3.2 Problem solving

Thirteen of the interviewees described incremental views of innovation linked to SMEs' problem solving activities. Such incremental views of innovation were exemplified by one interviewee's claim that: '… innovation is anything that improves our products, our outcomes, our quality of testing… even price… innovation covers many aspects' (Managing Director, Company G). Incremental views of innovation were frequently expressed in terms of 'small steps' rather than being the 'the new big thing':

> It's making things better… simply put. At one time I would have said it's… 'the new big thing'… but actually the more I'm involved in, sort of, creative thinking and trying to develop new products, actually, it's… the innovation's often much, much smaller. It's very hard from the inside sometimes to see what the innovation is… it often takes and external body, or person to point it out. (Service Manager, Company G).

This opinion was echoed by several interviewees, many of whom considered smaller incremental steps to be about the on-going development of current products, as one interviewee identified: '… there's constant development… I mean, you know, there's the product that you run with... the quick kit and then there's the kit that you might want to improve' (Technical Manager, Company E). Customers sometimes came to SMEs to find solutions to problems and had very specific requirements; however, more often they had only a vague idea of what type of solution they were looking for. Problem solving was seen as an opportunity to develop existing products and open up potential new markets:

> Sometimes people do come to us with very key requirements and a very clear, well understood idea of what they want. Other times it's just, sort of people coming in and saying "do you do one of these", or… "I'm looking for something to monitor this"… or… but a lot of the time…. Now we're trying to think beyond what we do currently… sort of where our innovation programme is coming in as… we want to try and find markets where we can use our skills and expertise to… open up new markets really. (Design Engineer, Company G).

In order to improve existing products and provide solutions, it was necessary to engage customers in dialogue about their needs:

> You can have an existing product you improve – that's innovation. You have an existing product you, that you change the way it's used, simplify it for the user - that's innovation. New products, of course, are innovation. So… there are many aspects to innovation and we're involved in all those, we're trying to make, we're looking to make our [product] easier for nurses to use. It's been used by health care professionals in the past. Now nurses need to

> understand it so we're taking steps to make it easier for them... and, but we're also working on brand new diagnostic tools for helping haemophilia patients. We have products being used in hospitals in Afghanistan by the blood surgeons out there. We're working on reagents that will allow that sort of work to be done far more easily. And so there are many aspects of innovation that we're working on with our customers. (Managing Director, Company B).

This finding is similar to Heiskanen et al.'s (2010) suggestion that CoPs can support knowledge transfer in user-led innovation. Von Hippel and Finkelstein (1979), for example, found that the customers of clinical chemistry analyzer equipment firms were the primary source of innovation and suggest that customers working in collaboration with the equipment manufacturers could be considered a metaphor for inter-organizational CoPs. Adapting existing products or making incremental changes to produce a range of products that would appeal to a variety of potential customers:

> We already make a device… which is very much for scientific use, so high accuracy, very small, driven from a USB. A lot of scientists would buy it for experiments, but there was a realization that that could be scaled down and made less sensitive by using a smaller piece of Cad Tel, a smaller piece of ZCT, so hence costs a lot less… and that starts to get into your… I suppose you market there is… your 'techy', your early adopter, the guy who's got his I Phone and various other things like that… it's still expensive but still somebody just might want to go 'just checking this apple [for radiation]' that kind of thing. (New Technology Manager, Company E).

Partnering customers in complex problem solving activities was thought to stimulate incremental innovation, as the Managing Director of Company G explains: … 'there's two reasons for that… it's amazing how people think when they're under pressure… but also when you take on something that's a bit of a challenge… obviously that expands your horizons as well' (Managing Director, Company G). On other occasions problem solving, as a form of incremental innovation, was associated with internal knowledge sharing and expertise. In the following excerpt,

the interviewee explains how the company pooled its existing knowledge to provide a solution for one particular customer:

> … we're doing a lot of work with a company that puts space craft into space… so they want to preserve life in the space craft and… there's all sorts of things can happen on a space craft, you know. There's a lot of vibration, a lot of acceleration… and other things that can happen. If a spacecraft springs a leak then the inside will go down to absolute vacuum until they find the hole, plug it and pump the pressure back up again. Now a lot of gas sensors would have stopped working at that point 'cause they're water based or liquid based and they'd just evaporate. So we used our existing knowledge and trawled the internet looking for new science… new technology and linked this to a bunch of old, it's twenty year old… technology, to come up with a solution for them. (Managing Director, Company G)

Taking on particularly challenging problem solving activities, away from their usual area of expertise was another way to stimulate incremental innovation. For example, Company G engaged in a number of 'special development' contracts in collaboration with customers, which they saw as a way to stimulate both organizational learning and innovation:

> … you can encourage people to collaborate… but there's another way this company's learnt… and that's by taking on 'special development' contracts. So effectively you go and accept a contract that is quite challenging … but usually, as you're going through that very challenging and painful experience, you pick up as lot of learning and a lot of innovation happens because you share expertise between companies. (Managing Director, Company G).

Some interviewees did not consider their work as innovation but as simply bringing together existing technologies to provide their customers with solutions: 'I don't really think that we do a lot of innovation… it's a case of buying tried and tested technology off the shelf and, sort of, putting it together, testing it a bit more, making sure it's fit for our application, then building it into a system' (R&D Engineer, Company G). In this instance, the SMEs' problem solving ability could be

considered to be their innovation capability, i.e. using their expertise and knowledge in combining existing science-based technologies to produce solutions for customers: 'We think our skills are really in sort of integrating gas sensing solutions into applications… niche applications really… understanding the particular requirements of a customer in their application, then building them a system with gas sensing in it' (R&D Engineer, Company G).

SMEs working with customers from commercial organizations, as opposed to R&D organizations, did not always recognize their work as involving innovation, because they did not produce 'new' products, rather they adopted an incremental view of innovation as a problem solving activity:

> We have no products of our own, and therefore, in terms of innovation, we don't generate any new products as such. We would class, in our case, the sort of innovation as finding solutions to customer's problems. Also, looking for areas where we can introduce different technology to the areas that we are already reasonably expert in. (Operations Director, Company A).

Working on behalf of customers, and designing solutions to their problems, was widespread in the firms dealing with customers from commercial organizations, i.e. Companies B, E and G, where innovation was about incremental steps to improve existing products: 'in terms of absolute innovation, that doesn't apply to our business. The innovation is more, sort of, trying to come up with ideas how to solve or provide solutions to problems that our customers may have' (Technical Director, Company E). Other interviewees confirmed the view that innovation was not always about 'new to the world' ideas, but could mean offering more incremental approaches, employing their existing knowledge and skills to generate new markets:

> So, from our point of view we sort of see the innovation as not necessarily finding out sort of brand new ideas… out of nowhere, its more kind of… incremental innovation in ways we can use what we know and our skills to open up new markets, perhaps, and just think a little bit beyond what we currently do. (Design Engineer, Company G).

Generating new markets through incremental innovation was closely linked to problem solving, and often meant providing a 'better' solution for customers, i.e.

making a product simpler, in order that customers find new uses for it: 'Yes it' a better solution. You're creating a market, you know, if you make a simpler product, I mean, will start to do things they perhaps didn't do before. They find other uses for the product' (Technical Manager, Company E). Incremental innovation was also viewed in terms of how firms used their existing knowledge and experience to find better solutions for customers: 'The innovation? I think it's the time and effort we put in to making [our products]. Rather than trying to… reinvent the wheel, 'cause I think from experience some products have been made but rushed so then now people's having to rethink how it works or solves their problems' (R&D Scientist, Company B).

Problem solving was closely linked to working in partnership with customers to understand their problem in order to deliver them a solution. As one scientist observed: '… we normally invite [customers] to come here, have a look round, tell them what we can do for them and explain what expertise we can offer... because that's what they want really - our help to solve their problem' (R&D Scientist, Company B). Working informally, in partnership with customers, helped SMEs understand their customers' requirements. In effect, they shared their expertise in an inter-organizational CoP, and in this way they could identify the most appropriate solution for their customer's needs:

> We've just brought together a bunch of building blocks, which were trivial, and then picked up little bit of technology to try and solve most of their problems… and along the way we've explained well, we can't solve 'that' for these gases, does it really matter if those gases don't work after it's gone to vacuum? No it doesn't. Right, ok, well we'll do a standard solution for that… and for these other ones, where it does matter, here's some more 'wacky' technology that we happen to know works 'cause we tested it for you along the way. (Managing Director, Company G).

This approach meant building and maintaining close relationships with customers, sharing knowledge and expertise to develop solutions: 'Problem solving is what you're trying to do. You're trying to solve a problem for somebody… and that then becomes understanding the problem, then it becomes trying to design the solution' (Technical Manager, Company E). Customers often sought expertise that was not

necessarily related to the SMEs' scientific knowledge. Company B, for example, had become quite expert in understanding the freeze drying technology it used as part of its processes and customers came to it for its expertise in this area:

> Yes, that's the idea. They want, 'cause we freeze dry a lot of our products to preserve them, and the issues that arise round that is, you know, trying to maintain the integrity of what we're freeze drying without... you know, making sure it's stable for so many years. So that's the sort of expertise that our customers want from us. (R&D Manager, Company B).

For most science-based SMEs, close relationships with customers was an essential part of the problem solving process because of the complex nature of their products:

> Right, you've got to be… you've got to be under the skin of what you're customer's doing in every area. You've got to understand their application really… I mean it's a well worn phrase but really what you have to do is provide solutions for people. It's not really, although we make catalogue products and obviously where possible we try to sell catalogue products, it's not really the product you're selling, you're selling a solution to their problem. So, you know, you can't sell a solution to their problem if you can't understand what their problem is. (Chief Technical Officer, Company E).

By engaging in incremental innovation in partnership with customers, some SMEs hoped their products would eventually move from being complicated, bespoke solutions to become 'catalogue' products that customers could provide an off the shelf solution for customers:

> I think we all try to have a close partnership relationship… it's very important [pauses]… I… we're selling product that quite complicated… we've probably got some stuff which is moving down to catalogue purchase and certainly it's our hope to make products that become a catalogue purchase but I think we're… in most cases we're a long way away from that. Our customers therefore rely on our expertise and advise to find suitable solutions. (Chief Technical Officer, Company E).

Other SMEs saw the provision of bespoke products as a key strength that helped them to provide innovative solutions in niche markets: 'We do a lot of 'specials', bespoke products for customers who do come to us… usually the likes of commercial dive customers who are possibly building new dive vessels and need a new sort of fully integrated atmosphere monitoring system' (Design Engineer, Company G). Problem solving was, therefore, closely associated with incremental views of innovation and often associated with improving or adapting existing products to suit specific customer requirements. The SMEs were seen to work in partnership with their customers on an informal basis, sharing expertise in inter-organizational CoPs, where they developed solutions to their customer's problems.

5.5 CHAPTER SUMMARY

The chapter began by identifying and examining the types of CoPs present in the participant organizations. Apprenticeship-based CoPs had emerged in Company B. Although there was no evidence of managed CoPs, both intra and inter-organizational CoPs had emerged or were cultivated by the SMEs. The findings show that these three types of CoPs were leveraged for a variety of purposes, including facilitating the acquisition of knowledge, supporting individual learning, improving absorptive capacity, and improving the firm's ability to generate innovative solutions to customer problems. Although there was some evidence of CoPs supporting radical innovation, they were more generally deployed to support incremental innovation in the guise of problem solving. SMEs acting as problem-solvers for their customers could be seen as a form of incremental innovation; this approach was reliant on the establishment of trust, which was often leveraged through personal networks and the pool of expertise and tacit knowledge found in the SME and its collaborating partner organizations. Cross-organizational interaction over time could generate shared understanding and a sense of engaging in a joint-enterprise, leading to the construction of the three types of CoPs identified in the findings. Thus, social capital was leveraged to generate trust and reciprocity between SMEs and the organizations with which they partnered, enhancing knowledge-sharing and innovative potential.

CHAPTER 6: DISCUSSION

6.1 INTRODUCTION

The purpose of this study is to understand whether, and if so, how, science-based SMEs engage with CoPs to acquire new knowledge and what innovations, if any, are generated through such engagement. The study asks: 'to what extent are CoPs a 'privileged locus' for knowledge acquisition and innovation in science-based SMEs?' It also considers whether CoPs help science-based SMEs to develop more focused innovation processes. The research addresses a number of research questions:

1. Are CoPs to be found in science-based SMEs?
2. If so, how and why are CoPs constructed in science-based SMEs?
3. How is knowledge acquired in science-based CoPs?
4. What innovation is generated from collaborative activities in CoPs?

The chapter discusses the implications of the empirical findings outlined in chapter 5, showing how they answer the research questions and overall aim of the study. I also bring together the findings in the form of a contextualized framework that can be used by science-based SMEs to support CoP construction.

6.2 CoPs AND INNOVATION

For science-based SMEs wishing to innovate, there are two clear imperatives: support the development and circulation of knowledge within and pursue alignments across CoPs. Innovation occurs both within the boundaries of organizations and also across the boundaries between firms, universities, research laboratories, suppliers and buyers (Moingeon et al. 2006). Open innovation involves searching outside the firm's boundaries for mutually beneficial relationships (Chesbrough, 2003), and focuses upon how firms manage their network of internal and external relationships (Dahlander and Gann, 2010). Open innovation has increasingly emphasized the role of communities in creating, shaping and disseminating innovations (Fichter, 2009). According to Autio et al. (2008), firms involved in collaborative innovation should purposely foster the development of CoPs. There are clear links between open

innovation and absorptive capacity, particularly with reference to the sourcing and exchange of externally developed knowledge (Vanhaverbeke et al. 2008).

However, SMEs have access to fewer resources than larger organizations and, as Tödtling (2001) suggests, they might compensate for their lack of resources by engaging in CoPs to support innovation and knowledge management (Partanen et al. 2008). It can, therefore, be questioned whether SMEs can spare the necessary resources required for cultivating CoPs (Roberts, 2006). McDermott and Archibald (2010), for example, suggest organizations must set aside time for CoP participation, provide training for CoP leaders and utilize simple IT tools to facilitate participation. Probst and Borzillo (2008) explore the use of 'governance committees' to assess CoP activities, and management sponsors to guide their activities. Such cultivation methods might not be seen as appropriate by SMEs as they divert resources from core business activities.

It can be concluded that CoPs may potentially provide an introductory vehicle for SME knowledge management (Du Plessis, 2008), a means to boost technological learning, and the ability to commercially exploit new innovations (Autio et al. 2008). However, the findings of this study show that for science-based SMEs the construction of CoPs can be problematic. In the next section I discuss my findings in relation to the research questions posed, considering what they tell us about the presence of CoPs and how they are constructed in science-based SMEs.

6.2.1 Constructing CoPs in science-based SMEs

Are CoPs to be found in science-based SMEs?

Wenger (1998) claims that CoPs exist in all organizations, but most research into CoPs and innovation have focused on large businesses, which prompted my first research question – 'Are CoPs to be found in science-based SMEs?' My data reveals three types of CoPs present in the science-based SMEs – apprentice-based CoPs, intra-organizational CoPs and inter-organizational CoPs. In Company B there was evidence of apprentice-based CoPs – a type of intra-organizational CoP, which emerged to support individual learning and internal knowledge-sharing related to their domain of scientific knowledge. In apprentice-based CoPs junior scientists were seen to move from 'novice' to 'master' and, through their participation as CoP

members, they moved from the periphery into a CoP, gaining the firm-specific scientific knowledge that they required to participate in innovation activities.

Intra-organizational CoPs were also present and were leveraged for a variety of purposes including individual learning, internal knowledge-sharing, as well as for supporting noncanonical practices. Scientists and engineers were seen to pool their expertise in problem solving activities. Intra-organizational CoPs emerged through such mechanisms as 'corridor meetings', for example in Company E, and shared many similarities with Orr's (1991) study of a community of photocopy repairmen in a large organization. In Company G, intra-organizational CoPs were constructed through the use of a boundary object – the Imagineering Wall – used to encourage informal collaboration and stimulate innovation. This is not dissimilar to the CoP cultivation approach adopted by the organizations in Probst and Borzillo's (2008) study, although Company G does not recognize it is cultivating CoPs.

Inter-organizational CoPs, comparable to those described by Moingeon et al. (2006), emerged between SMEs and two distinct sets of customers: commercial organizations, focused on developing new products and processes, and R&D organizations represented by universities and other research organizations which were seeking to commercialize their inventions. These CoPs were particularly evident in Companies B, D and E. In addition, there was also evidence of CoPs emerging between SMEs and their suppliers in Company A. There was evidence of mutual engagement, a shared repertoire and joint enterprise between these SMEs and their customers. In the next section I explored in greater depth *how* and *why* these CoPs are constructed.

How and why are CoPs constructed in science-based SMEs?

Wenger et al. (2002) sees a repositioning of CoP theory with the suggestion that, although CoPs cannot be managed, they can be cultivated. Wenger et al.'s (2002) conceptualisation identifying activities related to the community (mutual engagement), domain (joint enterprise), and practices (shared repertoire). More recent studies have concentrated on CoPs in larger organizations, often adopting a managerialist orientation focused on how senior managers can intentionally manage CoPs for strategic advantage. For example, recent treatments of CoPs (Macpherson

et al. 2009; McDermott and Archibald, 2010; Probst and Borzillo, 2008) have suggested that they can and should be actively managed and given specific goals, accountability, and have a clear 'executive oversight' (McDermott and Archibald, 2010, p.84). Efforts to adopt this type of managerialist approach in studies of CoPs and SMEs (Akkerman et al. 2008) have not been particularly successful. Some researchers have argued that efforts to manage CoPs could impose a form of control that stifles creativity, knowledge sharing and self-initiative (Andriessen and Verburg, 2004; Cox, 2005). My findings, it should be noted, indicate that SMEs are unlikely to recognize the term CoPs – let alone intentionally manage them.

An alternative view (Hildreth and Kimble, 2002; Saint-Onge and Wallace, 2003; Wenger et al. 2002) is that CoPs need to be cultivated, rather than managed. However, the present research has demonstrated that CoPs in science-based SMEs are an essentially emergent phenomenon, as exemplified in the apprentice-based CoPs that emerged in Company B. There was some evidence, however, of attempts to cultivate CoPs. The use of boundary objects (such as the 'Imagineering Wall' in Company G) stimulated the cultivation of multiple intra-organizational CoPs that were leveraged for incremental rather than radical innovation. The 'Imagineering Wall' brought together individuals who, through the building of shared repertoire, mutual engagement and joint enterprise, formed a variety of CoPs focused on both incremental innovation, i.e. improving existing products, and radical innovation, i.e. developing 'new to the world' products.

However, the 'Imagineering Wall' was not without problems and there were a number of issues related to its implementation. Some employees felt that, due to the commercial pressures of working in a small firm, they could not always use the 10% time allocated to become involved in projects that interested them. Others highlighted the fact that, once they had posted their initial ideas on the wall in an initial spurt of creativity, they struggled to generate new ideas. The wall initially acted as a boundary object, encouraging practice-based creativity, but in order to maintain momentum and ensure its long term success in generating 'big ideas', they would need to move beyond simply capturing the skills, expertise and creativity of existing employees and seek to engage external CoP members, enhancing their ability to generate new ideas and innovation.

Other efforts to cultivate CoPs included building and maintaining strong trust-based relationships and building credibility with customers- closely linked to developing reciprocal relationships. Building trust was essential in order to facilitate effective knowledge sharing and to help SMEs to understand their customer's needs, supporting Fields (2008) view that 'relationships matter' when building social capital. Through regular mutual engagement, sharing expertise internally with colleagues and externally with customers and suppliers, SMEs were often able to build effective trust-based inter-organizational CoPs, thus generating social capital, developing their capabilities and improving their ability to problem solve on behalf of their customers. This finding contradicts Hamburg and Marin's (2010) view that SMEs are unreceptive to knowledge sharing due to a lack of trust.

Trust was an essential element in building the social capital inherent in inter-organizational CoPs and the SMEs employed a variety of trust building activities to engage customers and suppliers. For example, Company A held free seminars and invited their customers and suppliers, Company B provided free specialist advice to [D] University, and Company D offered free validation testing. Each company used such events to build trust and stimulate informal networking. By offering on-going advice and support, effectively sharing their expertise, they were able to encourage informal interaction between individuals that frequently formed the basis of inter-organizational CoPs. Trust was linked to building credibility with customers and presented particular problems to the two start-up companies (C and D) which were wary of sharing knowledge and expertise externally because they felt they had to protect the intellectual property that was the basis of their innovations. For these two firms, trust presented a significant barrier to community building, an essential part of CoPs.

Some larger SMEs, notably Companies A and E, encountered similar difficulties when engaging in trust building activities and sometimes had to adopt a pragmatic approach in order to source external expertise. For example, for Company E, which was engaged in radical innovation in order to develop new products, trust building was sometimes a secondary consideration, coming after getting someone with the necessary expertise, particularly if the person is not within their existing external network. Company G, on the other hand, brought in external expertise for collaboration purposes, thereby enhancing their absorptive capacity. However, SMEs

were able to build trust-based collaborative relationships and, through regular mutual engagement with their customers, CoPs often developed, helping to understand their customer's needs and provide appropriate solutions.

Reciprocity was an important part of the trust building process and this was often achieved through offering free advice or additional services. Companies A, B and D all offered their services free to both commercial and R&D customers. Company A, for example, provided 'free' services to commercial customers in order to maintain regular, informal contact, build collaborative relationships and generate future business. For non-commercial customers, e.g. universities, Company D provided their services free in exchange for access to equipment or other testing facilities. These types of reciprocal arrangements often led to informal knowledge exchanges and the emergence of inter-organizational CoPs. An inter-organizational CoP emerged between Company B and [N] University. Those entrepreneurial leaders who displayed high levels of social presence, such as the MD in Company B, were better equipped to build these strong, longer-lasting trust-based relationships. The ability to 'be out there' making connections was an essential factor in building successful inter-organizational CoPs, based on trust and reciprocity.

The knowledge exchanges that occur in CoPs are an essential part of the innovation process in science-based SMEs, and in the next section I discuss how knowledge is acquired in science-based CoPs.

6.2.2 Knowledge acquisition in science-based SMEs

How is knowledge acquired in science-based CoPs?

The ability of firms to thrive and grow relies on 'know-how', i.e. making tacit knowledge explicit (Nonaka, 1991), much of which is acquired from external sources, with innovation an important part of this process. Harding and Pawar (2001), for example, studied 'know-how' transfer in 'heterogeneous' networks (i.e. different types of SME network) in the manufacturing sector, and examined the benefits networking brought in terms of competitiveness to the regional economy of the West Midlands. They suggest the main challenge for SMEs was building trust and developing strong personal relationships with other, often competing, firms. Their preliminary findings were used to develop a network-based taxonomy of small

manufacturing firms and, as previously discussed, an open horizontal network seems appropriate for sharing tacit knowledge and might also be viewed as a form of CoP because of its flexible and open membership.

This study confirms that internal and external knowledge acquisition is a key part of the innovation process for the science-based SMEs. Individual learning was often informal and there was evidence of both apprentice-based and intra-organizational CoPs that emerged in response to the need to support the sharing of existing scientific knowledge. Apprentice-based CoPs emerged to support member's needs to expand their existing scientific knowledge and often supported informal 'on the job' training and development. Although individual learning was recognized as important for innovation, it had to be aligned with the commercial goals of individual firms. This need for alignment inhibited the emergence or cultivation of CoPs by restricting the domain of knowledge to that which the organization deemed suitably linked to their commercial activity.

The individual learning that occurred in the apprentice-based CoPs in Company B could be considered more aligned to notions of incremental innovation, where there is a high level of reliance on building the shared repertoire that facilitates passing on of *existing* scientific knowledge internally between the CoP members. Conversely, for the SMEs involved in radical or disruptive innovation, such as companies C, D and E, the emergence and/or cultivation of apprentice-based CoPs was inhibited by the absence of a shared repertoire related to a lack of a shared domain of knowledge in a particular field of scientific research where there was a high level of novelty or uniqueness associated with the innovation. As one interviewee observed: 'we're not doing projects that are digging ditches or building walls'.

Both the emergent and cultivated CoPs, focused on specific domains of scientific knowledge, and were seen to support knowledge sharing between various professional groups, such as scientists and engineers. Members of these CoPs participated in a range of knowledge sharing activities including sharing the 'obvious stuff', as well as things they 'didn't yet understand'. The impetus for this phenomenon was often to support members' individual roles in problem solving activities they conducted on behalf of customers. This was exemplified by one interviewee's reference to informal 'corridor meetings' with colleagues in Company

E, where internal knowledge exchanges often occurred. CoP members pooled their expertise, participating in problem solving activities, a kind of incremental innovation, on behalf of customers.

However, there was some evidence that the construction of CoPs could be inhibited. In Company E, for example, the Chief Technical Officer suggested that, for senior scientists occupying strategic roles in SMEs, it was often difficult to access intra-organizational CoPs due to lack of 'band width', thus inhibiting their capacity to build CoPs relationships and leverage the social capital necessary for innovation. CoP participation became more difficult because they could not maintain regular contact with their network of scientific colleagues. Additionally, conflict frequently emerged between scientists, who viewed innovation as a 'journey' and engineers who considered innovation more in terms of a 'destination'. This sometimes restricted the emergence of intra-organizational CoPs. In general, scientists were considered to be less commercially aware than engineers who were more focused on developing an end product. In SMEs focused on radical innovation, i.e. companies C, D and, particularly, E, this conflict inhibited the knowledge sharing activities generated through the emergence or cultivation of CoPs, thereby restricting their ability to turn innovations into commercial products.

The literature suggests that in networks, individuals might fear losing their expert status, whereas organizations might fear disclosure of their competitive knowledge. This raises the question of whether organizations are willing to initiate innovation projects with new partners (Wohlfart et al. 2006). SMEs in particular might refrain from participating in such innovation networks because of the perceived increased risk to their competitiveness (Meeus and Oerlemans, 2000). On the other hand, Meeus and Oerlemans (2000) comment that the often limited resource base available to small firms does not negatively impact on innovativeness, and argue that they are able to develop adaptive behaviour conducive to innovative performance. This suggests that lack of trust rather than resources is a more likely barrier to innovation through collaboration.

Collaboration was an essential part of the commercialization of innovation for all the SMEs, for a variety reasons, including sourcing external scientific expertise from other firms and universities, seeking commercial expertise to help them exploit their

innovations, and as a route to market through licensing agreements and as a source of funding. Customers often sought collaboration with SMEs to acquire external knowledge. Companies A, B and G in particular used this approach to bind customers to them, in effect cultivating an inter-organizational CoP by building a shared repertoire through regular, informal contact. There was much evidence of the internal pooling of expertise and exchanges of tacit knowledge through collaborative activities, often resulting in or from the emergence of CoPs. SMEs acted as 'key experts', solving problems on behalf of their customers and there was evidence of increased absorptive capacity, based on SMEs' collaborative activities with customers.

The SMEs' collaborating with predominantly with R&D customers tended to value collaborative trust-based relationships more than those working in partnership mainly with commercial organizations. For the former, collaboration with universities was an important source of external scientific knowledge, as well as providing access to research and development funding and specialist scientific equipment and facilities. The latter tended not to consider themselves innovative, or to be involved in innovation *per se* and, although they engaged in collaboration with customers, they were generally suspicious of, or failed to see the value in, collaboration with other external organizations. This finding suggests that SMEs who acknowledge their engagement in innovation activities are more aware of the importance of collaboration. They are also more likely to actively seek collaborative relationships, engaging in CoPs that emerge through shared repertoire and joint enterprise focused on their specific scientific domain of knowledge.

In summary, the findings demonstrate how science-based SMEs acquire internal and external knowledge through the construction of, and participation in, CoPs. CoPs support individual knowledge acquisition and improve absorptive capacity, both of which are necessary for successful innovation. In the next section I discuss the impact this participation has on their innovation activities.

6.2.3 Innovation in science-based SMEs

Innovation generation through collaborative activities in CoPs

Previous research has attempted to define the role of CoPs in the innovation processes of organizations (Amin and Roberts, 2008; Hildrum, 2007; Swan et al. 2002) with a number of claims being made that they are effective in supporting both radical and incremental innovation. Amin and Roberts (2008), for example, posit that CoPs might support a range of radical and incremental innovation projects, whereas Swan et al. (2002) present a rather positive view of managerial support for CoPs involved in radical innovation, The work of Swan et al. (2002) demonstrates that CoPs can be used to mobilize external networks focused on a specific problem, providing a rationale for cross-disciplinary working between CoPs in a multinational science-based organization, thus helping to mitigate inter-professional conflict.

However, the findings of my research suggested that, in relation to radical innovation, the emergence of CoPs or their cultivation is inhibited by a lack of shared repertoire, especially for those science-based SMEs considered to be 'knowledge leaders' in their respective scientific field. Rather than managers supporting CoP development (whether managed or cultivated), this study found that senior members of staff sometimes found it difficult to access informal networks such as CoPs due to 'lack of band width'. An associated issue was that of voluntary participation. The literature indicates that participation in intra-firm knowledge sharing activities is often difficult because it is dependent on CoP members' willingness to voluntarily share their knowledge and expertise (Hildreth and Kimble, 2000; Kogut and Zander, 1996; Von Hippel, 1998; Von Krogh et al. 2000; Wenger, 2000). This suggests that CoPs were more likely to support incremental innovation in science-based SMEs.

My interviewees talked about both radical and incremental forms of innovation. For SMEs working with R&D organizations, innovation was often described in terms of novelty or uniqueness, i.e. aligned with ideas of radical or disruptive innovation and verified by 'new to the world' products and processes. The SMEs working with commercial customers considered innovation more in terms of 'problem solving' activities, i.e. aligned with views of incremental innovation, evidenced by collaborative activities as problem-solvers for their customers. Interviewees

generally agreed that innovation provided an essential source of competitiveness for their organization, enabling it to produce or enhance new products or processes. Enhancing their innovation capability often required SMEs to seek external knowledge which was often a source of conflict between scientists, who were considered to be less commercially aware than engineers. In companies C, D and E, focused on radical innovation, this conflict inhibited the knowledge sharing activities generated through the emergence or cultivation of CoPs, thereby restricting their ability to turn innovations into commercial products.

SMEs involved in producing novel innovations sometimes found it difficult to engage with external organizations because the uniqueness of the knowledge base associated with their innovation resulting in the lack of a shared repertoire. In effect, the SMEs were frequently the 'knowledge leaders' in their particular field. Interviewees in companies C, D and E, involved in generating novel innovations were also aware that further incremental innovation, often generated through collaborative activities, was required in order to successfully commercialize their inventions. However, lack of shared repertoire restricted their ability to engage in informal networks, such as CoPs, or to engage in the more formal collaborative relationships that often result from CoP relationships. There was no evidence of intra-organizational CoPs emerging in the two start up firms (companies C and D) due to the limited number of employees in each organization. Nevertheless, there was confirmation of collaborative relationship building and the emergence of shared repertoires through mutual engagement with a range of external organizations, including customers, suppliers and competitors.

A level of tension was observed between scientists and engineers concerning their views of innovation. At one extreme, there were scientists who sought to discover entirely new processes and knowledge. At the other extreme, there were engineers who used their knowledge to build useful devices. In general, scientists viewed innovation as a 'journey' and appeared to be less commercially aware than engineers who were more focused on developing an end product. In those SMEs focused on radical innovation, the level of conflict was often more pronounced because of the absence of a shared repertoire. This was related partly to a lack of existing knowledge, but also because of the uniqueness or 'novelty' associated with radical innovation. This aspect sometimes inhibited the internal knowledge sharing activities

associated with the emergence or cultivation of intra-organizational CoPs, thus restricting SMEs' ability to turn innovations into commercial products. On the other hand, these same SMEs, in particular Company E, often found it easier to collaborate with R&D customers, such as universities, and there was evidence of both resource sharing and knowledge sharing through inter-organizational CoPs.

The interviewees expressed a range of views of innovation. Those whose views were aligned with radical innovation considered their firm's products and processes to be unique, sometimes disruptive innovations, intended to replace the existing science. Others saw innovation in more incremental terms, i.e. offering 'better' solutions, often by making a product simpler in order that customers find new uses for it. Thus, companies A and B were able to create new markets for their products. Uniqueness was considered a source of competitive advantage to the SMEs, who were often operating in niche markets. However, interviewees did also recognized the importance of engaging in incremental innovation in order to develop new products based on their initial science-based innovation, or when commercializing their innovations. Although novelty, or uniqueness, was considered a capability advantage, the lack of shared repertoire (usually generated through mutual engagement) restricted the community building activities associated with inter-organizational CoPs.

Interestingly, interviewees in Company A did not consider their organization to be innovative because it did not manufacture its own products; those in Company G expressed a similar view because they created new products by 'integrating' existing technology rather than through their own R&D activity. Both these views, aligned with incremental approaches to innovation, were associated with their company's problem solving activities on behalf of, or in partnership with, customers which, in many ways, is similar to the to the examples of 'user-led' innovation communities discussed by both Heiskanen et al. (2010) and Von Hippel and Finkelstein (1979) and which, I argue are in essence a type of inter-organizational CoP. Problem solving did require close collaboration and, as these examples have shown, SMEs often worked in partnership with their customers, sharing knowledge, in order to develop complex innovative solutions. They employed a variety of methods for engaging with customers including hosting events to showcase their expertise and visiting customers to offer advice and training on their products. Customers were,

therefore, often reliant on sharing scientific expertise with the SMEs and this approach required individuals from both organizations to work closely together, engaging in problem solving activities that generated the mutual engagement and building of shared repertoires required for inter-organizational CoPs to emerge.

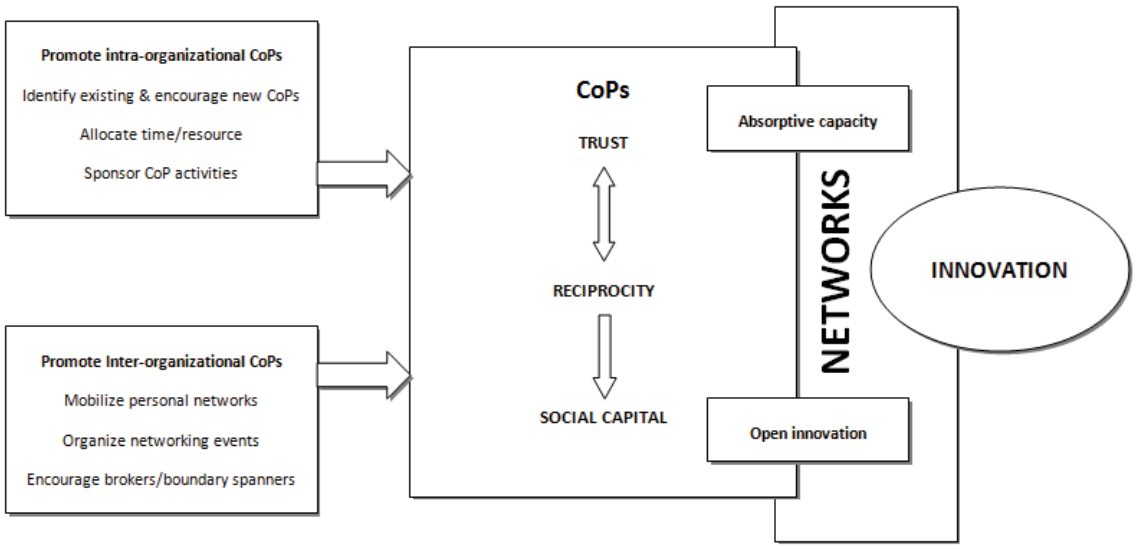
The findings thus show evidence of CoPs in the science-based SMEs. However, they also indicate instances where, although the conditions for constructing CoPs were present (i.e. there was mutual engagement, shared repertoire and joint venture), CoPs did not emerge. This suggests that science-based SMEs could do more to develop and support the cultivation of CoPs. In the next section I present my contextualized framework for the construction of CoPs in science-based SMEs.

6.3 A FRAMEWORK FOR CONSTUCTING CoPs IN SCIENCE-BASED SMEs

One of the main contributions of this study is the development of a contextualized framework for constructing CoPs in science-based SMEs (see Figure 15). The research highlights that science-based SMEs do not recognize either the presence of CoPs when they do exist in their organization, or the benefits they might gain from engaging in their construction. The contextualized framework for constructing CoPs, developed from the findings of this study, shows how science-based SMEs can promote CoP construction. The framework captures how intra-organizational CoPs can be promoted by SMEs by first identifying existing and potential CoPs and then encouraging their construction by allocating time and resource to their cultivation. In addition, inter-organizational CoPs can be promoted by SMEs by encouraging employees to mobilize their personal networks and by firms taking part in, as well as organizing, networking events. SMEs should also encourage individuals who show high levels of 'social presence' to act as brokers and boundary spanners, drawing external knowledge and expertise into their organization, thus enhancing their firm's absorptive capacity. The framework shows that, collectively, SMEs which pursue these sorts of activities can encourage the cultivation of CoPs, thus building trust and reciprocity and leading to enhanced social capital. The benefit from participating in intra-organizational CoPs is that it increases firms' absorptive capacity, whereas participation in inter-organizational CoPs stimulates open innovation (Chesbrough,

2003), both of which help SMEs build new networks and ensure better knowledge transfer, leading to more focused innovation in science-based SMEs.

Figure 15 Framework for constructing CoPs in science-based SMEs



6.4 CHAPTER SUMMARY

6.4.1 CoPs as the privileged locus for knowledge acquisition and innovation

The empirical findings of this research not only confirm the existence of CoPs in science-based SMEs, they also demonstrate how they emerge, or are cultivated, for a variety of purposes, including knowledge acquisition and innovation. This evidence supports the widely held view within the literature (Brown and Duguid, 1991; Hildreth et al. 2000; Lesser and Prusak, 1999; Wenger, 1998; Wenger et al. 2002) that CoPs exist in most organizations. Three types of CoPs were identified – (i) apprentice-based CoPs that supported individual learning, (ii) intra-organizational CoPs that facilitated internal knowledge sharing (particularly between different professional groups, i.e. scientists and engineers), and (iii) inter-organizational CoPs that emerged between SMEs and their customers and were leveraged to support a range of collaborative activities.

The emergence of apprentice-based CoPs confirms Lave and Wenger's (1991) original notion that learning is socially situated. In this instance, apprentice-based CoPs emerged to facilitate knowledge acquisition in the form of passing on existing

scientific knowledge rather than for stimulating creativity and innovation. Individuals shared existing knowledge and expertise, as well as acquiring new knowledge, both internally and externally. However, rather than being unwilling to share their experiences and insights, individuals often found knowledge sharing difficult due to the 'novelty' involved in generating new innovations which sometimes resulted in a lack of shared repertoire, which is fundamental to sharing meaning in CoPs.

Much of the literature on inter-organizational CoPs suggested that, although there are complex issues related to their manageability (or otherwise), it is possible to leverage innovation capability successfully through their careful cultivation (Amin and Roberts, 2008; Assimakopolous, 2007; Hildreth et al. 2000; Moingeon et al. 2006; Swan et al. 2002). The findings from the research indicated that inter-organizational CoPs supported a range of collaborative activities between the science-based SMEs and their customers and other innovation partners that were closely related to generating both incremental and, to a lesser extent, radical innovation. Collaboration occurred, for example, through the outsourcing or sharing of R&D activities by larger firms, or from larger firms' purchasing of innovation 'solutions' from science-based SMEs; in other words, through adopting open innovation approaches to their innovation activities.

The literature further suggested that trust and shared norms of openness and reciprocity facilitate organizational learning, lower the transaction costs involved in knowledge exchanges (Dyer and Singh, 1998), as well as supporting the development of future relationships (Autio et al. 2008) and promoting cooperation (La Porta et al. 1997). The findings support this view, demonstrating that the science-based SMEs often went through lengthy trust building processes with their customers and other collaboration partners, often supported through regular mutual engagement that occurred in emerging CoPs. Such CoPs generally emerged to support incremental innovation focused on problem solving on behalf of their customers. This process necessitated SMEs building strong trust-based relationships in order to build credibility with customers.

Building trust and reciprocity through mutual engagement enabled the SMEs to develop social capital, thus enhancing their innovation capabilities through

collaborative activities with customers, for example, acting as problem solvers (a form of incremental innovation). However, for science-based start-ups (companies C and D), participation in intra-organization CoPs was limited by low employee numbers. Engagement in inter-organizational CoPs was also an issue for these two SMEs, which were wary of sharing knowledge externally because they felt the need to protect their intellectual property. However, all of the other firms were able to leverage the social capital inherent in CoPs, these science-based SMEs were able to build trust and reciprocity, enhancing their innovation capability, thus elevating CoPs to become the privileged locus for knowledge acquisition and innovation.

CHAPTER 7: CONCLUSION AND RECOMMENDATIONS

7.1 INTRODUCTION

This research set out to explore the role of communities of practice as an enabler for knowledge acquisition and innovation in science-based SMEs, and has subsequently identified a variety of CoPs, both emergent and cultivated, that exist within the participant organizations, and that contributed in a number of ways to their innovation capability. The general literature on CoPs, as well as that specifically related to CoPs and innovation is inconclusive on several vital questions, particularly in the context of their deployment in science-based firms. The chapter begins with a summary of the previous chapters before going on to outline the contributions of the study. This is followed by an outline of the limitations of the study and recommendations for future research. The chapter concludes by commenting on the overall significance of the research and how it contributes to 'the body of knowledge' in the area of CoPs and innovation.

7.2 SUMMARY OF THE PREVIOUS CHAPTERS

In this section I summarize the previous chapters and how they contribute to fulfilling the overall aim.

Chapter 1: Introduction

The opening chapter begins by outlining the purpose of the study and stating the contributions the study makes to extant knowledge in three areas – theoretical, methodological and applied. This is followed by a description of the research aim and questions. The chapter then outlines the research framework, explaining both my epistemological and ontological positions and the chosen research method which follows from these positions. The next section outlines the rationale for choosing CoPs and science-based SMEs. Finally, the chapter provides an outline of the structure of the rest of the study.

Chapter 2: SMEs, science-based business and innovation

The purpose of this second chapter is to outline the contexts of the study, the background to the three main themes - SMEs, science-based business and

innovation. The chapter begins by illustrating the importance of SMEs and the role of science-based business, before discussing models of innovation relevant to the study. The chapter shows how these themes are bound together by the research questions and overall aim of the study.

Chapter 3: Literature review

Chapter 3 begins by defining innovation and, in the context of the research questions, provides a link to how the construction of CoPs supports knowledge acquisition and innovation in science-based SMEs. The chapter explains, in depth, the development of the systematic literature review protocol and how it was used. The chapter then examines the literature on CoPs, focusing on their changing role from a theory of situated learning in apprenticeships to their repositioning as a KM tool to support knowledge acquisition and innovation in organizations. The systematic review reveals that prior research has focused on CoPs and innovation in large organizations, leaving the concept underdeveloped in SMEs.

Chapter 4: Research methodology

This chapter presents an outline of the methodological approach adopted in the study, describing and justifying the choice of a qualitative interpretive approach and how this fits with my philosophical position as a social constructionist. The chapter describes in detail the research design, and how the participants were selected. It also describes the data collection process and how the thematic template was created. It explains how the template was used to analyze the data from transcripts of 25 semi-structured interviews with a range of individuals employed in both technical and commercial roles in 7 ‘science-based’ SMEs. Finally, it outlines the methods employed to demonstrate a reflexive approach throughout the design and execution of the research.

Chapter 5: Findings and analysis

This chapter presents the findings of the empirical data analysis, which examines a number of issues related to the overall aim and research questions - how CoPs are constructed in science-based SMEs, how knowledge is acquired within CoPs, and what innovations, if any, result from the construction of, and participation in, CoPs.

The findings of the data analysis chapter are presented under the three Level 1 themes of the thematic template: communities of practice, knowledge acquisition and innovation.

Chapter 6: Discussion

This chapter discusses the research findings and their significance in relation to the research questions and overall aim of the research. This relates specifically to how CoPs are constructed in science-based SMEs and what knowledge acquisition and innovation occurs through this process. In this chapter I present my framework for the construction of CoPs in science-based SMEs.

7.3 CONTRIBUTIONS

This study makes a number of contributions, presented below under the three main headings: theoretical, methodological and applied.

7.3.1 Theoretical contribution

Misapplication of CoPs label

Recent conceptualizations of CoPs have resulted in much misapplication of the term, resulting in the 'CoPs' label being used to describe a variety of organizational groups that could more accurately be described as formal teams or similar. The study, therefore, provides in-depth insight into claims that CoPs can be managed and aligned with organizational goals. Although the empirical data revealed no evidence of managed CoPs, both emergent and cultivated CoPs were identified in these science-based SMEs.

Lack of shared repertoire

The study shows that although CoPs exist in science-based SMEs, there are issues related to their construction. Data analysis showed that CoP development is often inhibited by a lack of shared repertoire, especially for those firms considered to be 'knowledge leaders' in their scientific field, i.e. where the SMEs were involved in the development of radical rather than incremental innovation.

Individuals exhibiting high levels of social presence

Individuals who displayed high levels of social presence were able to overcome lack of shared repertoire and were better equipped to build stronger, longer-lasting, trust-based relationships. The study, therefore, demonstrates how knowledge acquisition and innovation occur in science-based SMEs through participation in CoPs, thus making a contribution to our understanding of how CoPs are constructed in science-based SMEs.

7.3.2 Methodological contribution

Extending thematic template analysis

The study makes a methodological contribution through extending the use of thematic template analysis. This approach incorporates hierarchical coding to initially identify some broad *a priori* themes before then encompassing successively narrower themes generated through iterative analysis of the data. In an extension of this method, I developed a 'deductive-inductive' approach to coding the data. I incorporated *a priori* coding of the data *across* the hierarchy of the three levels of codes in my template (see Table 13), rather than just using *a priori* coding at the first level as King (2004) suggests. Applying *a priori* coding across the hierarchy enabled me to link the more iterative coding process with pre-existing theory.

7.3.3 Applied contribution

A contextualized framework for constructing CoPs in science-based SMEs

The study makes an applied contribution by contributing to our understanding of how CoPs can be constructed to support innovation within and between science-based SMEs. The contextualized framework for constructing CoPs (see Figure 15) shows how science-based SMEs can promote CoP construction. Intra-organizational CoPs can be promoted by SMEs by first identifying existing and potential CoPs and then encouraging their construction by allocating time and resource to their cultivation. Inter-organizational CoPs can be promoted by SMEs by encouraging employees to mobilize their personal networks and by firms taking part in, as well as organizing, networking events. Also, SMEs should encourage individuals who display high levels of social presence to act as brokers and boundary spanners,

drawing external knowledge and expertise into their organization, thus enhancing their firm's absorptive capacity. The framework encourages SMEs in the cultivation of CoPs, helping them build trust and reciprocity, leading to enhanced social capital. Participation in intra-organizational CoPs increases SME's absorptive capacity, whereas participation in inter-organizational CoPs supports collaboration and open innovation (Chesbrough, 2003) leading to more focused innovation in science-based SMEs.

7.4 LIMITATIONS TO THE STUDY

This research has provided an exploratory investigation into an important aspect of innovation in science-based SMEs. The research adopted an inductive approach, using template analysis to examine how CoPs emerged and were leveraged for innovation in science-based SMEs. It is recognized that the research project has certain limitations:

7.4.1 CoPs as a theoretical lens

Using communities of practice as a theoretical lens has shaped how I conceptualized innovation and the research questions posed. CoP theory has been criticized as a somewhat vague and poorly defined concept (Assimakopoulos, 2007). However, this thesis posits that rather than being considered vague, CoPs should be viewed as a flexible construct for examining the complex intra and inter-organizational relationships that emerge in science-based SMEs, and that are a key element of the innovation processes of such firms.

7.4.2 Access to science-based SMEs

Identifying suitable innovative science-based SMEs willing to participate in the research presented a number of significant challenges. SMEs have limited resources and time, which resulted in many potentially suitable SMEs declining to take part in the interviews. A few of the firms which were initially enthusiastic about participating later declined to take part in further interviews without explanation, which was very frustrating. Originally, this research had intended to focus on SMEs in the chemical industry. However, due to the challenges involved in finding suitable participants willing to take part, this pool was broadened to include a wider range of science-based SMEs, including biotechnology, chemical processing and

nanotechnology. The heterogeneous nature of the organizations that emerged from this has had an impact on the findings. Also, data from the transcripts of three interviews in Company F were not included in the final data analysis and discussion because, although they were a science-based business in the sense that they provided lab-based fuel testing services to commercial ship owners, they employed standard testing procedures used throughout the marine fuel testing industry. It emerged during the interviews with Company F that they were not engaged in any science-based innovation activities relevant to this research, resulting in further interviews being conducted in an additional SME (Company G).

7.4.3 Semi-structured interviews

The semi-structured interviews allowed interviewees to elaborate upon their thoughts and feelings about innovation. This method relied on the inter-personal skills of the interviewer and his ability to establish rapport with interviewees, which on some occasions was difficult. Some interviewees had been required to participate by their superiors and they made it clear they had 'better things to do'. Multiple visits were made to a number of the organizations, which helped to build good working relationships with participants. However, gathering and analyzing the data required a considerable amount of time and effort. Transcribing the interviews took much longer than originally anticipated and the assistance of a professional transcriber was used for some of the interviews (this incurred additional cost, which was offset by a small research grant from the Research and Development Management (RADMA) association).

7.4.4 Template analysis

Template analysis is a useful tool for analyzing qualitative data. However, there were a number of issues associated with its use in this research. The interviews produced a vast amount of data which had to be transcribed before being imported into Nvivo and coded, and this was time consuming. Deciding on the extent of the initial template and the number of codes was a rather subjective process, and was based on the research aims and the findings of the literature review – potentially leading to accusations of researcher bias. Because this study is a Doctoral thesis, the data was coded and analyzed by the candidate, and then discussed and reviewed at various stages with my supervisors. Although this provided some consistency in terms of

applying the template method, it did not allow for the inclusion of multiple perspectives. Involving a wider range of reviewers, including the interviewees themselves, might have provided some useful insights when developing the template.

7.4.5 Researcher bias

Every effort was made to mitigate researcher bias. Efforts to minimize design bias in the development of the template involved having each stage of the development of the template discussed and reviewed by my three supervisors. Sampling bias was more difficult to overcome because the science-based firms represented a heterogeneous group of SMEs, i.e. from a range of scientific disciplines. Nevertheless, they were all involved in using science at the core of their business and, therefore, represented a variety of typical, although not necessarily representative, organizations that were useful in illustrating key findings.

7.4.6 Generalizability of research findings

Whilst there cannot be any claim of 'representativeness' of the sample in relation to the wider population of science-based firms, I do maintain that the literature review and new empirical material on CoPs and innovation in science-based SMEs has made a significant contribution to our understanding of how CoPs are constructed in science-based SMEs.

7.5 RECOMMENDATIONS FOR FUTURE RESEARCH

The findings provide a number of useful insights and pointers for future areas of research. Firstly, it was not possible in the time constraints of the PhD bursary registration period to conduct a longitudinal study. Such a study would be particularly useful for examining, for example, the types of CoP activities and resulting innovations generated through the 'Imagineering Wall'. Secondly, future research would also benefit from a larger sample size to establish a better understanding of CoPs in science-based SMEs. Our understanding of the innovation processes of science-based SMEs would benefit from such a longitudinal study that examines the role CoPs play in supporting the innovation processes in science-based SMEs.

7.6 CONCLUDING REMARKS

The findings of the empirical research and the systematic literature review have illustrated that recent conceptualizations of CoPs have resulted in much misapplication of the term. This lacuna has resulted in the CoPs label being applied to a wide variety of organizational groups that could be more accurately described in terms of formal teams or similar terms. This study has identified the emergence of a variety of practice-based CoPs that have had a significant impact on knowledge acquisition and innovation in science-based SMEs. The study has, therefore, clarified the status of CoPs as a fundamentally emergent phenomenon that can, nevertheless, be cultivated – although not managed – by science-based SMEs.

The arguments and conclusions of this research are supported by the application of rigorous, appropriate and thorough methodologies, methods and data analysis. This research has shown that innovation management theories must become better equipped to understand the specific case of science-based innovation as a particular or distinctive type of knowledge-intensive commercial activity. This research has shown that understanding science-based innovation requires a broad scope of analysis, beyond instrumental and functionalist views of scientific, knowledge-based work. Finally, this research confirms that CoPs are the privileged locus for knowledge acquisition and innovation in science-based SMEs.

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APPENDICES

APPENDIX 1 INTERVIEW PROTOCOL

Interview Protocol

I want to thank you for taking the time to meet with me today. My name is Steven Pattinson and I would like to talk to you about innovation and networking/collaboration activities in your organization. The aim of this study is to provide Teesside Business School with a new understanding of how informal groups within SMEs might be cultivated to support innovation. The interview should take around an hour. I will be taping the session because I don't want to miss any of your comments. Although I will be taking some notes during the session, I can't possibly write fast enough to get it all down. Because we're on tape, please be sure to speak up so that we don't miss your comments. All responses will be kept confidential. This means that your interview responses will only be shared with research team members and we will ensure that any information we include in our report does not identify you as the respondent. Remember, you don't have to talk about anything you don't want to and you may end the interview at any time.

Are there any questions about what I have just explained?

Are you willing to participate in this interview?

Questions

1. Can you tell me something about the history of the company?
2. What sort of activities is your company involved in?
3. Tell me about your role in the company?
4. From your personal experiences can you tell me what sorts of things are important in your company's relationships with its stakeholders (e.g. customers, suppliers, etc)?
5. Can you tell me about the management structure of your organization?
6. What does 'innovation' mean in terms of your business activities?
7. Do you participate in any 'networks'?
8. Can you tell me about any 'collaboration' activities?
9. Are personal relationships important to the way you conduct business?
10. What role does 'trust' play in the company's business relationships?
11. In general terms, can you tell me about how the company is performing?
12. Have there been any 'critical factors' that have had a significant impact (either positively or negatively) on the company?
13. What does the future hold for the company?

APPENDIX 2 EARLIER VERSION OF TEMPLATE

Level 1 Themes	Level 2 sub-themes	Level 3 sub-themes
1. Communities of Practice	1.1 Identifying CoPs	1.1.1 Community - mutual engagement 1.1.2 Domain - joint enterprise 1.1.3 Practice - shared repertoire
	1.2 Types of CoPs	1.2.1 Informal 1.2.2 Formal 1.2.3 Intra-organizational 1.2.4 Inter-organizational 1.2.5 Nascent
	1.3 Building social capital	1.3.1 Reputation 1.3.2 Social presence (sharing expertise/experience) 1.3.3 Strength of personality 1.3.4 Trust 1.3.5 Reciprocity
2. Knowledge acquisition	2.1 Individual learning	2.1.1 Reproducing existing knowledge 2.1.2 Generating new knowledge
	2.2 Absorptive capacity	2.2.1 Linking prior knowledge with new knowledge 2.2.2 Recognizing the need for new knowledge 2.2.3 Recognizing the value of new knowledge
	2.3 Knowledge sharing	2.3.1 Internally with colleagues 2.3.2 Externally with customers/suppliers/competitors 2.3.3 Journey versus destination 2.3.4 R&D versus commercialization 2.3.5 Knowledge silos
3. Collaboration	3.1 Personal networks	3.1.1 Boundary spanners 3.1.2 Identification and acquisition of 'key experts' 3.1.3 Lack of 'band width'
	3.2 Academic networks	3.2.1 Sharing expertise 3.2.2 Academic/commercial synergy 3.2.3 Generating spin-outs
	3.3 Open innovation networks	3.3.1 As a route to market
4. Innovation	4.1 Novelty of the innovation	4.1.1 Uniqueness 4.1.2 Occupying niche markets 4.1.3 Novelty limiting knowledge sharing
	4.2 Innovation as problem solving	4.2.1 Designing solutions for customers 4.2.2 Expecting solutions from suppliers 4.2.3 Balancing R&D with 'productionization' 4.2.4 Academic versus commercial mindset