PROCESS IMPROVEMENT AND ORGANISATIONAL LEARNING:

EVIDENCE FROM ENGINEERING-ORIENTED SMALL AND MEDIUM-SIZED ENTERPRISES

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Abstract

Process improvement has been identified as a central topic of operations management, being relevant to the different functional areas and assisting in providing the benefits operations management aims to realise. While extensive research has been conducted on specific process improvement methodologies, high resource requirement of specific process improvement methodologies make them inappropriate for many Small and Medium Sized Enterprises (SMEs). Compared to specific improvement methodologies, organisational learning was identified as an appropriate theoretical perspective from which to analyse process improvement activities within SMEs, leading to the presentation of the following three research questions:

- How do engineering-oriented SMEs undertake process improvement?
- What is the applicability of the three models of organisational learning within engineering-oriented SMEs?
- How does organisational learning contribute to understanding of process improvement within engineering-oriented SMEs?

The research questions were addressed through in-depth, interpretive, interview based case studies with 14 Engineering Oriented SMEs. The six exploratory cases studies enabled the identification of specific process improvement practices that related isolated problems or opportunities with organisational level changes. These activities appeared to require management to implement formalised operational processes to ensure changes were captured within operational procedures and subsequently used by operational staff. Management support and culture then appeared to affect the ability of process improvement practices to provide firm level benefits to the case companies. Without directions by management or acceptance by operational staff, efforts directed towards process improvement tended to have limited impact on the benefits companies were able to realise from process improvement. Findings were then analysed from three conceptualisations of organisational learning identified within operations management literature. This provided theoretically underpinned insight to the exploration of process improvement, emphasising the importance of experience, involvement with external parties and the multi-level nature of organisational culture.

Following the analysis of the exploratory phase, the findings were confirmed within 6 additional engineering-oriented SMEs (2 were excluded). The confirmatory case companies allowed the further exploration of the relationships between the emergent themes in order for the third research question to be addressed. Organisational learning provided justification for the interaction and bidirectional relationship between process improvement and culture. Organisational learning also provided justification for the important role of management, in relation to interpreting the operating environment and adapting how they provided resources to process improvement.

The research thus contributes to operations management theory, by building upon organisational learning theory, in terms of how process improvement is conceptualised, factors affecting the benefits realised from process improvement and the importance of management to provide resources and direction to process improvement activities. Within all the case companies, this involved both providing sufficient resources in terms of training and time to engage in process improvement, but also selecting work that provided firms with sufficient process improvement opportunities. By effectively engaging in process improvement, firms appeared better equipped to compete against larger firms and low cost economies.

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OL	Organisational Learning
SME	Small Medium Enterprise
PI	Process Improvement
BPR	Business Process Re-engineering
RBV	Resource Based View
CNC	Computer Numerical Control
QMS	Quality Management System
TQM	Total Quality Management
BSI	British Standards Institution
BC	Building Contractor
EM1/EM2/EM3/EM4/EM5/EM6	Engineering Manufacture 1/2/3/4/5/6
IJ1/IJ2/IJ3	Injection Moulder 1/2/3
SI1/SI2	Systems Integrator 1/2

Chapter 1: Introduction

Sir Professor Mike Gregory of Cambridge and Ron Dennis CBE of the McLaren Business Group are amongst the many advocates of the importance of manufacturing to drive economic recovery (James 2012). Small and Mediums-Sized Enterprises (SMEs) represent a critical element of the manufacturing sector and the foundation of most economies. Not only do they represent the vast majority of firms and employ the majority of the workforce in most economies (Arend 2006; Desouza and Awazu 2006), SMEs also represent the foundation of the supply chains of many larger firms (Söderberg and Bengtsson 2010). The greater role of outsourcing within modern business has been driven by a need for larger firms to focus on their core competences (Quinn 1992; Hamel and Prahalad 1994) which often requires larger firms to subcontract noncritical activities to other firms (Cousins *et al.* 2008; Mangan *et al.* 2010). However, if smaller firms are unable to provide parts or services at a suitable standard, they may put their customer's supply chain at risk, jeopardising the ability of larger firms to operate (Gray *et al.* 2011; Tse and Tan 2012). The importance of reducing this risk is demonstrated by Government investment in best practice interventions that have been driven by, amongst others, the Society of Motor Manufacturers and Traders. These aim to develop operational improvement capabilities of smaller firms, however, research reports on mixed results of such interventions (for example Bateman and David 2002; Bateman and Rich 2003; Bateman 2005; Done *et al.* 2011).

The current research is focused upon process improvement activities within engineering-oriented SMEs, and the role process improvement plays in enabling SMEs to compete. Smaller firms represent an under-researched context (Chaston *et al.* 2001), that the author's personal experience is particularly relevant for addressing. The context also assists with PhD research due to the ability to research firms in a limited time period and with limited resources. The research will be conducted from an organisational learning theoretical perspective. Organisational learning provides an appropriate mechanism that explains how firms change to meet the needs of their operating environment. Organisational learning is the process that takes place from identifying a need to change to realising that change at an organisational level (Huber 1991). Organisational learning has also been stated as an appropriate organisational theory for use within operations management (Amundson 1998). Even though organisational learning represents an appropriate perspective from which to undertake research into operations management and be able to contribute to thinking on process improvement, to date, its effective use has been limited.

1.1 Theoretical Perspective

Process improvement activities will be explored within the context of engineering-oriented SMEs, which will be analysed from an organisational learning perspective. Three models of organisational learning were identified through the systematic analyse of operations management literature and employed to analyse and develop understanding of operational practices. The first is the learning curve, where improvement, in relation to reductions in production cycle time or cost, is an exponential function of the number of items produced (Wright 1936; Yelle 1979) or, more generally, experience of producing similar products (Senge 1993). The second model appreciates the role of both internally- and externally-sourced knowledge to solve problems and improve operational processes (Schroeder *et al.* 2002). These two models present the favoured conceptualisations of learning currently employed within operations management research. The third model will be the 4I framework presented by Crossan *et al.* (1999). The framework is the result of the systematic analysis of literature within the field of organisational learning (Crossan *et al.* 1995). The framework consists of multiple operational levels and considers how they are related to one another, making it appropriate for use within operations management. Figure 1.1 shows the various perspectives that will be taken to researching process improvements that will allow theories to be considered in turn to enable the identification, use and development of more effective theories (Schmenner *et al.* 2009).

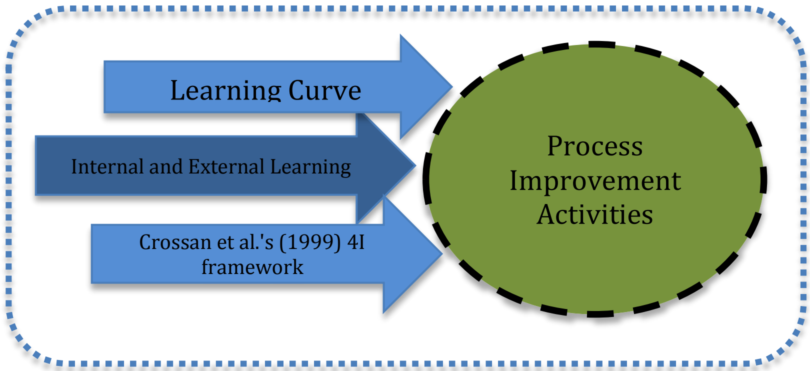

Figure 1.1: Theoretical perspective taken to analysing process improvement activities

1.2 Research Gap

The research is positioned at the intersection of process improvement and organisational learning. Although this is an area where research is being undertaken, and is increasing in volume[1], there are limitations within both areas of research. For example, process improvement has been identified as central to operations management (Anand *et al.* 2010), and a means to enable firms to adapt to their operating environment (Huang *et al.* 2008; Lee *et al.* 2011). However, process improvement is primarily defined as a means of improvement, without exploration of the nature of process improvement activities, other than within formalised process improvement methodologies (such as Six Sigma). The use of organisational learning is further limited with highly influential authors, including Bessant and Francis (1999a), West and Burnes (2000), Lee *et al.* (2011) and Jacobs and Swink (2011) drawing heavily from organisational learning, but fail to make use of structure provided by its theory. In combination, these two areas of research are complimentary, with process improvement providing a means of translating process-based learning into tangible changes in practice that can benefit the end user and organisational learning relating process level learning with organisational level improvement. Even though process improvement represents an important operational practice, particularly for smaller firms less able to engage in new product development (Mosey 2005), research within this area is also limited. Process improvement research

[1] Data available on request

employing organisational learning theory as a primary theme is extremely limited, with one publication in the last 21 years (1991-2011) in the top 11 operations management journals (ABS Ranking), and none within the SME context[2]. This particular piece of work (Anand *et al.* 2010) uses a very specific conceptualisation of knowledge creation, rather than organisational learning and a structured methodology for process improvement within large firms, emphasising the significance of the literature void at this intersection.

1.3 Research Questions

To reflect the important role of process improvement within SMEs, the first research question aims to explore how SMEs undertake process improvements. Process improvement represents an central topic within operations management (Anand *et al.* 2010), but frequently the practices and content of process improvement are overlooked in favour of the application of specific tools and techniques (for example Kaynak 2003). To address this research gap, factors contributing to practices and outcomes of process improvement will be explored, as well as the actual practices of process improvement. This addresses gaps within established conceptualisations of process improvement that look at policies (Powell 1995), process management activities (Samson and Terziovski 1999) or indirectly related organisational activities (Wolff and Pett 2006). Within this thesis, engineering-oriented firms will be defined as firms with an accredited QMS, undertaking some manufacturing. Engineering-oriented enterprises were selected to account for what Kaynak (2003, p.420) stated as the blurred line between products and services that allowed the inclusion of a wider range of firms and to ensure there were the necessary internal capabilities to undertake process improvement. By expanding the scope of the research, more diverse perspectives could be drawn from, important within exploratory research (Siggelkow 2007; Yin 2009). This allowed the relevance of particular process improvement practices and the different organisational learning theories to be explored within a wide range of organisational contexts. This led to the first research question:

[2] Data available on request

RQ1: How do engineering-oriented SMEs undertake process improvement?

The second research question will explore the relevance and applicability of the currently employed models of organisational learning (learning curve, internal/external learning and the Crossan *et al.* (1999) 4I framework) to developing further understanding of the process improvement activities identified while addressing research question 1. While the 4I framework represented one of a number of more developed organisational learning theories employed within operations management, it draws together components of many of them. The 4I framework has had considerable influence within management research (Crossan *et al.* 2011), but it is yet to be used as a primary analytical framework within operations management research. This led to the second research question:

RQ2: What is the applicability of the three models of organisational learning within engineering-oriented SMEs?

The third research question will build upon the first two research questions, to assess how organisational learning theory contributes to understanding of process improvement. Browning and Eppinger (2002) provide initial justification for a relationship between these two topics by stating that process improvement requires process understanding, implying a need for learning to take place before process improvement is possible. This led to the third research question:

RQ3: How does organisational learning contribute to understanding of process improvement within engineering-oriented SMEs?

Not only are the second and third research questions important for addressing the research gap, but they also help to address issues with operations management research that are not effectively underpinned by theory. Schroeder (2008, p.354) considered such atheoretical research as comparable with "*raw empiricism or data-dredging*". The author considers such research as that which may purport to be "theory building" (Eisenhardt 1989) or "grounded" in data (Glaser and Strauss 1967). Such a stance may infer that there has not been sufficient exploration of existing literature or theory, while simultaneously overlooking the important role of literature within theory building (Eisenhardt 1989) or grounded theory (Suddaby 2006). Consistent with Schmenner *et al.* (2009), the current research will enable more cumulative research, compared to research that appears to repeatedly address similar issues and report similar findings (for example Bateman 2005; and Done *et al.* 2011).

1.4 Research Aims, Objectives and Proposed Contributions

The aim of the research is to employ established organisational theories to develop better understanding of an important operational practice within SMEs, to help address problems experienced within competitive environments with limited resources. Continuous improvement has been stated as requiring continuous learning (Garvin 1993). Insight from an organisational learning perspective on process improvement may be able to provide insight into how process improvement activities can be sustained over time, which has been found to be difficult to achieve (Bessant *et al.* 1993; Anand *et al.* 2009) even when supported by external bodies (Bateman 2005; Done *et al.* 2011). Research within the associated field of project management calls for work that links operational processes to organisational learning (Newell *et al.* 2006), which highlights that this gap has been identified within other domains. Newell *et al.* (2006) also stated that focusing on processes, rather than products enabled much greater comparison which assists the learning process. This is possible by processes assisting in identifying AND understanding cause/effect relationships, which has been stated as important for assisting the learning process (Huber 1991). By conducting the research within engineering-oriented SMEs, the focus upon processes will be particularly important, due to the wide range of products and services engineering-oriented firms provide. The objectives of the research are as follows:

1. Explore how organisational learning is used within operations management literature
2. Identify the specific models of organisational learning used within operations management literature
3. Explore the potential components of process improvement within engineering-oriented SMEs.

4. Develop understanding of process improvement activities within a range of engineering-oriented SMEs, related to factors affecting process improvement and benefits firms are able to realise from engaging in process improvement

5. Identify topics affecting and affected by process improvement within engineering-oriented SMEs

6. Confirm the relevance of identified topics to the effectiveness of process improvement within additional firms and determine how organisational learning contributes to understanding of process improvement

The research will contribute to understanding on process improvement within SMEs. The research will contribute to operations management theory by making contributions developed upon identified models of organisational learning. The research will contribute understanding to how process improvement activities can be conceptualised within engineering-oriented SMEs, as a result of the insight provided by organisational learning. In relation to the SME context of the research, contributions will also be possible to organisational learning research within smaller firms, addressing the call by Chaston *et al*. (2001), who stated the need for exploratory research into organisational learning in SMEs. Together these contributions will go some way to addressing problems experienced by SMEs within highly competitive, contemporary environments, while simultaneously addressing important gaps within operations management literature.

The application of organisational learning theory within operations management will also help address the "*double hurdle*" of rigour and relevance as presented by Starkey and Maden (2001). By conducting research within a practical context, but drawing from established organisational theories, academic/practitioner collaboration can potentially be facilitated (Starkey and Madan 2001; Bartunek 2007; Bartunek 2011).

1.5 Research Methodology

The research will be in the form of interview-based case studies conducted with 14 engineering-oriented SMEs from an interpretivist perspective (Radnor 2001). Process improvement activities will be able to be researched from this approach by discussing how operational processes are changed to account for identified opportunities and external requests. Organisational learning will be able to be researched in this manner by conceptualising organisational learning as related to the presence, development and interpretation of organisational procedures, which can be acquired from interviews. While more objective measures are often associated with measuring the outcomes of learning activities (for example Wright 1936), such forms of data are difficult to collect through interview-based case studies. However, by aiming to develop understanding of the models, compared to objectively validating them, the lack of objective data was not considered a primary issue for concern, and has previously been explored at length (Yelle 1979). Done *et al.* (2011) also stated that SMEs often did not possess the necessary operational measurement data to make such forms of research possible.

Where possible multiple interviews were carried out to enrich the perspectives of practice that contributed to the research. The case study methodology consisted of a multiple-company exploratory case study to assess process improvement activities across a range of firms. The exploratory phase of the research was concluded by sharing findings with case companies to assess their relevance and ensure internal validity of the findings (Yin 2009). The exploratory phase allowed the identification of process improvement practices, themes related to process improvement and the development of a conceptual model that represented how the themes appear to be related to one another. The insight from an organisational learning perspective supported the development of the content of the model and theoretically underpinned justification for particular elements of the model.

Following the completion of exploratory case studies, additional, more structured case studies were conducted to extend the external validity of the exploratory findings. The confirmatory case studies allowed the relationships between emergent themes identified in the exploratory phase to be tentatively confirmed (Eisenhardt 1989; Eisenhardt and Graebner 2007). This process also enables the specific contribution of organisational learning theory to process improvement to be explored in greater depth. This consisted of assessing the empirical support and nature of a number of research propositions identified within the exploratory phase and additional ones that emerged during the confirmatory phase. This allowed a revised conceptual model of process improvement, informed by organisational learning, to be presented that was supported by data from both exploratory and confirmatory case companies.

Both exploratory and confirmation interview data was analysed using the qualitative analysis software NVivo9 that utilised a multiple coding approach, where different topics were the focus of particular phases of the analysis. Process improvement and other related operational activities provided the coding framework for addressing research question 1. The three models of organisational learning (learning curve, Schroeder *et al.*'s model and Crossan *et al.*'s 4I framework) provided the secondary coding frameworks to address research question 2. The emergent themes identified during the exploratory case studies provided the coding framework for addressing research question 3, which was refined to consider the individual relationships between each emergent theme. Table 1.1 presents the objectives, the research process and research methods involved in each phase of the research.

Table 1.1: Research objectives and the research process

Research Objectives	Research Process	Research Method
1) Identify the organisational learning theories used within operations management	Preparatory	Systematic Literature Review
2) Select the major organisational learning frameworks used within operations management	Preparatory	Citation and Co-citation Analysis
3) Identify process improvement practices within engineering-oriented SMEs (RQ1)	Phase 1	Exploratory Case Studies
4) Explore the applicability of identified models of organisational learning within engineering-oriented SMEs (RQ2)	Phase 1	Exploratory Case Studies
5) Identify topics affecting and affected by process improvement within engineering-oriented SMEs (RQ3)	Phase 1	Exploratory Case Studies
6) Confirm the relevance of identified topics to the effectiveness of process improvement within additional engineering-oriented SMEs and determine how organisational learning contributed to understanding of process improvement (RQ3)	Phase 2	Confirmatory Case Studies

1.6 Format of the Thesis

The thesis is divided into eight subsequent chapters. The next chapter is a literature review that introduces the state of the art of literature from operations management and general management specifically related to process improvement and organisational learning. The literature review will provide a context and justification for posing the three research questions. This will be undertaken in the form of two systematic literature surveys to ensure gaps presented have been identified rigorously. Specific attention will also be given to project-oriented process improvement, lean manufacturing, ISO quality accreditation and definitions employed within the literature. Citation and co-citation analysis (Pilkington and Meredith 2009) will be conducted on operations management literature that draws on organisational learning theory in order to provide objective evidence related to the selection of the three models of organisational learning used within the research. Chapter 3 outlines the research design and methodology. This includes details of the firm selection process, research design and analysis. Chapter 4 presents case data from the six exploratory case companies, providing details about each firm and practices undertaken, which are related to organisational learning theory.

Chapter 5 will present how the six, exploratory case companies undertook process improvement, followed by cross-case discussions to address research question 1. The analysis results in the identification of a number of themes that appeared to affect how process improvement was carried out within the exploratory firms. The relevance of these themes and model was tentatively explored within additional interviews with the exploratory case companies leading to the presentation of a conceptual model of process improvement. Chapter 6 analyses the exploratory case data from the three organisational learning perspectives identified within the literature review, assisting in addressing research question 2. Chapter 6 concludes with the presentation of the emergent themes and relates them to aspects of organisational learning theory. Chapter 7 reports on the confirmatory case studies, presenting how the additional case companies approached process improvement and the impact of the emergent themes of these practices. Chapter 8 presents how each of the research questions has been addressed with key research findings and discusses findings related to operations and wider management research.

Chapter 9 presents managerial implications, research limitations and areas for further research before concluding the thesis.

Chapter 2: Literature Review

The previous chapter briefly explained the background, initial motivation and outlined the primary objectives of the research. This chapter will present and critically analyse the state of the art of research within operations and general management that focuses upon process improvement and organisational learning. This will be achieved by using accepted analytical methods that will allow a structured approach to identifying and analysing literature within operations management. Following a brief discussion on quality management locating process improvement activities within the domain of operations management, a systematic review of literature within operations management will explore the use of process improvement within operations management more generally. This process will lead to the identification of literature on project-oriented approaches to process improvement as particularly relevant to the current research, which gives specific focus to research conducted on Six Sigma.

Selected literature on Six Sigma will be reviewed, to identify aspects of the approach that was considered critical to process improvement. Limitations of the work presented on Six Sigma will be reviewed to motivate further research. To account for the limitations, literature on alternative approaches to process improvement of Lean, best practice interventions and ISO quality management were reviewed, which appeared more relevant for use within the SME context. Literature focusing explicitly on SMEs was then reviewed, demonstrating topics identified within earlier sections of the literature review that are relevant to the SME context. From identifying the general use of organisational learning within process improvement, operations management research that draws from organisational learning theory will be reviewed. This will allow the models of organisational learning that are currently used within operations management to be identified. Each model will be reviewed in turn and related to operations management.

The chapter will provide justification for the presentation of the following three research questions:

RQ1: How do engineering-oriented SMEs undertake process improvement?

RQ2: What is the applicability of the three models of organisational learning within engineering-oriented SMEs?

RQ3: How does organisational learning contribute to understanding of process improvement within engineering-oriented SMEs?

Addressing the three research questions will allow the gaps identified within the literature review to be addressed. The next section will outline the methodology employed within the literature review.

2.1 Literature Review Methodology

Within scientific research, the systematic application of the scientific method is essential to ensure rigorous, cumulative research. Within medicine, for example, to ensure the advancement of the discipline, researchers must systematically review previous research to ensure they are building upon, rather than simply replicating previously conducted studies (Tranfield *et al.* 2003). However, within management research, and specifically operations management, the use of systematic reviewing techniques is limited. Without the systematic review of previously conducted research, it is difficult to undertake research that is able to advance theory, by refuting existing theories and proposing alternative theories (Popper 1961). The result is that, as stated by Schmenner *et al.* *(*2009), "*While much is said about theory in the typical [operations management] journal article, theory, as science defines it, is not at the center of much of our research*" (p.339). This led Matthews and Marzec (2012) to call for further systematic literature reviews within operations management, both in terms of operations management topics and alternative management theories. Evidence for the value of a systematic approach to reviewing literature is provided by Thorpe *et al.* (2005) and Macpherson and Holt (2007). Both pieces of research demonstrate how a systematic literature review was able to identify important theories and gaps within their chosen area of study.

The current research used an adapted version of their approach that was presented by Matthews and Marzec (2012) that is presented in Table 2.1 and Figure 2.1. Compared to print media indicator approaches to identifying trends (Thawesaengskulthai and Tannock 2008), the systematic review allows finer grained exploration of the contributing literature. The literature review drew from three and four star operations management journal (as defined by the Association of Business Schools[3]). This further addresses limitations of print media indicator approaches, but ensuring the standard and domain in which the trends are occurring. All articles published from 1991 to 2011 that used the terms "process improvement" or "organisational learning" were identified and stored within a citation software database (EndNote X3)[4]. 1991 was selected as the beginning of the study period, due to this representing the transition point for operations management (Pilkington and Meredith 2009), and when a number of influential works were published (e.g. Barney 1991; Huber 1991; and March 1991)**.**

Table 2.1: Summary of the Systematic review process and results (adapted from Thorpe *et al.* 2005)

Stage One	Stage Two	Stage Three	Stage Four
Identify Database	Identify Search terms and citation searches	Identify use of as key topics	Categorize resultant citations into themes
Key Results	Key Results	Key Results	Key Results
Databases (8) Journals (11)	Citations found Process improvement (984) Organisational learning (711)	Central theme PI (116) OL (64)	See Figure 2.2, Figure 2.4 and Table 2.3

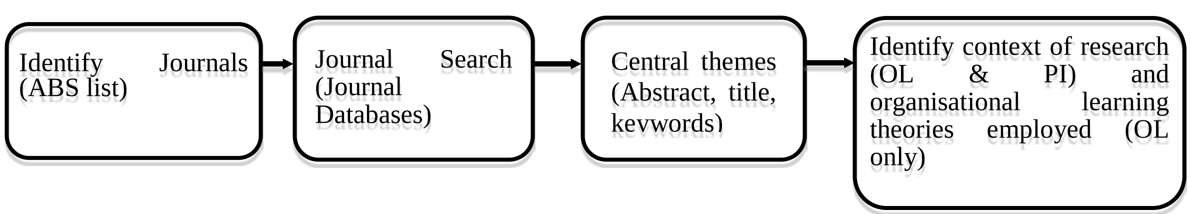

Figure 2.1: Systematic Literature Review Process

The use of the revised systematic literature review method enabled both articles using process improvement and organisational learning as central terms (e.g. in the title, abstract or keywords) and drawing from the topic (within the body of the article) to be

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[3] http://www.associationofbusinessschools.org/content/abs-academic-journal-quality-guide
[4] Citation database and paper summaries available on request

identified. The data set of papers was further refined to only include those articles that used the terms within their title, abstract or keywords, to create a more manageable data set. How each piece of research related to the topic of focus was then assessed. This enabled a picture of these topics within the domain of operations management to be developed.

Other systematic literature reviews have drawn from cross-disciplinary databases such as Web of Knowledge, Ingenta and Science Direct (Macpherson and Holt 2007). While this would have provided a larger population of literature to draw from, the task of reviewing all papers would have been too great within PhD research. For example, within Science Direct, searching "organizational learning" and "organisational learning" within the title, abstract and keywords returned over 700 articles. The sample could also have included journals focusing on operations management related topics, such as operations research or practitioner journals. These journals were excluded due to the relevance of such articles to the topic of research. Anand *et al.* (2010) stated that process improvement was central to operations management. Compared to operations research that may simply help "*facilitate process improvement*" (MacCarthy and Wasusri 2001, p.817), where process improvement may take place following operations research activities. Alternatively, operations research may emphasise the exploration of theoretical or mathematical problems, with less concern for how they may relate to practice (Meredith 2001; Voss 2010).

This perspective provides logical support by the nature of statistical process control or design of experiments that may represent important quality management practices, but do not in their own right constitute process improvement (Antony 2000; Antony 2001; Antony 2012). Practitioner journals were excluded due to them not providing sufficient academic rigour limiting the reader's ability to have confidence in presented arguments without checking the standard of sources individually. The same rationale is used for selecting only three- and four- star journals (as defined by the ABS rankings); even though some question the rating of certain journals. While the author could identify alternate journals and research quality measurement scales, these would have reduced credibility within the context of business school research.

Di Stefano *et al.* (2010) and Pilkington and Meredith (2009) used techniques of co-citations analysis to explore the intellectual structures of dynamic capabilities and operations management literature, respectively. This process was used to explore the extent to which articles drew from particular articles and then extent to which articles were cited together. This method provided a means of determining the structure of organisational learning theory within operations management literature. Before presenting the results of the systematic review, quality management literature that represents a central aspect of process improvement will be presented.

2.2 Process Improvement in Operations Management

Work related to process improvement has tended to reflect its origins within quality management and the viewpoints of two of the most influential quality gurus. The first, W. Edwards Deming, following the views of his teacher, Walter Shewhart, the father of statistical process control, considered a reduction in process variation would result in improvements in productivity and competitive position (Dale 2003). Harry and Schroeder (2000) provided numerous examples of how the reduction in process variation could dramatically reduce the cost of quality, by reducing rework and warrantee costs. Deming's other main contribution to thinking of operational improvements was his commitment to Shewhart's "*plan, do, study [or check], act*" cycle (Deming 1994). In combination with statistical process control, the "PDSA" cycle provided practitioners with a means of confirming the effectiveness of improvements in a scientific manner. Other quality management tools and techniques provided practitioners with a means of systematically exploring the nature of operational problems and supporting practitioners in identifying and addressing root causes of problems (Dale 2003). The second major perspective focuses upon optimisation and breakthrough improvements that introduce radically different, optimised operating systems. This view was championed by Joseph Juran (1951) (also a student of Shewhart), whose 'Trilogy' provided the foundations upon which the Six Sigma methodology was based. Six Sigma focuses upon the development of quality experts capable of formulating and implementing systematically developed, optimised improvement solutions (Harry and Schroeder 2000). The following section looks at how research within the field of quality has developed from its origins in statistical process control.

Handfield and Melnyk (1998) provided an interesting and insightful overview of how the 'science' of quality management had developed since its origins within statistical process control. They presented how research activities had developed in line with the accumulation of knowledge and the development of scientific knowledge of quality management. While the thinking of Deming and related quality gurus was considered well informed by practice, they could not be considered anything more than "*educated opinions*" (Handfield and Melnyk, 1998, p.321). Consequently, following the presentation of their ideas on quality, it was necessary to rigourously research their theories to discover, describe, propose, empirically test, refine or refute theories, in order for the 'science' of quality management to progress (Popper 1961).

Initially, the informed opinions were supported by case studies conducted by quality gurus on how quality management practices were employed within Japan, a context that was benefiting from focusing upon quality management (Handfield and Melnyk 1998). Companies in Japan had been willing to embrace the quality management teachings of Deming, which had provided a number of Japanese companies with a foundation on which they could outperform American companies on numerous performance criteria simultaneously (Handfield and Melnyk 1998, p.328). Research progressed to identifying critical factors that appeared to affect a firm's ability to realise value from TQM activities (Handfield and Ghosh 1994; cited in Handfield and Melnyk 1998), a particular approach to quality management. This work allowed the initial observations to be refined, away from the use of particular quality management practices, to the role management and corporate culture played in TQM's impact on firm performance. However, until accepted definitions and measures of the different aspects of TQM were established, it was difficult for initial propositions to be assessed on a larger scale. The development of established definitions of quality management practices was assisted by the establishment of a number of quality management excellence frameworks (Dale 2003).

While providing a framework that enabled firms to effectively pursue process improvement and receive public recognition for their achievements, firms who won such awards did not necessarily experience improvements in firm performance. For example, Hill (1993; cited in Powell 1995) reported on a number of past winners filing chapter 11 bankruptcies soon after winning the Baldrige quality award (a prestigious American award). To explore the relevance of these observations and the relationship between TQM and performance, Powell (1995) developed measurement constructs based on the ideas of Deming, Juran and Crosby, combined with the Baldrige Award Criteria (p.18). The measurement constructs allowed the testing of hypotheses across a wider range of 36 American firms to determine whether TQM contributed to improved quality and firm performance. While assisting the development of theory related to quality management, Powell (1995) found that it was necessary to draw from the established theoretical perspective of the resource-based view (RBV) to explain findings. RBV states that firms are only able to achieve a competitive advantage if they possess resources that are valued by customers, are not possessed by competitors and cannot easily be replicated by competitors (Wernerfelt 1984). Powell (1995) found that executive commitment, open organisation (culture) and employee empowerment provided firms with a competitive advantage. These findings are broadly consistent with Handfield and Ghosh's (1994; cited in Handfield and Melnyk 1998) findings presented above.

While refining and focusing measures of TQM, Samson and Terziovski (1999) modelled their measurements on the performance criteria set out by the Malcolm Baldrige National Quality Award (MBNQA). The constructs were tested on a sample of over 1200 firms in Australia and New Zealand, accumulating additional support for the findings of Powell (1995). Consistent with Powell (1995), Samson and Terziovski (1999) found that the aspects of TQM that were more complex and difficult to replicate (leadership, people management and customer focus) were more consistently related to firm performance. The tools and techniques that were considered easily transferred between firms of process improvement (management), benchmarking and information and analysis, were unable to positively impact firm performance. Without drawing from a management theory there was greater difficulty in explaining findings, but there was appreciation of a need to explore how the constructs related to firm performance through further exploratory, qualitative forms of research (Samson and Terziovski 1999).

While the use of an RBV perspective within Powell (1995) provided some explanation for findings, the firm-level nature of the RBV meant the causal link between the constructs and performance was not considered. Amundson (1998) stated the level of analysis combined with RBV not being process-oriented meant it was not an appropriate theory for use within operations management. Similar reservations have been raised within other management disciplines that attempt to correlate individual-level responses of management-level constructs to firm-level performance (Lyon *et al.* 2000). Without stronger theorizing and more comprehensively argued causal relationships, there is potential to overlook critical mediating variables (Evans and Davis 2005; Shaver 2005). The ability to address this limitation has been supported by the development of analysis techniques employed within quality management research of co-variance-based structural equation modelling techniques, that are able to test numerous hypotheses simultaneously (Reinartz *et al.* 2009).

Kaynak (2003) addressed the limitations of attempting to link operational practices with organisational performance by proposing and testing a structural model of TQM. She also identified additional elements of TQM above and beyond those employed in the previously discussed studies. The strengths of the analytical method allowed Kaynak (2003) to posit hypotheses of the relationships between different aspects of TQM in addition to their relationship with quality and financial and market performance. Whereas Samson and Terziovski (1999) simply defined leadership as providing resources for building and maintaining management systems (p.396), Kaynak (2003) explicitly tested the relationship between management leadership and various aspects of TQM. The greater structure of Kaynak (2003) allowed the previous findings of Powell (1995) and Samson and Terziovski (1999) to be reassessed. In particular, this included the positive relationship between process management (process improvement) and quality performance, which was rejected in the previous two studies. However, this relationship was dependent on leadership directing a number of activities (for example, supplier quality management and product/service design), which in turn were related to process management.

Zu *et al.* (2008) extended the findings of Kaynak (2003) to consider the impact particular Six Sigma (presented as an evolution of TQM) practices had on established quality management practices. While supporting the structure presented by Kaynak (2003), Zu *et al.*'s (2008) model included aspects of Six Sigma that played an important role in engaging practitioners and relating process improvements to firm level improvements in performance. Subsequent work was able to demonstrate how organisational culture affected the types of quality management firms engaged in (Zu *et al.* 2010). This work provided a means of confirming previously conducted research within quality management (Handfield and Ghosh 1994; cited in Handfield and Melnyk 1998). However, this work raised questions with many of the previously established theories related to TQM and did not effectively draw from work on organisational culture. While Schein's (1990) work was cited, the role management took in implementing procedures which have been found to affect organisational culture (Bititci *et al.* 2006) was largely overlooked.

Compared to earlier work, Zu *et al. (*2008) gave greater attention to structured process improvement, in particular Deming's PDCA cycle, which in Six Sigma is termed DMAIC (define, measure, analyse, improve, control). This potentially originates from the greater project orientation Six Sigma takes to process improvement, where activities are scoped, planned and reviewed based on the achievement of explicit goals (Linderman *et al.* 2003). This provides a different approach to researching process improvement and a different unit of analysis to connect individuals with firm-level performance. This qualitative difference between Six Sigma and established quality management practices highlights the need to reject previously established theories of process improvement and revisit operational practices through qualitative explorations (Handfield and Melnyk 1998, Schmenner *et al.* 2009). Before discussing project-oriented approaches to process improvement activities in greater depth, operations management literature that refers to process improvement will be systematically explored, to develop greater understanding of its use within the field of operations management.

2.2.1 Systematic Analysis of Process Improvement in Operations Management

Following the methodology described in section 2.2, 984 articles were identified within the nine, three- and four-star operations management journals that used the term "process improvement" somewhere in the article. As presented in Table 2.1, 116 of the 984 articles referred to process improvement within the title, abstract or key words. Drawing from the previous section, Deming's (1994) plan-do-check-act cycle appeared to represent an important aspect of research on process improvement. Juran's (1992) work, with the subsequent development of Six Sigma, also represented an additional topic of importance. With both of these appearing to be missing from early work presented in section 2.2, the impact of Deming, Juran and the improvement cycles needed to be determined within the process improvement literature. Table 2.2 presents the general and specific uses of process improvement in the 116 articles and how many articles referred to the improvement cycles and the quality gurus the cycles are associated with.

Table 2.2: The use of process improvement in Operations Management

	Description	Occurrences	Source(s)
Major Uses	Means of improvement	74	Jaber *et al. (*2010), Kornfeld and Kara (2011)
	An Outcome	30	Browning and Eppinger (2002)
Minor Uses	Aim of TQM	1	Porter and Rayner (1992)
	Means of increasing revenue/ Actioning Improvements/ Achieving Goals	4	Henderson *et al. (*1998), Ghalayini *et al. (*1997), Hedge and Nagarajan (1992)
	Dominant approach to improving quality and productivity	1	Hoopes and Triantis (2001)
	Interlinked with product improvements, to reduce cost	1	Bayus (1995)
	Internally focused	1	Herrman *et al. (*2000)
	Process improvement as a catalyst for knowledge sharing	1	Kock and Davison (2002)
	Process improvement requires process understanding	1	Browning and Eppinger (2002)
	Process improvement in quality is variation reduction	1	Williams *et al. (*2000)
	Important Process Improvement Topics		
	PDCA	4	Bateman and David (2002), Schroeder *et al. (*2008)
	DMAIC	10	Linderman *et al. (*2006), Anand *et al.* (2010)
	Influential Improvement Authors		
	Deming	18	Anand *et al.* (2010), Linderman *et al.* (2006)
	Juran	10	Porter and Rayner (1992), Anand *et al.* (2009)

Table 2.2 demonstrates that while process improvement represents an important topic within these papers, the majority of articles simply refer to process improvement as a means of improvement or an outcome of other activities (e.g. "*facilitate process improvement*" (MacCarthy and Wasusri 2001, p.817)). However, and consistent with

section 2.2, attention was not given to the specific mechanisms of process improvement. The specific uses of process improvement begins to outline the importance of process improvement within operations management in relation to facilitating change (Ghalayini *et al.* 1997) or promoting learning-related activities (Kock and Davison 2003). Of particular interest is Browning and Eppinger (2002), who stated that "*process improvement requires process understanding*" (p.81). This work provides initial evidence for the role of organisational learning within process improvement activities, which will be discussed later.

Figure 2.2 highlights process improvement as a primary operations management topic, with research on the topic relating to the major areas of operations management, reflecting Anand *et al. (2010, p304)* who stated "*process improvement is central to Operations Management*".

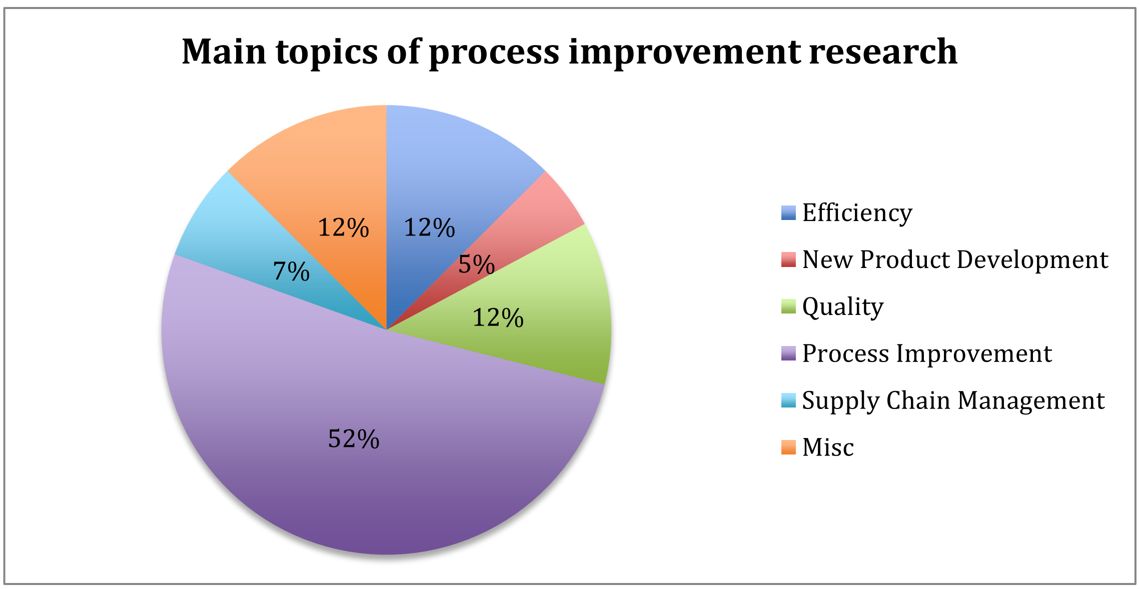


Figure 2.2: Breakdown of process improvement articles by paper topic

The following section will explore specific research that approached process improvement from a project oriented perspective, that is consistent with the improvement cycles. Drawing from the previous section, Six Sigma gives greater emphasis to process improvement activities. While the study by Zu *et al.* (2008) is not present within the identified papers on process improvement due to it referring to "quality improvement" compared to "process improvement" within the abstract, its use of Six Sigma ensures its relevance. The following section will begin by referring to a number of papers related to project-oriented learning. While providing a foundation for discussions on project-oriented process improvement, these papers further highlight the strong connection between process improvement and organisational learning that will be explored later in the review.

2.2.2 Project-Oriented Process Improvement

Li and Rajagopalan (1997; 1998) explored how improvements in operational process performance resulted from a combination of deliberate and autonomous learning. Deliberate (process) improvements resulted from the receipt of non-conforming parts with autonomous learning taking place as a function of the number of parts produced. The rate of improvement was modelled as an exponentially decreasing function, where it was necessary to continually increase process improvement effort to account for diminishing returns on effort. Zangwill and Kantor (1998) effectively addressed this issue, but developing a differential equation that related realised improvements to the potential for improvement. Rather than returns diminishing overtime, the effectiveness of managerial interventions could be assessed irrespective of whether improvement represented low hanging fruit or required more effort for improvements. Zangwill and Kantor (1998) also linked the PDCA cycle to management's ability to review completed improvements to inform subsequent improvements, which was outlined as enabling continuous improvement.

Mukherjee *et al.*'s (1998) explicitly project oriented approach conceptualised the PDCA cycle as the conceptual and operational learning cycle of Kim (1993; cited in Mukherjee *et al.* 1998). While focusing attention within a single company, the work provided an valuable framework for viewing the knowledge based outcomes of improvement projects and how the use of quality management tools could promote learning and support the adaptation of future behaviour (Mukherjee *et al.* 1998, pS43). Mukherjee *et al.* (1998) stated how conceptual learning could assist in breaking path dependencies that can limit a firm's ability to change over time and even recognising the need to change (Argyris 1977a).

The explicit project orientation of Six Sigma that builds upon existing research on quality management makes it particularly relevant for researching process improvement. Motorola developed the approach in 1985 to focus improvements on the pursuit of challenging goals via the application to a structured methodology by highly trained practitioners (Harry and Schroeder 2000). While the popular press reported on a number of companies who have realised significant gains from the implementation of Six Sigma, such as General Electric and Allied Signal (Bossidy and Charan 2002), other companies have experienced problems during implementation. Consequently it has been necessary to research Six Sigma practices from a number of different perspectives, compared to simply looking at the tools it employs (Linderman *et al.* 2006).

Consistent with the focus of the current research to draw from organisational theory to provide a strong theoretical underpinning to the research, particular research on Six Sigma has taken a similar approach. Linderman *et al.* (2003) used a goal theoretic perspective to explore aspects of Six Sigma that appeared to promote improved project-level performance. Training was identified as a central aspect for reducing task complexity and developing goal commitment, which in turn enabled individuals to pursue challenging goals (Linderman *et al.* 2003, p.197). Linderman *et al. (*2003) presented research using alternative theoretical lenses as important avenues for further research. Linderman *et al.* (2006) later demonstrated that challenging goals, when combined with the effective use of Six Sigma methods, improved project performance. Within Linderman *et al.* (2006), goal theory provided "*a foundation for developing scientific knowledge about Six Sigma*" (Linderman *et al.* 2003, p.193). Goal theory was extended by Choo (2011), who found that goals defined in terms of problem resolution compared to quantitative performance improvement targets (e.g. "*attain 70% reduction in defects*" p.87) were more strongly related to knowledge creation.

While goal theory provided a useful theoretical lens to explore motivation within process improvement projects, overly challenging goals were found to reduce motivation (Linderman *et al.* 2006). Choo *et al.* (2007a) explored how the development of an organisational context (culture) that supported risk taking could reduce this problem and support practitioners in pursuing challenging goals and solve complex organisational problems. Building upon Mukherjee *et al.* (1998), knowledge was considered a critical output of improvement projects. While organisational context was found to be important for the exploration of complex problems, the structured method of Six Sigma was found to be important for solving problems efficiently (Choo *et al.* 2007a). Choo *et al.* (2007b) confirmed this finding empirically, demonstrating that adherence to the structured method led to improvements in learning behaviour. Psychological safety, related to individuals' willingness to take risks during problem solving, related to the extent of knowledge that was created by a project. In combination, Choo *et al.* (2007b) found that both learning behaviour and knowledge creation directly impacted on the performance of improvement projects.

In addition to the exploration of process improvement within the context of Six Sigma enabling the accumulation of scientific knowledge in relation to goal theory and knowledge creation, aspects of the methodology have also been explored theoretically. Schroeder *et al.* (2008) employed "*field observation, the literature and... pure thought*" (p.537) to develop definitions and identify the underlying theory of Six Sigma. Organisational structure, improvement specialists, structured method and focus on performance metrics were found to be central to what constituted Six Sigma, broadly consistent with Zu *et al.* (2008). The attention on training combined with policies put in place to provide process improvement specialists with a structured career path created a foundation that sustained improvement activities. Anand *et al.* (2009) explored this aspect of Six Sigma further, demonstrating that process improvement infrastructure could enable firms to continually adapt to their operating environment, through the development of dynamic capabilities . Dynamic capabilities are specific and identifiable processes that support firms in proactively meeting changing requirements of their operating environment (Teece *et al.* 1997; Eisenhardt and Martin 2000).

Again building upon Mukherjee *et al.* (1998), but also Linderman *et al.* (2003; 2006), Anand *et al.* (2010) conducted a finer-grained assessment of the impact of particular quality management tools on knowledge creation. Different quality management tools were related to different quadrants of the knowledge creation cycle presented by Nonaka (1994). Rather than process improvement practices not being related to firm performance as presented by Powell (1995) and Samson and Terziovski (1999), quality tools promoted knowledge creation which in turn contributed to quality (Teece *et al.* 1997)performance (Choo *et al.* 2007b). While confirming the role of knowledge and learning within the context of Six Sigma has been important for accumulating scientific knowledge about Six Sigma, exploratory research into other aspects of Six Sigma has still been necessary.

Chakravorty (2009b), drawing from Schroeder *et al. (*2008), identified a number of practices that assisted in the successful implementation of Six Sigma. While providing additional support for Schroeder *et al. (*2008), Chakravorty (2009b) was unable to provide new perspectives, and without effectively drawing from theory, the research could not be considered cumulative. Chakravorty's (2009a) other case-based research provided considerably more insight, by exploring the role of escalation theory in a failed Six Sigma initiative. Chakravorty (2009a) highlighted the problems associated with the escalation of commitment for improvement initiatives, combined with the need to strategically align improvement projects. Zhang *et al.* (2008) empirically demonstrated the importance of strategically aligning improvements, finding strategic alignment of projects had a stronger relationship with performance compared to the adherence to a structured methodology.

In summary, Six Sigma is a well-defined approach to process improvement that provides structure and definitions on which to base further research into process improvement. The structure of Six Sigma also provides a framework for more general process improvement practices. However, although firms pursuing Six Sigma will carry out process improvement, firms carrying out process improvement need not be pursuing Six Sigma (adapted from Powell 1995, p.31). While process improvement practices may not be supported by formal organisational infrastructure, have a structured methodology or be undertaken by highly trained professionals, process improvement may still play an important role in how firms choose to compete. From the previously presented literature, the following section presents a number of definitions to assist in further understanding how process improvement is currently conceptualised.

2.2.3 Process Improvement Definitions

Within work on Six Sigma, process improvement represents the focus of improvement activities.

> "*Six Sigma is an organized and systematic method for strategic process improvement*" (Linderman *et al.* 2003, p.195)

This definition is consistent with the findings of Zhang *et al. (*2008), who showed the importance of the selection of strategic aligned improvement projects compared to the structure methodology. However, without appreciation of this focus on operational processes, attention may be directed to other operational activities.

> "*The problem is that managers waste their time in adopting the newest improvement tool [for example Six Sigma], using consultants, and spending very little time in driving process improvement from the bottom.*" (Chakravorty 2009b, p.9)

This observation appears consistent with the attention that was given to researching continuous improvement in the 1990s (for example Bessant *et al.* 1993; Bessant *et al.* 1994; Bessant and Francis 1999b; Bessant and Francis 1999a; Kerrin 1999 amongst others). While focus was given to achieving the goal of continuous improvement, attention was not directed towards how continuous improvement could be realised. For example Bessant and Francis (1999a) defined continuous improvement as "*an organisation-wide process of focused and sustained incremental innovation*" (p.1107), without focusing attention on the types of innovation that were taking place (for example, process, product, market, organisational (Schumpeter 1934)). In comparison, Terziovski (2010) stated the "*innovation in the manufacturing sector generally focuses on process improvement*" (p.893), which gives focus to firms who may want to work towards continuous improvement.

Work on continuous improvement can thus be viewed in a similar light to the early work on quality management presented in section 2.2. By researching continuous improvement without giving specific attention to the unit of improvement was similar to researching quality performance by focusing upon quality management tools and techniques while overlooking process improvement. Oliver (2009) assists in addressing this limitation by locating discussions on continuous improvement within quality management practices. As a result, practitioners were provided with a context, a focus, accepted tools, relevant training, measurement criteria and a theoretical underpinning to support practitioners in pursuing continuous improvement. Oliver (2009) even presented process improvement as an important performance measure.

While attention was given to learning within the work of Bessant and colleagues, overlooking operational processes introduced other limitations to this work. As the culmination of this stream of research, Bessant *et al.* (2001) identified a range of important aspects such a key behaviours, culture, resource-based strategies and incentives as being important for enabling continuous improvement. However, this overlooked the existing work within quality management, which could have provided a similar framework for achieving continuous improvement. Apart from the resource-based view (Wernerfelt 1984), the work also overlooked the relevance of theory, instead drawing on the concept of the learning organisation (Senge 1993). This gives greater emphasis to cultural aspects of learning, compared to the processes that are central to operations management and organisational learning (Tsang 1997). Anand *et al.* (2009) was able to address these limitations, providing a relevant definition of continuous improvement and basing discussions within the context of process improvement.

> "*Continuous improvement is defined as a systematic effort to seek out and apply new ways of doing work i.e. actively and repeatedly making process improvements*" (Anand *et al.* 2009, p.444)

Compared to Anand *et al.* (2009), Bessant and Francis (1999a) while also presenting continuous improvement as a dynamic capability, put less emphasis on engaging individuals or embedding continuous improvement behaviours within organisational systems. Anand *et al.* (2009) used Six Sigma to provide a framework that included incentives, training and structured methods, as well as providing a foundation on which an appropriate organisational culture could be developed. Compared to the learning organization used by Bessant and colleagues, Anand *et al.* (2009) drew more effectively from organisational learning that appeared to provide a stronger theoretical underpinning to the research.

Reflecting on the systematic accumulation of scientific knowledge, Anand *et al.* (2009), Six Sigma and organisational learning could represent a revised theory of continuous improvement, refuting previously held theories on continuous improvement presented by Bessant and colleagues (Schmenner *et al.* 2009). Organisational learning appeared to provide a stronger foundation on which to locate discussions on cumulative learning through process improvement and implementing changes to organisational policies and procedures. The role of organisational learning within Anand *et al.* (2009) is also consistent with other theoretically underpinned work on Six Sigma, for example:

> "*Six Sigma is an organizational learning process and one that results in greater knowledge*" (Schroeder *et al.* 2008, p.549)

Six Sigma could thus be considered the systematic and repeated use of process improvements to promote knowledge creation and organisational learning. Although particular work within Six Sigma chose to define improvements in terms of quality (for example, Choo *et al.*, 2007a, 2007b), consistencies between the two terms are present. Angel and Chandra (2001) drew from Juran (1951) to state that quality took the form of both conformance and design. This may take the form of process variation being reduced to improve conformance to specifications or the characteristics of a process being changed to improve the product as received by the customer. Consequently, quality improvements can be realized by undertaking process improvements.

> "*Quality improvement is inherently a learning and knowledge-based activity that emphasizes learning and knowledge creation*" (Choo *et al.* 2007, p.918)

The above highlights the similarity with Schroeder *et al.*'s (2008) Six Sigma definition. However, while the above discussions show the relationships between quality, continuous (Anand *et al.'s* (2009) definition) and process improvement, the specific nature of process improvement remains undefined. From a quality management perspective, process improvement may result in the refinement of operational processes to increase the level of conformance to specification (Juran 1951). This is consistent with

Williams *et al.* (2000), who stated that process improvement in quality management is primarily variation reducing. As a result, process improvement effort as resulting from being informed of non-conformances by customers (induced learning) can be defined as follows.

> "*Induced learning represents the result of conscious managerial actions such as process improvement projects, defect prevention efforts, quality circles and labor-training*" (Li and Rajagopalan 1998, p.1519)

> "*Defect levels as a surrogate for the effort devoted to process improvement*" (Li and Rajagopalan, 1997, p.183)

However, due to such forms of quality/process improvement diminishing over time (Argote and Epple 1990; Li and Rajagopalan 1997), the impact of process improvement efforts tends to reduce over time as the rate of non-conformances reduces. There may also be a risk of problems only being resolved once problems have been experienced by customers, with companies not undertaking more fundamental changes that may require the redesign of products and processes (Harry and Schroeder 2000).

However, non-conforming products may still represent an important initiating point for the plan-do-check-act cycle, Six Sigma improvement projects or more generally, process improvements. While this represents an accepted initiating point for process improvement efforts, proactive process improvements will also be considered within the current research. This is consistent with the Six Sigma approach to initiating improvement projects. Following the generation of a portfolio of potential projects (Kornfeld and Kara 2011), projects are selected by upper management, ensuring they are strategically aligned. Rather than simply addressing problems identified by customers, larger, strategic and fundamental issues can be resolved that may cross-functional boundaries. This can be important for reducing the pursuit of localised improvement goals with localised solutions (Schroeder *et al.* 2008).

The focus on performance metrics and achieving challenging goals within Six Sigma can drive improvement practitioners to deliver improvements in excess of the immediate complaint received from the customer, and provide improvements in line with a firm's strategy. Within such cases, process improvements are not only initiated by customer complaints, but also focus on reducing costs, increased value received by customers and achievement of strategic aims (Linderman *et al.* 2003).

To provide additional context to what a process improvement project may consist of, away from resolving quality non-conformances, it is necessary to provide a relevant example of what a process improvement project may aim to achieve. Mukerherjee *et al.* (1998) provided a simple example of an improvement project that aimed to "*Reduce wire fractures from 5 per ton to 3.5 per ton*" (p.S40). Through the application of quality management tools, improvements in process consistency were realised through changes in operational practices, implemented via standard operating procedures and improvements in process capability (Mukherjee *et al.* 1998). However, within the previously discussed literature on Six Sigma (Linderman *et al.* 2003; Linderman *et al.* 2006; Choo *et al.* 2007a; Choo *et al.* 2007b; Schroeder *et al.* 2008), while Six Sigma itself was defined, process improvement was not. This may have been due to process improvements being defined practically within Six Sigma as resulting from the application of a structured method to reduce variation or improve the ability of operational processes to meet the needs of customers (Antony 2012). However, this limitation can be addressed by Anand *et al.* (2009) who stated that a process improvement may consist of the following:

> "*For example, raw materials such as wood and iron fixtures go through several operational processes to manufacture a chair; information about the customer and aggregate risk-related data are processed to produce an automobile insurance policy. Process improvements are defined as enhancements in operational processes; e.g. improving a chair manufacturing process so that less raw material is consumed, or reducing the cycle time from proposal to delivery of an insurance policy*" (Anand *et al.* 2009, p.445)

In combination with the previous discussion and definitions of Six Sigma, the above provides important context. Six Sigma thus provides a structured method to realize process improvements that are aligned with firm strategy (Zhang *et al.* 2008) and aim for improvements goals that are challenging (Linderman *et al.* 2006, p.780). However, before accepting findings of the presented research on Six Sigma, the empirical foundation on which the work is based needs to be considered. While the above research has attempted to build upon a strong theoretical foundation, the variety of companies was extremely limited. As a result, while particular pieces of research (for example Linderman *et al.* 2006) attempted to validate theory, by drawing from a single organisation, the research methods does not provide findings that can be considered in relation to other organisations. This is of particular concern when two of the most highly cited papers on Six Sigma (Linderman *et al.* 2006; Choo *et al.* 2007b) appear to rely primarily on the same single company.

> "*MFG is a Fortune 500 company with more than 60,000 employees worldwide*" (Linderman *et al.* 2006, p.782, Choo *et al.* 2007, p.442).

While the previous section outlined the logical and theoretically underpinned arguments presented on literature related to project-oriented process improvement and definitions related of process improvement, the empirical foundations of the work is relatively weak[5]. Although Zu *et al.* (2008; 2010) explored Six Sigma practices across a range of firms (266) without the critical discussions presented by Roger Schroeder and colleagues, the relevance of this work was also limited. Although work on project-oriented process improvement provides useful insight to the drivers of process improvement, further exploration of process improvement practices within a range of companies is still required.

To help address this empirical limitation of research on Six Sigma (and process improvement); the insight provided by work on Six Sigma can be drawn upon to provide insight to viewing other process improvement practices. Due to the above research focusing upon larger firms and the current research focusing upon engineering-oriented SMEs, this issue also needs to be addressed. While exploring how British manufacturing SMEs employed Six Sigma, Antony *et al.* (2005) found that smaller firms had difficulty freeing up sufficient resources to implement Six Sigma. Smaller firms also found that the scope of Six Sigma projects was too large (>$300,000 per year). As a result, firms tended

[5] Summary data available on request

to pursue alternative improvement initiatives such as Lean or TQM with over 80% of the 60 firms contributing to Antony *et al.*'s (2005) research holding ISO 9000 accreditation. Similar observations were made by Thomas *et al.* (2008) within a small engineering company implementing Six Sigma. The firm has insufficient resources to provide the necessary statistical training to improvement practitioners. Antony (2007) at least partially addressed this issue by emphasising the importance of viewing Six Sigma as a logical and sequential problem solving framework. Antony *et al.* (2007) also highlighted the primarily importance of six sigma tools is develop process understanding in order to improve operational processes. These views move away from conceptualising Six Sigma as primarily the application of statistical techniques (Kumar *et al.* 2008).

Overall, this review of research on Six Sigma and definitions employed within Six Sigma literature, highlight how Six Sigma can provide a theoretically underpinned understanding on process improvement activities, however, it has also highlighted its potentially limited relevance as an improvement initiative in smaller firms. Work on Six Sigma within SME appears to give great benefits to confirming the relevance of improvement methodologies to the context (for example, Batmen 2005 or Kumar et al. 2006), compared to exploring the broader nature of process improvement within the SME context. The following sections consider Lean and ISO 9001 accreditation, as approaches that are popular in practice and an area in which empirical research has been conducted with SMEs.

2.2.4 Lean Manufacturing

Hines *et al.* (2004) explored the evolution that Lean has undergone since its inception. Lean is an approach developed during a research project on Japanese firms (Womack *et al.* 1990), who built upon quality management practices (Flynn and Flynn 2004) and pursued the elimination of waste in order to increase the value firms were able to provide customers from a given input. Consistent with the structured method of Six Sigma, Lean consists of practices that promote the visualization, analysis, identification and elimination of waste (Bicheno 2004). Bessant and colleagues (for example Bessant *et al.* 1993; Bessant *et al.* 1994; Bessant and Francis 1999b; Kerrin 1999) considered such tools as providing a foundation upon which to pursue improvement, which in turn promoted the development of continuous improvement capabilities. However, while presented as lower cost forms of improvement (compared to Six Sigma), without long-term investment in human resource development, firms had difficulty developing improvement capabilities and sustaining improvement initiatives (Bessant *et al.* 1993). Consistent with this view, Hines *et al.* (2004) emphasized the importance of integrating the basic Lean tools with more complex aspects of the approach to promote longer-term development and sustain the benefits firms were able to realise from Lean initiatives. This process of progressing beyond waste elimination was described as a means of providing firms with a more sustainable competitive advantage compared to the short-term benefits realised from the application of standard tools. Lean tools provided firms with a means of visualizing and developing understanding of operational processes and focusing on improving those processes customers valued, similar to aspects of Six Sigma. However, unless firms were able to make progress with the tools they used and developed the aims they pursued, following initial improvements, returns on improvement efforts would reduce over time, consistent with Li and Rajagopalan's (1998) and Zangwill and Kantor (1998).

Also consistent with the need to maintain investment in Lean initiatives, Narasimhan *et al.* (2006) found that firms performed better if they balanced the pursuit of Lean with maintaining organisational flexibility. If firms pursued waste reduction activities alone, Narasimhan *et al.* (2006) found they were less able to adapt to changing environments, compared to those firms pursuing an Agile orientation. This highlights similarities with particular work on quality management (for example, Benner and Tushman 2003), where over focus on reducing process variation limited a firm's ability to change or engage in innovative activities. Similarities between Lean and Six Sigma can also be found in De Treville and Antonakis (2006), who proposed Lean job design as having the potential of being intrinsically motivating for operational staff. This is consistent with the need to develop a sense of challenge within projects through setting stretch targets, but supporting those in projects with sufficient training and support (Linderman *et al.* 2003; Choo 2011). De Treville and Antonakis (2006) also found that "*excessive leanness*" (p.99) resulted in firms that were unable to resolve more complex operational issues. There were insufficient resources available to critically review completed projects and undergo more fundamental changes (Mukherjee *et al.* 1998) or engage in double loop learning (De Treville and Antonakis 2006, p.114), a term that will be discussed in section 2.4.

Bateman and colleagues' (Bateman and David 2002; Bateman and Rich 2003; Bateman 2005) explored process improvement via the implementation of Lean techniques. By engaging with government-funded initiatives (Society of Motor Manufacturers and Traders), firms received support to improve operational processes in order to improve the competitiveness of British Manufacturers (IndustryForum 2012). Support consisted of tuition in Lean tools such as waste reduction (seven forms), workplace management (5S) and value stream mapping, amongst others, applied via Deming's (1994) PDCA improvement cycle (Bateman and David 2002). By providing a relatively controlled sample of firms pursuing improvement and receiving relatively standard support, the work allowed the identification of inhibitors and enablers that determined whether improvement activities became embedded (Bateman and Rich 2003). Improvements became embedded once improvements were sustained and further process improvements were carried out following the removal of external support. Consistent with earlier work on quality management (Handfield and Melnyk, 1998) and work on continuous improvement (Bessant *et al.* 2001), culture and management support were considered critical to the success of process improvement activities (Bateman 2005).

Unlike the work conducted on Six Sigma, Bateman's work was empirically richer, covering 40 improvement activities across 22 companies. However, without a strong theoretical underpinning, the work did not explore the underlying mechanisms behind the identified enablers and inhibitors of process improvement. For example, drawing from De Treville and Antonakis (2006), while resources may have appeared to enable further improvements, the role of individual motivation was overlooked. The work also overlooked the potential impact of the 'Hawthorne effect', where the act of measuring performance resulted in performance improvement that was acknowledged in later work (Done *et al.* 2011). Alternatively, improvements may have been supported and enabled by the resources from the external body and motivated by customer participation in improvement activities. Herzberg (1968) stated that an important way of controlling for this effect was to include control subjects where no intervention took place, which was not done within Bateman's work. This can be observed in the results of Bateman (2005, p.264), where the level of improvement reduced overtime for some of the firm involved in the research. Done *et al.* (2011) partially addressed this issue by exploring how firms balanced short-, medium- and long-term outcomes of best practice interventions. However, without building upon a theoretical foundation, Done *et al.*'s (2011) findings were broadly consistent with those presented by Bateman and Rich (2003, p. 194).

What the finer grained exploration of Done *et al.* (2011) made possible was the identification of additional practices that affected the success of best practice interventions, which included rewards and recognitions. Done *et al.* (2011) stated that rewards in the short term promoted longer-term improvements in the effectiveness of interventions. Complimenting this view was practitioners sources, where exemplar cases consistently referred to the enrolment of practitioners in further training programmes (IndustryForum 2012). While the best practice intervention pursues a different approach to Six Sigma, this finding is consistent with Anand *et al.* (2009). They presented the importance of linking process improvement goals with individual career progression in order to sustain improvement initiatives. Training of this form may have also provided individuals with the skills necessary for solving more complex problems that had to be pursued once the basic tools had been applied and the simpler problems has been solved (Linderman *et al.* 2003).

2.2.5 ISO 9001

The nature and characteristics of Six Sigma appear more relevant to the requirements of larger firms (Harry and Schroeder 2000), and improvement interventions being initiated and supported by external parties, a large number of firms have potentially been overlooked. ISO 9001 is an externally audited QMS that requires firms to document operational processes to enable product traceability and enable firms to continually improve their QMS (ISO 2012). Hill *et al.* (2001) demonstrated that the achievement of ISO accreditation provided a foundation on which to pursue further improvement, such as TQM and subsequently Lean. Hill *et al.* (2001) considered it necessary for management to support the transition by supporting practitioners in understanding why they were making the transition from ISO to TQM. Mulhaney *et al.* (2004) also considered ISO as providing a foundation on which to build further improvements, highlighting the relevance of ISO 9001 to the current research. As part of this, it was necessary to embed performance measurement into firm practices to provide direction to improvements and support individuals in learning from improvements. De Leeuw and van der Berg (2011) demonstrated that performance management techniques were able to directly impact shop floor behaviour and in turn meditate performance management techniques' contribution to operational performance. Through improving performance, support can be maintained on improvement activities, so promoting improvements in becoming continuous.

Rather than considering the actual practices of ISO, Lo and Chang (2007) gave emphasis to the impact different motivations for implementation had on the benefits firms were able to realize from implementing an ISO system. Benefits realized from implementing ISO included standardization of operational process, improved product/service quality and enhanced customer satisfaction. Interestingly, while the research was not explicitly focused on the impact of firm size, the majority of respondents (76%) had less than 200 employees. Lo and Chang (2007) found that firms proactively implementing ISO to improve internal processes (pursuit of continuous process improvement) realized greater benefits than those implementing ISO 9001 as a result of external pressures (customer requests). Benner and Veloso (2008) reported similar results, with early adopters being able to create an advantage that later adopters could not overcome. Benner and Veloso (2008) also found that following the implementation of standard procedures, repetition promoted learning, which promoted the development of operational capabilities. Of particular interest for the current research, Benner and Veloso (2008) stated how external auditing provided a degree of consistency across firms, aiding comparison within their research. The relevance of ISO was further emphasized with more recent versions of ISO giving greater emphasis to process improvement (Benner and Veloso 2008). With operational processes requiring documentation and improvements being externally verified, firms holding ISO accreditation present firms undertaking process improvement and documenting process improvement, so an appropriate context for the current research. The following section will explore aspects of the SME context in greater depth.

2.3 Small and Medium-Sized Enterprises

Small and Medium sized enterprises are frequently defined as those firms with less than 250 employees or in terms of their turn over (McAdam and Reid 2001; OECD 2002; Wong and Aspinwall 2005; Desouza and Awazu 2006). SMEs represent a major part of most national economies, with 95% of enterprises in the UK being classed as such, employing 65% of the workforce (Desouza and Awazu 2006). Smaller firms also form the foundations of the supply chains of many larger companies, which further emphasises their importance (Söderberg and Bengtsson 2010). SMEs are considered the basis for growth within an economy, through innovation, which is made possible by the flexible and informal structures present within smaller firms (Koskinen and Vanharanta 2002).

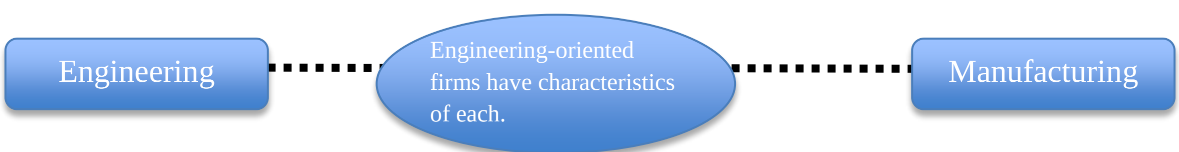
Unfortunately, SMEs are frequently defined by their limited resources (Bessant *et al.* 1993; Gunasekaran *et al.* 2000; Doving and Gooderham 2008; Terziovski 2010; Done *et al.* 2011), which may explain the low levels of adoption of Six Sigma within smaller firms (Antony *et al.* 2005). As a result of this resource limitation, SMEs tend to focus the majority of their attention and efforts towards direct revenue generation (Hudson *et al.* 2001a; Terziovski 2010) and require quick payback on investment in improvement initiatives (Thomas *et al.* 2008). Resource limitations can reduce SMEs' ability to experiment (Lumpkin and Dess 1996) with unsuccessful initiatives having a greater risk of affecting firm survival (Covin and Slevin 1991). While innovation within SMEs has been strongly linked with SME performance (Rosenbusch *et al.* 2011) resource limitations can affect their ability to engage in high risk, innovative activities.

Lee and Klassen (2008) explored the factors that affected the ability of SMEs to adapt to external pressures. External resources were highlighted as important for enabling change, however it was necessary for external resources to be leveraged with internal resources. Building upon internal resources ensured new resources became embedded, which in turn facilitated firm-level change, preventing new behaviours reverting following the removal of support. This finding is consistent with the findings of Rosenbusch *et al.'s* (2011) meta-analysis of the impact of innovation of SME performance. They found that it was more important for SMEs to develop internally to ensure they were able to maintain control of partnerships when dealing with external bodies. Internal developments may take the form of process improvements, which Tidd and Bessant (2009, p.60) stated as the primary form of innovation that took place in SMEs. This connection with innovation was further emphasized by Terziovski's (2010) exploration of innovation within 195 manufacturing SMEs and the important role of process improvement within this context.

While process improvement represents a particular type of innovation, innovation more generally will not be a focus of the current research. Process improvement can thus be considered consistent with the requirements of the SME context, due to process improvement requiring fewer resources, a short time frame and exposing a firm to fewer risks when compared to new product development (Covin and Slevin 1991; Thomas *et al.* 2008). However, Woolf and Pett (2006) found process improvement was not related to SME performance, and Laforet (2011) identified the negative impact of process improvement in terms of how it might lead to the loss of jobs within the SME context. Koskinen and Vanharanta (2002) then stated that larger firms were also better at refining products (through process improvements) than smaller firms. This may suggest that research in process improvement would be of little relevance to practitioners, due to process improvement not being an area on which they should focus attention.

To address this argument against undertaking research within SMEs on process improvement, Koskinen and Vanharanta (2002) also presented SMEs as being better able to engage closely with, and acquire knowledge from, customers. Desouza and Awazu (2006) and McAdam and Reid (2001), undertaking research with SMEs, stated that knowledge realized from involvement with customers was put into practice through process improvement. Woolf and Pett's (2006) findings can themselves be critically reviewed in relation to how they chose to define process improvement and the structure of the model they were testing. They overlooked how involvement with customers may direct process improvement to ensure they realized benefits that are valued by the customers. The ability of SMEs to systematically refine processes can also be addressed by focusing upon ISO 9001 accredited firms, where formalized, externally audited procedures may facilitate incremental process improvements through the systematically refinement of operational procedures (Benner and Veloso 2008).

The inconsistency with the role of process improvement and its relevance within SMEs requires further refinement of the definition of SMEs employed within the current research. Building upon the previously presented literature, it appears necessary for firms to possess particular characteristics, not simply defined in terms of their industrial sector. If it is important for SMEs to accumulate and build upon their internal resources, it appears necessary that there are sufficient capabilities within a firm to be able to resolve operations issues and there are systems in place to document improvements in order to accumulate internal resources. This suggests that not only should the selection criteria be defined by the size of the organisation, but also the nature of the activities that are carried out within the firm. With Wolff and Pett (2006) finding there was not a direct link between process improvement and performance within manufacturing SMEs, the definition for the current research needs to be refined away from pure manufacturing. As a small engineering firm, the company within Thomas *et al.* (2008) provided a context in which problems could be solved and resources developed without external support. This would suggest that conducting research in SMEs with engineering capabilities would provide a fruitful context to conduct research on process improvement.



Characteristics:

- Customers provide broad details of requirements (product or problem)
- Continual involvement with customers
- High variety
- Low volume or can be one of a kind
- Low degree of standardisation
- High degree of complexity
- High degree of uncertainty

  E.g. development focused: a civil engineering company

Characteristics:

- Products are manufactured to customer specified designs
- Following approval, limited involvement with customers, unless the customer experiences problems
- Low variety
- High volume
- Higher degree of standardisation
- Low degree of complexity
- Low degree of uncertainty

  E.g. delivery focused: a contract manufacturer

Figure 2.3: Engineering, Manufacturing continuum

Figure 2.3 provides an illustration of where engineering-oriented SMEs are located in relation to the two extremes of wholly engineering and wholly manufacturing companies. By conducting research into how engineering-oriented SMEs engage in process improvement, there is potential to develop a framework to support the development of SMEs. By also investigating process improvement within a context where firms are able to engage in development, emphasis can be given to continually increasing the value provided to customers through process improvement (Hines *et al.* 2004), rather than wholly focusing upon variation reduction (Williams *et al.* 2000).

The benefits SMEs have been stating as being able to realize from process improvement include improving quality (Arend 2006), reducing cost (Jones and Macpherson 2006; Terziovski 2010), improving productivity (Kerrin 1999; Gunasekaran *et al.* 2000; Raymond and St-Pierre 2010), achieving continuous improvement (Bessant and Francis 1999a; Bessant *et al.* 2001; Hudson *et al.* 2001a), helping improve working conditions (Laforet 2011) and reducing the negative effect of firm size (Wolff and Pett 2006) amongst other benefits. The current research will give greater emphasis to the practice of process improvement and the benefits SMEs are able to realize from engaging in process improvement compared to previous research. Unless practitioners are able to realize benefits from process improvement, it is unlikely they will direct resources towards them. By selecting engineering-oriented SMEs, there is greater potential that selected firms will be engaging in activities that add value to the customer and so process improvement t has the potential to play an important role within operational activities. This leads to the presentation of the first research question:

RQ1: How do engineering-oriented SMEs undertake process improvement?

Where, engineering-oriented SMEs are defined as firms with less than 250 employees, engaging in some manufacturing and possessing the necessary internal capability to accumulate firm specific internal resources without involvement with external parties.

2.3.1 Selection of a Theoretical Perspective

While process improvement represents a potentially important topic to research within SMEs, to address issues with existing operations management research (Schroeder 2008; Schmenner *et al.* 2009), it is necessary to identify an appropriate perspective from which to pursue the research. Operations Management as a discipline tends to draw from organisational theory in order to increase legitimacy in relation to other management fields (Schmenner and Swink 1998; Schmenner *et al.* 2009). Although operations management does have some of its own theories, operations management research can still benefit from undertaking research underpinned by rigourously developed theory drawn from other domains. Amundson (1998) stated that it was important to select a theory consist with the needs of operations management. However, Martin *et al.* (2011) observed that the majority of theory "*borrowed*" (over the past 5 years) was transaction cost economics (Williamson 1996) or resource base view (RBV) (Wernerfelt 1984), both of which were considered inappropriate by Amundson (1998).

Transaction cost economics (TCE) takes a short-term view of operations, emphasising cost minimization through selecting the appropriate contracts with external firms when outsourcing production (Williamson 1996; Lockett and Thompson 2007; Cousins *et al.* 2008). By focusing on cost reduction within a static view of a firm, TCE overlooks the role of relationships and trust that have been found to play important roles with relationship with external firms (Cousins *et al.* 2006). The short-term view can also result in the outsourcing of activities in an effort for cost reduction that can forfeit the long-term accumulation of resources that can create a competitive advantage (Dierickx and Cool 1989; Cohen and Levinthal 1990).

The RBV addresses this limitation, by acknowledging that sustainable competitive advantage is created by resources internal to the firm (Wernerfelt 1984). Barney (1991) then stated that those firms that possessed resources that were rare, valuable, inimitable and non-substitutable, were able to sustain their competitive advantage over those firms that did not. However, McWilliams and Smart (1995) stated that the RBV also takes a stationary view, overlooking the process orientation of operations management. Not with standing this criticism, Witcher *et al.* (2008) and Locket *et al.* (2009) identified RBV as one of the most influential theoretical perspective within strategic management frequently employed within operations management (Powell 1995; Schroeder *et al.* 2002; Paiva *et al.* 2008). RBV also tends to be considered the primary contribution strategic management has been able to make to operations management (MacCarthy *et al.* 2013, p.949. The intangible nature of many of the important resources RBV refers, then make it difficult to research (Newbert 2008) and not necessarily a theory as operations management defines it (Wacker 1998).

Contributions have been made in relations to the core competence/ capabilities perspective on RBV (Hamel and Prahalad 1990; Hamel and Prahalad 1994), which provides greater attention to the accumulation of strategic resources, as explored by Dierickx and Cool (1989). This perspective gives greater emphasis to the knowledge-based resources, that have been identified as the most strategic resource (Grant 1996), that have also been explored within operations management (Hult *et al.* 2003; Choo *et al.* 2007a; Anand *et al.* 2010). While the role of knowledge within small firms has been explored in depth (Thorpe *et al.* 2005; Macpherson and Holt 2007), from an RBV perspective, it is necessary for such resources to be applied by individuals within the firm (Wiklund and Shepherd 2003) or directed to revenue generating processes (Chaston *et al.* 2001).

As a development of the RBV, a dynamic capabilities perspective provides an alternative view on the accumulation and application of strategic resources to provide a competitive advantage (Teece *et al.* 1997; Eisenhardt and Martin 2000; Helfat *et al.* 2007; Ambrosini and Bowman 2009). While explored within the context of process improvement (Anand *et al.* 2009), dynamic capabilities have been identified as inappropriate for SMEs due to them having insufficient resources for "*a set of specific and identifiable processes*" (Eisenhardt and Martin 2000, p.1105) required by dynamic capabilities (Mosey 2005; Noke and Hughes 2010).

Although well established, neither TCE or RBV contributes significantly to operations, offering primarily explanatory power but increasing the research's perceived legitimacy (Schmenner *et al.* 2009). Amundson (1998) identified organisational learning as an appropriate theory for use within operations management, due to organisational learning being "*virtually identical to the OM (operations management) concept of processes*" (p.351). The greater process orientation and knowledge accumulation emphasis of dynamic capabilities has resulted in the concept being explored from an organisational learning perspective (Zollo and Winter 2002; Benner and Tushman 2003;

Schreyogg and Kliesch-Eberl 2007; O'Reilly III and Tushman 2008; Di Stefano *et al.* 2010). By emphasising how organisations learn, compared to engaging in specific best practices (Tsang 1997), organisational learning can provide a theoretical lens to develop greater understanding of operational processes. Amundsen (1998) also considered there was a high degree of potential integration between organisational learning and OM, with potential to explore "*how OL (organisational learning) occurs through process improvement*" (p.351).

Within the context of SMEs, an organisational learning perspective was employed by Jones (2005) and Jones and Macpherson (2006), who presented case studies on how firms were able to undergo strategic regeneration. Consistent with Lee and Klassen (2009), by engaging with external parties, SMEs were able to undergo fundamental changes in the businesses they operated. Organisational learning thus represents a potentially relevant theoretical perspective from which to research process improvement within SMEs, for relating isolated improvements to organisational-level changes.

The role of organisational learning within SMEs was a specific focus of research by Chaston *et al.* (1999). They stated that supporting SMEs to develop their ability to undertake organisational learning was more beneficial than funding interventions provided by external consultants. This was consistent with Mosey (2005), who stated that while SMEs may have difficulty developing dynamic capabilities, could benefit from the development learning capabilities that over time could become dynamic. Providing structure and support to learning behaviours related to process improvement also provides a connection with Mukherjee *et al.* (1998). By critically reviewing completed improvement activities it was possible to carry out more fundamental changes, rather than simply solving the problems that were identified or returned from customers. Undertaking learning activities related to process improvement activities could ensure that learning was captured from continuous improvement activities (Bessant *et al.* 1993) and ensure targets were being achieved or revised for subsequent projects (Linderman *et al.* 2006).

Drawing from discussions in section 2.3, organisational learning also provides SMEs with an appropriate mechanism for accumulating resources and undertaking improvement. For this reason, organisational learning will be selected as the theory to be employed within the current research. The relevance of other, alternate theory will be explored in relation to the research following presentation of the research findings in section 8.5.

The strong emphasis outlined within section 2.2.2 on project-oriented improvements highlighted the value that can be realized from qualitative, theoretically underpinned research. The complexity of the topics discussed within the previous sections, such as the development of internal resources, involvement with external parties, the role of procedures and the relevance of process improvement highlights the need for exploratory research within this area. The need for such research has not been overlooked within literature, with Tidd and Bessant (2009, p.516) calling for more research to address the problems small firms face. Chaston *et al.* (2001) explicitly called for less positivist and more case study research on organisational learning in small firms. Overall qualitative, exploratory research on organisational learning and process improvement in SMEs will assist in developing understanding of the phenomenon and each topics' role in enabling SMEs to realised benefits at a firm level from undertaking process improvement. The literature reviewed on Six Sigma provides a framework through which to view process improvement and to which one can relate the current research, to assist in ensuring its external validity.

While organisational learning has been identified as a potentially appropriate theoretical perspective from which to view process improvement activities in SMEs, an exploration of organisation learning theory is necessary. With numerous conceptualizations of organisational learning (Huber 1991; Crossan *et al.* 1995), the next section will systematically survey the operations management research that draws from organisational learning theory. This will allow the specific conceptualizations of organisational learning used within operations management to be identified to determine the specific models of organisational learning that should be used within the current research.

2.4 The Systematic Analysis of Organisational Learning in Operations Management

As stated in Table 2.1, 0ut of 711 articles that referred to organisational learning within the body of the articles, 64 referred to organisational learning within their title, abstract or keywords. Ahire and Dreyfus (2000) is the most highly cited of the 64 articles which confirmed the impact of design and process management on internal and external quality. Organisational learning was presented as a mechanism for enabling firms with more mature TQM approaches to achieve better levels of quality, broadly consistent with the development or embedding of improvement capabilities presented in section 2.2.4. Rozensweig and Roth (2004), which is the second most highly cited paper, used organisational learning in a similar manner. The work built upon Ferdows and De Meyer (1990) and Noble (1995) who attempted to explore and confirm a theory related to whether firms were able to cumulatively develop operational capabilities without being affected by trade-offs (Skinner 1974). Organisational learning provided a mechanism for relating accumulated knowledge at a process level (know-how) from improvement activities with improvements in profitability at a firm level. The third most highly cited article was Hult *et al.* (2003). They explored whether cultural aspects of organisational learning within supply management provided firms with a competitive advantage, realised through a range of performance outcomes.

The use of organisational learning within these most highly cited articles was consistent with many of the remaining 61 articles. Organisational learning was referred to primarily as a means of explaining improvements at one operational level and relating them to firm level outcomes, which was done across a range of contexts. This demonstrates the relevance of organisational learning theory to the domain of operations management. Figure 2.4 shows how papers related to organisational learning were distributed across major topics of operations management.

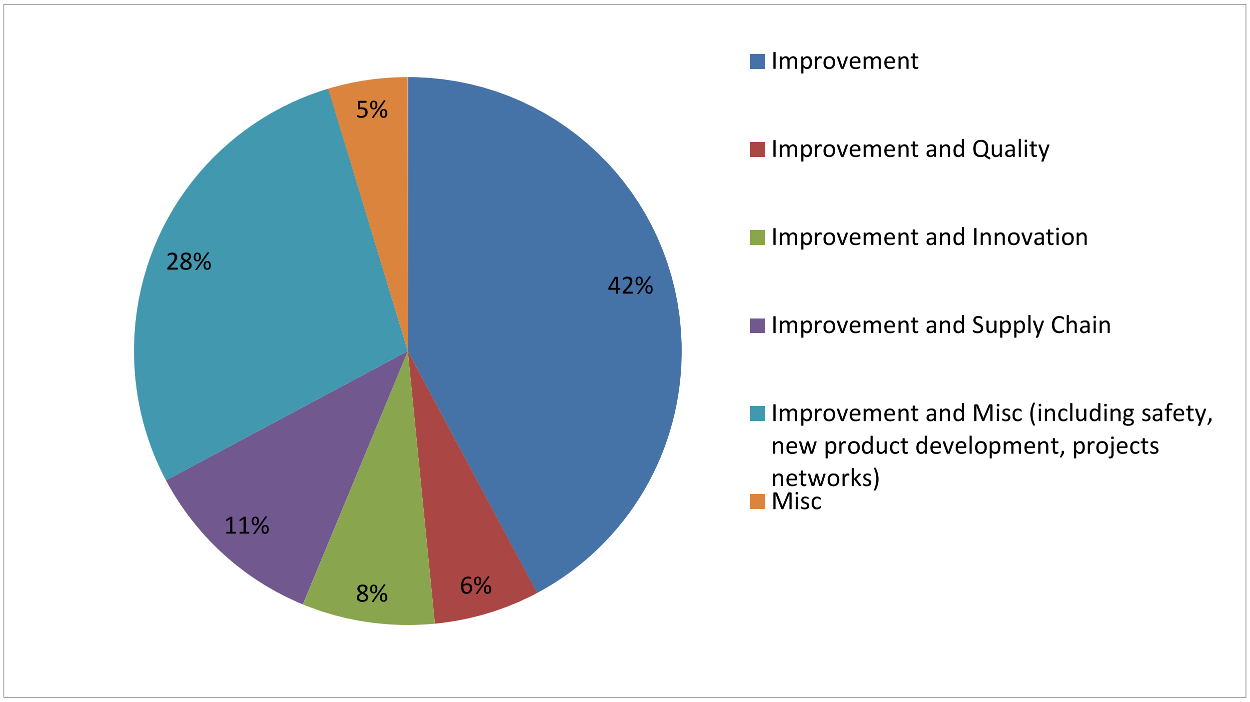


Figure 2.4: Breakdown of organisational learning articles by paper topic

To begin exploring how operations management defines and draws upon organisational learning theory, the population of articles was reviewed to identify the specific organisational learning literature the 64 papers cite. Table 2.3 provides both a picture of the literature that was drawn from and the relative impact particular organisational learning authors have on operations management (frequency of citation). Although some articles referred to different sources, for example Nonaka (1994) and Nonaka and Takeuchi (1995) or Argyris (1977a) and Argyris (1982), within the analysis they were attributed to the primary author. Reviewing the source articles and books ensured that the thesis of different sources was broadly consistent.

Table 2.3: Organization learning literature (drawn upon)

Organisational Learning Author	Citations
Senge (1993)	25
Argyris (1977a)	21
Nonaka (1994)	19
No Reference	15
Huber (1991)	14
Cohen and Levinthal (1990)	14
Garvin (1993)	12
March (1991)	9
Yelle (1979)	6
Fiol and Lyle (1985)	6
Crossan *et al. (1999)*	6
Wright (1936)	4
Levinthal and March (1993)	4
Levitt and March (1988)	4
Argote (1990)	3
Seely-Brown and Duguid (1991)	3

Building upon the methods used by Pilkington and Meredith (2009) and Di Stefano *et al.* (2010) co-citation analysis was carried out upon the 49 articles that referred to organisational learning literature. This is an analysis technique that allows the strength of relationships between particular works to be objectively assessed, by determining the frequency with which particular work is cited together. This was carried out by determining the degree to which use of one organisational learning article correlated with use of another article, using the statistical analysis program SPSS18[6]. The strength of the method lies in the ability to determine the strength of relationships with a statistical

[6] Analysis data available on request

degree of confidence, based upon objective citation data. Figure 2.5 presents how the different perspectives of organisational learning were cited together within the identified articles.

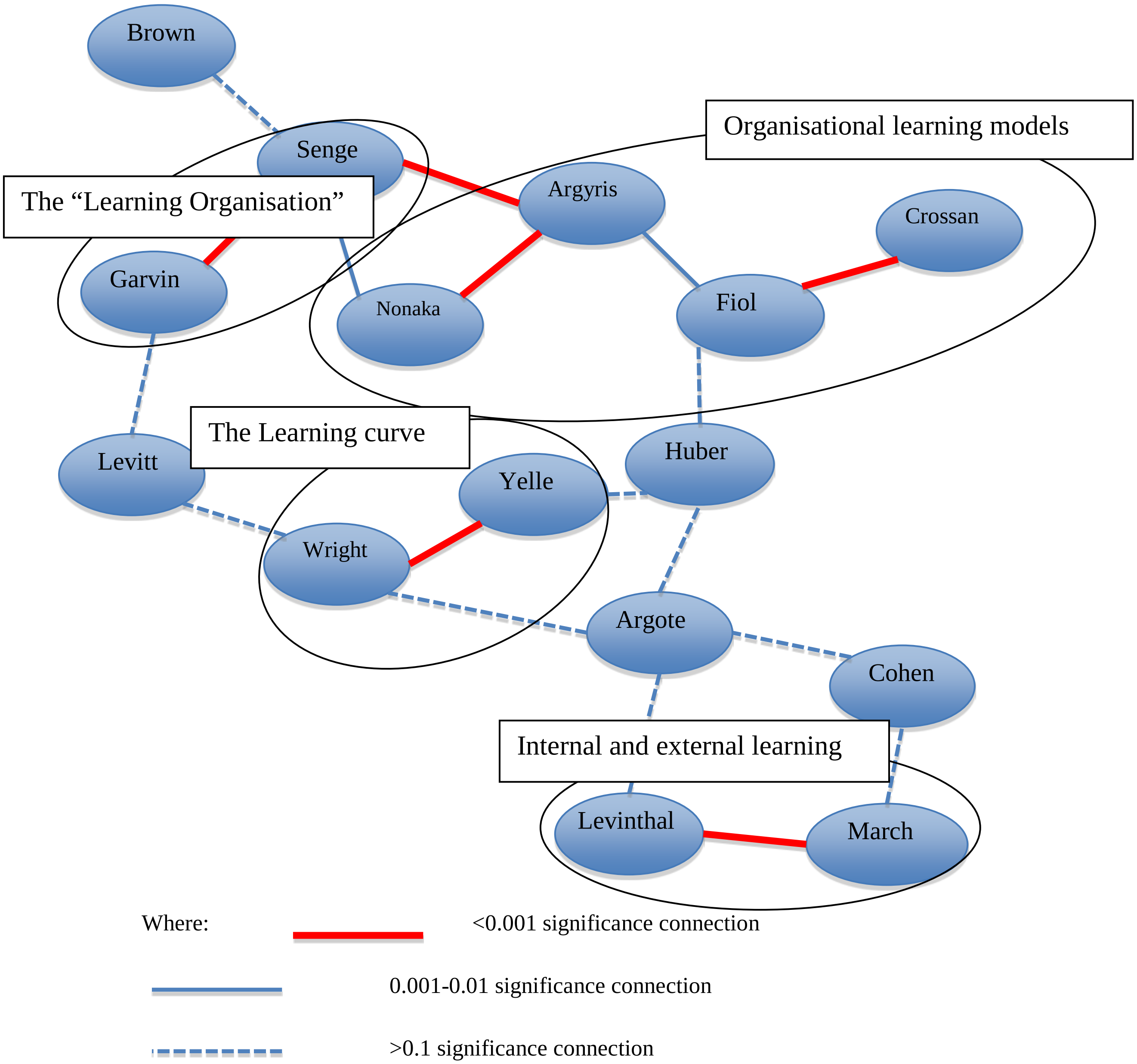


Figure 2.5: Co-citation Analysis Structure of Organisational Learning

Figure 2.5 shows that there are strong relationships between work focusing on the learning organisation (Garvin 1993; Senge 1993), the learning curve (Yelle 1979) and models giving attention to variation increasing and variation reducing forms of learning (March 1991). Although the learning organisation literature is cited most frequently, it has been considered less relevant for academic research (see section 2.2.3). Tsang (1997) stated the learning organisation was based upon limited empirical and theoretical foundations, tending towards telling "*managers the way that a company should learn*", compared to "*how organisations actually learn*" (p.74). Senge (1993) defined the learning organisation as a place where individuals continually expand their capacity to learn which results in an organisation continually able to create its future. Interestingly, the learning organisation was also the conceptualisation of learning used within most cited articles that referred to organisational learning (Ahire and Dreyfus 2000; Hult *et al.* 2003; Rosenzweig and Roth 2004).

This limitation of the learning organisation is effectively illustrated by Hult *et al.* (2003, p.545), who defined the learning organisation in terms of culture and organisational learning in terms of processes. While the accumulation of a learning-oriented culture may provide a firm with a competitive advantage (Hult *et al.* 2003), similar to research discussed in section 2.2, attention is not given to the processes that related culture to changes in behaviour. Within the context of SMEs, Chaston *et al.* (2001) found that cultural aspects of learning were insufficient to contribute directly to improvements in SME performance (a competitive advantage). This has resulted in organisational learning being considered of greater relevance to operations management than the learning organisation (West and Burnes 2000). For this reason, the Crossan *et al.* (1999) 4I framework will be considered the primary model employed within this area of Figure 2.5, which is not directly related to the work on the learning organisation. The 4I framework draws from the learning organisation literature (Crossan *et al.* 1995), but gives explicit attention to the individual and cultural elements of learning, while maintaining academic rigour. The following section will present the different models of organisational learning (the learning curve, variation increasing and reducing and the 4I framework) based on each of the original works that constitute the identified models.

2.4.1 Organisational Learning Theories

Amundson (1998) stated that the process orientation of organisational learning combined with its multi-level nature meant concepts in organisational learning and operations management were "*virtually equivalent*" (p.353). However, there are numerous different conceptualisations of organisational learning, meaning the selected model will have a considerable effect on its relevance to operations management research. Table 2.2 shows the range of organisational learning literature that is drawn upon within operations management, with a number of articles not referencing organisational learning literature directly. For example, Tucker (2004) explored the impact of failures in hospitals on nurses and patients. Organisational learning was presented as the primary area of focus to assist in the prevention of further failures. However, without drawing from an accepted definition directly, the work was unable to present mechanisms that connect issues experienced at an individual-level with improvements at an organisational-level. The previous section identified the main three models of organisational learning referred to directly within operations management. Each of the three models identified in Figure 2.5 will now be reviewed to understand their use and relevance to operations management research.

2.4.1.1 Learning Curve

Garvin (1993) stated that continuous improvement requires continuous learning, suggesting that for improvement to take place, learning must also take place. This was justified by the need to base learning related to improvements upon what had already been learnt to prevent the recurrence of errors. Wright (1936) and Yelle (1979) conceptualised such improvements as resulting from the number of products produced, which was observed within airframe manufacturing and various other contexts respectively. Unit cost of production was found to decrease as an exponential function of the number of units produced. Li and Rajagopalan (1998) considered this type of learning was autonomous, taking place outside the influence of management. This is consistent with it originally being identified as an organisation level phenomenon, with the effects of learning outcomes being accounted for in managerial planning (Yelle 1979). To assist management decisions, Wright (1936) and Yelle (1979) presented the learning curve as a mathematical function, where unit cost was proportional to an exponentially decaying function ($X = K X^{N}$).

Reflecting the process orientation of operations management, Li and Rajagopalan (1998) and Uzumeri and Nembhard (1998) employed the learning curve to explain the rate of improvements at an operational level. Ferdows and De Meyer (1990) emphasized such improvements as "*learning more about the process*" (p.176), which would contribute to cumulative capabilities at an organisational level. However, Zangwill and Kantor (1998) stated that making a connection between operational- and organisational-level improvements was not possible, due to the presence of numerous sources of error between these two levels of measurement. This implies that improvement at an organisational-level could not be related to operational-level improvement or the number of items produced.

Complementing this view from an operations management perspective, Schmenner and Swink (1998, p.99) stated that presenting a formula does not constitute a theory. While empirical observations may have been consistent with the mathematical function, without a strong theoretical underpinning, such research may be considered "*raw empiricism or data-dredging*" (Schroeder 2008, p354). Barkema and Schijven (2008) highlighted their concerns with the lack of theoretical underpinnings on the learning curve, considering that it provided limited insight to research. While the learning curve was not considered relevant, the role of experience appeared to have a considerable effect on a firm's ability to improve overtime (Barkema and Schijven 2008), effectively representing a more pragmatic conceptualisation of the learning curve. The role of experience was demonstrated within the context of strategic alliances by Kale and Singh (2007), as indirectly contributing to alliance success. From this insight, the learning curve will be defined within the current research as follows:

Learning Curve: Improvements result in the form of the gradual reduction in manufacturing costs, cycle time and non-conformances as a function of number of products produced or the gradual development of organisational experience of similar activities.

2.4.1.2 Schroeder *et al.* (2002) Model

In additional to the autonomous forms of learning related to the learning curve, deliberate forms of learning appear to be more appropriate when exploring operational processes. This is consistent with the perspective of Li and Rajagopalan (1998) who presented process improvement as a form of deliberate or induced learning. Li and Rajagopalan (1997) found that deliberate forms of improvement that resulted from the receipt of non–conforming products was a better indicator of improvement than simply total number of products produced. This particular finding from an organisational learning curve perspective is consistent with an alternative theory of organisational learning presented by Argyris (1977a) who defined organisational learning as an "*organization's capacity to detect and correct errors*" (p.3).

With quality non-conformances impacting customers, the role of external sources of learning need to be appreciated, which is overlooked by the organisational learning curve (Argote and Epple 1990). Huber (1991) acknowledged the role of external sources of knowledge by conceptualising organisational learning as being initiated by knowledge acquired from outside the firm. This process was conceptualised by March (1991) as the introduction of new members into an organisation. How quickly new members accepted existing operational routines would determine the impact new members had on the organisation as a whole. The process of accepting, socialising and adapting to new members was stated as affecting the firm's ability to adapt to the external environment. While the quick acceptance of organisational routines allowed firms to exploit existing organisational knowledge, over-exploitation could result in firms being unable to change (March 1991). The reverse situation also caused problems with adapting too readily to new members leading to firms continually identifying new opportunities, but having difficulty in realising value from their discoveries. Levinthal and March (1993) argued there was an inherent need to balance exploitative and exploratory forms of learning, exploring for new ideas and then refining them internally. Cohen and Levinthal (1990) presented a similarly argued logic, with their concept of absorptive capacity, where in order to be able to accept knowledge it was necessary to possess a foundation of similar knowledge, in order to be able to appreciate the potential value of new knowledge. Jacobs and Swink (2011) employed this model to outline the need to focus on internal operational improvements and accept new knowledge from external sources.

Schroeder *et al.* (2002) drew these complementary models of organisational learning together, refining them for an operations management context. Organisational learning was defined as a combination of internal and external learning activities that were translated to improvements in manufacturing performance via the creation of proprietary resources. Internal learning consisted of cross-functional problem solving, which is consistent with correcting errors (Argyris 1977a). External learning is conceptualised as involvement with suppliers and customers to ensure current processes are appropriate for meeting customer requirements and drawing from supplier expertise. This is again consistent with March (1991) and Cohen and Levinthal (1990) in terms of accepting information from external sources and improving internally.

Schroeder *et al.* (2002) found that internal learning was more strongly related to the creation of proprietary resources than external learning and the different forms of learning were related to one another. Huang *et al.* (2008) reapplied this model of learning and found that internal and external learning activities contributed to more effective process implementation (improvement). In combination with the findings of Chaston *et al.* (2001), learning activities were only related to improved performance when they led to the improvement of operational processes. This model of learning can be defined as follows and represented as Figure 2.6:

Schroeder *et al.* (2002) model: Internal problem solving and involvement with suppliers and customers leads to operational improvement that in turn improves manufacturing performance.

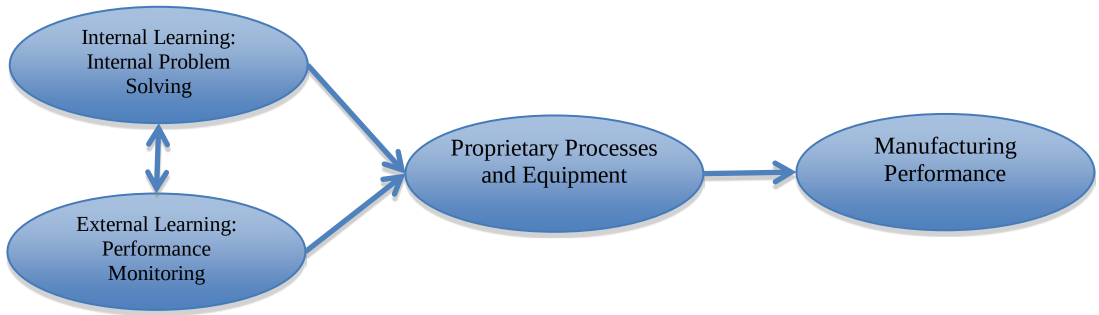


Figure 2.6: Schroeder model of organisational learning (Adapted from Schroeder *et al.* 2002)

2.4.1.3 Crossan *et al.* (1999) Framework

While there are a number of different organisational learning models drawn from within operations management, the Crossan *et al.* (1999) model was selected in favour of the other models. Crossan *et al.* (1995) systematically reviewed research on organisational learning to identify important elements of the theory, which provided the theoretical foundation for the 4I framework. This included Argyris (1977a), who, in addition to defining organisational learning as a "*detection and correction of errors*" described how this was only possible if individuals were able to notice new and potentially important information. This also included the need for individuals to critically review their own mental models, frames of reference or "*theories in use*" (p.122) through "*double loop learning*" so they were able to adapt to new operating environments consistent with Mukherjee et al. (1998) and DeTreville and Antonakis (2006). Other literature included Fiol and Lyle (1985), who acknowledged the role of operational processes, structure, culture and strategy in organisational learning, which was stated as necessary to direct organisational learning behaviour. This difference ensured organisational learning was not only defined as the adaptation to solve non-conforming products, but also the initiation of deliberate changes.

Another important model within Figure 2.5 was Nonaka and Takeuchi (1995), who provided an alternative perspective on organisational learning, based on tacit and explicit forms of knowledge. Their proposed process related to a knowledge creation cycle (similar to Kim 1993; cited in Mukherjee *et al.* 1998), consisting of socialisation, externalisation, combination and internalisation (Nonaka 1994). Through continual processes of knowledge creation, firms were able to innovate more effectively, drawing from and creating sources of knowledge that may be difficult for competitors to imitate. This model has been explicitly applied within operations management to assess how different Six Sigma tools and techniques created different forms of knowledge and in turn impacted on project performance (Anand *et al.* 2010).

Through the assimilation, analysis and critique of work on organisational learning, Crossan *et al.* (1995) were able to identify the constituent components of organisational learning. The limitation identified with much of the existing work on organisational learning was that it tended to be an extension of individual learning (Weick 1991; Tsang 1997). This point is consistent with the limitations of the learning organisation presented in section 2.4. The process of systematically analysing and critiquing existing models resulted in Crossan *et al.* (1999) proposing the 4I framework of organisational learning.

Crossan *et al.* (1999) defined organisational learning as consisting of primarily four processes, intuition, interpretation, integration and institution. When these processes were connected and carried out together, learning could be considered to have taken place at an organisational-level. Learning was also only considered to have happened if there had been changes in both behaviour and cognition (Crossan *et al.* 1999), differentiating it from adaptation (Fiol and Lyles 1985) and ensuring firm behaviour changed as a result of learning activities (Chaston *et al.* 2001). Crossan *et al.* (1999) defined learning as being initiated by individuals acting as entrepreneurs, identifying or intuiting problems or opportunities for improvement in the world around them. Following processes of interpretation, both individually and in groups, a shared understanding of a problem or opportunity could be developed. Further group-level activities are then integrated into organisational-level resources, such as operational procedures, product, policies and strategies, and institutionalised as they become embedded in the organisation. Once learning activities were institutionalised, organisation-level resources were said to feedback to lower levels of the organisation to inform behaviour, such as organisational policies, strategy and culture affecting group- and individual-level behaviour. As a result, the 4I framework of organisational learning can be defined as follows and represented as Figure 2.7:

Crossan *et al.* (1999) Model: From the individual actively searching out opportunities that are developed individually and collectively, ideas are formalised into organisation-level procedures, products, policies and strategies, which in turn influence organisational behaviour.

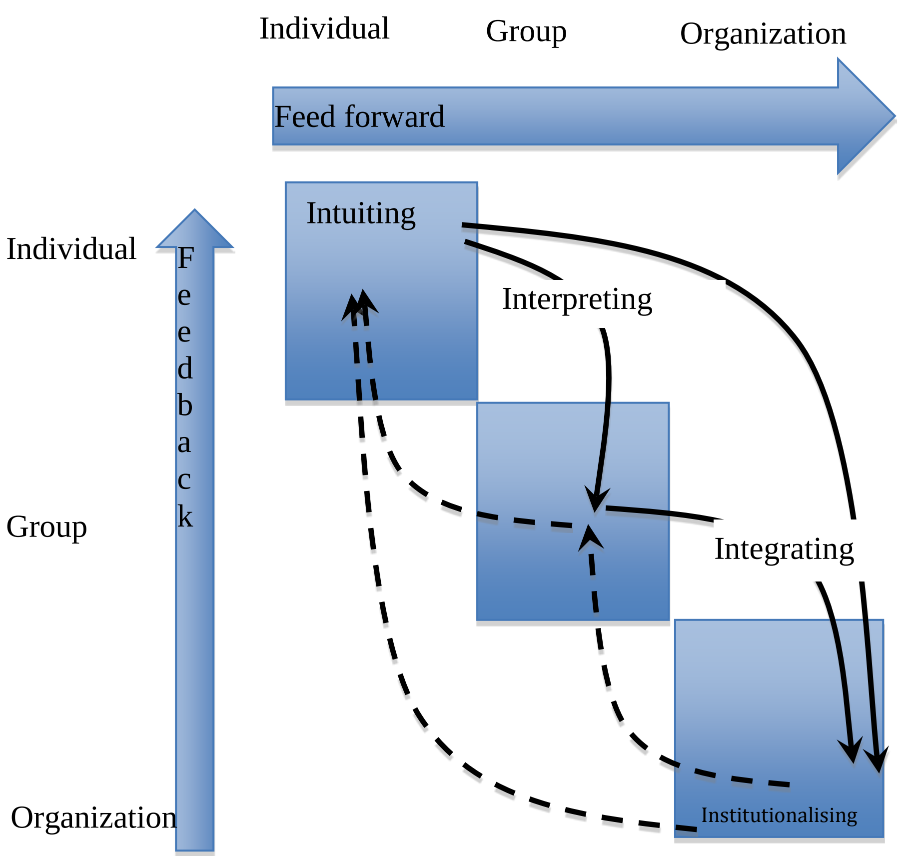


Figure 2.7: 4I Framework of Organisational Learning (source: Crossan *et al.* 1999, p.532)

While alternative models of organisational learning could be included within this research, the strong theoretical foundation that draws from alternate conceptualisations justifies the selection of the 4I framework over alternative models. The influence of the 4I model is demonstrated by it receiving the Academy of Management Review decade award, as the journal's most cited article between 1999 and 2009 (Crossan *et al.* 2011).

While the work was highly cited within management literature, Crossan *et al.* (2011) found that a large proportion of citations did not draw from the rich detail and structure provided by the framework. Bontis *et al. (*2002) was an exception that tested the 4I model of organisational learning empirically. This consisted of developing measurement constructs for each element of the model and applying the measurement model within an organisation. They found that the learning flows (feedback and feed forward) were as important, if not more so, than the accumulation of resources present at each level for contributing to firm performance. Other works drawing in detail from the framework were Jones and Macpherson (2006) and Crossan and Berdrow (2003), who explored the utility of the framework within cases that had undergone strategic renewal. The framework has also be extended theoretically, in terms of strategic leadership (Vera and Crossan 2004) and power (Lawrence *et al.* 2005). This shows the model's versatility and relevance across numerous domains.

On reviewing the operations management articles that drew from the 4I framework, similar observations can be made to those raised by Crossan *et al.* (2011)[7]. Many of the articles citing the framework only drew from particular elements, such as Yeung *et al. (*2007) who drew from it in terms of enabling strategic renewal or Azadegan and Wagner (2011) to relate internal knowledge to exploration. An example that drew more effectively from the model was Nemanich *et al.* (2010), who used the model to explain how knowledge was integrated into project teams. While not part of the population of papers presented in section 2.3, the work drew from absorptive capacity (Cohen and Levinthal 1990), so not referring to organisational learning within the title, abstract or key words. Within Nemanich *et al.* (2010), the 4I framework was able to theoretically underpin justification for operational activities, addressing limitations of absorptive capacity (Cohen and Levinthal 1990), with operations management providing context to the theory. Drawing from this application, the Crossan *et al.* (1999) 4I framework appears to provide a relevant framework through which to conduct operations management research, assisting in linking operational processes within organisation-level

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[7] Paper summaries available on request

changes. The use by Jones and Macpherson (2006) shows the framework is relevant for application within SMEs. However, with this application focusing upon strategic renewal, there are opportunities for further research using this framework to analyse operational processes more generally.

The learning curve, Schroeder *et al.'s* (2002), and Crossan *et al.'s* (1999) models of organisational learning represent three models that relate learning activities to operational processes. The simpler models (learning curve and Schroeder model) represent conceptualisations of organisational learning that have been specifically identified and applied within operations management research. The Crossan *et al. (*1999) framework represents an alternative model of organisational learning that is yet to be used as the primary analytical framework through which to analyse operations management practice. Although this model may be, by definition, more applicable to structuring observations, this has yet to be confirmed within operations management and may provide a means of developing better understanding about operational practices. This leads to the presentation of the second research question:

RQ2: What is the applicability of the three models of organisational learning within engineering-oriented SMEs?

Building upon the definitions presented, Table 2.4 presents the coding framework that will be used to analyse operational activities in terms of organisational learning with the associated literature from which the definitions were drawn.

Table 2.4: Components of organisational learning models

Model	Elements	Source
1) Learning Curve	Reduction in unit cost/ cycle time as a function of production volume or the accumulation of production experience	Wright (1936), Yelle (1979) Argote and Epple (1990), Li and Rajagopalan (1998), Ahire and Dreyfus (2000)
2) Internal and external learning	Internal problem solving from cross functional interactions	Schroeder *et al. (*2002)
	Involvement with customers and suppliers	Schroeder *et al. (*2002)
3) 4I Model	Individuals identifying new ways of solving organisational issues	Crossan *et al. (*1999), Bontis *et al. (*2002)
	Group activities focused upon identifying and questioning individually held assumptions	Crossan *et al. (*1999), Bontis *et al.* (2002)
	Organisational policies, culture and strategies that focus upon long-term development	Crossan *et al. (*1999), Bontis *et al. (*2002)
	Feed forward ideas from individual and group activities into organisation-level processes	Crossan *et al. (*1999), Bontis *et al. (*2002)
	Feedback organisational resources, policies and procedures to inform individual and group-level behaviour	Crossan *et al. (*1999), Bontis *et al. (*2002)

By addressing research question 1, process improvement activities can be identified within SMEs. The findings from addressing RQ2 can be used as a means of interpreting, understanding and extending the findings of RQ1. While the logical and theoretical connection between process improvement and organisational learning has been present throughout the literature review, the specific contribution of organisational learning to understanding on process improvement needs to be determined. On comparing the two systematic literature reviews, Anand *et al.* (2010) was the only paper that appeared in both searches (using both process improvement and organisational learning as keywords). This provides further evidence that research needs to be conducted at the intersection between process improvement and organisational learning. This leads to the presentation of the third research question:

RQ3: How does organisational learning contribute to understanding of process improvement within engineering-oriented SMEs?

2.5 Chapter Review

This literature review presented the state of the art of thinking on process improvement and organisational learning within operations management. Process improvement was presented as a central topic of operations management research by building upon the foundations of particular quality management gurus. This led to a presentation of cumulative research within quality management that while oriented around process improvement, appeared to overlook specific process improvement practices. To further explore this observation, a systematic review was conducted to identify how operations management literature referring to process improvement used the term. This allowed the use of process improvement to be assessed across the discipline of operations management.

Literature explicitly focused upon process improvement activities, compared to quality management was then reviewed. This section focused specifically on the Six Sigma methodology, which was identified within discussions on quality management. This assisted in the identification of additional topics related to process improvement such as organisational context, the role of improvement goals, training and connections with organisational learning. Definitions of process improvement and related improvement activities used within existing literature highlighted the need for exploratory research into the nature of process improvement within SMEs. Limitations of research focused upon Six Sigma were identified, which led to the review of the related improvement approaches of Lean and ISO 9001 accredited QMS that were considered more relevant for research within SMEs. Research focusing upon SMES was then reviewed, outlining the relevance of process improvement leading to the presentation of research question 1 and an associated definition of engineering oriented SMEs. Organisational learning was then identified as an appropriate theoretical underpinning for research within SMEs.

Organisational learning was also presented as an appropriate theory for research within operations management. Its use within operations management research over the past 21 years was systematically surveyed. This was done via citation and co-citation analysis, to identify how organisational learning has been conceptualised within operations management. The identified theories were then discussed in relation to how they were used and related to operational improvement activities, which led to the presentation of research question 2.

From this position, the current state of literature has been presented, with gaps, research questions for addressing them and context to investigate them being based upon comprehensive reviews of the domain. The methodology used ensured a systematic and repeatable approach for identifying relevant literature, however, related research focusing on topics such as quality improvement and continuous improvement could also have been explicitly included within these searches. This limitation was acknowledged in section 2.2.3, although more in-depth exploration of the related topics may have been beneficial. Process innovation represents an alternative area of research that has not been explicitly covered within the above review. While innovation was considered within section 2.2.3, it could be considered to be related to the degree of improvements, rather than their nature (see Lee *et al.* 2011). This view is consistent with Schroeder (1990) who described the development of a process innovation which had numerous similarities with those described in the current review of literature. As a result, literature referring to process innovation may be able to extend this literature review.

A similar limitation is present in relation to organisational learning and 'the learning organisation'; this was stated within section 2.3 as not being considered a limitation due to them being two different areas of literature. Specifically, work related to the learning

organisation has a more prescriptive nature, giving less emphasis to academic rigour (Tsang 1997). This indicates the learning organisation literature may be inappropriate for use within the current research.

Finally, in addition to operations management not employing theory as science defines it (Schmenner *et al.* 2009), the majority of operations management research related to organisational learning does not actually draw from the theory. This final observation highlights an additional justification for the current research, with the need to explore operations management practices using a theoretical perspective based on an understanding of the contributing literature on the topic. Interestingly, if Senge (1993) and Garvin (1993) (primary learning organisation sources) are removed from the co-citation analysis, the structure of Figure 2.5 remains largely unchanged. As a result, not explicitly including the learning organisation within the literature review is consistent with the theoretically underpinned, rigorous approach that will be taken to the current research. Due to the limitations in space and resources in conducting this literature review, these limitations are considered acceptable, especially when compared with the population of nearly 22,000 operations management papers that were considered within this review. This process allowed the identification of a particularly relevant article, Anand *et al.* (2010), as the only paper related to organisational learning and process improvement as key themes. This provides strong, objective evidence that this is an area that requires further research.

The next chapter will present the philosophical, epistemological and methodological perspectives necessary for undertaking research within this area. The next chapter will also outline the research method and data collection completed in order to answer the presented research questions and address the identified gaps within operations management literature.

Chapter 3: Research Methodology and Design

Chapter 2 reviewed a wide selection of literature on process improvement and organisational learning within the domain of operations and general management. The aim was to explore the content and use of process improvement within operations management and determine the relevance of organisational learning as a theoretical perspective from which to conduct research within SMEs. The following chapter will present the research methodology and design appropriate for addressing the three research questions posed in Chapter 2. This will consist of the presentation of research philosophy, methodology, design, data collection and analysis techniques undertaken in the research, which consists of two stages from exploratory to confirmatory case studies. The following chapter will justify why the selected research methodology and design are appropriate for addressing the three research questions presented in Chapter 2.

3.1 Research Philosophy

Operations management research that related to process improvement and draws from organisational learning covers a range of topic areas (Figure 2.2 and 2.4). Process improvement represents an inherently practical domain, a central topic of operations management (Anand *et al.* 2010) and an important practice that provides many benefits to SMEs (section 2.3). Organisational learning is then able to provide a theoretical underpinning to interpreting operational process improvement practices and relate them to organisational-level changes. Consequently, the ontology for research on process improvement and organisational learning cannot be wholly objective or subjective. Pragmatism allows the selection of numerous worldviews simultaneously. This will allow the consideration of physical changes made of operational equipment as well as adaptations of individual perceptions of operational systems. Pragmatism also focuses upon addressing real world problems, requiring an ontological position that appreciates there are both social and physical worlds (Crotty 2003). This view is consistent with discussions on process improvement presented in Chapter 2 and the selected theory of organisational learning.

Nonaka's (1994) knowledge creation cycle that was touched upon in section 2.4 and employed within process improvement research (Anand *et al.* 2010) is appropriate for understanding the nature of process improvement. The knowledge creation cycle provides a means of conceptualising the social and physical aspects of process improvement practices, providing direction to an appropriate research philosophy. Consistent with Nonaka (1994), knowledge will be defined as "*justified true belief*". The knowledge of interest to the research will be knowledge about operational processes, realised from both personal experience and the interpretations of operational procedures. While "*justified true belief*" has been outlined as inappropriate in relation to scientific knowledge (Gettier 1963), due to the context being commercial, practically-oriented knowledge (Demarest 1997), it is considered an appropriate definition for the current research.

Reflecting this ontological position, the research will be conducted from an interpretivist epistemology, due to the world being viewed by interpretivists as "*socially constructed and subjectively viewed by the people who give it its meaning*" (Noke and Hughes 2010, p.138). This perspective does not overlook the objective world or its role within process improvement, but focuses upon the social aspects. This is consistent with the philosophical thinking of Max Weber (Crotty 2003, p.67), with research from this perspective concerning the development of *verstehen* or understanding of social phenomenon. This epistemological perspective is considered necessary for addressing the three research questions, which aim to develop understanding about process improvement, organisational learning and the relationship between the two concepts.

3.2 Research Methodology and Methods

To develop understanding of process improvement and organisational learning, where relationships and content are not fully understood, research that enables descriptions, mapping of processes and building relationships is necessary (Handfield and Melnyk 1998, p.324). McCutcheon and Meredith (1993), Meredith (1998), Stuart *et al.* (2002) and Yin (2009) highlight that case-based research is appropriate and necessary for answering such 'how' and 'why' research questions. Case study based research is consistent with a pragmatic ontology and interpretivist epistemology (Saunders *et al.* 2007) necessary for undertaking exploratory research into process improvement. By taking the firm as the unit of analysis, a holistic analysis of each firm will allow a more representative depiction of the firm as a whole that accounts for the views of a number of individuals (Yin 2009).

A pragmatic worldview suggests the need for a research methodology that is able to make use of multiple forms of data. Case studies represent an appropriate research methodology, being able to draw from both objective and subjective forms of data that can include observational, interview, archival, numerical and publically available forms of data, helping locate the research within the contemporary environment (Stake 2005). Stuart *et al.* (2002) and Radnor (2001) considered this aspect of case studies important for improving reliability of findings and enabling a degree of triangulation between different types of data (Jick 1979). From an interpretivist perspective, case studies based primary on interview data are considered most appropriate (Meredith 1998). Interviews allow the development of understanding of the world from the subjects' point of view (Kvale and Brinkman 2009). This view is consistent with Stuart *et al.* (2002), who stated that "*the most important data come from analyzing and interpreting what individuals are trying to say*" (p.427). Interviews allow interaction with practitioners to discuss the processes that are in place and how practitioners interact with them, that will be necessary for addressing the three research questions.

Holstein and Gubrium (2004) considered that emphasising facts alone was like viewing an interview as simply a knowledge pipeline, through which knowledge was extracted as interviewees answered defined, survey style questions. Stuart *et al.* (2002) even highlighted that tightly defined interview protocols may get in the way of collecting the best information (p.425). Kvale and Brinkman (2009, p.48) defined this as perceiving the interviewer as a miner, extracting valuable knowledge in an unaltered form. Unless the construct/phenomena under investigation was well understood, with very little ambiguity between the researcher and the subject, misinterpretation of data was considered likely. Handfield and Melnyk (1998) highlighted the importance of matching research techniques with the nature of the research problem.

Section 2.2 presented the wide range of perspectives on, definitions and aspects of process improvement. Section 2.4 outlined the range of models of organisational learning employed within operations management. To account for the wide-range of definitions, testing posits related to process improvement or organisational learning was considered inappropriate within initial stages of the research. Instead discussions need to be initiated in a manner that allowed interview candidates to discuss these topics in their own terms related to their own experiences (Miller and Glassner 2004). Also researching organisational learning in SMEs, Zhang *et al.* (2006) asked questions about specific episodes to initiate discussions. This is considered important within interpretivist research, to move away from standard or rehearsed responses to questions (Radnor 2001, p.103) and reduce bias associated with posing leading questions (Kvale and Brinkman 2009, p.301). For example, practitioners may consider process improvement as the application of quality management tools by quality professionals as presented in section 2.2. Defined questions on process improvement may elicit rehearsed responses about interviewees' knowledge of quality tools, which may provide limited value for addressing exploratory research questions.

To address the potential risks of misinterpretation when not asking defined, unambiguous interview questions, there is a need for an active approach to interviewing, where shared understanding of topics is created during the data collection process (Holstein and Gubrium 2004). Within this setting, common examples can provide a means of ensuring topics have been correctly understood by the interviewer or interviewee, which can help improve the reliability of data (Radnor 2001, p.108). A structured interview, with defined interview questions would not allow the development of shared understanding, so increasing the risk of misunderstanding of interview topics.

Crotty (2003) highlighted the need for consistent epistemology, theoretical perspective, methodology and methods. The approaches selected for the current research are the highlighted elements of Table 3.1, showing consistency between them. The selection of research methods is also shown to be appropriate with consideration of Saunders *et al.*'s (2007) "Research Design Onion" (Figure 3.1). As the research progresses and understanding is developed about process improvement and organisational learning by addressing research question 1 and 2, the research will become more deductive in nature (demonstrated by the arrows). However, efforts were made to manage the interplay between theory and context, to allow for inductive insight during the deductive stages of the research. The approach reflects the types of case studies McCutcheon and Meredith (1993) described where "*the researcher may take an* *interpretive approach in understanding and explaining the data or a more positivist approach*" (p.244). This was operationalized by the exploratory phase focusing upon developing understanding of operational processes and practices of practitioners. The confirmatory phase then attempted to determine the relevance of the researcher's externally developed perspective on process improvement to operational practices within other firms.

Table 3.1: Relating the four elements of research design together, (adapted from Crotty 2003; p5)

Epistemology	Theoretical Perspective	Methodology	Methods
Objectivism Constructionism **Subjectivism** (and their variants)	Positivism (and post-positivism) **Interpretivism** **- Symbolic interactionism** **- Phenomenology** Etc.	Experimental research Survey research **Ethnography** **Phenomenological research** **Grounded theory** Action research Etc.	Sampling Measurement and scaling Questionnaire **Observation** **-Participant** **- Non-participant** **Interviews** **Focus Group** **Case study** Narrative Comparative analysis Interpretative methods Etc.

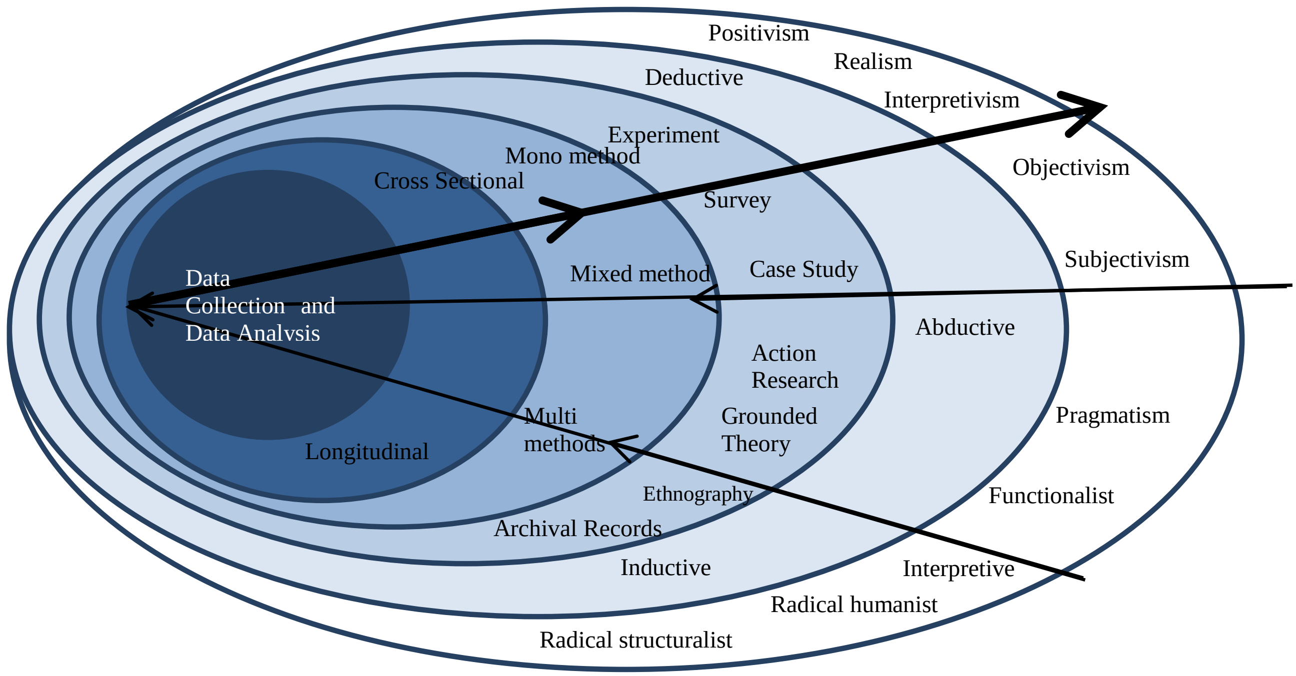

Figure 3.1: The Research Onion (adapted from Saunders *et al.* 2008, p102)

The exploratory phase of the research was primarily inductive, focusing on discovering, describing and mapping process improvement practices in order to identify and explore relationships (McCutcheon and Meredith 1993; Handfield and Melnyk 1998). While process improvement practices were explored, the frameworks presented within Table 2.3 provided a means of assessing the relative applicability of the different organisational learning frameworks. This highlights aspects of a deductive research appropriate for addressing research question 2, but still aiming to develop understanding of the relative applicability of the different models of organisational learning. Established theoretical frameworks were considered to provide construct validity for this element of the exploratory phase (McCutcheon and Meredith 1993, p245).

Following the exploratory phase of the research, the confirmatory stage gave greater emphasis to confirmation and deduction. By taking a more positivist approach to collecting and analysing data, it was possible to confirm the findings from research questions 1 and 2, and allow finer-grained analysis from addressing research question 3. This approach guides the research as a whole towards an abductive research approach (Järvensivu and Törnroos 2010) that is both inductive and deductive, which is broadly consistent with an interpretivist approach to research.

3.3 Research Design

The decision about research design has been strongly influenced by the author's ontological and epistemological viewpoint. As stated previously, primarily interview-based case studies will be used to explore process improvement practices and to assess the applicability of competing theories of organisational learning. Initially, this indicates the need for a theory building case study approach (Eisenhardt 1989; Meredith 1998). Theory building allows in-depth research into social phenomena that may not be fully understood (Handfield and Melnyk 1998). While Yin (2009) repeatedly stressed case studies as a methodology able to achieve scientific rigour, consistent with the positivist epistemology he shares with Eisenhardt (1989), the exploratory phase of the current research did not aim to test posited hypotheses. Importantly, the time at which Eisenhardt's (1989) work was written reflects the infancy of qualitative, management research, illustrated by her use of quantitative terminology. With the literature presented in section 2.2 being unable to provide the author with a suitably refined analysis framework for process improvement, such forms of case studies appear inappropriate.

From an alternative perspective, Meredith (1998) and Stuart *et al.* (2002) appreciated case studies as complimentary, rather than alternative research methodologies to large scale, quantitative surveys. Case studies were presented as a means of investigating, without necessarily having to confirm particular rules or present general, normative theory. McCutcheon and Meredith (1993) stated the importance of interpretation within case study research and the importance of research maintaining a logical analysis process to ensure rigour. Although raising questions of the inherent subjectivity of case research, by acknowledging and accounting for it, issues can at least be addressed rather than leaving them "*cloaked in objectivity*", as survey instruments often are (McCutcheon and Meredith 1993, p.244). This risk is further reduced in the current research due to the pragmatic research philosophy, which allows interpretations to be validated with data from a variety of sources, such as the types of products a company produces, introduction of new machinery or changes in number of employees.

Case studies also provide a foundation upon which large scale forms of research can build (Handfield and Melnyk 1998). McCutcheon and Meredith (1993) explicitly stated that case studies were a "*good method for developing robust operational measures*" (p.251) necessary for effective survey-based research. Consequently, on completion of exploratory case studies, there was greater understanding of process improvement and organisational learning, allowing more positivist forms of research. This allowed the use of more defined research methods within the confirmatory phase of the research to test the findings from the exploratory phase. Table 3.2 presents the research objectives with the different stages of the research process and research methods used.

Table 3.2: Research Objectives and the research process

Objective	Research Process	Research Method
1) Identify the organisational learning theories used within operations management	Preparatory	Systematic Literature Review
2) Select the major organisational learning frameworks used within operations management	Preparatory	Citation and Co-citation Analysis
3) Identify process improvement practices within engineering-oriented SMEs (RQ1)	Phase 1	Exploratory Case Studies
4) Explore the relevance of identified models of organisational learning within engineering-oriented SMEs (RQ2)	Phase 1	Exploratory Case Studies
5) Identify topics affecting and affected by process improvement within engineering-oriented SMEs (RQ3)	Phase 1	Exploratory Case Studies
6) Confirm the relevance of identified topics to the effectiveness of process improvement within additional firms and determine how organisational learning contributed to understanding of process improvement (RQ3)	Phase 2	Confirmatory Case Studies

3.3.1 Exploratory Case Study Research Design

The research design of the exploratory phase of the research was informed Yin (2009), who stated that case study research was "*A linear but iterative process*" (p.1).

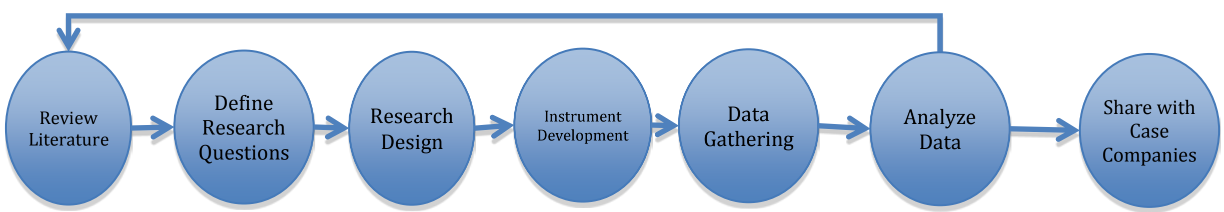

Figure 3.2: Exploratory Research Design

Combining the view of Yin (2009) with Stuart *et al.*'s (2002, p.420) "*research process model*", Figure 3.2 represents the exploratory phase research design, where following analysis of data, further data collection was refined to account for initial findings.

Chapter 2 presented a need to undertake research that drew on both process improvement and organisational learning as central themes. Consequently, while the theoretical and logical justification for a connection was argued within chapter 2, there was limited empirical evidence connecting the two topics. To determine whether there was a relationship in practice, it was necessary to undertake initial data collection before conducting the main body of the exploratory phase of the research. Stuart *et al.* (2002) stated that such initial interviews (or pilot cases) should be conducted locally, to allow interview protocols and selection criteria to be refined inexpensively, while developing understanding of the domain and the phenomenon under investigation.

3.3.2 Exploratory Case Study Data Collection

Initial interviews were conducted with established connections, with whom the author had previously conducted research (Matthews 2008; Matthews 2010) or had professional experience with. The nature of the connections provided a foundation on which to secure interviews when the research was in an undeveloped form. Initial data collections served, to a degree, as a pilot, initially exploring research questions and context, while also allowing the relevance of the research to be critically discussed with practitioners (Yin 2009). The previous involvement with these companies provided a rich source of data related to the context under investigation (Reimer 1977), which when combined with the rapport and trust established with the interviewees reduced the risk of interview discussions being misinterpreted (Miller and Glassner 2004).

The primary topics of discussion within the initial interviews were operational practices, process improvement, resolving non-conformances identified by customers and product development. Drawing from Chapter 2, process improvement can be considered the process of identifying an opportunity for improvement, developing a solution, implementing the solution and then maintaining the change. Discussing how the firms addressed non-conformances represents a means of researching process improvement, and if the organisation was able to learn from non-conforming parts and prevent recurrence, it also represents an example of organisational learning (Crossan *et al.* 1999; Bontis *et al.* 2002).

Linderman *et al.* (2003) considered that improvement projects could relate to both processes and products. This is consistent with Juran (1951), who stated that improvements to products could result from improvements to processes and Bayus (1995) who considered process improvement was interlinked with product improvements.

Consequently, discussions related to improving products represented an alternative perspective from which to view process improvement. Finally, the role of training, quality management accreditation and general firm performance were also included within discussions on process improvement. Firm performance was defined in general terms in relation to increases in the profitability of work, increases in added value and customer satisfaction, consistent with the benefits SMEs realise from process improvement presented in section 2.3. Following initial interviews, preliminary analysis and reviewing additional literature, an interview protocol was developed that was informed by the protocol used by Anand *et al.* (2009) (Appendix 3.1). While including defined questions, the protocol was used to provide structure to interview discussions, ensuring key topics were covered (McCutcheon and Meredith 1993), so were often not asked directly. The interview protocol provided greater structure to subsequent data collection, while leaving sufficient flexibility to allow the emergence of additional topics from rich discussions with practitioners.

Initial data collection consisted of three informal interviews with two established contacts and a consultant employed by one of the established contacts. In addition to providing preliminary data on process improvement and organisational learning, the initial data collection also informed the firm selection criteria. Both firms were SMEs (<100 employees), with ISO accredited QMS (although in one, it had lapsed). As stated in section 2.2.5, an externally accredited QMS provides a stronger foundation on which to base discussions due to the presence and continual review of operational procedures. Operational procedures also related discussions indirectly to learning, that was promoted through the repeated use of procedures (Benner and Veloso 2008). The presence of the accredited QMS also inferred there was a requirement to plan, initiate and demonstrate improvements to external parties on receipt of non-conformances (either customers or third-party auditors). The presence of an ISO accredited QMS was considered to provide an important selection criterion for researching both process improvement and organisational learning.

While research previously conducted by the author provided a rich foundation on which to base data collected from the Building Contractor, the complex operating environment and involvement of multiple parties was considered too complex to effectively research. Injection Moulding 1 provided a more appropriate firm type, engaging with tangible operational processes within a single unit. Due to the richness of data collected from the Building Contractor, it remained within the research to extend the range of firms involved in the exploratory phase.

The size of SMEs was considered to assist PhD research, due to its limited time frame and resources. A small group or even a single, appropriately placed individual can be considered representative of the firm as a whole (Lumpkin and Dess 1996) or at least have a relatively complete view of operational activities (Laforet 2011).

Table 3.3: Nottingham Population Profile

Firm Sector

	Rubbers and Plastics	Engineering Services
Nottingham	19	358

Firm Size

Not given	1-20	21-100	101-250	>250
82	261	71	16	8

Additional firms were identified using a business directory (Applegate[8]) from the sectors of 'plastics & rubber' and 'engineering services' sections in the Nottingham area (Table 3.3). This selection criterion was consistent with those of survey-based research related to process improvement. For example, fabricated metal, rubber, and measuring, analysing and controlling instruments were well represented within related research (see Kaynak 2003; Tu *et al.* 2006; Swink and Nair 2007; Zu *et al.* 2008). Defining the search criteria as engineering-oriented allowed the inclusion of firms operating as primary or secondary contractors. With such contractors not owning the materials they work on, by definition, they can be considered service providers (Roth and Menor 2003; Pawar *et al.* 2009), meaning they could be excluded if a strict manufacturing selection criterion was employed. Due to service-oriented firms often engaging with the same process

[8] www.applegate.co.uk

improvement methodologies as manufacturing firms (Antony *et al.* 2007), their inclusion was considered appropriate. This selection criterion also meant the Building Contractor could be included. The engineering-oriented criteria also ensured sufficient competences were present within each firm to undertake process improvements internally, without the need for external support.

Details of all firms with company websites included within the directory, with less than 250 employees were documented (~100). From this list, five firms were selected at random, and introductory letters outlining the proposed research were sent to managing directors (or equivalent) of each firm by email and post (Appendix 3.2). This was repeated four times, with follow-up emails and letters sent to firms that had already been contacted. This resulted in a single response from a firm that was unable to be involved in the research at that time. Although the economic climate may have affected the response rate, the level of response may also reflect the amount of requests firms receive, the low impact of relatively impersonal letters and the limited resources of SMEs to direct to non-revenue generating activities. This was illustrated by two Directors involved in the exploratory phase receiving, reading the letter and being interested in the content, but not responding, which provided some evidence for this tendency. However, this was likely to be one of many possible explanations for non-responses. Following this low level of response, an alternative strategy of contacting firms directly was pursued, including some of those already contacted.

Firms were selected from the initial database and contacted by telephone. Firms were chosen that described their business on their website in a manner that covered topics of process improvement and stating that they held an ISO accredited QMS. For the firms that had already been contacted, the initial letter provided a basis for the discussion, allowing the topics to be fleshed out and highlighting the potential value of the research. By maintaining a broad selection criteria, diverse perspectives on process improvement could be acquired, which is important for exploratory research (Siggelkow 2007). Out of 15 selected firms, contact was made with appropriate individuals (primarily the Managing Director) in eight firms; four of these firms were involved in the research. With all willing companies being interviewed, although implicit bias of firms interested in improvement may have been present, diversity of the exploratory cases companies was maximised.

The exploratory interviews were directed by the research protocol (Appendix 3.1) to promote the repeatability of interviews. Consistent with McCutcheon and Meredith (1993) "*Interviews may be structured to ensure coverage of key topics but the interview format is generally open-ended, allowing the interviewer to explore areas that come to light during the course of discussion*", (p.241), rather than a tightly defined interview script. The structure of the protocol allowed the impact of process improvement activities to be considered from a number of different perspectives and related to a range of benefits firms were able to realise from process improvement. This approach to interviewing also addressed an issue raised by Mihaly Csikzentmihalyi (1996) in relation to exploring an area of interest with experts:

> "*I felt, however, that it would be insulting, and therefore counterproductive, to force these respondents to answer a mechanically structured set of questions. Because I hope to get genuine and reflective answers, I let the exchanges develop around themes I was interested in, instead of forcing them into a mould.*" (p.16)

The discussion topics covered numerous operational levels, from individuals receiving information about non-conforming parts to organisational processes being changed. This provided rich details of process improvement activities necessary for addressing research question 1. By covering numerous organisational levels, involvement of external parties and the ability to improve over time, data was also collected that was able to address research question 2. As stated previously, it was considered important not to pose questions specifically about process improvement or organisational learning, as without being directed to draw from their experiences, response richness may have been limited (Radnor 2001, p.103).

As stated in section 3.2, the interview moved away from closed ended questions, instead aiming to elicit rich stories about concrete episodes of process improvements (Kvale and Brinkman 2009). This allowed interviewees to describe how they perceived activities in their own terms, important for interpretive research (Radnor 2001). In comparison to this approach, Yeung *et al.* (2007) asked questions such as "*Do you believe that an employee's ability to learn is the key to improvement?*" (p.2475). Asking such direct questions, while providing data specifically related to aspects of interest to the research, implies the importance of particular topics to interviewees, leading interviewees and potentially biasing responses. To address this issue, interviews had similarities with therapeutic interviews, where through a process of reflection, interviewees were able to develop a better understanding or indeed "*verstehen*" of their own processes (Kvale and Brinkman 2009, p.39-40). While data collection instruments were not related to eliciting particular data, the link or chain of evidence (Yin 2009, p.123) between interview topics, interview questions and research questions is presented in Table 3.4. This provides justification for related broad discussions on topics related to process improvement to addressing research questions related to process improvement and organisational learning.

Table 3.4: Chain of Evidence from Protocol to Research Questions

Interview Protocol Topic	Contribution	Case Study Analysis Framework	Research Question Addressed
Nature of your job	Rich contextual information	Supported by website information	n/a allowed findings to be located within practice
Process improvement initiative in place	Confirms they have an ISO system in place	Supported by website information	n/a locates findings within previously collected data, process improvement and organisational learning
Training	Individual focused learning activities in place	Compare process improvement topics and 3 models of OL	RQ1 & RQ2
		Analyse in relation to 3 OL Models	RQ2
Process Improvement	Identifies practices	Describe process improvement activities	RQ1
		Analyse in relation to 3 OL Models	RQ2
Structured approach to problem solving	Policies specifically related to process improvement	Process improvement topics and 3 models of OL	RQ1 & RQ2
New Product Development	Represents more exploratory types of learning	Process improvement topics and 3 OL models	RQ1 & RQ2
		Analyse in relation to 3 OL models	RQ2
Process Review			
How is employee performance assessed?	How are employees engaged with the operating system?	Describe how this contributes to process improvement	RQ1
		Analyse in relation to 3 OL models	RQ2
		Compare process improvement topics and 3 models of OL	RQ1 & RQ2
How is the ISO system perceived?	Overall insight of how the operating systems are perceived	Compare process improvement topics and 3 models of OL	RQ1 & RQ2
		Analyse in relation to 3 OL models	RQ2
Performance	How do PI activities affect performance?	Compare process improvement topics and 3 models of OL	RQ1 & RQ2
		Analyse in relation to 3 OL models	RQ2

Due to the firms identified from the Applegate database being new contacts for the author, the development of trust and credibility with each firm had to be given attention, to assist in securing further involvement (Stuart *et al.* 2002). Following the initial interviews with new contacts, a brief company-specific report was prepared and returned to each firm, offering an outline of the topics discussed (for example report see Appendix 3.3). This allowed initial feedback before the transcription of interviews and in-depth analysis was carried out. The report had four purposes; firstly, the report ensured that any primary data collection and initial interpretations of the firm were captured, similar to a contact summary form (Miles and Huberman 1994) that was employed by Guinery (2006). Secondly, it allowed the researcher to articulate the topics of the discussion, and by returning them to the interviewee, could ensure the interpretation was accurate, improving internal validity (Kvale and Brinkman 2009; Yin 2009). Thirdly, the reports allowed each of the firms to appreciate how they could benefit from further involvement in the research. Finally, the report provided quick feedback for participants that is often not possible with qualitative research (Leonard-Barton 1990). When combined with the practical experience (in engineering and quality management) of the author, these practices were considered critical to building trust with companies, which led to further engagement. This was demonstrated by one participant commenting on the attention the author gave to relationship management and each firm agreeing to be involved in further interviews both within and outside the management team.

Details of each of the six firms are presented in Table 3.5, including interviews conducted with the two established contacts.

Table 3.5: Exploratory Case Study Summaries

Company Name	Staff	Industry	Market	QMS	Number of Interviews	Interview participants	Total time	Additional Data Sources
BC	49	Construction	Residential/ Care homes/ Various	ISO 9001	4	Managing Director (MD), Quality Consultant, Project Managers	9h	Website, Customer and supplier interviews, site tours, 10 site meetings, follow-up meeting
IJ1	73	Injection Moulding	Automotive/ Various	ISO 9001 lapsed	3	Production manager, project manager, assistant operations manager	5h 30m	Website, Site Tour, 2.5 years professional involvement as a customer, follow-up meeting
IJ2	35	Injection Moulding	Double glazing/ Various	ISO 9001	4	MD, Project manager and production Manager	6h	Website, follow-up meeting
SI	25	Advanced Manufacturing Equipment	Manufacturing Companies	ISO 9001	3	2 x Directors and Project Engineer	7h 40m	Website and associated website
EM1	23	Sheet Metal	Various	ISO 9001	4	MD, General Manager, project Engineer	5h	Website, Site Tour, follow-up meeting
EM2	10	Compression Plastics	Oil/ Gas/ Various	ISO 9001	2	MD	3h	Website, initial meeting, site tour, second informal meeting 1 year on
					20		**36h 10m**	

When numerous interviews were conducted within a firm, the research protocol (Appendix 3.1) was re-administered to promote consistency (McCutcheon and Meredith 1993; Yin 2009). However, company-specific changes were made to the protocol for follow-up meetings on the review of interview recordings and the summary report. This process allowed both the exploration and confirmation of specific topics, while also demonstrating the interest of the researcher in the company. Interviews were on average over 2 hours in length, ranging from 1h 20m to over 3 hours. All formal interviews were recorded with the explicit consent of the interviewees.

As stated in section 3.2, interview questions were not tightly defined or closed ended due it being important for the interviewer to allow interviewees to described practices in their own terms. This process was supported by the length of interviews that allowed the important aspects of process improvement to emerge from discussions on the topics included in the interview protocol. Consistent with a funnel model of interviewing (Voss *et al.* 2002), more sensitive topics were introduced at the end of interviews, for example the general perceptions of the ISO 9001 initiative. Recordings were transcribed verbatim (resulting in over 750 pages of transcription) with the resulting interview data being combined with observational data collected during site visits to make up the case study database. The additional sources of data are considered important for validating interpretivist research by providing "*interpretive renderings of sounder quality*" (Radnor 2001, p.51). Such an approach to data collection could also be considered a form of opportunistic research (Reimer 1977), where more subtle insights could be gathered than those available through interviewing alone.

When interviews were conducted with organisational members outside the management team, the context of the interview needed to be carefully considered (Miller and Glassner 2004). Without developing trust and appreciating power dynamics that may be created by the researcher's previous contact with management, the data collection process may be affected (Kvale and Brinkman 2009, p.33-34). To address this, questions were tailored to account for the specific role of interview subjects, to assist in focusing data collection on operational practices and developing trust with interviewees. Rather than discussions about impersonal processes, discussions were oriented around the practitioner's responsibilities, such as "*what's your involvement…?*" or "*how did you get into…?*". This process was considered important for the author not to undermine the practical abilities of the research subjects, who may perceive academic research in a particular light (removed from practice, IJ1, P.142). The professional experience of the author played an important role in addressing this issue, which was commented upon by interviewees, due to the author's ability to relate to and contribute day-to-day operational stories to interviews (for example, one interviewee said "*it's good you've worked in similar sort of surroundings*" (MD, EM2)).

The aims of the exploratory case studies were to explore how each company undertook process improvement (RQ1) and determine the applicability of the identified models of organisational learning (RQ2). To ensure aims were achieved, it was considered appropriate to return to the exploratory case companies following analysis. This enabled the validation of findings by ensuring they were relevant to those operating within the exploratory case companies, thus confirming face and internal validity (Yin 2009). Findings were validated within follow-up workshops by presenting findings and discussing them with previously interviewed research participants. The follow-up interviews allowed the emergent themes to be discussed, critiqued and extended, based on the interviewees' perceptions of the different topics. These were initiated via emails, letters, telephone calls or site visits, which resulted in meetings with five of the six firms, four of which were conducted as interviews, recorded and used to augment the discussion section of the exploratory phase. The fifth meeting was informal, and although a follow-up was verbally arranged, no formal interview was conducted.

Each firm was provided with a copy of their firm-specific case report (including those not involved in follow-up interviews) to allow them to benefit from the research. Firms were also provided with initial cross-case analysis (based on Chapter 5), to allow them to assess their practices against other, similar firms. With the pretence of the research originally being access to comparative information of firms within their domain, sharing cross-case findings were considered important for 'rounding off' the engagement. This has been stated as good research practice (Squire 2011).

Follow-up interviews were oriented around exploring how each firm had progressed since the exploratory interviews. They covered topics of recruitment, new business development and general business, but primarily focused on process improvement during the period following initial data collection. These interviews lasted from half an hour for the unrecorded interview to between 90 and 140 minutes, resulting in a further 7 and a half hours of recorded interviews. Each of the formal interviews was structured around a presentation that covered the findings of the exploratory phase of the research (Appendix 3.4). The presentation provided a foundation on which to base discussions related to the emergent themes. The presentation included definitions of the emergent themes, which ensured discussions were based on consistent conceptualisations of the terms, ensuring construct validity. This process provided data specifically directed by the findings from the exploratory research to enable the validation of the emergent themes as relevant to practitioners before confirmatory data collection began. The process also allowed piloting and refinement of a revised interview protocol that was used within the confirmatory phase of the research.

3.3.3 Confirmatory Case Study Research Design

Following the exploration of process improvement practices and organisational learning theories within engineering-oriented SMEs, the confirmatory stage aimed to confirm the applicability of findings of the exploratory phase (RQ1 and RQ2) within additional engineering-oriented SMEs. The confirmatory phase also aimed to explore in greater depth the contribution organisational learning was able to make to understanding of process improvement. Following initial confirmation of emergent themes with the exploratory case companies, to determine the relevance of the emergent themes, additional literature was reviewed to identify relevant conceptualisations of the themes. On identifying relevant definitions and conceptualisations in the form of primarily measurement constructs, it was possible to develop a "*more positivist*" (McCutcheon and Meredith 1993) interview protocol for the confirmatory stage (Appendix 3.5). This protocol included specific questions developed from measurement constructs to structure data collection and to test the relevance of the identified themes to other similar organisations. Within these interviews, the protocol guided the interviewer to discuss particular aspects of the emergent themes with practitioners. The protocol also provided a coding framework for analysing the data collected from the confirmatory phase of the research. Figure 3.3 represents the research design of the confirmatory phase of the research.

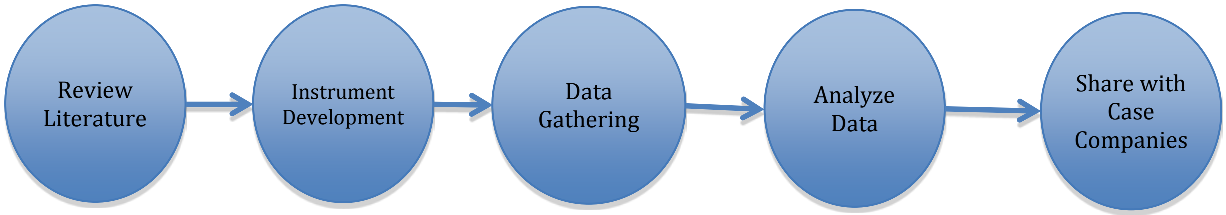

Figure 3.3: Confirmatory Phase Research Design (Adapted from Stuart *et al.* 2002)

Due to the themes that were identified from the exploratory phase emerging from the discussions on process improvement, initiating questions related to process improvement were similar to those included within the exploratory phase of the research. However, due to the definitions of the emergent themes being defined it was necessary for the interviewee to be aware of the definitions before discussing the topics. In addition to the interview protocol, the presentation given within the exploratory workshops was reused to ensure all definitions were stated explicitly (Appendix 3.4), which assisted in guiding discussions to cover relevant topics. This ensured that data was based upon consistent definitions allowing the comparison of interview content in a more positivist manner (Krippendorff 2004). Maintaining a focus on eliciting rich stories from interviews ensured that discussion topics were defined by interviewees, reducing the need for the interviewer to pose leading questions (Kvale and Brinkman 2009).

3.3.4 Confirmatory Case Study Data Collection

To assess the relevance of the findings outside the six exploratory case companies and extend the research's external validity, interviews were conducted with additional engineering-oriented SMEs. Firms were identified from the same geographical and sector categories the exploratory cases were drawn from (Nottingham, Telford (IJ1) and Northampton (BC)) using the same company database[6]. With the diverse range of firms included within the exploratory stage of the research, the external validity of the emergent themes and preliminary conceptual model was potentially improved, reducing the need to identify theoretical replications (Yin 2009). Firms similar to the exploratory cases represented literal replications, assisting validation, confirmation and refinement of the findings from the exploratory phase.

Consistent with the additional interviews conducted with the exploratory case companies, the confirmatory interviews enabled data collection specifically related to confirming the findings of the exploratory phase. Additional data was also collected from related sources that included involvement with authorities on process improvement (Antony 2012) and sharing elements of the research findings with a range of academics in the form of prestigious academic conferences (see Marzec and Matthews 2012; Matthews *et al.* 2012; Matthews *et al.* 2013a; and Matthews *et al.* 2013b). This provided information on the relevance of the findings to practice, as well as assisting in the identification of additional relevant literature.

Companies were selected that had a company website on which ISO 9001:2008 accreditation could be identified and that had more than 20 employees (due to this information being present on the source database). The nature of the observations from EM2 inferred a qualitatively different context within micro organisations, due to the greater direct impact of management on operational processes. Involvement of slightly larger firms was considered important for assessing the findings within more complex management environments.

A letter (Appendix 3.6) outlining the research content, progress to date and requesting involvement of the firm was sent to firms that met the selection criteria. An email copy of the letter that was then followed up by a telephone call later accompanied the initial letter. Contact was aimed towards the Managing Director of the company, as the individual most likely to be able to initiate involvement with external parties. Letters and emails were sent to 36 companies. 28 of these companies were contacted by telephone, of these, messages were not returned by nine companies, seven companies were not interested or did not consider the research was relevant to them, three firms were too busy to be involved and one firm was involved with the Manufacturing Advisory Service. The remaining eight firms agreed to be involved in the research representing a satisfactory response rate of over 20%. Again, reflecting the difficult operating environment and resource constraints of SMEs, each firm involved wanted to know what they could expect to receive from involvement in the research before agreeing to participate. Following initial interviews, follow-up interviews were arranged with other members within those companies that were able to spare resources. The details of the confirmatory case companies and data collected with additional sources of data are presented in Table 3.6.

Table 3.6: Confirmatory Data Collection

Data Collected	Number of Contacts	Length	Participants	Relevance	Contribution
Academic Feedback	4	Email communications and conference presentations	Various academics within the field of operations management	Assess the relevance of the theory and topic of research	Introduced alternate perspectives from which to critique findings
Practitioner Training	Various	1 Week	Process improvement experts and process improvement practitioners	Assess the relevance of findings to an accepted improvement methodology (Six Sigma)	Confirmed the relevance of research to practice

Confirmatory Case Studies	Number of Staff	Number of interviews	Length	Participants	Additional Data Collection
Window Mechanism Assembler	43	1	1h 30m	Conformance Manager	Website, site tour
Folder Manufacturer	20	1	1h	Managing Director	Website, site tour
Injection Moulding 3	20	3	3h	Technical Director, Commercial Director and Production Manager	Website, site tour
Systems Integrator 2	40	3	4h	Sales and Marketing Director and Technical Support Engineer	Website, site tour
Engineering Manufacturer 3	64	3	3h 30m	Quality Manager, Production Manager and Managing Director	Website, Site tour
Engineering Manufacturer 4	65	1	1h 30m	Quality Assurance Manager	Website, site tour
Engineering Manufacturer 5	~100	1	2h	Managing Director	Website
Engineering Manufacturer 6	28	1	1h 30m	Managing Director	Website
Total		14	18h		

Table 3.7 presents how interview questions included within Appendix 3.5 initiated discussions on emergent themes and how they relate to addressing research question 3.

Table 3.7: Chain of Evidence

Interview Protocol Topic	Example interview question related to topic	Theme Covered	Contribution to addressing research question 3
Process improvement	When non-conforming parts are received from a customer, what is the process for implementing improvements?	Management support, Culture, Process Improvement and Benefits realised from process improvement	Provides rich contextual information about the procedures in place to undertake process improvements. These covered topics of management support, culture and benefits realised from process improvement.
While discussions on process improvement tended to cover the emergent themes, to elicit further information on the specific themes, additional questions were posed to explore the role of the emergent themes within process improvement activities.			
Management support	What involvement does management have in process improvement?	Management support, Culture, Process Improvement	Provides evidence related to how management enabled, supported and promoted process improvement by providing resources necessary for changes in behaviour and cognition.
Culture	How do members of staff perceive process improvement activities?	Culture, Process Improvement, Benefits realised from process improvement	Provides evidence related to how individuals perceived process improvement activities.
	How closely involved are you with customers and suppliers?	Culture, Benefits realised from process improvement	Provides evidence related to whether individuals within the firm directly add value to customers and increase their satisfaction
Benefit realised from process improvement	How do process improvement activities affect the customer?	Management support, Process Improvement, Benefits realised from process improvement	Provides evidence related to whether process improvement activities benefited customers and the firm as a whole

The interview protocol was developed using valid and reliable measurement constructs employed within high quality operations and general management research (Appendix 3.5). These constructs are considered to be able to measure the social phenomenon of interest (valid) and provide consistent results (reliable). The identification of these themes and measurement constructs was informed by the exploratory case findings. Measurement constructs on culture (Terziovski 2010) were contributed to by work on organisational culture by Schein (1990) that was combined with Radnor's (2001) interpretation of culture in terms of it being the result of shared definitions within an organisation. Management support was drawn from Samson and Terziovski's (1999) construct for leadership, which was complimented by Schein (1990). Consistent with the potential benefits firms could realise from process improvement identified within the exploratory case companies and presented in section 2.3, benefits realised from process improvement were also informed by Beltran-Martin *et al.*'s (2008) construct of organisational performance. This construct gave particular focus to customer satisfaction compared to relative performance or profitability that smaller firms may be unaware of or unwilling to share. The exploratory phase of the research provided a foundation for the content of process improvement, due to limitations in existing conceptualisations of process improvement (Powell 1995; Wolff and Pett 2006).

3.4 Data Analysis

3.4.1 Exploratory Case Analysis

The exploratory nature of phase one required an approach to analysis that was structured around the topics of discussions and the three models of organisational learning. This process allowed the emergence of themes relevant to process improvement and the development of the emergent themes from an organisational learning perspective. Due to the need to explore process improvement activities, coding was informed by discussions within section 2.2 but not structured by them. This included both discussions related to the resolution of quality non-conformances, changes to organisational processes and new product development activities. This process allowed initial open coding that allowed the identification of themes grounded in data (Glaser and Strauss 1967). Table 2.3 provided the secondary coding framework that was used to analyse discussions on process improvement from an organisational learning perspective. This process allowed more structured analysis through an accepted and appropriate theoretical lens (Amundson 1998). During the coding process, notes were also taken in relation to higher-level insight, which was used to inform subsequent analysis consistent with Radnor's (2001) 6 stage analysis technique for interpretivist research that was employed within Noke and Hughes (2010).

Portions of transcriptions related to particular codes were reviewed together. This allowed the exploration of process improvement activities and aspects of organisational learning activities across the six exploratory case companies. This reflects the approach taken by Crossan and Berdrow (2003) to explore processes of organisational learning.

The qualitative analysis software, NVivo9, was used to manage the case database. This allowed the frequency with which topics were referred to in different interviews to be compared and identify portions of transcript coded across multiple nodes, allowing the data to be explored as a whole (Crowley *et al.* 2002). NVivo9 also assisted in navigating the case database and maintaining the chain of evidence between quotes and source data.

Although analysis was conducted following data collection, it was possible to reach theoretical saturation within the exploratory phase, where additional interviews using the existing interview protocol would provide minimal incremental learning (Eisenhardt 1989, p.545). The data provided a range of perspectives on process improvement and the different aspects of the organisational learning coding framework. Six case companies was also within the range presented by Eisenhardt (1989) as sufficient to provide convincing findings without the volume of data and complexity making analysis unmanageable. The firm was considered the unit of analysis, resulting in an holistic, multi-case research design (Yin 2009, p46). An embedded multi-case approach was considered inappropriate due to the research being oriented towards relating process improvement to firm-level changes and the firm-level concept of organisational learning compared to individual learning. From this position, a multi-perspective presentation of most of the firms (five out of six) was possible, accounting for firm-level requirements (upper management) as well as operational nuances (project level).

Within interpretivist research, transparency of the data collection and analysis processes is considered an appropriate measure of validity (Radnor 2001). Transparency allows the reader to appreciate how the author arrived at conclusions by interpreting the raw data themselves. This was ensured by presenting connections between topics of discussion (Table 3.3) and within-case analysis being presented with evidence in the form of numerous direct quotations with logical interpretations. The emphasis on presenting rich within-case analysis also addresses a weakness of a lot of qualitative research presented by Eisenhardt and Graebner (2007). Drawing from Tracey *et al.* (2011), Figure 3.4 presents the data structure in order to summarize Table 3.4, highlighting how each interview topic contributed to each of the initial emergent themes (arrows represent how particular topics contributed to the emergent themes). While Tracey *et al.*'s (2011) work related to institutional entrepreneurship within social enterprises, so was not included within Chapter 2, the research qualitative methodology was relevant to the current research.

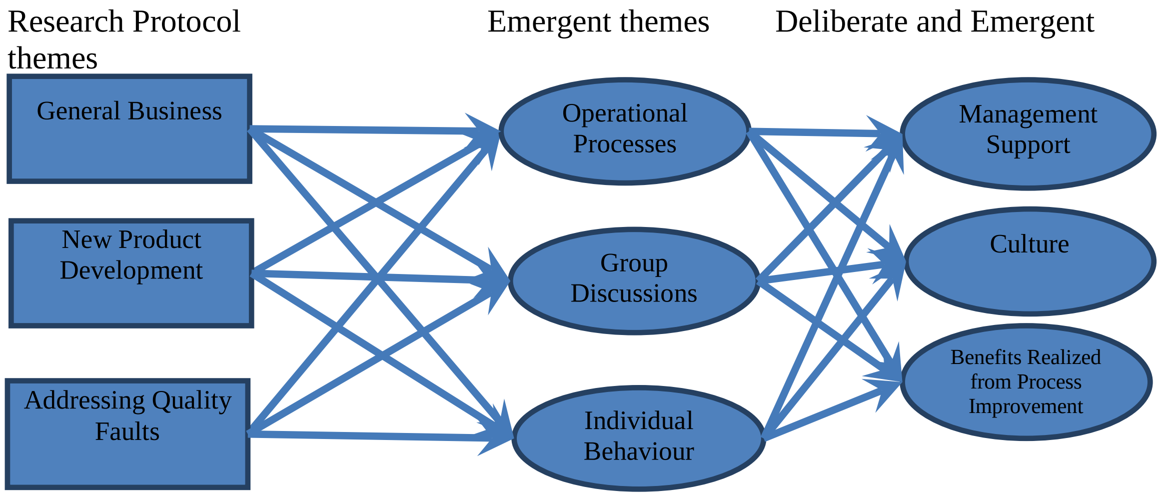

Figure 3.4: Data Structure of the Primary Analysis

The primary analysis provided the foundation for the within-case analysis that is presented in Chapter 4. By basing discussions on topics relevant to practitioners, case reports could be returned directly to the case companies, allowing them to be confirmed and substantiated (Noke and Hughes 2010, p141). Variations across the content of case reports reflect the particular emphasis given to the different topics within interviews, which ensured company-specific relevance of reports when returned. The within-case analysis provided the foundation for the cross-case analysis related to how the different firms engaged in process improvement. The cross-case analysis from a process improvement perspective is presented in Chapter 5.

The secondary analysis process also followed the structure presented by Tracey *et al.* (2011) but instead of exploring process improvement activities, the organisational learning coding framework presented in Table 2.3 was used to structure the analysis process. This process ensured a greater level of construct validity when analysing from a perspective that could provide accepted, theoretically underpinned definitions of the topic of interest. Figure 3.5 shows how discussion topics related to the different models of organisational learning and the identification of additional elements of the identified emergent themes. The dotted lines between the learning curve and the Schroeder *et al.* *(*2002) model represent how the emergent themes were not explicitly considered within these models.

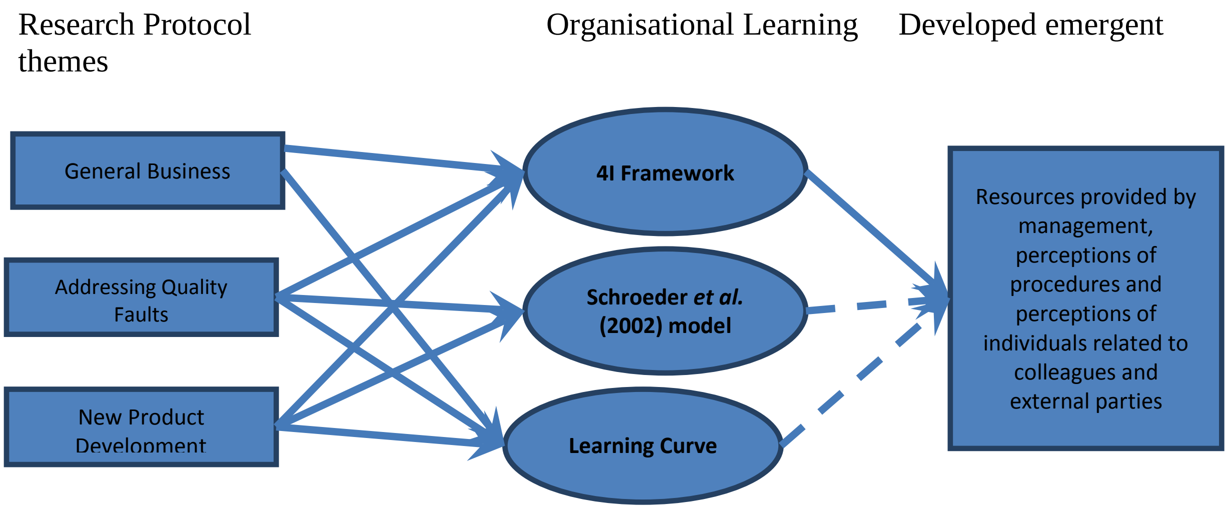

Figure 3.5: Data Structure of Initial Case Analysis

Analysing the data from an organisational learning perspective provided a structure upon which understanding of operational processes could be developed, such as the need for operational processes to take place at different organisational levels. Using NVivo9 to explore the different aspects of the three models of organisational learning, understanding of the role of organisational learning within the exploratory case companies could be developed. The cross-case analysis from an organisational learning perspective is presented in Chapter 6.

While the process improvement within-case analysis was conducted around the topics of the interviews, the secondary analysis provided a rigorously developed and theoretically underpinned structure for interpreting findings. The analysis approach was deemed necessary to address practice related issues experienced by each firm (Chapter 5), while simultaneously providing theoretically underpinned insight from an organisational learning perspective (Chapter 6). Reflecting Weick (1989; 1998), Csikszentmihalyi (1996), Starkey and Madan (2001) and Bartunek (2007; 2011), this process ensured initial insights were located within the domain, which was combined with theoretical understanding. This process effectively provided discipline to the theory development process (Weick 1989) to ensure relevance of insight to both practice and theory.

Following the cross-case analysis and presentation of emergent themes related to process improvement, the relevance of the emergent themes to the exploratory case companies was presented. This drew from the additional interviews described in section 3.3.2 conducted with four of the six exploratory case firms. This provided an initial assessment of the developed emergent themes in terms of their relevance and began to identify potential connections between the themes. While providing support for the relevance of the themes, the process also highlighted the need for further data collection. Chapter 8 will present discussions on Chapters 5 and 6 related to how research questions one and two were addressed within the exploratory phase.

3.4.2 Confirmation Case Study Analysis

Due to the confirmatory interviews being explicitly focused upon the themes identified during the analysis of process improvement activities and organisational learning, the emergent themes were the primary coding frameworks for the analysis of the confirmatory interviews. By confirming the relevance and content of the emergent themes, the confirmatory phase was able to confirm findings from the exploratory phase of the research. Reflecting the focus of the confirmatory interviews and resource constraints, recordings were partially transcribed. By transcribing extended portions of interviews, verbatim, in combination with noting the point within the recordings quotations occurred, the chain of evidence could be maintained with the source data (Yin 2009). From the 18 hours of confirmatory case interviews, this provided an additional 117 pages of transcription, compared to approximately 500 pages that could have been produced if transcribed in full. From previous transcriptions, a large number of these pages would have related to the author introducing the research, so was considered to provide limited contribution to the analysis process. This provides some justification in addition to the time and cost savings made by choosing not to fully transcribe all recordings from the confirmatory phase.

Preliminary data analysis was carried out during the data collection process to assess the relevance of case companies to the research. This resulted in two firms not being considered sufficiently engineering-oriented (Window mechanism assembler and Folder manufacturer). These firms experienced problems in undertaking process improvements due to possessing limited engineering capabilities, so were unable to address operational issues and improve processes internally (for additional information see Matthews *et al.* 2013b).

The data was coded in relation to the emergent themes that were identified within the exploratory phase using the qualitative analysis software NVivo9 as a means of structuring the data (Crowley *et al.* 2002). Where excerpts related to more than one theme, they were coded across multiple codes. Following initial coding, recordings were repeatedly listened to and transcripts repeatedly read to ensure codes were consistent with the selected definition and content of each emergent theme. Initially, this allowed confirmation that the interview protocol had been used appropriately by ensuring that each interview covered each emergent theme (Appendix 3.7). The emphasis given to each of the emergent themes within each interview could also be compared. This enabled those interviews were only single interviews were conducted to be compared with other interviews to determine whether they could be included within the analysis. Although multiple interviews with each firm would have been ideal, due to the workload of some of the companies this was not possible. Rather than removing single respondents from the case database, by assessing whether these interviews were similar to those with multiple respondents they could be included. This ensured that the findings of the research could be assessed in relation to a larger number of firms, without being excessively influenced by extreme cases.

Source and node cluster analysis functions available within NVivo9 were used to explore the similarities and differences between the interviews. This enabled the similarities of words used within interviews to be compared quantitatively. With two interviews being conducted with the same person in one company (SI2), the consistency with which interview topics were covered could be assessed within a controlled environment. The initial analysis conducted is presented in Appendix 3.7 is represented by Figure 3.6.

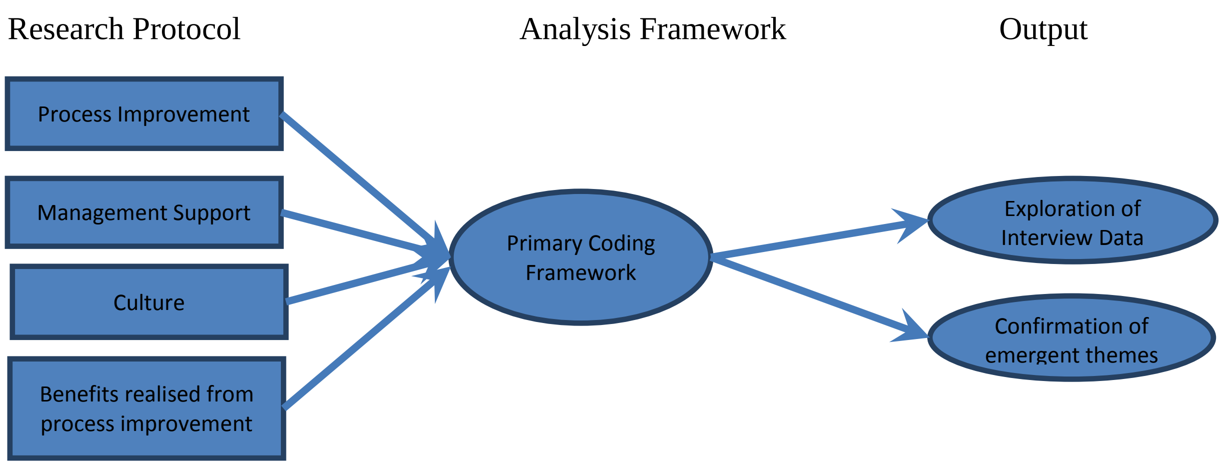

Figure 3.6: Initial analysis of confirmatory phase

Following the assessment of how consistently the interview protocol was administered, the relationships between the different themes were analysed. This allowed the further exploration of the connections identified within the exploratory case analysis. Excerpts coded simultaneously across different themes were identified using the matrix-coding query function within NVivo9. This provided evidence on how the emergent themes related to one another, with further word similarity cluster analysis showing the similarity of the different themes. However, the high number of excerpts coding across numerous themes meant that a second coding framework was employed, to focus upon the specific connections between the different themes.

The finer-grained secondary coding framework allowed specific relationships to be identified that appeared across multiple interviews. By "*enfolding literature*" (Eisenhardt 1989, p.544-545) it was possible to relate the individual propositions to organisational learning theory. By focusing upon the individual propositions, it was possible to determine the level of support across the companies and interviews, as well as the direction of the relationships, consistent with other exploratory research on process improvement (Nair *et al.* 2011). Figure 3.7 represents the data structure of the secondary coding framework of the confirmatory case data.

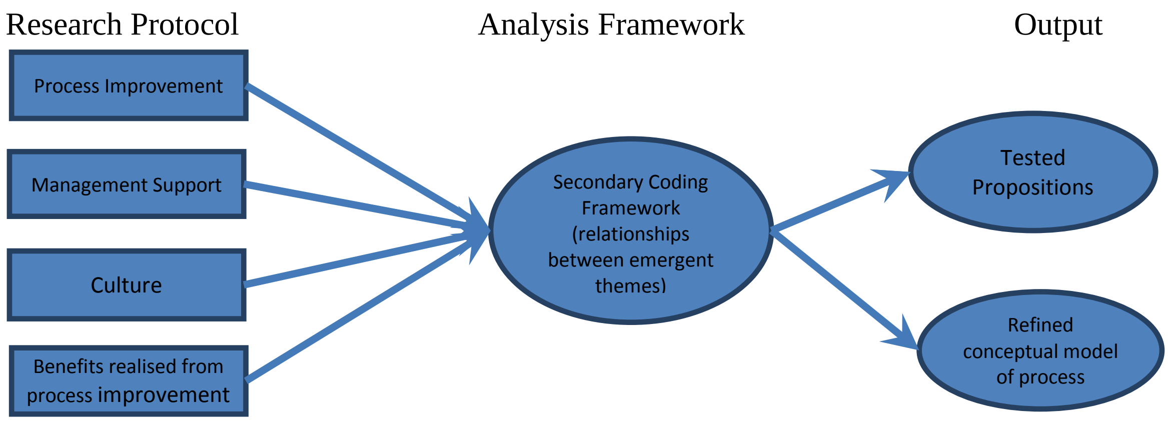

Figure 3.7: Confirmatory case study data structure

Figure 3.7 presents the data structure of the secondary confirmatory case analysis and the outputs of the confirmatory phase. The secondary coding framework related to the analysis of each of the relationships between the emergent themes. The data presented within Appendix 3.7 allowed the confirmation of the emergent themes identified within the exploratory case studies, and the exploration of research propositions, which are presented in Chapter 7.

During the confirmatory case studies, data collection and analysis were conducted simultaneously, which allowed interviews to be conducted until theoretical saturation was reached (Eisenhardt 1989). While the confirmatory interview protocol was strongly influenced by survey-based measurement constructs, it "*should not be misconstrued as a "small-sample survey*"" (McCutcheon and Meredith 1993, p.246). The objective was to accumulate evidence appropriate for validating and confirming the exploratory phase of the research and further explore the role of organisational learning within process improvement activities. To prevent this stage of the research being construed as an attempted to "*substitute words for numbers*" (Crowley *et al.* 2002, p.193), extended interview excerpts provided evidence related to connections between the different themes. Excerpts were interpreted in relation to the context of each firm.

3.5 Chapter Review

This chapter has outlined the ontological (worldview), epistemological and theoretical perspectives, followed by outlining the methodological, data collection and data analysis approaches that were used within the research. Importantly, due to the requirement of operations management research to be relevant to practitioners, the approaches chosen reflected this, basing the justification for worldviews and epistemology upon the nature of process improvement and organisational learning. Due to the need to develop an understanding of how practitioners view and interact with their operating environment, an interpretivist approach to researching process improvement was considered necessary.

The data collection and analysis process was described, in the form of exploratory and confirmatory case studies. The exploratory phases consisted of a two-stage analysis process that was structured by the interview topics and organisational learning coding frameworks. By presenting within case analysis in a manner focused around discussions related to practice, the practical relevance of reports could be ensured, allowing them to be returned to case companies for review and confirmation. The confirmatory case study analysis allowed the emergent themes identified and developed during the exploratory phase to be explored within new contexts. Having shared the research findings with the exploratory case companies, data collected from new case companies ensured the face, internal as well as the external validity of the findings.

Overall, this chapter has outlined a multi-element, multi-perspective research methodology, appropriate for research on process improvement and organisational learning within operations management. The following chapter presents within case analysis of the exploratory case companies.

Chapter 4: Exploratory Case Data and Within Case Analysis

The previous chapter presented the research design, methodology, data collection process and outlined how the data were analysed. This chapter reports on the within-case analysis of the exploratory phase of the research, described within sections 3.3.1, 3.3.2 and 3.4.1. Each exploratory case study is presented with an introduction to the operating context of the company before the main topics of the research protocol (Appendix 3.1 and Table 3.4) are discussed in turn, where operational development was the theme of discussions related to general business. Within case analysis is then presented, which includes relating the case data to the three models of organisational learning. The case companies are presented in the order in which the first interviews were conducted with each firm. This resulted in BC being the first case presented. This particular case was able to draw from previous research projects and draws indirectly from primary data collected during site meetings to provide additional context-specific information to the case discussions. While similar data was not present for the other five cases, where available, observational and secondary data was used to validate data collected from interviews. The variation in the data collected from each firm reflects variations in the topics discussed in relation to each exploratory case company. Summaries of each case are presented in Section 4.7, before the conclusion of this chapter.

4.1 The Building Contractor

BC was located in Northamptonshire, operating as a primary contractor on construction projects across a range of sectors throughout the UK. BC was established in 2001 to pursue business in the growing sectors of logistics and distribution facilities. It had focused primarily upon the construction of large warehouses and had built a reputation as "*the UK's leading 'shed' specialist*" (Netsquared 2011), growing the business to 50 people and over £80 million turnover by 2009. However, as a result of the global financial crisis of 2008, it had been necessary for BC to refocus their business. Many of their established customers had pursued highly leveraged projects, accessing bank funding before identifying potential clients. The global financial crisis had had a considerable impact on BC's clients' ability to secure such funding. The effect of this was demonstrated by the building industry having experienced two years of consistent decline in 2008 and 2009 (Lead-Edge.co.uk 2011). To address this contraction of their established market, BC were repositioning themselves at the time of the interviews into the public sector. To make this transition it had been necessary to implement an ISO9001 accredited QMS.

Although BC's reputation was based on delivering high specification projects, to budget and on schedule, the reputation could not be transferred to the public sector. The implementation of the QMS allowed BC to demonstrate to prospective customers they had externally validated systems in place to control operational processes. However, it was also necessary for BC to pursue related projects to demonstrate to public sector client they possessed the necessary competences to deliver public sector projects. Such projects allowed BC to refine and test their operating systems, providing evidence to prospective clients their newly implemented systems were fit for purpose. The related projects were the construction of care homes for the elderly that were more complex, had higher completion standards and lower profit margins than projects BC had experience building.

As stated in section 3.3.2, previous research projects, that had been conducted within the care home sector (Matthews 2008) and with BC (Matthews 2010), assisted in gaining access to BC. Before conducting the interviews for the current research, ten project meetings were attended on two of the care home projects, which were located in Nottingham and Dudley. This provided context rich data related to project-level discussions that were covered in the interviews, enabling interview data to be validated with observational data. In addition to the primary data collection from attending the project meetings, three exploratory interviews were conducted with BC. The first, conducted with the Managing Director, covered topics of general business, recent projects and the role of the QMS. This led to the second interview with the consultant that BC had employed to implement their QMS. This interview focused primarily on process improvement and operational procedures within BC and other SMEs the consultant worked with. The third interview was conducted with the project manager who had been the project manager on the Dudley project. This interview focused upon operational process improvement activities and the duties of the project manager. This resulted in a case database of numerous notes from attending meetings, site tours, discussions with customers, the company website and over ten hours of interview data which was codified into over 100 pages of transcription.

The aim of the case study is to explore the role process improvement played in allowing BC to compete in a difficult operating environment. This will be presented in three sections; operational development, product development and process improvement. Discussions on BC will conclude with within case analysis.

4.1.1 Operational Development

The difficult and changing business environment BC operated within highlighted the need for them to reposition their business to prevent them from being adversely affected by changes in a single sector.

> *"So we want to add a bit of robustness into the business as obviously being dependant on one, two, three, four clients all in the same sector is a bit risky"* (MD)

Expanding the scope of the business also provided BC with greater opportunities for growth. Having analysed the construction industry for potential areas of growth, the directors of BC had identified the public sector as one with opportunities for multi-million pound projects. However, as a knock-on effect of the global financial crisis, funding for such large projects had been removed by central government.

> *"They apparently had allocated 500 million... and then it was scrapped, but they've obviously got some of their own money... so hopefully we'll get [what's left over], well it's the student union building, they call it the social centre, it's a 4 million pound job"* (MD)

Although BC had to revise the aims of their growth strategy, securing smaller public projects had provided income and valuable experience for securing further work. Compared to the types of projects BC had experience with, public sector projects have specific requirements that included dealing with numerous parties simultaneously who may not be familiar with the building industry. As a result, experience of public sector or related projects was important to demonstrate BC could "*deal with those special circumstances… because they [public sector clients] are [very] awkward, there's no* *doubt about it*" (MD). To account for the requirements of public sector clients, operational procedures could provide a foundation on which to base decisions.

> *"I mean we've had two project managers from the client side change already, there is likely to be a third one coming in very shortly, so… all of that information about the fit out… and scoping work and how far they've got, what I've instructed and what they haven't has just walked out the door" (MD)*

Without operational procedures in place to formally document progress on projects, it would be more difficult (if not impossible) to verify progress following changes in personnel. The implementation of the ISO accredited QMS supported BC in this new situation, by ensuring experience and "*knowledge is transferred through the business*" (consultant). A more practical issue BC had to consider when moving across sectors was that compared to industrial warehouses, care home sites were considerably more compact, requiring more careful management.

> "*Crikey, I'm going to have an interface problem there, I've got three or four different trades all working in one area, it's like fire fighting, when you turn up on a Monday and you've got three or four trades working in that area, oh [no], you'll have to go home you can go and work over there, and you two are just going to fight out for the space*" (MD)

Without demonstrating they were able to account for the requirements of particular types of projects, oversights similar to the above example were described as resulting in project delays. In order to reduce the risk of such situations, BC had been able to "*put a system in place now that is much more managed*" (MD). In addition to the reduction in public sector funding, due to the difficult operating environment, competition had increased, making it increasingly difficult to secure all types of business, including care homes. Following the successful completion of their first three jobs, it had been difficult to win further work at a price BC were able to make money.

> "*Those jobs [the three completed projects] were won at different times... compared to now, [the client] have got, what was it, a tender list of 6 that was all arm's length stuff [allowing the selection of the best tender]*" (MD)

Although the strategy BC had selected had become less profitable than originally planned, they were continuing to develop, using their QMS to support further changes. This willingness to continually review existing strategies and target alternative sectors supported BC in adapting to new environments they faced. This was reflected by the view of a project manager and how he approached managing projects.

> "*We are all for change, about questioning tradition, think outside the box, why are you doing this, well we've always done it like that, well why?"* (PM)

This view was contrasted with a competitor of BC who had 50 years of experience, but was not embracing current building techniques "*they're dinosaurs, and you know what happened to the dinosaurs*" (PM). BC could have continued to define their business as a "shed 'specialist'" (Netsquared 2011), focusing on similar work, only accepting work with suitable profit margins. However, by critically reviewing sectors where money was being spent and accepting the levels of profit within such sectors, BC had been able to remain in business and maintain levels of employment through a difficult period of the building sector.

4.1.2 Product Development

The highly competitive environment within the building sector meant that during the tendering processes, due to the fixed costs of the building materials, there were limited opportunities for firms to make profits. Clients were able to explore the make-up of contractor quotes, with profits being competed away.

> "*Slash 10% off them [quotes] and go and win the job, but you end up working with a supply chain that you don't know, you end up with… commercial problems, design problems*" (MD)

The MD described how the company who won the work, tended to be the company that wanted the work the most. However, the above highlights problems that could occur, if attention was focused wholly on providing the lowest prices quote. With an appreciation that BC had higher overheads than competitors, it was difficult for BC to win tenders with this approach. Such an approach would also introduce the risk of projects being delivered late or not to an appropriate standard, which were described as impacting on customer satisfaction.

> "*So a team of people who decide that is a compliance scheme [what the customer is asking for] for the drawing, and we'll prices that, we've got to price that, but let's look at a couple of options as well*" (MD)

Rather than providing a single quote, BC provided clients with a selection of alternate solutions, with cost and build schedules associated with them. This process allowed BC to draw from their accumulated knowledge and experience from other sectors, to provide solutions competitors may not be able to directly compete against. While a client tended to employ an architect for such insights, the warehouse and industrial sector experience of BC meant they were not limited to the accepted approaches to building care homes.

> "*We've not made that many friends with the design team [the client's architect] at the moment, because we are challenging the design, we are a design-led business, so we challenge, look for value for the client at the end of the day*" (MD)

The impact of this approach was that BC was able to provide solutions that met client requirements but were qualitatively different to those provided by competitors. This included drawing from their building knowledge, but also working closely with suppliers to redesign aspects of projects.

> "*This guy at Dudley was very very helpful, and talked us through all the processes, 'this can shift if you do this', and he helped you to value engineer the job... we're using him on several jobs now, because he's helped us we're using him and his company*" (PM)

In combination with relationships with suppliers, unless competitors had similar experience and knowledge of building techniques, even if quotes were returned to contractors to be retendered, competitors (the "*dinosaurs*" (PM)) may not be able to provide similar quotes.

"*About £640000... Yeah, so that's the sort of revenue difference, not profit, but difference, that that [design improvements] has offered and it has been a no cost extra, we've gone into the design at the same price as a masonry design."* (MD)

The above shows the scale of the benefits BC was able to provide customers with a design-led approach to construction. Unfortunately, this had not provided BC with a means of continuing to secure work with acceptable levels of profit. The ability to redesign projects was dependent on specific characteristics of a project. For example, the Nottingham project was only two storeys, which meant that it would not have benefitted from the design improvement implemented on the Dudley project. In addition to designs being affected by the characteristics of a project, the ability to win work in this way was also affected by the knowledge of the client. Without an appreciation of the problems that may arise if contractors worked with low cost suppliers and did not manage processes appropriately, clients may tend to choose the lowest cost tender, which had been experienced by a client of BC (Matthews 2008).

"I mean at that point, 20 grand on a four five million pound job is nothing, compared to falling out with site managers" (MD)

To mitigate this issue, it was important for BC to build on further company specific assets, ensuring the client was able to interact with the proposed project team. This allowed BC to demonstrate the competence of their project team, providing the potential client with confidence that during the project process, it would be possible to solve problems they experienced and deliver projects to schedule.

4.1.3 Process Improvement

With operational issues tending to be resolved with the site team, BC considered it important to introduce the proposed project team to a perspective client as early as possible.

"*They don't want to hear the director talking about what they're going to do on that job, it wants to be the project manager that's going to run that job, because at* *that stage they tend to be buying the team that they're going to be working with*" (MD)

Through a willingness to engage with clients and solve operational problems on receipt of feedback, the "*managed system*" (MD) that BC had implemented assisted the implementation of deliberate changes. Through the analysis of data from completed projects it was possible to identify and address problems at an organisational level.

"*They've identified that actually… some of the techniques that they were using were causing issues across a number of homes, so although they are each individually addressed, to start with you can start to say we've got to be very careful what is specified on the next project*" (Consultant)

Following the identification of operational issues, BC focused upon developing solutions and implementing changes in operational procedures, to ensure problems were not repeated. As part of their approach to process improvement, forums were conducted twice a year to provide project managers with opportunities to share ideas with other project managers.

"*If somebody comes up with an innovative idea, you know, 'well he did this, but he did that, oh that's right', well we have forums, project manager forums, a couple of times a year, where we all sit around the table together and discuss processes, better ways of doing things* " (PM)

The forums provided project managers with an opportunity to discuss operational issues amongst peers and develop solutions to operational problems. To ensure issues were not only solved at a project or project manager level, BC had a formal "*defects management system which does capture post completion issues*" (MD). This system, in combination with internal auditing, provided BC with a formal mechanism to identify problems within projects and initiate changes in operational procedures to prevent problems recurring. While resources had been provided to implement a QMS, attention was also directed to ensure the aims of implementing the system were achieved

"*We're looking to be more effective on site by controlling [systems], it's a balancing act, keep the paper work down to spend more time on site*" (PM)

"*I've been, we all have, in big companies, where you have a massive wodge of a… quality document, that you employ people just to do that document, and it doesn't mean to say that what is important… out there on the site, is any better*" (MD)

By focusing the aims of the QMS on reducing process variation to improve consistency at site level, BC had been able to receive benefits from implementing the system. The increased level of consistency ensured BC was able to complete projects to schedule, "*every time I go out, I'm still able to say we finish every job on time, that's key for us*" (BC). Having moved across sectors, BC had no direct project experience. The QMS provided BC with a means to transfer knowledge across sectors. In addition to delivering projects to schedule, BC also gave attention to following up completed projects, to address any problems that occurred following completion.

"*I'm very conscious as well at [BC] about after service care, we don't just build it and go off into the sunset*" (PM)

In combination with BC aiming to present themselves as competent within initial tender meetings, and able to resolve issues they identified within projects, attention was focused on meeting the needs of the customer. Following up on completed projects provides evidence for customers that BC were focused upon meeting their needs, rather than simply winning tenders or building to schedule. By focusing on providing clients with a service they valued, there was potential for BC to secure repeat business as a result of improved customer satisfaction. The approach discussed within interviews on engaging with suppliers and clients was consistent with primary observations from project meetings that involved suppliers and clients.

4.1.4 Within-Case Analysis

Within each interview, attention was given to firm-level activities that included the pursuit of a new business strategy and new product development. This provided evidence related to topics that BC considered central to how they operated. Within discussions on these topics, process improvement played a central role, in terms of changing and improving operational processes to achieve ISO accreditation. The implementation of operational process improvements within formalised procedures ensured that changes made following the identification of non-conformances were transferred to subsequent projects. This process assisted BC in consistently delivering projects on time and ensuring customer satisfaction, providing a foundation on which to secure repeat business.

With the need to accumulate experience of related projects, the learning curve, consistent with Wright (1936), was implicitly referred to within the interviews, where the number of projects completed was related to competence. For example, the MD stated "*as soon as you've got a bit of it [public sector work] on your track record it shows that you can deal with those special circumstances*" (MD). However, the limitations of this perspective were also unpacked by considering the accumulation of experience occurring at the individual or team level. Unless there was a means of capturing the learning from completed projects, "*all the staff… have [gone] off around the industry*" along with "*the knowledge and skills*" (MD) associated with them. This situation would make it difficult (or impossible) for a company to draw from accumulated experience that no longer resided within the company. Large firms running multiple projects simultaneously, "*the big boys*" (MD), were able to select specific projects to include on their list of completed projects, even if there were projects that had not been successfully. As a smaller company, with limited experience, it was necessary for BC to make the most of every project they completed. The QMS ensured BC captured as much knowledge as possible from projects, and by effectively drawing from related experience it was possible to "*minimize the learning curve on any job*" (MD). This perspective acknowledges that competence is not simply the result of the number of projects completed, but the effort to learn and adapt behaviour to account for any experience they had.

The nature of project activities within BC meant that while giving attention to "*reducing variation*" (consultant) and improving consistency of internal processes was important, attention was also given to external parties such as suppliers and clients. The nature of construction projects required the subcontracting of work to third parties. In a similar way to the need to engage with customers, it was necessary for BC to work with subcontractors to resolve more complex operational issues. The Schroeder *et al.* (2002) model of learning effectively maps this relationship with engagement with customers and suppliers and internal problem solving both contributing to the improvement of internal resources (in the form of operational processes). BC's ability to solve internal problems effectively appeared to promote the integration of information from external parties, providing evidence for the bi-directional relationship between the two forms of learning within the model (Figure 2.6).

Across operational development, new product development and process improvement, activities took place at numerous organisational-levels. At an organisational-level, BC had identified and pursued a new organisational strategy that required the pursuit of new types of business and the implementation of the QMS. The QMS formalised individual and group-level behaviours, and it was possible to ensure they were carried out consistently. Through interactions with customers, suppliers and within groups, it was possible to identify and develop solutions to site-level problems. The project manager forums and project meetings (that were observed), provided a means of developing shared understanding and agreed upon solutions to problems that could be implemented by updating procedures. This process of feeding forward individual knowledge to groups and the organisation, and individuals and groups drawing from organisational resources closely matches Crossan *et al.*'s (1999) 4I framework of organisational learning. As a result of BC having undergone a strategic renewal from focusing wholly within the industrial sector and moving to the public sector reflects their ability to have undergone organisational learning.

Overall, this case study has provided a multi-perspective view of a company that has proactively undergone strategic renewal within a relatively short period of time (around 24 months). From this perspective, the multi-level factors affecting strategic renewal of the firm could be identified, which included changes in organisational systems. An aspect of changing organisational systems was supporting personnel during their implementation of systems to ensure their use and to ensure processes were adapted to account for learning that took place while using new procedures. For BC, the implementation and embedding of the externally accredited QMS appeared to be a central element of this. The involvement of the consultant and external auditing provided external pressures to ensure operational procedures were used and kept up to date.

While design and effective new product development capabilities supported BC in securing work, other factors played an important role in how they pursued their strategy. Process improvement in particular supported BC in transferring learning from individual projects and involvement with clients to organisational changes. Formalised process improvements, compared to isolated problem solving allowed improvements to be transferred across projects that enabled the organisation to learn.

The case provides an example of a firm that has been able to adapt via process improvement activities, without requiring a highly structured and resource intensive strategic initiative such as Six Sigma discussed in Chapter 2. The findings indicate that not only is process improvement a relevant context for researching how firms are about to adapt to difficult operating environments, but how ISO 9001, are able to support strategic renewal in a similar manner to more complex strategic initiatives.

4.2 Injections Moulding 1

IJ1 were part of a larger European firm, which in turn was part of a global Japanese firm, but operated as an independent injection moulder with less than 100 employees. When originally set up in 1984, IJ1 manufactured a range of branded products, which included audio and videocassettes, and more recently mini-discs. At its largest in 1995, IJ1 had around 2000 employees. However following the move to digital technology that removed the need for audio consumables (and limited success of mini-discs), the size of IJ1's traditional market reduced massively leading to a gradual reduction in staff to its current size of 73 employees 15 years later.

To account for the decline in demand for analogue media consumables at the end of the 1990s, IJ1 began to pursue work in the automotive industry. Compared to their branded products, automotive components were more complex with fine dimensional and aesthetic tolerances that were shipped to external customers. Additional complexity was added by mechanical specifications that meant parts were moulded from tightly controlled materials, which were very different from those IJ1 had experience moulding. In combinations, these characteristics of automotive products represented major changes in the requirements of operational processes compared to previously moulded products. This reduced IJ1's ability to transfer their injection moulding knowledge and capabilities to the automotive industry. Notwithstanding the differences in the requirements of producing automotive products, IJ1 has been able to secure work delivering to Japanese suppliers of major Japanese automotive manufacturers. Securing the work had been assisted by a requirement for Japanese automotive manufacturers and original equipment manufacturers to source a percentage of components locally. The shared Japanese origins of IJ1 and the automotive suppliers had assisted IJ1 in winning business and assisted IJ1 in working closely with their new customers.

Although IJ1 had been able to initially win business, it was necessary for them to develop existing and new capabilities in order to supply parts of a suitable standard to their new clients. These included improving operational process capability to a level that ensured customers would receive conforming parts. It was also necessary for IJ1 to develop their capabilities in quality control, metrology and inventory management to meet other requirements of the automotive sector. When IJ1 manufactured branded products, customers were essentially internal, with non-conforming parts being identified within downstream processes. In comparison, automotive customers would formally reject non-conforming parts, requiring corrective actions to prevent recurrence. This required considerable changes in formal operational procedures, but also how individuals within IJ1 perceived their roles within the firm from moulding plastic to delivering quality assured products to a customer. The process of change was supported by engineers from client firms (including the author) spending considerable periods of time within IJ1 to audit operational processes. This process was also augmented by visits to customer plants and the customer suppliers' plants in Europe and Japan (attended by the author). This provided IJ1 with knowledge of how other companies operated and how customers expected IJ1 to operate.

Complementing the pursuit of automotive business, IJ1 were willing to accept other types of business in order to maintain the utilisation of their 35 moulding machines. This included work supplying the pest control and medical sectors, which had allowed the development of additional capabilities such as sterilising and the maintenance of existing capabilities of prototyping and mould design. However, the pursuit of additional business had not prevented a continued reduction in size and in 2010 IJ1 sold their facility and surrounding grounds, although a portion of the reduction could be attributed to the closing of areas of the business (e.g. repackaging). The moulding section was stated as continually improved turnover, "*every month we're making* record" (ProdM). Rather than a general decline in the business, the reduction in head count could instead have been related to the refocusing of the business. However, the continued decline of the firm was an area of concern for customers, who would experience considerable problems if there was a disruption of products supplied by IJ1.

Combined with this concern, IJ1 had continued to experience operational difficulties, which resulted in frequent returns from customers. This introduced risks into the supply chain of non-conforming parts reaching customers, which had the potential to affect vehicle safety. In an effort to address or at least reduce this risk, at the time of the interviews, IJ1 had recently engaged with a government initiative aimed at developing automotive supply chains through best practice interventions as discussed in section 2.2.4. This took the form of training and coaching to support changes to operational practice, with an aim of developing continuous improvement capabilities.

The following case study looks at operational development, product development and process improvement activities. Findings will be tentatively discussed in relation to the three models of organisational learning as a means of interpreting observations. The report is based primarily upon interviews with three organisational members; the production manager (ProdM), the project manager (ProjM) and an assistant operations manager (AOM), which were recorded and transcribed, resulting in 63 pages of codified data. This introduction and the case interviews were contributed to by the company website, site tours and over two and a half years that the author spent working for one of the customers of IJ1. The professional involvement of the author consisted of working as a Product Engineer responsible for localising the manufacture of components from Japan to the UK. This involved numerous visits to IJ1, coordinating improvement activities with

IJ1 and visiting Japan to receive improvement training, providing rich, primary data related to process improvement within IJ1.

4.2.1 Operational Development

Due to the business having been formed as a manufacturer of relatively consistent, standard parts in a mature market (audio consumables), changes to products had been limited until the introduction of automotive products. This had resulted in a highly functional organisational structure, focused upon internal, efficiency-oriented goals. Within the more complex and less stable environment of the automotive industry, a higher degree of cross-functional integration was important to coordinate the manufacture of products. Integration allowed products to be produced to an appropriate standard, at an appropriate time and delivered to customers when they were required without having to hold high levels of inventory. Unfortunately, the functional structure of IJ1 limited the ability to coordinate action across functions. This had led to the ProdM beginning to question the organisational structure, to explore high-level improvements:

> *"We don't know how other people, what kind of management strategy they've got… I don't know what we've got here... are suitable for us... during this two years we're changing in the organisation system wise*" (ProdM)

To support their focus on automotive business, IJ1 were pursuing the automotive quality assurance accreditation TS16949 (an extension of the ISO9001 QMS), to assist them in securing more business within the automotive sector. However, the functional orientation of IJ1 had made this a difficult process.

> "*The quality management system is being driven by TS [TS16949] as well, we haven't got TS yet, we're supposed to be in the process of implementing it, but again time is an issue for everybody…. so from that point of view, that's sort of driving the quality management system, the existing ISO quality management system is not, it's out of date, it needs updating"* (AOM)

Comparing the nature of the company when the previous QMS was implemented, ProjM outlined how responsibility was focused upon a small group of individuals;

“*there’s not enough people... involved in it*”. This meant that without sufficient resources to update and maintain the system, “*it’s not kept pace with the business*” (AOM). The history of IJ1 created further issues, where in the past they had the “*luxury*” (ProjM) of individuals dedicated to updating the system.

In addition to pursuing automotive work, other types of new business were introduced by the new business development executive (NBDE), “*who actually brings people in*” (ProdM). However, the aim of NBDE was to grow the business, with IJ1 being willing to accept any new business tenders they were able to win, which were primarily in the form of tool transfers from other injection moulding companies.

> *“If you’ve been given a tool transfer, you’ve got age, quality issues, problems inherent in the tool design, because you don’t know why it’s actually been moved, it could be cost, it could be quality, could be other things, the customer is not really going to tell you, sometimes you’ll have to… fish it [the reason for transfer] out of them”* (ProjM)

Such transfers could be seen as the deliberate introduction of operational problems, directing attention away the implementation for “*TS*” and away from consistent improvements as new issues had to be identified and resolved. While tool transfers introduced problems, new tooling also had the potential to introduce problems due to IJ1 tending not be involved in the development of the tooling. This meant there were limited opportunities to ensure products could be produced consistently, “*they’ll look at the fine-tuning here... you still cannot change that actual CAD design [tool layout]*” (ProjM).

To reduce risks associated of new tooling, where possible, IJ1 used customer-approved suppliers to ensure tooling would be consistent with the standards and requirements of the customer. However, with differences between moulding machines at the tooling manufacturer, combined with the supplier’s choices of initial designs, the ability for tooling to mould parts was effectively out of IJ1’s control. One approach IJ1 had considered was to develop direct relationships with low cost tooling manufacturers in the Far East. However, the cost of developing new relationships limited IJ1’s ability to pursue this particular avenue.

"*If we wanted to go on say two visits to China, just to prove the tool, it would be so costly, you might as well have had the tool made in England*" (ProjM)

Although deciding not to pursue this particular avenue, IJ1 had gained a contact with a firm who subcontracted tooling manufacture to China. By operating through them, IJ1 had the potential to exploit the supplier's experience of managing Chinese tool manufacturers following numerous tool development projects. With this particular aspect of development not being pursued, the ability for IJ1 to develop new products was limited. However, it was still necessary for IJ1 to work with customers and introduce new tooling, which will be discussed in the following section.

4.2.2 Product Development

Although IJ1 tended not to be directly involved in the initial product and moulding design, there was still considerable complexity in the introduction of new tooling. This included scheduling machine time to mould products, gaining approval of samples and validating internal process capability. While simpler than developing tooling with customers, the process was made more complicated by the limited and out-of-date QMS. Without formalised procedures combined with the refocusing that had taken place within IJ1, individuals operating in particular roles did not possess the relevant experience and were unable to draw from relevant organisational procedures.

"*It went from Zero to 100 mile an hour… you have to unpick all [the last Project manager's] work, and there is nothing down there in the first place, nothing to tell you where to find that information in the first place, there are no procedures…. if you hit on a problem, you experience it, you obviously write it down for the next time*" (ProjM)

Even though IJ1 did not have formal systems in place, due to the requirement of their customers for quality assurance, especially the automotive customers, structure was provided to the introduction of new tooling. The formalised pre-production processes involve numerous trials, for dimensional, assembly and customer production process and product confirmation. As trials progress towards production, the quantities involved increased, and consequently, so did the impact producing parts for these trials had on normal production.

> "*It's still a one man job... In the early stages of a project, until sort of T1 T2 [moulding trials] that I've just got to now, I mean T2, you need a greater input from production side... it starts to mushroom… you need a little bit more input*" (ProjM)

Consistent with the functional structure, the goals of production were related to machine efficiencies, meaning that stopping production to run moulding trials created a conflict, which, without planning in advance could cause difficulties in rescheduling. Unless moulding trials were planned with sufficient lead-time that would have been facilitated by formalised procedures, moulding trials may have to be delayed until there was a gap in production. A lack of involvement of productions staff led to further problems with the process of transferring tooling from trial stage to production status.

> "*When you're trying to reintroduce the hand over to production, you're doing it in stages, it's not like, I go to [AOM] and say that's yours, because you're still responsible, it's handed over to production, but I'm still responsible for certain items*" (ProjM)

With emphasis on the early stages of the project being the responsibility of ProjM, when parts were transferred to production, production had limited knowledge of the tooling or the client. As a result, production had to learn about the requirements of the customers and the nature of a particular product or tool. In addition to this, unless production staff were willing to take responsibility for new tooling, and accept performance criteria set by customers, if problems occurred, product staff tended to be unwilling to accept responsibility for them.

Further complications were introduced if parts were assembled into more complex products, interactions of tolerances could mean that even if parts were in specification, they may not be fit for purpose (conform to specification but not to requirements). With tooling and components being produced by numerous suppliers, if issues occurred during assembly trials, following discussions with customers, IJ1 may need to modify parts away from specifications, in order for them to be acceptable.

> "*I can make that part, the process can be perfect, but it may not fit the mating part that's on the drawing, but by the time the other suppliers have supplied the mating part, it's the customer who then decides which one's going to be modified, which is the one they're going to say we're going to keep this one as it is"* (ProjM)

This highlights issues when different parties carried out tooling design, tooling manufacturing and part manufacture with limited cross-party involvement. In such cases, IJ1 may have to alter moulding conditions and fine tune processes away from an optimised state in order to meet the requests of customers. This situation was further complicated by IJ1's pursuit of business growth and a willingness to accept tooling with inherent problems. The impact on production was that the state of tooling was not known until tools had been delivered to IJ1 and customers may be expecting parts to be delivered immediately.

> *"We're looking for any business, there is a fine line between... you can win business you can sometimes not really desire, but it's revenue… I can't start my control plan or my FMEA [failure mode and effect analysis] until I've seen it moulded in here… because there are certain things, like jigs, a lot of other things, until you've seen the process here, you might have a good idea what's going to happen, but it's never reality*" (ProjM)

The above excerpt highlights the scale of unknowns experienced by IJ1 within the introduction of new products and the transfer of tooling. Although the introduction of new products was a central part of IJ1's aim to expand, it was only once parts were in production and producing parts that they would be able to create revenue. In addition to this, once tooling was introduced into production, the majority of improvements that could be made were related to process characteristics. While product characteristics were primarily defined by the tooling, other processes were potential areas where improvements could be made. These included quality, logistics, printing, and inventory management, that all had the potential to provide benefits to IJ1 and the customers of IJ1.

The next section focuses primarily on IJ1's involvement in a best practice intervention, and its impact on operational practices.

4.2.3 Process Improvement

IJ1's customer who had initiated the best practice intervention had two primary aims, the first being to improve the performance of their suppliers, and they "*probably choose bad supplier[s]*" (ProdM). Improving the performance of their suppliers could have a direct impact on the customer's performance, reducing the risk of receiving non-conforming components or directly shipped products that may create problems for the automotive manufacturer. Secondly, by improving the performance of their suppliers, the customer was effectively investing in the sustainability of their supply chain. For example, if suppliers were unable to make money from supplying automotive customers, in the long term they were more likely to go out of business.

> "*The only reason for that was we were losing money basically, and obviously [the customer] knew we were losing money because they were privy to our information and basically we had hit a block [and couldn't improve] because from their point of view, we needed to be profitable to keep supplying their part"* (AOM)

The intervention involved a government-supported organisation, Industry Forum (IF) (IndustryForum 2012). The process consisted of receiving training at workshops conducted by IF "*on some theory and some practical application*" (AOM) to assist in developing understanding of operational problems to enable improvement. With the help of "*very knowledgeable*" (AOM) trainers, who "*hadn't been years in academia*" (ProjM), the solutions proposed by IF were developed in order to make them appropriate for IJ1.

> "*It wasn't biased to either business… if it was normal operations and they [the customer] would normally dictate the terms for supply or whatever else. This one was basically put it all down, setting up the synergies really or the mismatch in the businesses and then sort of getting some compromise but obviously you do have to meet what our business runs like and theirs and obviously you need to connect them*" (ProjM)

Consistent with the view of synergies or integration, attention was spread across different departments, with a range of individuals being involved in the initiative, such as planning, quality or engineering. However, it was AOM who was primarily responsible for reporting results, which were presented at workshops and sometimes directly to the automotive manufacturer. Focus was given to presenting actual improvements, with "*real data*" (AOM), with anything less not accomplishing the aims of the intervention.

> "*We all wanted improvement and they were showing us the tools to use to achieve the improvement*" (ProjM)

> "*A lot of it is just common sense. We have used a lot of the tools*" (AOM)

This highlights that rather than a lack of knowledge of improvement tools, the benefits of the intervention resulted from the involvement, direction and support from IF, combined with involvement of the customers, who required process improvements. The opposite was also reflected within normal business practices that gradually deteriorated. This may have resulted from the outdated QMS, where there were no formalised systems in place to ensure adherence of operational procedures.

> "*The process has started to change quite a bit, it sort of jumped, the level of quality and inspection, verification of that part prior to being dispatched, was totally different to the original quote, now you can't go back and say we want extra money off you*" (ProjM)

> "*They couldn't reduce the cycle time because it had raised to 50 seconds, so we're losing 10 seconds… if I had been involved in that, I wouldn't have been accepting [that performance]*" (AOM)

With agreed upon samples being produced with very specific moulding machine settings, when adaptations were made to processes, product characteristics would also change. Having audited the moulding process, this resulted from moulding engineers using "*last off*" samples and moulding conditions, and attempting to optimise on every moulding run. The effect on the process was that not only was there potential for process cycles times to increase, but process stability and product quality could also reduce. In combination with the moulding processes, ancillary processes of inspection or assembly could also require increases in cycle times, to ensure processes were balanced. This resulted from operators not following instruction and becoming slower over time. The above highlights that responsibility for maintaining performance was not transferred once AOM moved to a different area. This meant that knowledge acquired during the improvement intervention was not being used and behaviour reverted towards pre-intervention norms.

Those within IJ1 who had been involved in the improvement initiative did, however, appreciate the importance of continuing to pursue improvements. This led management within IJ1 to initiate further improvement activities on other products. Having archived presentations and documentations from the IF initiative, further improvements were, in theory, reapplications of previously learnt concepts.

> "*I'm going to also repeating, that kind of projects, on other manufacturing processes, we done this time, for one of [the customer's] products, because that was what they wanted*" (ProdM)

Within the interviews, attention was directed towards maintaining operations, resolving new issues as they arose and delivering products to customers. With additional issues being introduced with new tooling, this created a high workload for the ProjM and AOM, "*we're definitely overworked*" (AOM). Compared to improvement activities, direct revenue generating activities were of primary importance to maintain turnover. This was reflected in the recently initiated *"process innovation" (AOM)* company-wide initiative that appeared to give process improvement a high priority, but its acceptance at an operational-level contradicted this. By drawing directly from the improvement intervention, "*you'd think they were from IF as they are that similar*" (AOM), the company was attempting the exploit previously accumulated process improvement knowledge. However, while "*key to the business*" (AOM), responsibility for this improvement initiative remained with a few individuals who were unable to implement further improvements. The initiative included implementing relatively simple 5S (housekeeping) changes in practice, which was not being accepted or maintained by operational staff.

"*We're still sort of first second approaching third S stage, I mean some areas are not even first S really, or they keep slipping back*" (AOM)

The functional orientation of IJ1 created challenges for those undertaking improvements. Without allocating responsibility for outcomes of improvement activities across different functions, individuals were less willing to accept new approaches to operating.

"*We were trying to sell it, in the business that was the problem we were having, we were trying to sell these improvements instead of them buying into it*" (ProjM)

"As soon as they sniff the accountability, they don't want to know see, where as if it's to benefit them, 'oh I'll have that, that'll make my life easier'" (AOM)

Without being made personally responsible for improvements, individuals were able to resist changes that, while benefiting the value chain as a whole, may negatively affect particular functions. This was illustrated by moulding engineers making negative comments about new approaches to working (such as standard operating procedures) that did not allow them to fine tune processes and draw from their personal expertise.

"*Then when you were sort of drafted into the moulding side, and they're not keen or friendly regarding the tools and things there, you realise very quickly that they haven't got it… it's like going back 20 years… it's took years really, and even now, it's a total resistance to change, I mean we're forcing through the change, but even so, it's more difficult because they're resisting it [change], and it scuppers it [the intervention], it's sort of two steps forward [and one step back]"* (AOM)

The functional orientation of IJ1 that was described by those interviewed provided a potential cause for the problems experienced. Combined with inconsistent emphasis on business development, acquisition of new business appeared to contribute to issues experienced by IJ1. Emphasis towards revenue generation appeared to result in limited resources provided to improvement, which meant that improvement behaviours did not become embedded. The following explores how organisational learning theory may be able to provide explanatory insight into understanding observations.

4.2.4 Within-Case Analysis

IJ1 had undergone considerable changes in recent years to account for changing market conditions. The reduction in size from around two thousand staff to fewer than one hundred over a period of 15 years could be seen as a gradual deterioration of the business. This had been observed by the author while working with IJ1 with regular redundancies and unutilised areas of the facility. However, the increasing revenue (in terms of turnover) of the injection moulding section may reflect the reduction in head count resulting from the refocusing of the business to less labour intensive activities. However, the refocusing explanation does not address IJ1's inability to resolve operational issues. As a result, although IJ1 may have undergone considerable changes to account for external pressures, individual perceptions of operational process appeared to have undergone fewer changes.

Having moulded relatively low specification parts for internal customers for many years, the moulding engineers had been able to establish consistent organisational targets to work towards. Previously it had been possible for moulding engineers to gradually perfect moulding processes, consistent with the learning curve (Wright 1936), where gradual refinements were made to improve a particular process characteristic. Yelle (1979, p308) referred to how this may impact individual behaviour if new processes or products were introduced. If new products were introduced that were measured in relation to standard metrics, if it was not possible to operate at previous levels of performance, changes may be resisted. With work acquired in the automotive industry being geometrically complex, difficult to mould, with tighter tolerances, once moulding conditions were agreed, there were very limited opportunities to make incremental improvements. As a result, moulding engineers were unable to apply their moulding knowledge to automotive products in the same manner, and would not be able to improve how they performed in relation to entrenched performance measures. This resulted in a tendency to attempt to fine tune conditions in order to search for improvements, which resulted in the deterioration in end product characteristics, inconsistent with the learning curve.

In addition to machine-level changes, to deliver products to customers it was necessary for improvements to be made across organisational functions. Schroeder *et al.*'s (2002) model of learning provides structure for interpreting this type of learning, outlining the importance of cross-functional training, which was a focus of the IF improvement initiative. The model also acknowledged the role of external learning that related to learning from suppliers and customers to promote improvements that were consistent with customer requirements. However, with operators having a "*total resistance to change*" (AOM) there were only limited, short-term outcomes, inferring there may not be a direct relationship between external learning and process improvement, inconsistent with Figure 2.6. Apart from the involvement in the best practice intervention, there appeared limited involvement with suppliers and customers, with new business relating to transferred tooling. Discussions and observations within IJ1 appeared to highlight the limitations of the Schroeder *et al.* (2002) model, as it does not account for how internal learning affected the impact of external learning.

While improvements took place internally and involved external parties, the internal improvement process took a specific form. From the receipt of quality non-conformances, solutions were developed, returned to customers for approval and corrective actions implemented. However, management appeared to provide insufficient resources to implement and maintain formalised procedures. This meant that it was not necessary for individual operators to adhere to particular practices allowing behaviour to change and process performance to deteriorate. Alternatively, the lack of procedures meant that individuals had to personally remember processes and document their own mistakes, being unable to draw from organisational systems or experience. Between the formulation of solutions and lack of operational processes were group-level activities with external and internal parties. While specific individuals worked closely with customers, others resisted changes and were less willing to engage in operational improvement activities. While IJ1 experienced problems with implementing process improvements, the processes and issues experienced are broadly consistent with Crossan *et al.*'s (1999) framework. The framework indicates that not only were insufficient resources provided by management to implement operational procedures, but also for changing the perceptions of particular operators, who resisted change.

Within IJ1, other than resolving quality issues, internal improvement activities were initiated by external sources (customers or group level management). However, both types of improvements experienced similar issues, which appeared to be affected by the lack of QMS. While improvements were developed and implemented, without formalised operational procedures, procedures not being audited and the resistance of operational staff, improvement behaviour appeared unable to result in benefits.

The dual methodology for case studies proposed by Leonard-Barton (1990) allowed interviews to provide richness to the depth and detailed data that could be collected through prolonged primary observations from professional involvement with IJ1. This data collection process allowed insights to be drawn from a number of different perspectives, including customers, which were viewed through the author's own experience (Reimer 1977; Radnor 2001). With this added dimension to the case database, issues and stories shared during interviews could be confirmed against representative observations, such as a resistance to changing operating procedures, even when requested by important customers. Analysing observations from the perspective of organisational learning provides a means of structuring evidence related to improvement activities. Without attention towards changes in cognition, as outlined by Crossan *et al.* (1995), changes may be forced, with a higher risk of them reverting over time.

4.3 Injection Moulding 2

Injection Moulding 2 (IJ2) was a small injection moulding company based in the East Midlands, formed in 1989 to supply parts to the double-glazing industry. Over 20 years later, products for the double-glazing industry still represented around 50% of the products IJ2 manufactured. Their low complexity combined with relatively high profit margins provided IJ2 with sufficient capital to develop additional capabilities in tooling, quality management and distribution. For a company of its size, it considered such capabilities were "*quite unique*" (MD). However, a weak construction sector was considered to have had a significant impact on the level of demand for double-glazing that had had a significant impact on IJ2.

Since 2007, IJ2 had reduced in size from 55 to 35 employees in 2010, having made "*a big loss for 18 months*"(MD), then to 27 in late 2011, a reduction of over 50%.

Although having reduced in size, IJ2 had maintained their tooling capabilities, recruited a new quality management professional, as well as continuing to invest in new machines and processes (Arcsus 2011). This meant that IJ2 had a high level of operational and human capital for a company of their size, considering that they were in a good position to pursue growth once the market returned to pre-“*depression*” (MD) levels.

To address the risks associated with depending upon a single industry, IJ2 had secured business in a range of industries including medical and automotive. This allowed IJ2 to broaden its portfolio of business, but also work on more complex products for specific applications enabling IJ2 to develop knowledge of more complex mouldings. MD considered IJ2 as “*one of the best kept secrets in the country*”, seen as a “*whole company of knowledge*” that could be applied across industries.

Table 4.1: IJ2 Company Characteristics

<table>
<tr><th>Staff</th><th>Equipment</th><th>Capabilities</th></tr>
<tr><td>3 Directors (2 Managing, 1 Business Development</td><td rowspan="2">17 Moulding machines, Pad Printing, Laser marking, Surface decoration (foiling), Ultra sonic welding, Insert moulding</td><td rowspan="3">Small batch production, quality control, components from stock, assembly, clean room assembly, storage and distribution</td></tr>
<tr><td rowspan="2">5 Functional Managers (Project, Production, Tooling, Quality, Business development)</td></tr>
<tr><td rowspan="2">3 Axis high speed machining, 4/5 axis wire EDM, 2 Axis CNC machining, 2 Axis CNC turning</td></tr>
<tr><td>19 Production and Administrative Staff</td><td>Injection mould making</td></tr>
</table>

Table 4.1 demonstrates the range of equipment, staff and capabilities present in IJ2 (Arcsus 2011). The following case report is based upon four and a half hours of interviews with the Managing Director (MD), the Project Manager (TM) and the Production Manager (PM) that resulted in 155 pages of transcription. Information acquired from interviews was complimented with information collected from the company website. The following three sections relate to operational development, product development and process improvement within IJ2, which are discussed in relation to the research.

4.3.1 Operational Development

Having given attention to the development of internal capabilities, IJ2 were able to provide customers with a complete service from product concept development and prototyping to mass production.

> "*It resolved a massive problem that he [a prospective customer] came to a small company and we were that full, turn-key package that we could look at the design of the mould tool, we had enough knowledge of the performance of the raw materials from other industries that we knew roughly what grade [of material was needed]... We can do that for you for £3,000 and you'll get a hundred actual components that have been moulded in the polymer that you specified or we've recommended; it's actual... it's not a prototype really, it's actual*." (MD)

This approach allowed IJ2 to move away from price-based competition related to the transfer of pre-manufactured tooling to adding value to the design of products and tooling through close involvement with clients. By drawing from knowledge of injection moulding, product characteristics could be altered to improve product functionality, assist part manufacturability, or reduce product or tooling cost while maintaining the profitability of work for IJ2. While the reduction in company headcount had been necessary for survival, the importance of growth was highlighted as not only a general aim of the business, but something that would assist IJ2 to further develop through the improvement of operational efficiency. Whether changes took the form of machines dedicated to particular materials, or operating 24 hours a day, "*the reduction in downtime is massive*" (MD) due to not having to start up machines or change materials. As part of this aim to grow, a Business Development Director had been recruited to work part time who had experience of managing larger firms:

> "H*e comes and spends time with a company like this to help them go beyond this glass ceiling that all SMEs hit*" (MD)

To support and enable growth, IJ2 had begun restructuring the business to reduce the number of managerial levels and ensuring those that remained were able to manage themselves. Such restructuring had potential to provide opportunities to recruit university graduates and promoting the general up-skilling of staff. The intention was that individuals would be able take more responsibility, allowing the firm to grow, without having to increase the proportion of supervisory staff. However, IJ2 were put in a difficult situation, with a need to recruit graduates to support growth, but until the firm had grown, the MD stated, "*I've got nothing here that would remotely stimulate her"* in relation to his unemployed graduate daughter. The next section presents how IJ2 were applying their tooling and moulding capabilities through product development to the pursuit of their growth strategy.

4.3.2 Product Development

Although working with a customer from initial concept to designing products and tools together provided the best opportunities for IJ2 to add value, IJ2 often won business where tooling had already been manufactured and was (or had been) in production (similar to IJ1). Due to the difficult operating environment, customers would withdrew and relocate tools with new suppliers in order to reduce costs, or protect against suppliers going out of business. By drawing from their knowledge of tooling and moulding, IJ2 aimed to address issues that may arise when transferring tooling. For example, a customer may expect good products, without knowing problems that were experienced by their previous supplier. "'*Well it ran before, it must be alright'*" (MD), but this may not account for the 70% scrap rate experienced by the previous supplier, which would make parts very unprofitable to produce. It was stated that IJ2 would not be able to absorb such losses, and would be unwilling to take on the moulding of such parts.

Unfortunately, if "*they've paid out perhaps £20/30,000 for a suite of tools*" (MD) they would be unwilling or unable to buy replacement tools, giving IJ2 little choice but to turn the business away, "*take it away, I don't want it*" (MD). To support the transfer to tooling, quality management procedures had been introduced to formally assess the state of tooling, which were submitted to the customer before tooling was transferred and run. This provided IJ2 with different sources of information to support discussion and attempt to address the "*blame culture*" (MD) present within the injection moulding sector. The important role of understanding the moulding process, tooling designs and product design was also highlighted within new product development:

"*If a customer says no, they're not bothered, go straight to press [making the final tool], we would normally spend the money ourselves. Because I don't want to waste time making a mould tool that we know is not going to work*" (MD)

The above excerpt related to the use of rapid prototyping within IJ2 to provide customers with physical representation of the products undergoing development. This allowed customers to get a feel for new products or even carry out preliminary tests. Prototypes also allowed IJ2 to illustrate why particular product characteristics may need changing to allow them to be manufactured by injection moulding processes.

Although accumulating a range of internal capabilities, IJ2 acknowledge they were unable to carry out all activities internally and relied heavily on suppliers. This included outsources recruitment activities, product design and the manufacture of production tooling. Outsourcing allowed IJ2 to focus on a specific set of internal capabilities, preventing them from over diversifying. The approach taken to outsourcing promoted close working, long-term relationships with suppliers that meant IJ2 were able to learn from these suppliers and develop trust in their abilities. In relation to tooling manufacture, IJ2 had developed relationships with overseas manufacturers who were able to provide low cost tooling. The moulding capabilities present within IJ2 allowed tooling to be actively managed, ensuring that when tooling was received by IJ2, it met their own and their customers' requirements. This facilitated IJ2 in accumulating knowledge about processes and products of customers, enabling IJ2 to take "*away their [the customer's] perceived problems*" (MD).

"*We will always question and we almost apologise when we first meet somebody [a prospective customer] that we will question you about why [a product is the way it is]. And they like that... they like that because they realise that we're buying into their products and they feel that… and quite rightly, we do, we cuddle these people*" (MD)

As a result, IJ2 considered it important to not "*just taking the money*" (MD), with improvements in the product, tooling and service all affecting long-term customer satisfaction. Consequently, IJ2 considered itself better positioned to secure subsequent work with customers, as well as ensuring the profitability and sustainability of the work they secured. The next section looks at process improvement activities undertaken within IJ2.

4.3.3 Process Improvement

As presented within the IJ1 case, the majority of injection moulding process characteristics are defined by the tooling. This means that changes in injection moulding processes, either adaptation or improvement, will impact on part characteristics. To account for this and ensure the consistency of products received by customers of IJ2, process consistency of the injection moulding process was emphasised over incremental process improvement. The emphasis on process consistency was also given to non-injection moulding processes.

> "*Once you've assembled it, we don't know whether it's right or not, so we've got to have that trust in place for our staff that they have put the correct amount of ball bearings in there so that that will work for probably ten years*" (MD)

The above highlights the importance of quality assurance compared to quality control, which was supported by IJ2's accredited QMS. The system ensured there was appropriate attention given to implementing new procedures, promoting use of procedures and implementing training to ensure procedures were being adhered to. Certain injection moulding processes were so sensitive, that slight changes to temperature or the time mould tools where held following injection could affect product quality, so "*if you added or took away one second off the cycle time, it becomes a failure*" (MD). Small variations from specified procedures could result in inconsistencies of manufactured products.

> "*The trick with them [moulding engineers] is not to try and deskill them, it's to make them understand yes, your skill is you set that on day one, you set the standard, you told us that that's the best and it's written down now*" (MD)

While injection-moulding processes were sensitive to slight changes, non-injection moulding processes were stated as causing the majority of problems, particularly the warehouse. "*50% of our rejects are related to the stores department not* *manufacturing"* (MD) where individuals did not adhere to operational procedures. In a similar manner to supporting moulding staff to adhere to predefined mould machine settings, attention was given to supporting those working with other operational processes to adhere to procedures and accepting changes when problems occurred.

> "*The best solution I find to resolving production problems is to involve everybody. And I said it recently to our stores department, 'I am not going to dictate to you how you should run the stores department.' 'I'll put some corn down for you [provide some incentive] and you pick up and run with it'… And the beauty of that is then of course then is if you have that discussion, everybody's bought into it. You're not dictating to somebody because you know, we all made the decision collectively. I think generally… well it's not perfect, of course it's not, generally it works*" (MD)

Outcomes of discussions were codified into procedures so that problem-solving activities were captured. "*No matter how innocent you think that request is, that has to go through the procedures*" (MD) highlights the importance of a structured approach to process improvement. The accredited QMS required auditing of the procedures ensuring the use of procedures following changes, which were validated by a current certificate (Arcsus 2011). The MD provided support for those within the company to solve their own problems, by providing staff with sufficient resources and incentive (corn) to discuss problems and develop solutions within groups. Staff were also facilitated in discussing problems openly, sharing knowledge of the problem and moving away from attempting to apportion blame for problems.

Further forms of deliberate process improvement were also described that consisted of the MD identifying opportunities for improvement through automating manual processes. While such processes could be viewed as a means of reducing the number of staff, emphasis was given to freeing up staff from monotonous tasks.

> "*On paper, you think oh, 'just shy of £7,000, lot of money isn't it?' Does somebody really sit there for half the year, from a salary point of view, squirting those?... Probably not. But I know after a period of time it's the right thing to do…*

And the cost of … 'we've got to down-mark this one because we only did a part delivery' [justifies the amount spent]" (MD)

Attention directed towards such capital-intensive forms of process improvement provided evidence to operational staff that the MD was committed to and would provide resources for process improvement to improve their working environment. With such activities directly contributing to the reductions in labour or manufacturing costs of particular parts, "*the smart thing to do is to win the order on what you know and now how can I make more profit out of it?*" (MD) which process improvement enabled.

4.3.4 Within-Case Analysis

The above evidence from IJ2 describes practices within a company operating within a difficult economic environment, which had significantly affected the company. However, IJ2 had been able to maintain their focus upon developing internal capabilities, in order to add value to their customers' business and had continued to invest in new machinery. The result was that the reduction in head count of the company appeared to primarily relate to production staff. While production staff would have received training and accumulated company specific knowledge, they were less critical to IJ2's plans for development and were potentially easier to replace. From this position, IJ2 focused their business on their core activities during the "*depression*" (MD) focusing future recruitment in a manner that would support growth. Operational processes provided a means of structuring and controlling processes when the MD could no longer be directly involved in activities. By recruiting capable staff ensured individuals would accept the use of operational procedures, which in turn allowed the MD "*to get people around you that can take care of all this stuff*. With direction from the Business Development Director, further systems and structures were being put in place to support growth beyond the "*glass ceiling that all SMEs hit*" (MD).

Although operational improvements were primarily focused upon tooling and product development, process improvements still played an important role within IJ2. However, process improvements were explicitly not related to the number of products produced, where the cost or cycle time gradually reduced as implied by the learning curve

(Yelle 1979). Such improvements were actively suppressed, where slight changes to operational settings (changes which “*added or took away a second*” (MD)) could result in non-conforming parts. Other than initial product and tooling designs, process improvements were primarily related to non-moulding processes, such as assembly, packing and despatch. However, quality assurance of manual processes also required a high level of consistency, where variation of operator behaviour could result in problems. This led to the MD supporting operators to adhere to procedures and giving the instruction “*don’t cut corners*” (MD). With process performance not improving as a function of number of products produced, the learning curve does not appear to be applicable to operational processes within IJ2.

IJ2’s approach to business accounted for the particular nature of injection moulding, where highly specialised tools were necessary to produce customer specific parts. By giving emphasis to the front end of production (product development and tooling design), dedicated staff for tooling development allowed IJ2 to provide a “*wholesome service and not just a moulding company*” (MD). By pursuing this approach, it was possible for IJ2 to ensure that moulding tools were “*fit for purpose*” (MD), assisting them in developing tooling that would produce parts that added value to their customers’ business. Through balanced attention upon internal improvements and involvement with customers and suppliers, IJ2 made improvements internally that reflected the knowledge they acquired from suppliers and the requirements of their customers. How internal and external elements appeared to affect improvement was consistent with the Schroeder *et al.* (2002) model of learning (Figure 2.6). The accumulation of product and process knowledge from internal and external learning appeared to contribute to improvements in manufacturing performance. By developing tools and products with customers and implementing them internally, tooling was better able to produce parts that met customer requirements, without incurring high levels of waste.

While involvement with external parties and internal discussions appeared to contribute to process improvement, process improvement behaviour was more nuanced. Either quality faults, information from customers or “*vision*” (MD) provided an initiating point for improvements, which were discussed within a group setting or with customers to formulate solutions. By providing support for individuals to engage in group problem solving, individuals were willing to share their knowledge, to develop solutions that draw from a range of perspectives. Through formalising solutions into operational procedures, individuals appeared more likely to use procedures, helping improvement practices contribute to changes to operational behaviour. Overall, the processes within IJ2 plastics could be considered to share similarities with the Crossan *et al.* (1999) framework of organisational learning. These social elements of process improvement also supported individuals within the firm to accept new ideas, allowing IJ2 to continually introduce new products, across a range of industries and supply them consistently.

IJ2 provide an interesting candidate for research within process improvement, emphasising deliberate and documented improvement, compared to gradual refinement of process characteristics. The result was that much greater emphasis was given to deliberate forms of improvement, whether they were in the form of changes to product, tooling design or changes to operational processes. With process characteristics being highly related to tool and product characteristics, the potential role of process improvement may be limited. However, process improvements still represented an important activity that IJ2 were involved in. Involvement in process improvement activities appeared to help develop buy-in of operational staff - “*you’re not dictating to someone*” (MD) - that improved operators’ willingness to adhere to new procedures, ensuring process consistency. The high level of involvement in product and mould tool development allowed IJ2 to apply new product and process knowledge to existing processes, which assisted in identifying new sources of improvement. The continual introduction of new products, as well as new machinery, allowed IJ2 to bring new perspectives to existing work, promoting repeated process improvement.

4.4 Systems Integrator

SI described themselves as providing “*turnkey automation solutions to industrial companies*” as a systems integrator (Widagroup 2011). SI provided solutions to many global and highly regarded companies that included Mars, Reckitt Benckiser, British Gypsum, Toyota and Rolls Royce. Systems integration focuses on ensuring that separately manufactured and developed process equipment works together and effectively meets the requirements of a specific and often unique process application. The types of machines related to material handling, inspection and production processes. In particular industrial applications, companies needed to develop their own machinery, requiring the integration of lower level processes to ensure heaters and motors worked together within individual machines. Due to customers requiring unique combinations of equipment to solve company specific problems, work was project oriented. This led to normal business activities focusing upon the continual tendering for new business and delivering agreed upon solution within given timeframes (similar to BC). Projects consisted of identifying and specifying selections of machinery, developing control software, building control panels and implementing the system in client facilities.

SI was formed in 2002 by two Directors, one from an engineering background, the other from sales. Each had worked at SI’s main supplier of production equipment and had identified an opportunity for providing systems integrations services to the customers of the equipment supplier. Although operating within a difficult economic climate following the global financial crisis of 2008, SI had grown rapidly from 15 to 25 employees in the last two years (up to 2010). At the time of the interviews, the company consisted of four directors (one Operations, two Engineering and one Sales), 13 engineers of various types and eight administrative staff, working out of a new facility located in the East Midlands. The growth was attributed to the need for larger firms to continually improve operating efficiencies and improve profit margins. With SI providing services related to the integration and implementation of new process technologies that promoted improved efficiencies, SI were able to benefit from a difficult economic climate. SI had seen demand from particular sectors, such as aggregates that supply to the building industry, reduce; however, demand from other industrial sectors such as chocolate and tobacco “*has gone through the roof*” (Project Engineer). As an aside, these last two sectors highlight what people consume in economically difficult periods (chocolate and cigarettes)

The following case study is based on three interviews, two with Directors (one engineering-ED and one operations-OD) and one with a Project Engineer (PE) responsible for the QMS. With the majority of SI's work not being related to tangible products, they represent a different proposition to the other, more manufacturing oriented firms involved in the exploratory phase of the research. However, due to the presence of an ISO accredited QMS, there was a requirement for similar operating procedures to the other exploratory companies, providing consistency between the firms. Each interview lasted between 2 hours and 20 minutes and 2 hours and 40 minutes, and was recorded and transcribed, which resulted in 244 pages of transcriptions. Interview data was complimented by data from the company website and a related website of a product SI had developed. The case study is presented in three main sections, operational development, product development and process improvement before analysing the case data in relation to the research.

4.4.1 Operational Development

To support the growth of the firm and meet the requirements of customers, SI had recently implemented an ISO accredited QMS. The development of the system had allowed the Directors to remain informed of practices within the firm once it had grown to a size when they were no longer directly involved in all projects. It was stated that unless individuals followed consistent approaches to working there was no way to ensure that separately developed aspects of a project would work together and no way of controlling costs.

> "*They're [management] realizing that they must make the new people work to procedures, for them to have a successful business*" (PE)

To develop the QMS, PE had spent six months speaking with those within the company to prepare a system that conformed to the standard. However, it was acknowledged that *"we've gone OTT [over the top]" (ED) or* even *"way overboard"* (OD*)* with the detail of the system. Fortunately, through subsequent auditing it was possible to *"simplify those processes"* (PE) *"because we'd put too much process in"* (OD). The result was that much of the initial improvements removed unnecessary details from the system, making the system easier to use.

However, the QMS was only officially related to the manufacture of the physical control panel, meaning the software writing process was outside the system. This meant that is was not necessary to give explicit attention to formalizing the software writing process. This has led to mistakes being repeated across projects or that engineers were continually "*reinventing the wheel*" (ED). This was stated as resulting from the nature of the software writing process, which required individuals to work for numerous weeks writing software code, which was time-consuming to check and the it not being possible to validating the software until implementation. The impact of a lack of a formalised process was highlighted with a large portion of problems identified during final inspection resulting from the mis-interpretation of specifications ("*seven or eight times out of ten*" (ED)), which procedures had the potential to reduce.

Unfortunately, highly structured software writing procedures were not considered appropriate by those interviewed (particularly ED), with customers needing to be able to adapt systems following implementation. This meant that software had to be written in a manner that conformed to the internal standards of each customer. To account for this, rather than software writing procedures, "*implement[ing] good software*" (OD) was considered necessary for preventing errors. Unfortunately, if engineers did not meet this requirement, in some cases it was "*cheaper to rewrite*"(PE) existing, poorly structured code rather than identifying and correcting errors.

The size of SI limited the scale of projects they were able to work on, with larger projects requiring SI to be subcontracted by primary contractors appointed by a customer. This resulted in a large proportion of SI's work being contract-based, to supply defined systems where there was often limited opportunity for them to add value. While SI aimed "*to get as close to the end user as possible*" (OD) to better understand client requirements, limiting SI's ability to develop direct relationships with clients that was stated as important for identifying and winning follow-up projects. Being contracted through a third party also led to problems during the tendering stage, where SI were unable to adapt customer specifications to account for identified oversights. Without sufficient knowledge of the context, a client may focus on price - "*they're ten grand* *cheaper, I'm going with them"* (ED) - overlooking limitations in specifications or whether particular companies were able to add value.

Oversights in project specifications could result in mis-interpretation during projects and/or require multiple variation orders during a project to resolve issues with original specifications. The continual refinement of specifications within projects could result in "*death by a thousand cuts*" (PE). While individual changes may be insignificant in isolation, "*a million little changes… cause project overrun*" (PE) as additional changes required rework of previously made decisions. To address this issue, ED stated the need to *"get beyond the purchasing director"* in order to develop direct relationships and specify projects with clients. Unfortunately, it was stated that this might be difficult, due to SI effectively being run by an Engineering and a Sales Director. While SI did not possess technical knowledge to reposition the company, they did appear to possess the managerial knowledge that may have facilitated such changes.

> "W*e always try to be in a position where we understand more about the technology influences, then our customers then see…. we can actually add value*" (ED)

> "*Some of the smaller companies we [work with] are a bit more vague … and we get more involved*" (OD)

With three of the four Directors being ex-employees, SI had good working relations with their main supplier providing SI with a means of "stealing *a march on our competition" (ED).* However, without being able to work with clients to develop project specifications, cost-based competition resulted in there being fewer resources to develop specifications during the project process necessary for adding value, with every hour being billable by each engineer assigned to a project.

> *"It's much more delivery-oriented… I suppose one of the challenges that we have is we do tend to find that projects are already identified, budgets are already planned and then we're bidding on the basis of cost."* (ED)

Developing direct relationships and discussing problems with clients helped initiate further work, something SI considered an important area for development. An alternative example of a proactive development consisted of a partially funded consortium that developed a process to track materials and prevent product counterfeiting. Although not resulting in further work, the project established a solution and developed a selection of contacts, which included Oracle (a high profile ERP provider) and the University of Loughborough. SI were exploring the use of elements of the solution with other customers, emphasizing "*we need to build on that back of [that] project*" and potentially achieve more "*leverage from a contractual point of view*" (OD). Unfortunately, without managerial expertise necessary to reposition SI, it has not been possible to realise value from this development project. The next section looks in more detail at how project specifications and solutions were developed within SI.

4.4.2 Product Development

A project for SI typically consisted of "*unique panels and unique systems [software and machinery]; bespoke all the time" (PE)*, with relatively standard machine modules being configured to meet unique requirements. As a result, highly customized software was required to integrate systems, which created potential problems for clients attempting to articulate and specify requirements in a way a third party could understand. This process also meant that SI had to develop solutions that met client budgets, but unless clients are willing to accept feedback they may become tied to particular ideas, a "*Rolls Royce… but they've only got the money for a Mini"* (PE). Such a situation could result in the need for numerous variation orders as clients developed an understanding of what they needed, but the client also being unsatisfied with the end result. Unless there was an appreciation that specifications needed to be continually verified to prevent misinterpretation, oversights in the contract may remain unresolved throughout the life of the project. This was highlighted by PE who stated that the "*savvy customers will ask why*" (PE) there were differences between quotes, and knowing not to base decisions wholly on price. The aim of repositioning the business closer to the client would help to address this issue, as "*we're closer to understanding their needs*" (OD), which could reduce the risks of mis-specification and mis-interpretation.

> *"You may get a user requirement specification out of a customer, so these are the requirement specifications it should be, so this is exactly how they expect the machine or process to operate. Any grey areas in there you know, the lead engineer and equally the detail engineers should be clarifying, in my opinion, as you go through*" (ED)

Unless this was carried out, rework could result from the misinterpretation of specifications, and a client may not be obliged to pay for the rework. With relatively tight margins, accurate specifications were important, so *"if there is rework to be done, they [the client] have to pay for it"* (ED). Issues occurred if an engineer involved did not raise concerns immediately and "*let it ride until final testing stage" (ED)*, the "*most expensive moment in time to make a change*" (PE). This was clarified by an example where an engineer had not "*chased*" (ED) the client for clarification of specification until final testing.

The unique aspects of each project meant that there were similarities with product development. Following the statement of requirements, specifications may require altering through the project process, and it only being possible to assess project success following implementation. However, it was noted that client satisfaction was not only determined by end product performance. Client satisfaction could also be affected by whether they had been involved and informed through the project process.

> "*I always tend to try and keep a dialogue going with the customer and every time … I always try and make them aware of where we are and what we're up to*" (ED)

> "*The idea that they [a client] need reassurance appears to an engineer as being a negative*" (OD)

Informing clients reduced the risk of "*having to re-engineer it at the end"* (ED), reducing the rework that could lead to project delays. However, if "*you've got a customer who is full of ideas and can't stop themselves having ideas*" (PE), there needed to be a trade-off between involvement and limiting variation orders. The following section focuses upon how SI was able to pursue improvements internally to reduce the risk of project overruns and promote the delivery of projects on time to budget.

4.4.3 Process Improvement

Although ED explicitly stated he had "*I would say limited*" involvement in improvement activities, topics related to process improvement were covered in depth within the interview with him. This highlighted a perception of process improvement being related to administrative processes compared to software writing. However, the potential to improve the process of software writing was not overlooked, with software writing improvements having the potential to reduce the occurrence of repeated errors, when "*we have missed a few tricks the last sort of year or so*" (ED). Following procedures also provided engineers with evidence to "*back up whatever stories you want to tell*" (PE) when dealing with clients. Using operational procedures to present and get agreement on specifications reduced the ability of clients to change specification without agreement from all parties. However, while procedures were a means of reducing the occurrence and recurrence of errors, procedures were only effective if they were followed and updated.

> "*My guess is if you saw a repeating mistake, then yeah, we would try and make sure we communicate that back to everyone saying you know, beware, be careful, don't do this or make it more formal, you know. I've not seen… I can't give you an example when that [happened]… normally it's an oversight or misunderstanding… anything we find through that process [auditing] whereby it was fundamentally a mistake on our behalf, then that would lead to corrective action and then we'd have follow through into the quality processes through that.*" (ED)

The above highlights an inconsistency between the formal QMS process, and the approach taken by ED who emphasised "*implement[ing] good software*" rather than adhering to procedures. With the majority of issues being misinterpretation or unclear specification ("*probably seven or eight times out of ten*" (ED)), the above process was either not adhered to consistently or engineers did not follow procedures.

This conflict between formal (procedures) and informal processes (individual behaviour) reflects how the system appeared to be transferring from a means of securing business to a "*means of managing the business*", a "*subtle change*"(PE). However, as the QMS was not explicitly related to software writing, it did not require the implementation of and adherence to procedures related to the software. The OD outlined this in relation to the continuous improvement required by the QMS being more directed towards the manufacturing side. The manufacturing process was more easily quantified and measured, errors in bills of materials or errors in drawings lent themselves to being measured, although they were "*probably over analysed" (OD)* when it was the software writing where more costly problems occurred. However, the difficulty in formalising the measuring the software writing process meant that formalising and improving the process would potentially be very complex:

> "*Where we do tend to have more problems is in the designs of the software because software tends to be done by one person or maybe two people and it's not something you can easily see mistakes*" (OD)

The conflict between informal and formal processes was further emphasized by the approach ED took to writing software in order to promote consistency and reduce errors.

> "*Well last year or the year before, I had a sequence to do and I typically do a little spreadsheet, step one, step two, special conditions. And then I had a conversation with [PE] and a few others, 'Oh can I copy that spread sheet?', 'Yeah, okay'. Next minute it's on a standard form and it was like it didn't need to be a standard form*" (ED)

Although the importance of software standards and improving software standards was important for improving software consistency, explicit procedures were considered less appropriate by ED. Rather than procedures being necessary, software writing was considered more related to how individuals approached these activities, "*an attitude issue rather than a clear training issue"* (ED) and "*a lot of quality comes out of just experience"* (OD). Having grown relatively quickly, some of the individuals recruited were stated as being "*much more comfortable*" (ED) to just do their job, not necessarily striving to improve and challenge themselves. The growth in terms of staff and number of concurrent projects had also resulted in all hands meetings being stopped. All hands meetings had provided a forum for the "*cross-pollination in terms of ideas*" (ED) and interaction between all members of staff. This may have resulted in a perceived division between the existing and newer members of staff that "*don't necessarily mingle*" (PE).

> "*We are getting to the point now it's difficult to understand who is facing what challenge and might I have an answer for them in terms of what I've experienced before?*" (ED)

With the QMS being necessary to meet customer requirements, less attention was given to operational procedures being a means of capturing knowledge, sharing knowledge and informing practices. With individuals not necessarily adhering to procedures, changes to procedures would not necessarily affect individual project behaviour. The result was that although the QMS was aimed at improving project consistency, only once those in the system accepted and engaged with the system, would it affect project level behaviour and help reduce errors in projects.

4.4.4 Within-Case Analysis

From the content of the three interviews, the types of improvements related to two main areas. The first related to the project process, that related to more efficiently providing customers with defined solutions to ensure costs were controlled on competitively bid projects. The second related to expanding the scope of projects before or during the tendering process, where there was potential to draw from technical knowledge and increase the value received by the client, by moving away from like-for-like project tendering.

Since the implementation of the QMS, improvements had been made to remove detail from the system to allow the system to be used more efficiently. While operational systems had improved in terms of their ease of use, such improvement only indirectly contributed to customer satisfaction, if they were able to contribute to greater project consistency. With many issues experienced by customers resulting from misinterpretation during software writing, as the system did not relate directly to the software writing process, the standard of software was dependent on the individual engineer. While experience provided relevant knowledge, the attitude of engineers affected how engineers viewed the process and whether they aimed to produce error free software. Consequently, while the refinement of operational system had resulted in their gradual improvement as a function of time, similar to the learning curve (Wright 1936), with software writing being affected by individual attitudes, software writing may not necessarily improve in the same way. This would suggest that the learning curve is not applicable to describing improvements that take place within SI, as project performance did not appear to improve as a result of the number of completed projects.

Consistent with the adaptation of operational procedures, when issues were identified on completed projects, SI initiated group activities, which contributed to the development of operational procedures. The growth of the company had limited group activities (specifically the all hands meeting), reducing the ability to learn from the experiences of others, which had led to SI "*reinventing the wheel*" (ED). As individuals did not necessarily adhere to procedures when writing software, the impact of group problem solving activities was further limited. The client specific and highly specialized nature of the SI's work required close involvement with clients and suppliers. Unfortunately, with the specification of projects frequently being predefined, this limited SI's ability to develop project designs and specifications that reflected their knowledge of technology. Over involvement with clients was also outlined as having a negative impact on project progress, due to the introduction of rework, or being unable to match customer expectations. Within SI, it appeared that unless it was possible to make use of knowledge acquired from suppliers and formulates project specifications through involvement with clients, learning from external parties was unable to contribute to improved project performance. Findings from SI suggest that unless involvement with clients and suppliers can contribute to the development of project specifications that are implemented internally, involvement with external parties will not necessarily contribute to improvement manufacturing performance. Evidence collected from SI thus provides limited support for the structure of Schroeder *et al.*'s (2002) model of learning.

Reflecting on previous discussions, operational activities took place across numerous organisational levels, from individual software writing, to involvement with customers and colleagues to operational procedures at an organisational level. However, while operational processes had been implemented as part of the QMS, due to management not actively supporting their use, procedures related to the software writing processes had a limited impact of individual behaviour. The attitudes of some of the engineers and directors within SI also appeared resistant to the use of such procedures, but also affected how individuals engaged with colleagues and external parties, through sharing experience or asking for clarification respectively. The attitudes of some of the staff in SI appeared to have been affected by SI's rapid recent growth, where it had not been possible to change how individuals viewed operational procedures. Rather than procedures being viewed as devaluing individual experience, viewing procedures as a necessity within a larger firm. Overall, the process improvement behaviour maps the structure of Crossan *et al.*'s (1999) 4I framework. Observations highlight the need for management to feedback support for the use of operational processes and change individual perceptions in a manner that meets the requirements of the new, larger organisation.

SI provides an example of the service end of the product-service continuum. The majority of what SI provided customers was intangible and related to engineers providing software-writing services, with physical control panels being a smaller portion of their business. Even so, SI implemented the same QMS as firms providing considerably more tangible products. The result was that those involved in the research viewed the processes undertaken as being divided into tangible and intangible, with the QMS being less relevant to the craft of software writing. To address this, SI were beginning to focus upon critically assessing and refining their QMS in order for it to provide appropriate levels of structure without affecting the individual nature of software writing. However, procedures related to the software side of the business appeared to require further adaptation to prevent prescription, while promoting "*implement[ation of] good software*" (ED). Such practices, supported by management, may involve coaching engineers to take pride in producing error free code by following procedures, or alternatively relate to the regular in-process testing of software, which was to *"review our software design process" (OD)*.

Unfortunately, with the amount of experience held by many of those within SI, there had already been instances where engineers resisted new approaches to working. This was discussed in relation to certain individuals being "*highly sceptical*" (PE) of continuous improvement.

4.5 Engineering Manufacturer 1

Engineering Manufacturer 1 (EM1) was located in the East Midlands and had been operating since the 1960s. While possessing a long operating history and still using traditional metal working techniques, EM1 had invested in modern manufacturing equipment, operating across a range of industries, both locally and globally. While they had been significantly affected by the global financial crisis of 2008, EM1 had been able to maintain employment levels, enabling them to retain trained and experienced staff through particularly difficult periods.

The following case study is based on a two-hour meeting with the Managing Director (MD) and the General Manager (GM) and an hour and a half meeting with the Project Engineer (PE) responsible for actioning improvements within EM1. Meetings were recorded with the consent of interviewees and transcribed to produce 85 pages of transcriptions. The interviews were complemented by two informal site tours to observe operational practices and collect a small amount of observational data related to how operational staff engaged with management. Data was also drawn from the company website, which included a number of publically available videos on operational processes within EM1.

Table 4.2: EM1 Company Characteristics

Staff	Equipment	Capabilities
Managing Director, General Manager, two administrative staff, Project Engineer, three Software engineers, three welders, ten production staff, three warehouse staff	Three CNC cutting machines, laser and mechanical	Laser profiling
		CNC punching
	Five CNC sheet bending machines (press brakes)	CNC bending
		MIG and TIG welding
	Two clinch fasteners	Thread and nut inserting
	Eleven welding plants	Production tox joining
	Various machining equipment (milling, drilling etc)	Power coating
		Metal plating
	Programming and solid works drafting systems	Hot dip galvanising

Table 4.2 presents the make-up of staff within EM1, the equipment that was present and the operations capabilities that EM1 possessed. The following case study reports on how EM1 were operating within a difficult environment, where both lower cost economies and alternative materials had the potential to reduce demand from existing customers. The case is discussed in three sections related to operational development, product development and process improvement that were the primary topics of discussion within the interviews. The case will be concluded by analysing findings in relation to the three models of organisational learning.

4.5.1 Operational Development

The MD took over the company in 1998 and has focused attention on investing in the firm to promote development. This was demonstrated by the type of machinery within the company that included numerous CNC press brakes for bending sheet metal and both mechanical and laser CNC sheet metal cutting machines. Production equipment was complemented by hardware and skills related to the design of products and programming of production equipment.

> "W*e've got quite a good level of machinery… they're fairly new, fairly up to date, but also we're using some of the good old ideas, things that they were using 50 years ago*" (GM)

The older process techniques included manual punching, drilling as well as various forms of welding. The range of production equipment provided EM1 with a range of capabilities with which to approach opportunities customers brought to EM1. For example, although the laser-cutting machine was very flexible and capable, *"an old press tool that would form it in one go"* (GM) may be considerably more cost effective on particular products. Combined with investment in machinery, the importance of training and developing staff was also acknowledged, which enabled EM1 in utilizing machine capabilities.

> "*I think we've improved the guys tremendously, I mean, I suppose on average we've got twice the press brake skill level here than what you would have normally with the number of press brakes we've got*" (MD)

Such investment in human capital resulted in an increased level of flexibility, through an ability to reallocate operators depending on the make-up of work within the factory at any given time. If necessary, capacity could be further increased by using agency staff. This was supported by an established relationship with a recruitment agency, who sent *"the right type of people to us"* (GM).

> *"The other thing that the sound trained base helps with, is if we get wanting more production, we're comfortable to bring in a couple of temps because we've got the skill level to keep their eye on them, so that works really well*" (MD)

This approach provided EM1 with an ability to expand capacity without having to expand full-time worker head count that may result in a need to incur redundancies if demand reduced. Forced redundancies were stated as something "*I'd hate to deal with, you know, the culling of parts of the business to make it survive*" (MD). This approach was also consistent with the MD "*not deliberately trying to expand*". The view to expansion was instead oriented towards incremental and cumulative development to promote gradual organic growth.

Importantly though, the focus by the MD on development did not overlook one of the basic motivators of employment, pay, with low levels affecting motivation, which would have affected EM1's ability to realise value from their investment in machinery

> "*Trying to raise individual skill levels, the more they can do [in production], the more they can do for us, if you know what I mean, the idea is get a lot of good lads and pay them quite well, innit [isn't it], but we're bringing them on at the same time... we've got a very, very good work force, not just in their skills, but in their attitudes and performances and things like that*" (GM)

In combination, the staffing policy appeared to create an organisation where individuals were willing to share ideas and openly discuss problems. This was demonstrated by the interview being interrupted by a young operator suggesting an improvement to an operational process. The willingness of individuals to share ideas was likely to be at least partially the result of the MD's commitment to maintain employment during the recent difficult periods of the economic slowdown.

> "*We struggled, there were times when we had blokes painting and all sorts and doing things... well [the MD] made a decision to keep as many people here as we could, obviously it was at the back of our minds [that the approach wasn't sustainable], but I think with hind sight we did the right thing*" (GM)

With management demonstrating to the staff that they considered them more important to them than short-term profits, individuals were potentially more likely to behave in a manner that benefited the firm as a whole, through the sharing of knowledge even if they did not benefit personally. The following section reports how the environment developed within EM1 contributed to product development activities within EM1.

4.5.2 Product Development

Within what was effectively a sub-contracting business (as they did not own the designs of the products they produced), combined with their small size, it was stated, "*we purely couldn't compete on price*" (GM). EM1 were competing against lower cost countries, lower cost materials (for example plastics) or larger companies who could benefit from economies of scale. If EM1 had chosen to compete directly with other companies, profits could be competed away during tendering, resulting in work that was not profitable to produce. The risk of this approach was illustrated by a job EM1 inherited from a competitor, who had potentially won the work on price.

> "*The original cabinets were incredibly poorly priced, and you could see why the supplier sort of went bust*" (GM).

To address this issue, EM1 focused upon applying their knowledge of sheet metal, machine capabilities and where possible involvement with the customer to continually develop the design of products.

> "*One of the biggest things I believe we do is take a product and improve it, you know, somebody comes to you and says can you do this? And we'll say no, but we can do it better, and change it around and the customer makes a benefit and we make a benefit, because we're not so much in direct competition with what somebody else had done*" (MD)

> "*Looking at the products and saying, let's make it this way, let's make it that way, or make it better, and it's a policy that has worked well for us, hasn't it [directed towards the MD], and we'd like to continue with that, because it's just that little extra that you're giving to the customer, that perhaps some of our competitors don't offer*" (GM)

The outcome of this was well encapsulated by the GM, "*If you're good at something you can offer a price to your client and maintain a decent profit*". However, the processes that were employed to achieve this were also expanded upon within the interview with PE, who was able to outline how he applied his knowledge of metal forming to redesign products. If a client's product designer did not have sufficient production knowledge, product designs would not account for the manufacturing process. PE's approach to improving product designs consisted of breaking down the design to assess how it would be made differently.

"*Take the engineering out of this and make it very, very simple, very cheap and a lot less cumbersome really… sometimes they [designers] don't know the fundamentals of what the machines can do, i.e. what sort of length of bend and what sort of shortness of bend you can do*" (PE)

The process of product development, improvement and redesign was described as taking place in two ways, dependent on how EM1 were approached by a client. If a customer had been let down by their supplier, EM1 may need to supply like-for-like parts, potentially at a loss, to allow their client to honour existing orders.

"*We'll take an order on for you, and we'll make them, because he needed them doing quickly, so we did that, and looking at how they went together, immediately, [PE]… started looking at it said… 'that can go there'… The first order, got it through, while that first order was going through [PE] was redesigning the unit*" (GM)

EM1 would present redesigned products to the customer for approval or refinement at the end of an initial order. This meant that the parts EM1 supplied for subsequent orders were more profitable, effectively meaning they were able to supply a client in a sustainable manner. Some improvements also directly benefited their customers, such as providing greater flexibility by reducing the need for the customer to hold large quantities of stock. GM and MD considered that this process changed how clients perceived EM1, as a partner rather than simply a contract manufacturer.

"*If we can keep learning about their product, and making it better, and they'll modify things slightly, they'll learn about us as well, and at the moment, they're working with us to improve it [a product], which I wouldn't say its guaranteeing the business, but it's going a long way to making sure we get it, and we can keep performing and showing them savings*" (GM)

Each of these instances shows EM1 proactively investing in improvement activities that were not initiated or funded by clients. If customers chose not to accept changes or even took redesigned products to other suppliers, there was a risk EM1 would not benefit from their investment in improvement activities. This risk was reduced by trust developed between EM1 and their clients, but also by appreciating that other suppliers may not be able to imitate designs that EM1 had developed (due to the presence of specific production equipment within EM1). In addition to the immediate benefits related to improved product designs, there was also potential for improvements to increase the volume of products clients were able to sell.

> "T*hey're still talking about doubling it [orders for a particular product], so we could end up with four times the business on that particular front*" (MD)

In addition to securing business and improving products, close-working relationships with clients appeared to assist EM1 in securing subsequent work with existing clients. From a foundation of successful past transactions, a client would be more likely to trust EM1 in providing them with a good solution, choosing to forgo time-consuming tendering processes. By dealing with EM1 directly, there were opportunities for client to engage in more fundamental product redesigns that would not be possible within price-based tendering processes. This emphasis on continually identifying opportunities to make improvement to products also took place within the factory where incremental changes were made to operational processes. While not changing the nature of the parts received by clients, such changes also were able to realised benefits for EM1.

4.5.3 Process Improvement

Due to product development activities drawing from process and material knowledge, the defining line between process improvement and product developments appeared blurred within EM1. However, with certain process improvements not affecting the product received by clients, operators were able to make certain process improvements without requiring explicit approval from management or clients. These consisted primarily of reordering operational processes and introducing new tooling that improved the manufacturing process, reducing cycle times and reducing costs. This process was supported by the positive attitudes of operational staff, described within section 4.5.1, oriented towards company aims. The benefit of these smaller scale improvements was the effective unit cost of parts gradually decreasing overtime as operational processes were refined. The outcome of this was that if material prices increased, EM1 had the potential to absorb a portion of the price without reducing profitability.

> "*We'll have to put our prices up [as a result of material price increases], and we systematically went through our products, and we did put our prices up, but we made a policy that every time a job came through, we were going to re-evaluate [the product cost in light of current manufacturing techniques], and look at the products, and I tell you what, that made a big difference [to how much prices increased]*" (MD)

Rather than choosing not to inform clients and absorbing all price rises, EM1 were able to take a strong position with clients, "*a couple of customers disappeared, but they came back*" (GM). This process of incremental process improvement also provided EM1 with a way of demonstrating commitment to their clients to continually improve parts and feed improvements back to clients. By re-evaluating improvements made by operators, management were able to document changes in operational procedures to ensure changes were not forgotten and transferred to subsequent batches. The process also allowed management to validate the effectiveness of improvements made by operators. In comparison to initial improvements to products that may be motivated by winning tenders, proactive, incremental improvements demonstrated a continued willingness to pursue improvement. Compared to the one-off benefits of new product tendering, continual refinement of products provided more opportunities for clients to observe and benefit from EM1's skills in manufacturing and product design.

Process improvements were also initiated reactively in order to resolve product quality issues received from customers. On receipt of a non-conforming product, it was necessary for EM1 to identify the root cause of a problem and implement a corrective action. An example was given related to outsourcing certain activities, that was an alternative strategy EM1 used to increase capacity, but on this occasion was requested by a client.

> "*I cast my mind back to the parts we do for the roof rack now, we used to send these out [to a laser cutting company]… and what we used to find is there were*

variations in the material thickness, so one bend to the next there are a differences in angle and it was horrendous" (GM)

By outsourcing this process, EM1 were unable to ensure the consistency of operational processes. Within this example, the client received non-conforming parts, which were blamed on EM1. Through knowledge of the metal bending process, and identifying where the variation in the process had originated, EM1 was able to identify the problem, provide a satisfactory explanation and corrective action to their client. In this particular example, the laser cutting was actually in-sourced to EM1, increasing the value of the job to EM1. PE provided details of the process that was carried out to identify the source of problems following identification.

"*If it takes a group of you to get together before we found out we've got a problem, I'm sure the group will get together and work it out, and we'll find a solution*" (PE)

Once the source of a problem was identified, product route cards were updated to ensure that following the identification of a solution to an issue, changes would not be forgotten on subsequent batches. The problem solving process that was described appeared to both be supported and enabled by the attitudes of individuals who instead of apportioning blame focused upon identifying and resolving the problem at hand. Interestingly, such improvement discussions appeared self-reinforcing, with involvement in such activities promoting the development of positive attitudes of individuals.

"*So the knowledge is out there, and again I think if they see a movement [improvements] in production, a movement in modernising [investing in new machinery], they'll have the tendency to go on [contribute] more*" (PE)

With product route cards being part of the ISO-certified QMS, internal and external auditing ensured the latest versions of route cards were in use, validating that documented improvements affected production behaviour. In addition to internally initiated changes to product processes and following receipt of non-conforming parts, changes were also requested by customers in the form of engineering changes that may result in new drawings.

> "*We will get a new drawing, an issue will change, they'll change the [route] card and pass through to programming whatever necessary changes they need to make and the card's updated for next time*" (GM)

The QMS appeared to promote consistent manufacturing processes, which when combined with part-cataloguing enabled EM1 to ensure that parts received by customers were those ordered. Procedures also included a list of approved suppliers, which helped remove variation when processes were outsourced, ensuring outsourced activities met clients' requirements. In a similar way to the development of relationships with customers, repeated involvement with suppliers allowed EM1 to learn about what particular suppliers were good at.

> "*We have an approved list of suppliers basically, it's quite big, we've got quite a few of them… we try and build a relationship with the suppliers, and we find through experience, that so and so is good at this, so and so is good at that… sometimes we'll put it on a card*" (GM)

Although the QMS provided a foundation upon which to base improvements, emphasis was given to the value the system provided the firm; "*if it's no benefit to the company, then I'm not doing it*" (MD). This included the negative associations of externally audited systems and carrying out particular processes because they were required the QMS.

> "*It [external auditing] was stressing people up so much, that I said, we've just had enough… because I just didn't want to put people through the hassle*" (MD)

Following the change in management, the QMS had been developed in a manner that ensured it met the needs of EM1, provided value to their clients and conformed to ISO 9001 requirements. From attending a course at the BSI, GM identified a need to change, which was supported by working with an auditor from BSI.

> "'*Let's work with you here', and he [BSI auditor] made us see the light basically, didn't he [directed towards the MD]? Because we can look at the manual and say*

that's it, the manual was written how we work, rather than us changing our methods to suit the manual, and I think that's the major difference" (GM)

Rather than "*fudging the week before he comes*" (GM), the system became consistent with the way EM1 operated, acting to support operations and give direction to how individuals undertook operations. The result was a QMS with "*no non-conformances as such and we've been able to embrace it now*" (GM).

4.5.4 Within-Case Analysis

The evidence collected on EM1 presents a firm operating within a difficult economic environment but pursuing active development. Process and product improvement represented important activities within EM1 that appeared to allow them to compete with both lower cost economies and lower cost materials. By discussing process improvement within the context of operational and product development, process improvement's central role within EM1 could be appreciated through its ability to improve profitability of work and win business. Overall, process improvement provided EM1 with a means of converting customer requirements and operational insight into tangible changes to product characteristics. These included both the design of the product, but also the processes by which they were made.

Compared to other types of production processes, such as injection moulding for example, the processes within EM1 were not defined by tooling. This allowed PE and operational staff to continually refine production methods without having to make permanent changes to expensive tooling [as is the case with injection moulding]. Such small-scale process improvements had the potential to gradually reduce cycle times and manufacturing costs. The benefits realised from such improvement were measured when product pricing was reviewed. Following initial redesigns of products that could realise large savings over time, the scale of improvements was considered to reduce, which is consistent with the learning curve (Wright 1936). PE acknowledged this limitation of the learning curve; "*until you get to the ultimate and you can't improve anymore*". Within EM1 it appeared to be the attitudes and performance of those within the system that determined whether such forms of improvement took place, which appeared to be the result of the support provided by management.

Complementing the gradual improvements to operational process initiated by individuals, improvements were also initiated as a result of group discussions, which were captured within operational procedures. Through involvement with suppliers and customers, product designs, product equipment and procedures could be further adapted, which enabled the further accumulation of resources and improvements in manufacturing performance. This appears broadly consistent with the Schroeder *et al.* (2002) model of learning, where internal and external learning contribute to the accumulation of proprietary resources. However, Schroeder *et al.*'s (2002) model does not give suitable direction on how internal and external forms of learning may relate to one another (Figure 2.6). Within EM1, it appeared to be the willingness of individuals to share operational insight, follow procedures and accept new approaches to working that allowed EM1 to implement improvements realised from involvement with customers and suppliers. This indicates that while there were some similarities with the Schroeder *et al.* (2002) model of learning there were aspects of EM1 that was inconsistent with the model.

Viewing operational improvement activities more generally, they can be appreciated as taking place across a number of operational levels. As a result of the PE or an operator identifying improvement opportunities and developing improvements individually or through group discussions, new approaches were implemented through changes in procedures and route cards. The accredited QMS ensured that current issues of route cards were used, that ensured production benefited from improvement activities were not forgotten across batches. This conceptualisation of process improvement matches the structure of the 4I framework of organisational learning (Crossan *et al.* 1999).

The evidence presented on EM1 outlines how the company approached business with severe competitive pressures from a difficult operating environment, lower cost economies and lower cost materials. The approach taken was to provide manufacturing, design and product refinement services to customers in order to win work, retain customers and assist in securing further work with existing customers. This was being realised through management investing in modern machinery, continually developing the skills of staff and paying them well. Investment in operating systems, in the form of the ISO QMS, provided a foundation for improvement that ensured improvements were documented and procedures were used. Following the management takeover, the perception of the QMS had changed, from a requirement of an external body to a means of adding value to the business.

4.6 Engineering Manufacturer 2

Engineering Manufacturer 2 (EM2) was a small firm based in the East Midland producing machined plastic seals primarily for use in oil and gas exploration and had been operating for nearly 30 years. Although operating within the difficult economic environment, the continued need to explore for oil reserves explained why EM2 had remained busy, with plans to buy new machinery, increase the work force and potentially move premises in the near future. The effect of the global financial crisis had, however, been observed with reduced demand from smaller, domestic customers.

Dealing with larger firms operating within high-risk environments, operating to an ISO9001:2008 accredited QMS was a customer requirement. The QMS ensured processes were documented products were traceable down to the individual who machined the part, a requirement of supply of particular customers. The production process consisted of compressing plastic granules into forms before sintering and machining them into customer defined shapes on manual and CNC lathes or milling machines.

The company structure consisted of two long serving Directors responsible for the business development and production portions of the business (Managing and Works respectively). Other members of staff consisted of three part-time administrative staff responsible and five machine shop operators who were involved in machining, programming, moulding and sintering operations. The following case study is based primarily on an interview with the MD that lasted over two hours, which was recorded with the explicit consent of the MD. The recording was transcribed verbatim and resulted in 47 pages of transcription. In addition to the interview, observational data were collected from a short site tour. The tour included a demonstration and explanation of the compression process, the machinery in use and how operational staff used the procedures that were displayed around the facility. The following report covers the main topics of discussion, in the form of operational development, product development and process improvement. The analysis section will relate the case data to the three models of organisational learning and the research as a whole.

4.6.1 Operational Development

The high demand from existing customers meant that the MD did not *"go out and look for new business*" (MD). Adverts were placed in trade magazines when combined with general enquiries, provided sufficient new business opportunities; these complemented the two other sources of new business. The first source came from purchasing managers changing companies and drawing from their existing contacts in their new jobs. The second source was a result of the difficult operating environment, where suppliers had gone out of business and potential customers of EM2 "*have lost their supply chains"* (MD).

Enquires that were received from new contacts, related to industrial sectors other than the oil and gas generally did not result in new business. However, if there was an opportunity to develop new contacts, the MD would aim to meet with potential customers to discuss the product application face-to-face, explore customer requirements and assess what would be expected of EM2. The presence of opportunities within the environment provided EM2 with opportunities to grow; "*If you've got the bottle, it's a good time [to expand]"* (MD).

> *"[We have] tried to increase slightly, try and take the pressure off slightly [by increasing capacity], I mean the pressures been on because the [work] load we've got, without sort of expanding, just change a couple of machines that we've got at the moment, employ one or two new people to sort of, bring them on board*" (MD)

To realise these aims, the MD wanted to buy a second hand CNC lathe, which could be financed by renewing an existing loan, allowing them to purchase an additional machine without any additional monthly outlay; "*it's basically a free machine*" (MD). However, potentially as a result of the economic climate, such machines were not available - "*it's finding one at the moment [that is the problem]"* (MD) - preventing the

MD from pursuing this avenue of his expansion plan. Previously, EM2 had purchased a new machine, which included the provision of external training. Due to the current operator being considered competent and them attempting to buy a similar machine, the premium of a new machine could not be justified. This cautious approach to expansion, although not reflecting growth opportunities, did account for the risks of interest rate increases but also the risks for customers and suppliers if expansion was not effectively managed. Unless consistent growth was reported in accounting data, insurance companies would "*take a dim view*" (MD) if financial performance declines, which could increase insurance premiums for customers and suppliers. Customers and suppliers "*are then reluctant to supply to you*" (MD) as a result of increased insurance premiums.

Although EM2 were able to invest in new machinery, it was necessary to meet high levels of demand and potentially beneficial for the company as a whole; internal issues had to be considered. Unless internal issues were considered, MD stated that they could affect the companies' ability to operate. As a result of the simple nature of the products produced, individuals were able to focus on their own work at a machine level and were stated as not wanting to appear to be singled out or favoured by being selected for additional training. Operators that were not selected may think (or say) "'*why shouldn't I have what you've got?*'" (MD), even if the decision was based on the abilities of the selected individual. Such perceptions and attitudes of operational staff led to them rejecting offers of further training, with one example given when an operator "*got a bit of a mardy on [grumpy]*" and ended up "*staying on the job I'm doing*" (MD) when offered training. This resulted in the MD having to select individuals other than the best person for the job. It was necessary to select those who were better able to "*brush off any sarcasm or criticism*", admitting, "*it is quite psychological sometimes*" (MD). The next section reports on parts of the discussion related to how EM2 went from customer enquiries to producing new parts.

4.6.2 Product Development

Following initial enquiries, if the MD met with prospective customers to discuss opportunities in detail, it was possible to determine if the MD wanted to get a "*foot in the door*" (MD). Although not holding the design portion of the ISO certification, the MD stated that with his knowledge of the manufacturing process, he was able to advise on or "*recommend*" changes or modifications to the design of products. By discussing product applications with potential clients, the MD was able to refine designs to account for the specific application. On occasions, this involved suggesting more appropriate or even less profitable materials, "*which is effectively losing me money*", but "*a little bit of honesty*" (MD) assisted EM2 in acquiring further orders and in developing a relationship.

With the relative flexibility of the operational processes that were not defined by tooling combined with relatively low material costs, "*I'm quite happy to make samples and go up [to the customer] with them and test them*" (MD). This allowed EM2 to quickly provide potential customers with near production ready products, allowing customers to assess the potential of products supplied by EM2 without having to wait for new tooling to be produced (as was the case with injection moulding companies, for example).

> "W*e occasionally have to change things, because it's not feasible to produce it, 'why have you got this like this? Why don't you just have it as a straight edge?... it would be a lot cheaper for you, it would be a lot easier for us to make, we'd be able to do it a lot quicker for you', things like that, for ease of manufacture point of view, occasionally the draftsmen, the people who do these drawings have not got much knowledge of production*" (MD)

Although representing relatively simple changes, the benefits received by customers in terms of product costs and the service received by customers, in terms of delivery lead-time, could be significant. However, unless it was possible to question customer designs through close interactions, specifications may not be changed, leaving design inefficiencies within the system. A lack of close involvement could have considerable impact on EM2's performance as perceived by customers. Unfortunately, a policy of particular customers actually perpetuated low levels of interaction with suppliers. Some customers dealt with EM2 via a third party purchasing company, who employed contracted purchasing staff. By only holding posts for a set period of time, purchasing staff were not able to develop relationships with suppliers; so they selected suppliers wholly based on the presence of quality accreditation and objective performance data, which they had access to.

"*He [the purchaser] will go through all the supplier base and decide who is the cheapest, who's got the best delivery record, who's got the best quality record, because they've got it all on file from previous purchasing personnel*" (MD)

This situation not only limited the ability to interact with customers but also increased the importance of undertaking internal improvement activities to improve in relation to the performance measures they were being measured on. The next section presents evidence related to such forms of internal improvement, systems in place that supported them and issues that were experienced by EM2.

4.6.3 Process Improvement

Within EM2, the limited focus on business development combined with limited opportunities for product development meant that the interview discussions focused primarily on process improvement. A specific portion of discussions focused upon the ISO accredited QMS that was in place as a requirement of specific customers; "*we wouldn't have got any business if we didn't have it*" (MD). The system had been in place for over 20 years, which meant there had been a considerable period of time for the system to become embedded into the company. With the MD having worked at EM2 for nearly 30 years, it was possible for him to reflect on how the system had changed over a considerable period of time. Changes had allowed the system to reflect the activities undertaken within EM2, rather than adapting internal operations to meet the needs of ISO. Through a process of refinement, it had been possible to reduce the manual to only "*40 pages"* (MD), in an effort to make the system as easy as possible to use. The gradual refinement of the system was reflected in a recent external audit report that was "*glowing*" (MD) in relation to how the system ran.

"*Just for doing it anyway, a signature here and there, a tick here and there on occasion, it's as easy to do that as not do it [rather than] then try to play catch up when the guy's [external auditor] coming*" (MD)

The responsibility for the system remained with the Directors and one of the Administrators to prevent problems if an operator left EM2 without warning. The system was considered important for providing process consistency, resulting in a relatively low rate of external non-conformance, "*something like 0.08% rejects, we get very few back, it's three or four [parts] a year at most*" (MD). Even though the quantities and cost of these non-conformances was small, non-conforming parts provided the MD with opportunities to improve operational systems and prevent recurrence.

> "*I'd like to see them, just to see what… see if there is any sort of link, any road you can go down, that tells you why it has happened... from my experience*" (MD)

Through experience, combined with knowledge of the product, process and materials, it was possible for the Directors to identify reasons, explanations or causes for non-conformances. This provided EM2 with opportunities to determine whether defects observed by a customer were the result of EM2's actions or whether they had been identified incorrectly as non-conforming. An example was given that related to a ring that had failed, which on inspection appeared to have been cut and "*our inspection staff are not that incompetent*" (MD) to send such a part to a customer. Alternatively, the MD had to inform a customer to measure products at the correct temperature before rejecting them - "*it's minus 17 degrees outside*" (MD). The traceability of the system facilitated this process of identifying the source of non-conformance and allowed customer feedback to be related back to the individual who had produced the part.

> "*It's good to give good news about their work.... good or bad feedback we report it to the people, the personnel involved, be it anything from manufacturing, packaging, occasionally things get damaged in transit, plastic is plastic [it can get damaged accidentally], so we have to revise methods [of packaging]*" (MD)

In addition to the identification of the causes of non-conformances, non-conformances also provided an initiating point for updating and improving operational processes and procedures. While the QMS was considered streamlined and easy to use, unless it was adhered to and used appropriately, it would not assist in improving process consistency.

> "*The more problems that arise when we're busy like I say, the delivery schedules tend to go out the window... it's a freak problem that has occurred [when] things get through the net that may be shouldn't but they do, I mean even with the ISO*

system in place, things still slip through the net, if there is a rushed job, you get a bit too busy, people tend to skip things [procedures]" (MD)

Such ad hoc rescheduling appeared to result in the QMS being overlooked in favour of meeting a specific delivery schedule. As stated previously, the manufacturing process consistency was relatively high, that was reflected in a low level of non-conformance originating from the manufacturing process ("*0.08%*"). However, not following procedures that resulted in the delivery of incorrect parts to customers created the same problems for customers as non-conforming parts (customers were unable to use the products that had been delivered). Delivery errors required EM2 to send replacement parts at EM2's expense and provide clients with non-conformance reports, including corrective and preventative actions. As issues were caused by operator oversight, while it may be possible to identify root causes, addressing them and preventing recurrence with confidence was stated as being more difficult. Implementing further training in procedures was unlikely to be sufficient, when all operators had already received training in the use of the QMS in order for the system to be accredited.

Due to errors being caused by operators not following procedures of the QMS, it was difficult to plan improvement activities for the coming year. Although quality and delivery performance was easily measured, improvement targets that were required by the QMS were effectively plucked out of "*fresh air*" (MD). The low rate and cost of production non-conformances meant there was limited motivation for the MD to pursue more in depth improvement activities in these areas, particularly when issues were frequently caused by non-adherence to procedures. This resulted in the MD viewing the improvement target aspect of the QMS as a "*bugbear*" and "*a bit of a drudge*" due to the limited relevance and ability to focus efforts towards improvement targets.

Although planned improvement activities were difficult to realise, other forms of process improvement had much greater relevance to the MD. However, as these took place as improvement opportunities were identified, rather than being planned in advanced, they fell outside the QMS.

"*we're continually improving our production methods on the jobs that we do over and over again*" (MD)

In a similar manner to product development, process improvements had the potential to improve the products and services received by the customer, whether in terms of conformance to specification, product cost or speed of delivery. While product development activities assisted in securing work, as stated in section 4.6.2, such improvement could reduce the money EM2 were able to make on parts. However, process improvements that resulted in reductions in process costs to previously secured products could directly improve the profitability of particular parts. An example was given where three parts were made out of a single rod by arranging the parts concentrically compared to making the rings from three separate rods.

"*Makes it very cost effective and being as our prices were initially based on buying the three different rods it's all profit*" (MD)

The savings in wasted material translated directly to increased profitability of the part due to it not necessary to change the price at which the products were sold. An alternative way EM2 were able to reduce waste and improve the profitability of work was by investing in new compression tooling. By having tooling that was closer to the final dimensions of a product, it was possible to reduce the amount of material that had to be machined off, reducing waste and increasing profit. Compared to the recording and graphing of delivery and quality performance, such improvements allowed the MD to apply his process knowledge as he identified opportunities. It was possible for the MD to subsequently validate the effectiveness of tangible improvements in terms of reductions in waste and increases in profitability.

"*You think of a way of doing one job, and you suddenly realise you can incorporate that into jobs you've been doing for years, that saves you money, and that's probably the most interesting part of the job, that's probably the bit that gives me the biggest kick, suddenly you wake up in the middle of the night [with an idea], scribble it down on a bit of paper.... it's silly little things like that, that just save you money*" (MD)

As well as the MD carrying out process improvement, "*the lads on the shop floor tend to do it as well*", but while the MD was open to ideas, "*sometimes they don't even tell me…. It's very difficult getting people to interact*". However, as these improvements were ad hoc and undocumented, they were not considered continuous improvement activities by the QMS and as they were not documented could be forgotten over time. These ideas that "*you come up with out of your head*" provided motivation for the MD and potentially made operators' jobs more interesting, while simultaneously were considered to save "*vast amounts of money*". Unfortunately, without operational staff formally engaging in such activities, the effectiveness of improvement activities could not be measured, meaning it was not possible to attribute savings in product cost to the actions of individual operators.

4.6.4 Within-Case Analysis

EM2 provide an interesting example of a firm operating within a relatively protected market, with high demand for relatively profitable products. However, while there were opportunities for expansion, with the difficult economic environment, management attention was given to controlled, organic expansion in order to limit the risks if growth could not be maintained. The structure of the business environment provided further interest, with limited opportunities to interact with certain customers, reducing opportunities to identify product improvement opportunities. Without an ability to interact closely with all customers, there were fewer opportunities to refine products and apply process and material knowledge. Although having limited opportunities to adapt products, where opportunities arose, product and process improvements had the potential to provide a range of benefits both to customers and EM2. The flexible nature of the manufacturing process lent itself to such forms of improvement, due to an ability to quickly change product design without having to make permanent changes to production tooling. This flexibility also lent itself to working with potential customers, where production ready samples could be inexpensively manufactured for testing.

The continual improvement of repeated jobs resulted in the gradual refinement of production processes and product designs that had the potential to result in reductions of process cycle-time and costs. Over time the benefits realised from such improvements were likely to reduce, reflecting the structure of the learning curve (Wright 1936; Yelle 1979). However, some of the improvements made by operators were not documented. Such improvements could not be measured, reducing the ability to validate the effectiveness of improvements and increasing the likelihood improvements could revert over time if process changes were forgotten. The lack of direction or involvement of management in this form of learning highlights similarities with the autonomous nature of the learning curve that has been described in the literature (Li and Rajagopalan 1998).

Apart from autonomous improvements made by operators, the MD and Works Director appeared to carry out the majority of improvements that resulted in updated operational procedures. With operators tending not to be involved in the QMS, group problem solving was not carried out - "*it is very difficult getting people to interact*" (MD). The nature of the relationships with customers also meant that there was only limited involvement with customers and suppliers only being referred to in relation to buying a new machine "*three years ago*" (MD). While there was only limited involvement with external parties, involvement appeared to have a significant and positive effect on operational process. As a result, the findings from EM2 are not consistent with the Schroeder *et al. (*2002) model, due to low levels of both internal and external learning being able to have a positive and significant impact on manufacturing performance. The evidence also appears to indicate that without greater levels of internal learning, it may be difficult to benefit from further external learning. The example of the introduction of new machinery (section 4.6.1) infers that external learning would require internal learning in order for new technology to benefit internal operations. Unless operators accepted new machinery, it is unlikely that involvement with external learning would positively affect manufacturing performance.

While process improvements benefited from involvement with external parties and were implemented internally, formal (rather than autonomous) process improvements appeared to take a particular form within EM2. From being initiated by the insight of the MD or receipt of a non-conformance from a customer, they were explored individually or at times with the Works Director. Following agreement, improvements were documented within operational procedures, with subsequent auditing validating their use. While group discussions did not formally take place within EM2, due to a lack of involvement of operational staff, by reflecting on their large stores of personal experience, the MD and Works Director were able to develop ideas in a manner that was similar to a group discussion. Consequently, while the practices were broadly consistent Crossan *et al.*'s (1999) 4I framework. The attitudes of operational staff (culture) and the MD not actively pursuing new business (strategy) provide explanations for the situation within EM2, inferring the 4I framework was applicable for interpreting findings from EM2.

Although a very small firm operating within an environment providing limited opportunities for improvement, EM2 still provided an interesting context in which to view process improvement activities. Without it being necessary to undertake process improvement to aid firm survival, apart from quality non-conformances, operators and the MD effectively undertook process improvements voluntarily. Process improvement provided EM2 with a means of reducing waste, reducing production cycle times and improving the profitability of work. Where improvements resulted in updating procedures, the QMS ensured that improvements were not forgotten and changes in behaviour were maintained. While operational staff did not necessarily engage fully with the system, due to the small size of EM2, it was possible for the two Directors to monitor adherence to procedures directly. This meant that while the firm culture appeared not to be oriented towards following instructions from management, management were still able to ensure procedures were generally adhered to.

By providing additional resources, there were opportunities for management within EM2 to support operational staff in engaging with deliberate, group-based process improvement activities, which may result in a greater willingness to accept training in new approaches. In relation to the 4I framework, this would result in individuals contributing to group discussions that would result in more frequent adaptation of operational procedures. This may in turn assist in the introduction of new process equipment or products. As a result of more active management, it may be possible for the MD to pursue growth without the risks associated with operational staff rejecting new operational approaches and potentially leaving the company.

4.7 Within Case Summaries

Table 4.3: Within Case Summaries and Findings

Company	**Topic**	**Illustrative Quote**
BC	Operational development	Management pursued new types of business to reduce risks associated with operating within a single sector and implemented new operational systems to achieve this
	Product development	Emphasised the development of product designs in order to provide increased value to customers and move away from competing on price
	Process Improvement	Implemented changes to operational procedures based on contributions from operational staff to transfer site level and forum based improvements across projects
IJ1	Operational development	Targeting business in a range of sectors including automotive but were not pursuing the implementations of the necessary quality management systems
	Product development	Focusing on the acquisition of work in an effort to increase turnover, reducing opportunities to develop products and resolve problems with tooling
	Process Improvement	Had recently been involved in a process improvement intervention, but without formalised systems in place, improvements were not maintained over time and operations staff resisted changes to practice
IJ2	Operational development	Management focused on introducing a range of new of business supported by developing tooling development capabilities and systems to ensure consistency of operational processes
	Product development	Working with customers to develop products in order to adapt product designs to ensure products meet customer requirements and could be moulded consistently
	Process improvement	Improvements are carefully managed to ensure changes to tooling or process settings do not adversely affect product characteristics through group discussions, which were documented in operational procedures
SI	Operational development	Management had implemented operational procedures to support business growth and meet customer requirements
	Product development	SI aimed to develop project specifications with customers but tending to pursue projects that had already been specified, limiting opportunities for SI to change project designs
	Process improvement	Improvement opportunities discussed within groups, but due to engineers not accepting the role of operational procedures and management not enforcing their use, operational practices remained unaltered following improvement efforts
EM1	Operational development	Management implemented operational procedures, invested in new machinery and supported the development of operational staff to be able to work with customers to develop product designs in order to move away from price based competition
	Product development	Work with customers to redesign products so they reflected operational processes and accounted for the needs to the customers
	Process improvement	Operational staff looking for ways to improve operational processes and improvements documented within operational procedures through involvement with the project engineer
EM2	Operational development	Management implemented operational procedures but did not actively pursue new types of business and particular customers making in difficult to develop relationships with them
	Product development	Some, ad hoc involvement with customers to redesign products to make them easier and cheaper to produce
	Process improvements	Process improvements transferred across products by management reducing costs and making products easier to make, operational staff improving processes, but not documenting changes making them difficult to validate

4.8 Chapter Review

Following the direction of Eisenhardt and Graebner (2007, p.29), this chapter has given specific attention to exploring the exploratory case companies individually. By focusing upon the companies individually, it was possible to explore the relevance of each firm to the research. Within this chapter, it has been possible to begin exploring process improvement behaviour within the six exploratory case companies, as well as the relevance of the three models of organisational learning identified within Chapter 2. Within the exploratory case companies, process improvements allowed each organisation to develop in terms of winning new business, improving profitability, reducing production cycle times, improving process consistency or reducing the occurrence of non-conformances. Process improvement also appeared to play an important role within operational and product development activities. The insight from each case is, however, company- and context-specific, so cannot be considered to be applicable to other firms (Yin 2009). The next chapter will present cross-case analysis related to process improvement activities within each case company to present evidence for addressing research question 1. Chapter 6 will relate findings to the three models of organisational learning, so presenting evidence related to addressing research question 2.

Chapter 5: Cross Case Analysis 1 - Process Improvement

Building upon the literature presented in chapter 2, chapter 4 presented within-case analysis of the six exploratory case companies. The within-case analysis emphasised the processes and activities undertaken within each firm that supported process and general improvement. Findings of each case were then discussed in terms of the relevance of the three models of organisational learning to practice. The following chapter draws from the within case analysis to analyse and structure process improvement activities within each of the exploratory case companies and identify factors that appear to affect how they carry out these activities. Findings will be used to accumulate evidence related to addressing the first research question:

RQ1: How do engineering-oriented SMEs undertake process improvement?

While focusing upon the process improvement practices, due to the overlap between the topics presented within chapter 4, operational transformation and product development will also be considered within the analysis.

5.1 Cross Case Analysis

The six exploratory case companies provide a diverse range of perspectives on process improvement within engineering-oriented SMEs, which was a result of the broad selection criteria presented within section 3.3.2. While there was variation between the nature of process improvement activities within the exploratory firms, portions of the variation appeared to be explained by how defined the operational processes were. This related to the types of operational/manufacturing processes that were present in each firm, from injection moulding (IJ1 and IJ2) being defined by product-specific tooling, to engineering services (BC and SI) being determined by the behaviour of those within the company. In the middle of these two relative extremes were the engineering manufacturers that used relatively generic processes of machining, drilling and welding to produce a wide range of products.

Across the firms, processes appeared to gradually improve, as process characteristics were adapted and refined as opportunities were identified for improvement as more parts were produced. However, within the injection moulding companies, machine settings were initially optimised to get an acceptable match between process and product characteristics that were accepted by the client before production began.

> "*[The production manager] will go there and he'll run it, make one alteration and wait, do another one. And then we do this system where we run a tool for four hours and as long as it runs consistently for four hours, you know you've optimised [the process]….'your skill is you set that on day one, you set the standard, you told us that that's the best and it's written down now [in a procedure]'*" (MD, IJ2)

IJ1 and IJ2 also highlight how problems could occur if procedures were not adhered to following optimisation.

"*It [the cycle time] had raised to 50 seconds, so we're losing ten seconds*" (AOM, IJ1)

"*If you added or took away one second off the cycle time, it becomes a failure*" (MD, IJ2)

Where process characteristics could not improve following initial optimisation, deviation from procedures could lead to the deterioration of process characteristics, highlighted by the MD of IJ2. Where operational processes were less defined, operators were able to identify and implement improvements, as long as they did not change the final product characteristics. The MD of EM2 highlighted this where "*the lads on the shop floor tend to do it [make improvements] as well…. sometimes they don't even tell me*". Without informing management and documenting these improvements, it was possible for operators to forget improvements between batches and made it more difficult to measure the benefits realised from improvements.

Gradual improvements to process characteristics or product design tended to *"get to the ultimate and you can't improve anymore"* (PE, EM1), which resulted in diminishing returns of further improvement activities. Within the more service-oriented firms (BC and SI), while procedures were important, the greater flexibility of processes appeared to required greater attention on the accumulation of personal expertise. However, formalised operational procedures were able to augment personal experience, which allowed individuals to learn vicariously from mistakes experienced by others.

> "*The intention of the quality system is very much along the reducing variations, managing issues, so that you deal with them once, so they don't come [back], so you are learning from what's happened*" (Consultant, BC)

The presence of a QMS allowed all the firms (apart from IJ1) to accumulate and document experience. Current procedures were the result of older procedures that had been updated and refined to account for the solution of previously experienced issues. Procedures thus reduced the risk of individuals forgetting previously learnt lessons or not informing others of the lessons they had learnt. Unless lessons were shared across operators, situations could arise where "*we have missed a few tricks [opportunities for improvement] the last sort of year or so*" (ED, SI) where mistakes were repeated. With the nature of work within BC and SI where projects could last up to a year, it was unlikely all lessons could be remembered by individuals and it was more difficult to share all lessons informally, making the use of procedures more relevant within this context.

BC, IJ2 and EM1 paid explicit attention towards managing gradual changes to operational procedures. This ensured that changes had the desired effect of process outcomes and if it was found that they did not (through measuring the effect of changes), it was ensured that further revisions were made to procedures. Within BC, IJ2 and EM1, management supported operational staff to discuss potential improvements within groups.

> "*If somebody comes up with an innovative idea, you know, well 'he did this', 'but he did that', 'oh that's right', well we have forums, project manager forums, a couple of times a year, where we all sit around the table together and discuss processes, better ways of doing things*" (PM, BC)

> "*You've got to have that group discussion... 'look guys, don't blame anybody here; this is the problem and how are we, as a group... [going to] resolve this problem?'*" (MD, IJ2)

Within IJ1, SI and EM2, less attention was given to managing gradual process improvements, with changes being made by individuals and not using group discussions to develop solutions to issues. Operators within IJ1, SI and EM2 tended to draw from personal experience, refining procedures (or personal practices) through processes of trial and error.

> "*They're not keen or friendly regarding the tools and things there [the improvement intervention], you realise very quickly that they haven't got it [understood the new approach]*" (AOM, IJ1)

> "*There's definitely a two culture existence… their office can be very quiet [don't share ideas] and yet our office can be full of banter and laughter*" (PE, SI)

> "*It is very difficult getting people to interact*" (MD, EM2)

The unwillingness of individuals to interact, share ideas, and accept improvements to work practices suggested by others, either through personal instruction or by using procedures, appeared to affect the consistency of processes within IJ1, SI and EM2. Without systematically developing and adhering to operational procedures, an unwillingness to use operational procedures also affected IJ1, SI and EM2's ability to improve systematically. These firms appeared less able to develop solutions that reflected the accumulated organisational experience, compared to "*my experience*" (MD, EM2). Without being involved in the development of the solutions, operators appeared less likely to follow the procedures that were present. Within SI, the issue of not engaging with procedures was not addressed (or acknowledged) by management, who instead emphasised "*skills, experience, attitude*" (ED, SI) as contributing to process consistency.

This lack of management support for adhering to procedures was further emphasised by an example related to a routine for systematically writing software, considering that "*it didn't need to be a standard form*" (ED, SI). The use of such a form had potential to contribute to improved process consistency and systematically developing software structure, but without management promoting the use of such procedures the ability of SI to improve operational processes was reduced. Consistent with EM2, without being able to validate the effectiveness of improvements by measuring operational procedures, it was also more difficult to identify particularly successful improvements. This prevented successful improvements from being systematically implemented within other procedures, on other products or within subsequent projects (in the case of SI), which led to missing "*a few tricks*" (ED, SI).

The implementation of altered procedures provided change points where those affected by changes may need to be trained in new approaches or at least informed of new procedures that have to be adhered to. While the smaller, single-site firms were able to do this informally ("*update the card*" MD, EM1), with BC operating across a number of locations it was necessary for a formal system to be implemented.

> "*When there's an update, the update happens straight away.... every time the document's updated, you or I would get an instant email saying certain documents have been updated*" (MD, BC)

Internal auditing, a requirement of the QMS, ensured that the correct versions of procedures were in use. However, within SI, software writing was outside the QMS, which meant that it was not necessary for engineers to adhere to procedures that were present.

While auditing ensured general adherence to procedures, it was also necessary for individuals to personally accept the role of procedures and follow them to promote consistency. However, the small size of EM2 meant that it was possible for the Managing and Works Directors to directly supervise operational staff to ensure adherence to procedures: "*it's telling them how to do the job, how to make sure they've checked everything they're doing*" (MD, EM2). This meant it was not necessary for individuals to personally accept the role of procedures and willingly follow them. Unfortunately this also meant that if there was a "*rushed job*" and operators were not properly supervised, they had a tendency to "*skip things*" (MD, EM2).

With a QMS that "*had not kept pace [was outdated]" (ProjM, IJ1)*, operational procedures were not present within IJ1 to document operational experience or inform operational practices. Even though it was not up-to-date, systems were used "*in times of desperation*" (ProjM, IJ1), simply to get direction on how activities were completed previously. The situation within IJ1 provided an example of how operational procedures were able to act as a substitute for personal experience, an issue that was described by BC. Unless experience had been captured in procedures, if individuals left a company, "*all of the knowledge and skill of those jobs had gone*" (MD, BC), representing a situation where an organisation had effectively forgotten experience it once had.

In addition to how defined operational processes were, the level of involvement each case company had with external parties (primarily customers) also appeared to affect the benefits the exploratory case companies were able to realise from process improvements. In a similar manner to group-level discussions, interaction with external parties allowed process improvements to draw from additional sources of experience and knowledge about an operational issue (for example). Involvement with customers also ensured that any improvements that were made would benefit the customers or not adversely affect product functionality. Involvement with customers also assisted in the identification of further improvement opportunities through clarification of customer requirements. This took the form of adaptations to product characteristics, which were stated as resulting in reductions in cost or improvements in functionality (IJ2, EM1 and EM2).

> "*We will always question and we almost apologise when we first meet somebody that we will question you about why [a product is designed in such a way]*" (MD, IJ2)

> "*Sometimes they [designers] don't know the fundamentals of what the machines can do, i.e. what sort of length of bend and what sort of shortness of bend you can do*" (PE, EM1)

> "'*Why don't you just have it [a product characteristic] as a straight edge?'... 'it would be a lot cheaper for you, it would be a lot easier for us to make, we'd be able to do it a lot quicker for you', things like that, for ease of manufacture point of view*" (MD, EM2)

Product specifications were often developed during the development process. This resulted in the specifications BC and SI worked with often changing as customers learnt about the requirements of the project they were working on. While involvement with customers was important for ensuring customer requirements were met, changes could result in the rework of previously completed work that could delay projects and not actually improve the end product.

> "*If [the client representative] hadn't come along, others could have said we want this done, this done, that doing, and it would have given no value*" (PM, BC)"

> *"A million little changes… cause project overrun ... death by a thousand cuts*" (PE, SI)

In a similar way to managing incremental process improvement, SI and BC had to carefully manage the introduction of changes to ensure they positively impacted customer satisfaction without negatively impacting project performance (in terms of cost and schedule adherence). This was highlighted by the MD of BC who stated that "*the only way of ever winning anything is programme [build schedule*]", which could only be achieved by carefully managing the introduction of changes. With product specifications frequently being defined, suggesting changes that improved build schedules assisted BC in winning work, without having to reduce profit margins.

> "*About £640000... Yeah, so that's the sort of revenue difference, not profit, but difference, that that [design improvement] has offered [the client] and it has been a no cost extra, we've gone into the design at the same price as a masonry design*" (MD)

> "*I suppose one of the challenges that we have is we do tend to find that projects are already identified, budgets are already planned and then we're bidding on the basis of cost*" (ED, SI)

Without working closely with clients, it was more difficult for SI to develop solutions so they had to compete directly on price with other systems integrators. The greater role of product development within IJ2 and EM1 was consistent with the design-oriented approach of BC. Developing new products with customers provided them with greater opportunities for identifying product and subsequently process improvements.

Initial improvements tended to take two forms: firstly, improvements were made to the initial project design to account for the process and product knowledge of IJ2 or EM1, consistent with BC.

> "*So at the end of the first order, we said right, there's your product, as requested, what you wanted, we've got it to you as quickly as we can, you go off and satisfy your orders, for any new ones, we've offering this now, what do you think, customer comes down, he [the customer] must have spent three or four meetings with us, 'change that', 'I'd like it like that'… we make samples and prototypes, he takes it away, builds it and says 'great off you go'*" (GM, EM1)

The second form of improvement resulted from working with clients to develop new products.

> "*I wouldn't say it's [designing products] guaranteeing the business, but it's going a long way to making sure we get it, and [if] we can keep performing and showing them savings [we can keep winning similar work]*" (GM, EM1)

As outlined within Chapter 4, the deliberate pursuit of new types of work by BC, IJ2 and EM1 required management to provide resources specifically for the development and refinement of product designs. This was similar to the resources they provided for the systematic improvement of operational procedures within group discussions. Resources took the form of either specifically employed personnel (for example, PE in EM1) or spare time for product designs to be discussed with operational staff. The deliberate pursuit of new business within BC, IJ2 and EM1 also introduced a larger variety of new work into these firms. At times, this required different approaches to manufacturing, making it necessary for these firms to learn new techniques.

> "*Which I'm quite keen to do as a plastics company, I want to be involved in many aspects of plastics, so that we bring that knowledge, then transfer [that] knowledge into the [new] industry*" (MD, IJ2)

The introduction of a variety of products also provided new perspectives from which to view existing work, which assisted BC, IJ2 and EM1 to identify additional improvement opportunities. Within IJ1, SI and EM2, the same level of attention was not given to deliberately introducing new types of work or actively learning from involvement with clients. IJ1 focused upon acquiring work where tooling had already been manufactured, which assisted in the generation of revenue, but meant that product development work (section 4.2.2) related primarily to the introduction of new tooling and approval rather than actual development.

> "*We're looking for any business, there is a fine line between... you can win business you can sometimes not really desire, but it's revenue… [if] it's a tool transfer you have no input and you can have the design issues, process issues related to that part [embedded in the tooling], which we've had*" (ProjM, IJ1)

EM2 was explicitly not pursuing new business ("*I don't go out looking for business*" MD), combined with limited opportunities for involvement with existing customers and limited opportunities to improve relatively standard products. However, the MD of EM2 did acknowledge the benefits he personally realised from transferring improvements on one product to another ("*that gives me the biggest kick"*). In comparison to IJ1 and EM2, SI had an intention to secure work with more opportunities for development, in order to move away from competitively bidding for predefined projects.

> "*You've got to get beyond the purchasing director, you've got to get to that level above… In an ideal scenario, you want to get out of the competitive [bidding]*"(ED, SI)

Inconsistent with this aim, management did not appear to provide the necessary resources to change how engineers viewed and approached their work, in terms of adhering to procedures to promote consistency. In an effort to address this situation, "*they're actively pairing people up in projects to try and start making this merge [of cultures]"* (PE, SI) to ensure all operational staff pursued improvement in a manner that was consistent with management's aims. Until this had been achieved and project performance could improve consistently, it appeared unlikely that SI would be able to secure the higher value-added projects they were aiming for.

As a result of this lack of support for process improvement and not deliberately introducing new types of business, IJ1, EM2 and SI primarily focused their process improvement attentions on reducing the occurrence of non-conformances. Consequently, process improvement was primarily initiated on receipt of non-conformance notifications from clients. This can be compared with the more deliberate process improvements behaviours within BC, IJ2 and EM1 that resulted from product development activities initiated by management, as well as operators proactively identifying improvement opportunities.

Figure 5.1 illustrates the level of involvement with clients compared to the types of processes that were present within the exploratory case companies. As processes became less defined from injection moulding to machining and bending to engineering services, there was a tendency for greater involvement with customers. Figure 5.1 also reflects the greater level of involvement BC, IJ2 and EM1 had with clients compared to IJ1, SI and EM1, which was necessary due to the pursuit by BC, IJ2 and EM1 of product development activities.

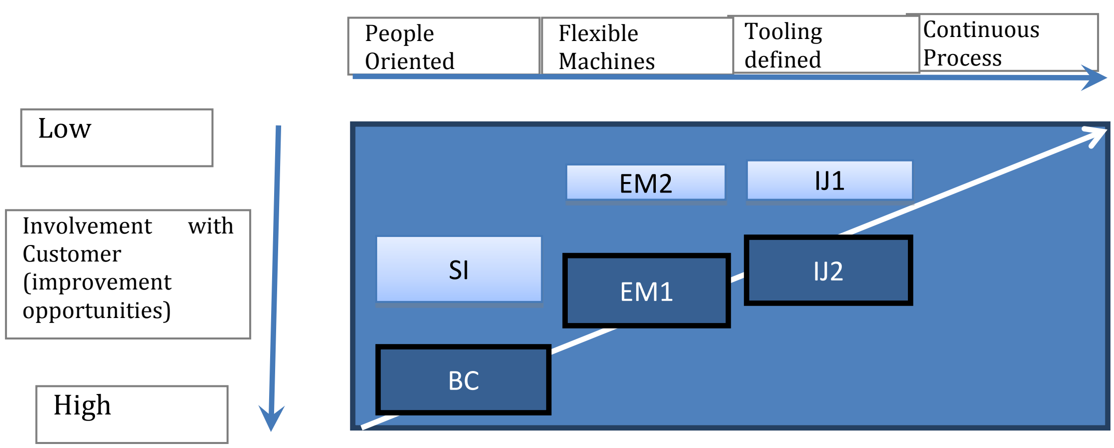

Figure 5.1: Process/Involvement Matrix

While there was variation across the different firms in relation to their ability to undertake process improvement, the types of operational processes present and how closely they engaged with customers, there were similarities in the process improvement practices each firm engaged in. The presence of an ISO accredited QMS was likely to have explained some of these activities (e.g. presence and auditing of procedures), although others were not required by their QMS (group discussions). The generic process that was observed consisted of:

- Identifying issues/improvement opportunities (or receipt of non-conformance notification)
- Discussing problems/ opportunities within a group setting
- Discussing problems/ opportunities with customers and suppliers
- Updating existing or introducing new procedures
- Informing those affected of new procedures/ implementing training (dependent on the degree of change)
- Auditing procedures following implementation to ensure maintenance of changes.

The observed practices appear broadly consistent with Deming's (1994) PDCA or Six Sigma's DMAIC improvement cycle discussed in section 2.2. Within these improvement cycles, process understanding is gradually developed before changes are implemented and improvements are made, which has been presented as a requirement of process improvement (Browning and Eppinger 2002).

While there are similarities with existing improvement frameworks, the process improvement practices identified within engineering-oriented SMEs are defined in terms of general practices, rather than in terms of the use of particular quality management tools or techniques. The focus on operational practices rather than tools may reflect the SME context. The processes present within smaller firms tending to be less formal (Antony *et al.* 2005; Marlow *et al.* 2010), reducing the need for rigour within the later phases of process improvement (analysis and control). Within the exploratory case companies, auditing and general performance measurement was considered sufficient for demonstrating and validating the effectiveness of improvements to management. For example, if the non-conformance that initiated an improvement did not recur, an improvement activity was deemed successful. While statistical process control and measurement systems analysis were conducted with in particular firms, these were a requirement of particular customers, compared to embedded internal processes.

Orienting attention upon organisational practices allows process improvement practices to be considered in relation to the product development activities that also took place within the exploratory case companies. Within each exploratory case company (to varying degrees), improvements during product development required discussions within a group setting and formalisation of product specifications. Without following a process with a similar structure to the identified process improvement practices, there appeared to be a greater risk that changes would not add value to customers, could negatively affect project progress or not be implemented following a request. Within both process improvement and product development settings, the identified practices ensured changes met the needs of customers, changes drew from the combined knowledge of involved parties, reflected organisational experience, operational staff were informed of changes before they were introduced and the effect of changes was validated.

5.2 Identification of Emergent Themes

Within Chapter 4, it was possible to identify consistent themes that were present within each exploratory case company. The first of these was how management appeared to support process improvement activities by implementing and maintaining a QMS, providing sufficient resources for group discussions and, in particular cases, engaging in new product development activities. The second was whether individuals within each company accepted operational procedures and actively engaged in process improvement activities. The third emergent theme was benefits firms were able to realise from engaging in process improvement activities, in terms of securing repeat business, increasing profitability or reducing non-conformances. Table 5.1 provides the chain of evidence between interview quotations, interpretations of the quotes and the emergent themes.

Table 5.1: Emergent theme chain of evidence

Interview Excerpt	Interpretation	Emergent Theme
"*it's telling them how to do the job, how to make sure they've checked everything they're doing*" (MD, EM2) "*I suppose one of the challenges that we have is we do tend to find that projects are already identified, budgets are already planned and then we're bidding on the basis of cost*" (ED, SI) "*Which I'm quite keen to do as a plastics company, I want to be involved in many aspects of plastics, so that we bring that knowledge, then transfer [that] knowledge into the [new] industry*" (MD, IJ2) "*We're looking for any business, there is a fine line between... you can win business you can sometimes not really desire, but it's revenue… [if] it's a tool transfer you have no input and you can have the design issues, process issues related to that part [embedded in the tooling], which we've had*" (ProjM, IJ1)	Different roles of management across the exploratory firms, such as instructing operators, introducing business, increasing revenue and providing the firm with opportunities for further development.	Management Support
"*You've got to have that group discussion... 'look guys, don't blame anybody here; this is the problem and how are we, as a group... [going to] resolve this problem?'*" (MD, IJ2) "*They're not keen or friendly regarding the tools and things there [the improvement intervention], you realise very quickly that they haven't got it [understood the new approach]*" (AOM, IJ1) "*There's definitely a two culture existence… their office can be very quiet [don't share ideas] and yet our office can be full of banter and laughter*" (PE, SI)	The willingness of those within the different companies to work together in a constructive manner and accept information from colleagues or external sources	Culture
"*the lads on the shop floor tend to do it [make improvements] as well… sometimes they don't even tell me*" (MD, EM2) "You've got to have that group discussion" (EM, IJ2) "*We will always question and we almost apologise when we first meet somebody that we will question you about why [a product is designed in such a way]*" (MD, IJ2) *"so that you deal with them [quality issues] once, so they don't come [back], so you are learning from what's happened*" (Consultant, BC) "*all of the knowledge and skill of those jobs had gone*" (MD, BC) "*When there's an update, the update happens straight away.... every time the document's updated, you or I would get an instant email saying certain documents have been updated*" (MD, BC) "*reinventing the wheel*" (ED, SI) *"within the standard, there is quite a big emphasis on auditing, continually auditing your processes and procedures to check there are no non-conformances"* (GM, EM1)	Identifying improvement opportunities from an individual level, developing them within groups and with customers, formalised to prevent forgetting and then audited to ensure their use.	Process improvement

Table 5.1: Emergent theme chain of evidence (continued)

Excerpt	Interpretation	Emergent Theme
"*the only way of ever winning anything is programme [build schedule*]" (MD, BC)	Improvement activities providing firms with an increase potential to win business and produce parts at a better price without forfeiting profit margins	Benefits realised from process improvement
"'*Why don't you just have it [a product characteristic] as a straight edge?'... 'it would be a lot cheaper for you, it would be a lot easier for us to make, we'd be able to do it a lot quicker for you', things like that, for ease of manufacture point of view*" (MD, EM2)		
"*About £640000... Yeah, so that's the sort of revenue difference, not profit, but difference, that that [design improvement] has offered [the client] and it has been a no cost extra, we've gone into the design at the same price as a masonry design*" (MD, BC)		
"*I wouldn't say it's [designing products] guaranteeing the business, but it's going a long way to making sure we get it, and [if] we can keep performing and showing them savings [we can keep winning similar work]*" (GM, EM1)		

The GM of EM1 drew these themes together by outlining how procedures that were implemented by management and developed through process improvement activities could realise benefits if accepted and adhered to by operational staff.

> "*The more procedures you have, to try and stop that [problems reaching customers] happening, and the more people that adhere to them, the more chance you've got of sending a product out correct*" (GM, EM1)

Building upon this, the MD of IJ2 provided evidence related to promoting the acceptance and use of operational procedures, while also "*not to try and deskill them [machine setters]*". Changes in how individuals perceive and define operational procedures, group discussions, information from external parties and improvement opportunities can be conceptualised at an organisational level as organisational culture (Schein 1990; Radnor 2001). BC, IJ2 and EM1 appeared to possess cultures that did not inhibit the implementation of process improvements. This is consistent with related research stating that culture is one of the most common inhibitors of process improvement (Terziovski 2010). An appropriate organisational culture then provided an organisational environment where individuals were willing to share ideas within active group discussions, which appeared to facilitate process improvement.

“*People will come up and say ‘I can’t get this’, ‘I can’t get this angle’, ‘I can’t get this bent’, and we and the shared knowledge of the workforce, we get around it*” (PE, EM1)

Within BC, IJ2 and EM1, the organisational culture also meant that procedures were not seen as fixed or a replacement to individual expertise, but as a means of capturing and formalising individual insights that could inform future behaviour. Within IJ1, SI and EM2, procedures were either not present (IJ1) or not always adhered to (SI and EM2). This resulted from operational staff not accepting the value procedures added to operating, so only following them when supervised.

Table 5.2 draws from the exploratory case studies to present the high-level themes that emerged during analysis from a process improvement perspective. Table 5.2 summarises how each of the case companies related to the emergent themes of management support and culture, but also how these themes related to process improvement and benefits realised from process improvement activities.

Table 5.2: Emergent Themes and Definitions

Emergent Theme	Definition
Management Support	Management providing sufficient resources to engage in process improvement and support group problem solving activities.
Culture	How individuals perceive procedures and process improvement activities, and individuals’ willingness to engage in process improvement activities with colleagues, customers and suppliers.
Process Improvement	Multi-level practices that translate individual insights into changes in operational procedures and operator behaviour.
Benefits realised from process improvement	Products produced more cheaply, delivered more quickly with reduced non-conformance, improved profitability and assisting in securing repeat business.

While management support appeared to play an important role in their being sufficient resources for those within the firm to engage in process improvement, management also played an important role in directing the type of work introduced into each firm. Rather than simply a managerial role, this emergent theme also related to how those interviewed led each company in order to account for their operating environment. While management support can be viewed as resourcing operational activities, the emergent theme also reflected the importance of leadership within the firms. Summaries of how each of the exploratory firms related to the emergent themes is presented in Table 5.3.

Table 5.3: Case Company Comparison

Emergent Themes	**BC**	**IJ1**	**IJ2**	**SI**	**EM1**	**EM2**
Management Support	Engaged MD and explicit development strategy	Limited support and direction for operational improvement	Engaged MD with explicit development strategy	Management not enforcing use of operational procedures	MD and GM investing in operational procedures, equipment and training	MD not actively seeking business
Culture	Focused on product design and service improvement	Resistance to change	Team problem solving	Two culture existence (old and new staff)	Customer-focused improvement	Operators focused on own work
Process Improvement	Continual product and process improvement	Unsustained refinement of existing processes	Product and process improvement	Technology selection and project consistency	Continual product and process improvement	Ad hoc product and process improvements
Benefits Realised from Process Improvement	Increased customer satisfaction and repeat business	Expansion of work, declining staff numbers	Adding value to customers, declining staff	Rework affecting reputation and customer satisfaction	Supporting business growth and increasing profitability	Ad-hoc improvement of operational processes

Table 5.3 presents the firms that appear to more effectively undertake process improvement as being supported by the emergent themes that assist in realising benefits from process improvement. The following section reports on the confirmatory workshops that were conducted with four of the six exploratory firms, which assisted in validating the relevance of the high-level emergent themes.

5.3 Confirmatory Workshops with Exploratory Case Companies

By returning to the exploratory case companies, it was possible to assess the relevance of the identified themes within the companies in which they were identified. This process allowed the face validity of each theme to be confirmed. While the primary aim of the interviews was to share the research findings with the exploratory case companies to close the research project (Squire 2011), it was also possible to collect additional data explicitly oriented towards the emergent themes.

By engaging primarily with Managing Directors, it was possible to assess, with a degree of confidence how they provided resources and support to process improvement activities. Within IJ1, where a project manager was interviewed, this was more difficult to assess. However the resources provided by management were discussed in relation to their strategic aims and how insufficient resources were provided, which appeared to limit IJ1's ability to undertake process improvement.

> "*We need TS[16949, an automotive QMS] with being in automotive... it depends on how it's driven, the willingness of the business has to come from the top, it has to be driven from the top, I think they haven't seen the value of that, I don't think they can see a tangible value in it*" (PM, IJ1)

Although IJ1 were focused upon working within the automotive industry, support was not given to achieving an accepted quality standard. Implementation of the system did not appear to meet management requirements in terms of the return on investment. While IJ1's business strategy explicitly stated that "*50% of the business needs to be automotive*" (ProjM, IJ1), there appeared to be no strategy for the remaining 50%. Although the automotive industry was part of IJ1's strategy, due to its highly competitive nature, it was accepted that while there was cache associated with supplying automotive products, profit margins on such products were low. With other sectors providing higher profit margins than the automotive sector, an explicit "non-automotive strategy" that was supported by management appeared to be relevant for IJ1, but was not present. Within BC, IJ2 and EM1, management appeared more willing to provide resources, opportunities and direction that promoted consistent process improvement.

> "*We're now getting some closer monitoring of it [the building process]… we've now got a team of three people internally, doing the auditing… the beauty of that is… they're not just looking at the health and safety… they're there to do health and safety checks because it's mandatory, but while they're there, they're picking up other issues, making sure we are doing inspections*" (MD, BC)

In addition to putting the operational systems in place, BC, IJ2 and EM1 also provided resources to change how individuals viewed processes.

> "*My job is to get the best out of the people I've got; it's that certain amount of giving them direction*" (MD, EM1)

Consistent with section 5.2, if individuals were supported in changing how they viewed operational processes, operators were described as being more likely to use procedures as a means of improvement. However, IJ2 and EM1 described problems when individuals were supported and promoted to engage in process improvements independently.

> "*I've put them in one office, but we're still fighting against 'ivory towers' and people protective of their ends and it's incredibly difficult [to get around this issue]... 'how could that happen [everyone not being aware of a new product introduction] when you're all here to talk about it before it happened'... and they're not seeing the much bigger picture*" (MD, IJ2)

> "*These guys have been at loggerheads, it's like they all wanted to prove to me [who is the best], I kept saying 'that's not what I'm after, I know who's good at what, I want you to work as a team to produce the product'*" (MD, EM1)

Not only was it important for individuals to be personally committed towards improvement, but also that they were willing to share ideas and responsibility. This provides tentative evidence related to the need for management not only to change individual perceptions related to process improvement, but also to directing perceptions away from the pursuit of individual goals. This issue also provides tentative evidence related to management support impacting both process improvement and culture, and culture impacting process improvement. With process improvement being a focus of the exploratory case interviews and benefits realised from process improvement being a logical focus of management, the ability for process improvement to affect the benefits firms were able to realise from process improvement was an important topic covered within the confirmatory workshops.

"*Yes, an all-electric machine, very very fast machine, energy efficient and a totally automated process... it's about putting effort into knowing what you're getting into*" (MD, IJ2)

By emphasising the specific aims of process improvements, management could ensure that improvement activities were effectively oriented to delivering value to the business and clients. By spending time and effort learning about improvements to explore the potential benefits they could realise, management appeared able to improve the chance that changes would benefit customers and provide the company with benefits.

"*It was more about developing the products…. All we did was develop the product better to keep costs down so they [the customer] could sell more*" (MD, EM1)

By continually orienting efforts towards the improvement of processes and increasing the value BC, IJ2 and EM1 were able to provide customers; the above appears to highlight how there was potential to improve their customers' ability to compete. Overall, the above discussions provide tentative evidence supporting the relevance of the emergent themes to process improvement activities within the exploratory case companies. As a result, the face and internal validity of these themes can be initially confirmed. The confirmatory workshops, combined with the exploratory case interviews, provide tentative evidence on how the emergent themes relate to one another (Figure 5.2). The direction of the arrows relates to how one emergent theme appeared to affect other emergent themes within the exploratory case companies (e.g. management providing resources for process improvement).

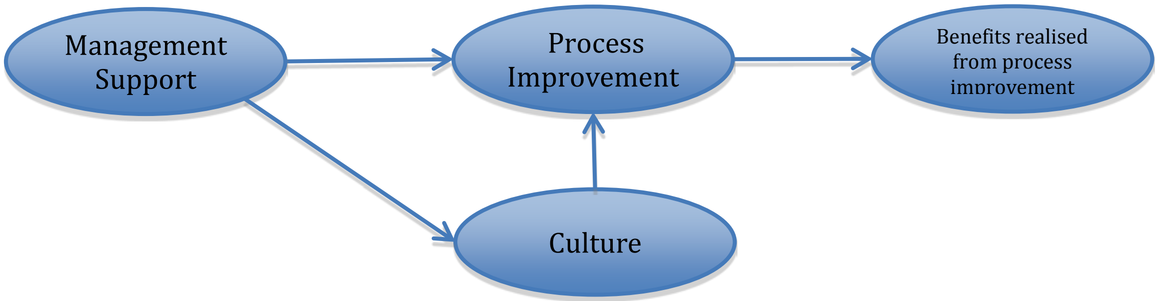

Figure 5.2: Conceptual Model of Process Improvement

This model presents factors that potentially affect the benefits firms are able to realise from process improvement activities. Evidence collected from confirmatory workshops with the exploratory case company was also broadly consistent with those reported in Table 5.2. However, findings from the confirmatory workshops suggested there was a need for further exploration of culture's role in process improvement activities.

5.4 Chapter Review

In summary, this chapter has presented evidence specifically related to how the exploratory case companies undertook process improvement. Building upon within case analysis, this chapter has also identified three broad themes that appeared to affect each firm's ability to engage in process improvement and the benefits firms realised from process improvement. This chapter has also presented tentative connections between the identified process improvement practices and emergent themes. The next chapter will build upon the foundations presented within this chapter to explore the applicability of the identified models of organisational learning to process improvement practices. This process will also allow the relevance of the emergent themes to be assessed in relation to organisational learning to provide theoretically underpinned justification for their relevance.

Chapter 6: Cross Case Analysis 2- Organisational Learning

Building upon Chapter 5, which explored how process improvement was carried out within the exploratory firms, the following chapter will interpret findings from an organisational learning perspective. Organisational learning will be defined in three ways, consistent with the three models of organisational learning identified within chapter 2 and will provide a theoretically underpinned framework for the analysis (see Table 2.3). This chapter will extend the external validity of the case-specific discussion on organisational learning presented in chapter 4 and general discussions in chapter 5, by discussing the applicability of the three models of organisational learning across the six exploratory case companies. This will result in the presentation of appropriate data to address research question two:

RQ2: What is the applicability of the three models of organisational learning within engineering-oriented Small and Medium Sized Enterprises (SMEs)?

Within this chapter, each model of organisational learning will be used to structure analysis of the exploratory case data. This will allow the applicability of each model to be determined. The analysis will be used to identify limitations or topics of particular relevance related to each model within the context of engineering-oriented SMEs in order to provide additional detail to the themes identified within Chapter 5. The following chapter will present the 4I framework as the most applicable to understanding process improvement activities within engineering-oriented SMEs. The framework highlights the need for multi-level elements of process improvement and culture to translate management support to benefits realised from process improvement. These findings highlight that organisational learning provides support for the themes identified within Chapter 5.

6.1 The Learning Curve

The learning curve was defined within Chapter 2 as the incremental improvement in operational performance that was a function of number of products produced or experience. Within EM1 and EM2, as more products were produced, operators were able to identify improvement opportunities within products and make changes to operational processes. As a result, improvements appeared to be a combination of both the number of products produced and the ability of individuals to identify improvements, which was supported by personal understanding of the production process. Consistent with the learning curve, overtime, as more improvements were made, the benefits realised from improvements gradually reduced.

"*[Product designs] get to the ultimate and you can't improve anymore*" (PE, EM1)

While such improvements were the result of deliberate actions of operators, improvements were also described within EM1, where there were no noticeable changes to processes. The project engineer gave an example of a large order that was outsourced, which allowed the effective cycle time of a single product to be measured as a function of the number of items produced.

> "*The supplier was just giving us enough for 500 [units] a day, 500 a night [12 hour shifts], so I was seeing what they [production staff] could do, as they improved, day and night, it become fewer hours [to produce the same amount], so what I suggested is take the night shift off, get a day and an afternoon, or a morning and an afternoon, because they'd become so efficient at what they were doing, again, carrot [incentive], target work [goals], they was given a pound a piece for one of these units, there was five in a team, and they was doing 500, sorry 500 a shift, which gives £100 a day in about three hours, that was how efficient they'd got*" (PE, EM1)

The above highlights that as the number of items produced increased, the cycle time to produce a single product within EM1 appeared to reduce. However, this same situation was not present within the injection moulding companies. Due to the tooling being fixed, there were limited opportunities to make improvements following the manufacture of tooling and initial process optimisation.

> "*The process has started to change quite a bit [as more products were produced], it sort of jumped, the level of quality and inspection, verification of that part prior to being dispatched, was totally different to the original quote [resulting in*

increases in cycle time], now you can’t go back and say we want extra money off [the customer]” (ProjM, IJ1)

Instead of process characteristics improving as a function of the number of products produced, the above presents a situation where the opposite was observed. The greater level of attention to process consistency within IJ2 provided an explanation for the observation within IJ1. Rather than operators making gradual adaptations to operational processes, following initial optimisation of process parameters, process settings were fixed.

"'*I did well on my shift, I got another 500 mouldings out [than were scheduled to be produced]’; ‘you've actually scrapped your whole shift’… if you added or took away one second off the cycle time, it becomes a failure… don't cut corners [and change processes yourself]”* (MD, IJ2)

While the operator had been able to shorten the cycle time to produce additional products, due to the impact on product characteristics, changes to processes needed to be carefully monitored. Within BC and SI, due to the greater complexity of operational processes, it was not possible to define all process characteristics within operational procedures. The timeframe of projects also limited the ability to gradually improve over time as small refinements to processes could easily be forgotten between projects and greater variation in projects making the effect of improvements more difficult to validate. However, general experience of delivering similar work appeared to play a greater role, compared to simply the number of items produced.

“As soon as you’ve got a bit of it [public sector work] on your track record, it shows that you can deal with those special circumstances” (MD, BC)

While the accumulated experience may not directly lead to reduced cost or improved cycle time, experience demonstrated to prospective customers that BC had been able to complete similar work. Within each firm, demonstrating relevant experience to customers of producing similar products helped to effectively "*minimise the learning curve on any job*" (MD, BC), so reducing the likelihood of making critical errors on further work. BC and SI highlighted experience at an individual level as important -

"*Seeing things, making mistakes and correcting them"* (OD, SI) - where accumulated experience demonstrated that such mistakes had already been made and learnt from at an individual level.

Within BC, IJ2, EM1 and EM2, procedures reduced the reliance on individual experience, and promoted consistency across batches or projects (in the case of BC). Procedures thus limited the risk of forgetting what had been learnt previously so reducing the need for relearning, something that was referred to as "*reinventing the wheel*" (ED, SI) within a case where procedures appeared to be used less effectively. Within IJ1 and SI, a lack of procedures or difficulties enforcing them, respectively, thus resulted in a reliance on individual expertise that limited these firms' ability to operate consistently and improve systematically over time at a firm level. The formulated and systematically refined processes within BC, IJ2, EM1 and EM2 allowed these companies to improve more deliberately, rather than relying of the gradual improvements of individual ability.

Within each case, the willingness of individuals to both engage with operational procedures and implement improvements to procedures appeared to determine whether improvements were realised at a firm-level or they remained at an individual-level. In summary, the need for process consistency that required operational procedures, initial optimisation/ systematic improvement and whether operational staff adhered to procedures limited the applicability of the learning curve to contribute insight to operational practices within the exploratory case companies. While much of the data was not consistent with the traditional learning curve conceptualisation of learning, the accumulation of organisational and individual experience did appear to play an important role within each firm. Consistent with Chapter 5, as procedures were gradually updated and refined, firms were able to accumulate and document production experience.

6.2 The Schroeder *et al. (*2002) Model of Learning

The Schroeder *et al. (*2002) model focuses upon specific operational practices, compared to the organisational learning curve that simply linked improvements to cumulative production or experience. The Schroeder *et al.* (2002) model also gave explicit attention to suppliers and customers, but also attention to the resolution of internal problems through group problem solving. To account for BC operating across a range of projects sites, it was necessary for them to hold meetings to bring project managers together to discuss operational issues.

> "*If somebody comes up with an innovative idea, you know, 'well he did this', 'but he did that', 'oh that's right', well we have forums, project manager forums, a couple of times a year, where we all sit around the table together and discuss processes, better ways of doing things*" (PM, BC)

Through internal learning activities, BC, IJ2, SI and EM1 appeared able to develop solutions to identified issues that drew from a range of different perspectives provided by operational staff. Such activities formed a basis for updating procedures that prevented solutions from being forgotten, although within SI, procedures were not always adhered to following development within group discussions. The result of this was that within SI, solutions were forgotten or not actioned, with mistakes being attributed to "*an oversight or misunderstanding*" (OD, SI). IJ1 and EM2 appeared to engage in internal learning to a lesser extent, with individual operators being unwilling to share insight or accept new approaches to working.

> "*They're not keen or friendly regarding the [improvement] tools and things there [at IF], you realise very quickly that they haven't got it…. It's like going back 20 years... [they] select what is suitable for their needs, rather than the business needs*" (AOM, IJ1)

> "*It is very difficult getting people to interact... 'why didn't you tell me?' [in relation to an identified improvement]*" (MD, EM2)

Without undertaking internal improvements, it was difficult for IJ1 to make use of external learning, where external parties suggested new approaches to operating but operators would reject or resist changes. This appeared to be less of an issue within EM2 due to the small size, where only the MD was involved with external parties who was able to implement changes, formalise them in procedures and ensure adherence through direct supervision.

"*We occasionally have to change things, because it's not feasible to produce it, 'why have you got this like this? Why don't you just have it as a straight edge?'... 'it would be a lot cheaper for you [the customer], it would be a lot easier for us to make, we'd be able to do it a lot quicker for you', things like that, for ease of manufacture point of view, occasionally the draftsmen, the people who do these drawings have not got much knowledge of production*" (MD, EM2)

The small size, combined with the ability to codify product characteristics allowed the MD to implement improvements through changing procedures as a result of involvement with external parties. Within SI, there was a much higher level of involvement with customers within normal business practices to ensure product specifications were correct.

"*Ask a million questions to be able to get a feel [for what the customer wants]… their dream is this… but they haven't got the money to pay for it. And… they'll never be happy*" (PE, SI)

While involvement with customers was necessary for clarifying specifications, involvement did not appear to relate to improved project performance, in relation to meeting customer expectations. A similar situation was also present in relation to the close relationship SI had with their main supplier. This relationship was stated as improving their understanding of technologies better than SI's competition, but also their customers.

"*Projects are already identified, budgets are already planned and then we're bidding on the basis of cost [unable to use knowledge about technology]*" (ED, SI)

Without involvement with customers during the development of projects, there were limited opportunities for involvement with suppliers to contribute to improving project specifications. The greater emphasis BC gave to engaging with suppliers and clients to develop projects highlights how involvement with suppliers had potential to contribute to improvements in projects and process improvement.

"*The contractor gave more reasons for using it [a solution] as well… this guy at Dudley was very, very helpful, and talked us through all the processes, 'this can shift if you do this', and he helped you to value-engineer the job [reduce costs without reducing functionality]... we're using him on several jobs now, because he's helped us we're using him and his company*" (PM, BC)

Through involvement with suppliers, BC appeared able to develop the design of products that built upon the knowledge accrued during involvement with suppliers that would be more difficult for competitors to imitate. While both IJ2 and EM1 drew from involvement with suppliers to ensure they had up-to-date equipment, involvement with customers appeared to play a larger role in discussions, which supported both IJ2 and EM1 to develop products and refine operational processes.

"*We will always question and we almost apologise when we first meet somebody that we will question you about why [products are designed as they are]. And they [customers] like that... they like that because they realise that we're buying into their products and they feel that… and quite rightly, we do, we cuddle these people*" (MD, IJ2)

"*They [clients] don't know the fundamentals of what metal can do... our processes are speeded up and made a bit easier [as a result of changes]"* (GM, EM1)

Through close involvement with customers, IJ2 and EM1 were able to adapt processes and product designs, which resulted in numerous benefits that included reduced cost, improved functionality and improved process cycle times. Within IJ2 and EM1, involvement with customers ensured products could be manufactured consistently, while maintaining acceptable profit margins. This process also improved the ability of IJ2 and EM1 to secure repeat business with existing customers. Within BC, IJ2 and EM1, involvement with customers contributed to changes in operational processes, which required internal learning. Fortunately, within these firms "*they [operational staff] seem to be quite acceptable to change"* (MD, IJ2), which facilitated the process of changing procedures.

Aggregating internal and external learning together, the evidence is broadly consistent with the Schroeder *et al. (*2002) model. For example, high levels of internal and external learning appeared to be related to improved operational processes that in turn led to improved customer satisfaction and reduced internal errors (BC, IJ2, EM1). The converse was also observed, with firms giving less emphasis to internal and external learning processes appearing to have greater difficulties in translating learning activities into operational improvements (IJ1, SI, EM2). However, through finer-grained analysis of the case data, inconsistencies between the data and the model can be identified.

Within IJ1, attention was given to external learning through involvement with customers, but less attention was directed towards internal, group problem-solving activities. While attention was given to group problem-solving activities within SI, outputs of discussions did not appear to affect the subsequent behaviour of engineers. SI also gave attention to involvement with suppliers and customers, although they appeared to have difficulty in making use of knowledge accumulated from these external sources due to projects already being defined. This appeared to limit IJ1 and SI's ability to translate knowledge they acquired from external learning into improvements in operational practices. An alternative perspective was provided by EM2. While low levels of internal and external learning took place, limited interactions with external parties appeared to result in the improvement of operational processes through the Managing and Works Director implementing changes and ensuring adherence of procedures.

Also inconsistent with the model was a potential negative impact of over-involvement with customers. SI provided evidence related to the negative effect of client over-involvement on the ability to complete projects to schedule. Over-involvement of clients could result in the continual refinement of specifications, resulting in the deterioration of process performance ("*death by a thousand cuts*" PE, SI) or customers not being satisfied with what they received ("*Rolls Royce… but they've only got the money for a Mini*" PE, SI). Within BC and IJ2, the negative impact of client changes was managed by informing them of the schedule and cost implications of changes, before agreeing to them.

Drawing from section 6.1, the lower levels of internal learning within IJ1, SI and EM2 appeared to result from emphasising the development of individual experience compared to engaging in group problem-solving or using operational procedures. Through the refinement of individual behaviour that was directed towards gradual improvement, individuals tended to resist changes initiated by external sources. Within IJ1, SI and EM2, external sources were both related to other members of the organisation and to customers. As a result, although internal and external learning may relate to one another in a bidirectional manner, internal learning may also affect the ability of external learning to positively impact operational improvement. This provides tentative evidence that there may not be a direct relationship between external learning and improvement. In summary, while the Schroeder *et al. (*2002) model provides additional structure for viewing operational practices, limitations can be identified with the structure of the model. Specifically, this related to how individuals within an organisation perceived the different types of learning activities and whether they were willing to engage with and accept ideas from these learning activities.

6.3 The 4I Framework

In comparison to the learning curve and the Schroeder *et al.* (2002) model, as stated in section 2.4.1.3, the Crossan *et al. (*1999) 4I framework provides greater detail to the different aspects of learning and how they relate to one another. The following four sections will present evidence on the different elements of the 4I model and compare differences between the firms.

6.3.1 Organisation

As presented in Table 2.3, organisation-level assets are defined as organisational strategies, policies, products, structures and culture. Following the slowdown in the construction industry, it had been necessary for BC the implement a new strategy, to add robustness to the business.

> "*We are looking to diversify into the public sector as a strategy… to create a civil engineering business and an FM business, which is a facilities management business, so we can put roads and infrastructure in to [retail] parks*" (MD)

As part of the strategy it was necessary to implement operational procedures and have them externally accredited to be able to qualify for public sector work. To address the risk of operational systems introducing bureaucracy and limiting flexibility, BC implemented the systems to help make them "*much more managed*" (MD, BC), "*making sure that knowledge is transferred through the business.*" (Consultant, BC). The pursuit of work in a range of other sectors and investment in equipment by IJ2 and EM1 also represented strategies oriented to the development of organisational level resources, similar to the intangible resources BC were able to accumulate by implementing operational processes.

> "*I'd like to think it's because of my enthusiasm to bring different product types and different industry sectors into the company. And by their own need to change and [provide] different challenges"* (MD, IJ2)

> "*We've got quite a good level of machinery… they're fairly new, fairly up to date, but also we're using some of the good old ideas, things that they were using 50 years ago… the idea is get a lot of good lads and pay them quite well, innit [isn't it], but we're bringing them on [through training] at the same time*" (GM, EM1)

The active role of management within BC, IJ2 and EM1 appeared to promote involvement of operational staff to contribute and accept introduced changes.

> "*We are all for change, about questioning tradition, think outside the box, 'why are you doing this?' 'well we've always done it like that', 'well why?'*'" (PM, BC)

Management within IJ1, SI and EM2 appeared to play a reduced role in the development of organisational resources necessary to promote development, instead giving greater emphasis to carrying out operational activities that generate revenue. The strategy of IJ1 and EM2 reflected this, providing little direction to how the firm operated or pursued development.

> "*We're looking for any business… you can win business you can sometimes not really desire, but it's revenue… automotive is very much the strategy of the business*" (ProjM, IJ1)

> "*I don't go out and look for the new business because it comes to us in the way of an enquiry, or somebody rings up and says 'do you supply?', 'I want some PTFE [plastic] rings'*" (MD, EM2)

Without actively targeting particular types of business, it was not necessary for IJ1 or EM2 to implement internal changes in order to meet the requirements of particular customers. As a result, the QMS in EM2 was oriented towards ensuring the traceability of products and IJ1 wanting to, but was not actively pursuing, implement an automotive QMS (TS16949). SI had also implemented their QMS at the request of their customers, but it appeared to still be in the process of being accepted and senior management did not actively promote the use of the system

> "*So I think they've [senior management] gone through a real pain barrier of wanting freedom [owning their own company] and at the same time recognising that they've got to have structure*" (PE, SI)

With senior management resisting the acceptance of structures and procedures, management within SI did not actively support operational staff in adhering to procedures as a means of promoting consistency, instead accepting *"we still have that sort of variation in how peoples' minds work" (ED, SI).* Without the QMS being an integral aspect of management's approach to development, it appeared more difficult for the systems in SI and EM2 to added value to the business in the same way they appeared to within BC, IJ2 and EM1. This was well illustrated by the MD of EM2.

> "*I think the BSI has just put it into a neat folder, put a few signatures on, to be honest, I think it is just making sure people do follow that regime, making sure they sign off when they've done the job, making sure the inspector signs off that the job's been inspected…. it's telling them how to do the job*" (MD, EM2)

Within SI, EM2 and to an extent IJ1, operational procedures appeared to be viewed as a requirement imposed by customers and enforced by management, rather than an accepted aspect of operating. This perception of operational processes appeared to realise itself as an organisational culture that resisted changes to operational practices as identified in Section 5.2, with procedures not being integrated into how the firms operated.

Overall, the support provided by management (including strategy), perceptions of individuals and use of operational procedures appeared to be important firm-level resources that affected how each firm operated.

6.3.2 Group

Crossan *et al.* (1999) defined group-level learning as active discussions necessary for developing new insight, rather than simply reaching a consensus. To achieve this, it was necessary for individuals to be confident in presenting their own thoughts within a group setting, but also being willing to reassess and question their own assumptions. Within the exploratory case companies, such group-level activities took place with both internal and external parties, in order to develop existing approaches or resolve identified problems.

> "*Our designer wasn't familiar with the drainage system they'd used at Dudley, and it was very much, 'ooo… scary', you know, I had to be a bit forceful to push it through [get the changes accepted]*" (PM, BC)

> "*You've got to have that group discussion... look guys, don't blame anybody here; this is the problem and how are we, as a group... [going to] resolve this problem*" (MD, IJ2)

Without confidence in presenting ideas and a willingness to accept opinions of others, it appeared to be unlikely such discussions would have a positive outcome.

> "*If [the client representative] hadn't come along, others [companies contributing to a project] could have said we want this done, this done, that doing, and it would have given no value*" (PM, BC)

While individuals within BC were willing to accept opinions of others, within project meetings, other parties were less willing to accept views of others (observed in project meetings). As a result, it was necessary for the client representative to provide direction and clarify customer requirements, which helped to maintain progress on the project. A similar situation was also highlighted within EM1, where it was necessary for individuals within group discussions to be focused upon improving processes.

> "*If you can create that team work... you've got to constantly be thinking what would better this process*" (PE, EM1)

In addition to internal discussions, discussions with external parties were also described as being active, helping both customers and suppliers to develop shared understanding of problems in order to develop a solution together.

> "*We will always question to take away their [customers'] perceived problems and they like that*" (MD, IJ2)

The reverse was highlighted within SI, where individuals were less inclined to initiate contact with customers to clarify aspects of product specification.

> "*Well the classic one is there was an email complaint in the other day saying the security module's [project element] not working correctly on this HMI [project unit], so you go to the particular employee and 'Why didn't you sort this out two weeks ago? We discussed it and you said you were going to deal with this'… 'have you chased him?'*"" (ED, SI)

Unless individuals were focused upon improving operational processes, they appeared less likely to actively contact customers to question aspects of the specification, increasing the risk of "*oversight or misunderstanding[s]*" (ED, SI) creating problems at the end of a project. Other examples of resistance to engaging in active group discussions were present within IJ1.

> "*In the business, that was the problem we were having; we were trying to sell these improvements, instead of them [the moulding department] buying into it*" (ProjM, IJ1)

Without engaging in actively group discussions, operational staff were not required to question their existing mental models or assumptions, making changes more difficult to implement. Within EM2, in addition to this impacting individuals' willingness to accept new ideas, group-level perceptions also limited the ability of EM2 to implement new approaches to operating.

> "*You tend to pick not the best person for the job, for the training, [you pick an individual] because you know he'll accept it better or he'll fit in better doing it, because he's got the dominance to do it and brush off any sarcasm or criticism*" (MD, EM2)

While individuals were potentially unwilling to accept new approaches to working, the MD of EM2 had to select the individual best able to overcome the group-level resistance to change. The higher level of focus on group level activities of BC, IJ2, and EM1 then appeared to assist these firms in taking a strong position with clients. Rather than accepting all customer requests, customers' assumptions and ideas were questioned. This allowed the customers of BC, IJ2 and EM1 to learn about the capabilities of these firms, in addition to building trust that they were receiving valuable advice. Close involvement with clients provided further benefits through helping BC, IJ2 and EM1 to secure further development work from clients with whom they had already worked closely. This resulted from clients appreciating that involvement with BC, IJ2 or EM1 would result in the further improvement of product designs that had the potential to benefit them, which was articulated well by the MD of IJ2.

> "*You're seen then as this whole company of knowledge, aren't you, that it doesn't matter what somebody brings to us in plastics, we want to know more about the products [in order to improve it]*"(MD, IJ2)

The important themes identified were broadly consistent with Schroeder *et al.*'s (2002) model related to the individual perceptions of colleagues and clients, although greater attention was given to the nature of interactions. Involvement of clients and suppliers is an aspect that was not explicitly considered within the original 4I framework (Crossan *et al.* 1999), however, "intertwining" was added to the framework when employed within an SME context (Jones and Macpherson 2006). This highlights an area of the 4I framework that requires refinement for the context of engineering-oriented SMEs.

6.3.3 Individual Level

Rather than cumulative production cycles or production experience consistent with the learning curve, Crossan *et al. (*1999) defined individual level activities as the presence of entrepreneurial intuition. This determined how individuals approached their work and whether they were able to identify and pursue improvement opportunities within existing systems. However, consistent with the learning curve, experience played an important role at an individual level, but individuals did appear to have difficult in articulating how experience related to the ability to carry out new types of work.

> "*The gut feeling at tender stage was 'we'll get over it', 'it'll need some fine tuning'*" (MD, BC)

> *"I think a lot of it is with manufacturing; for me personally anyway, it's gut feeling*" (MD, IJ2)

The experience of individuals provided a foundation for carrying out activities, but also allowed individuals to identify opportunities for improvement.

> "*Because I have 20 years of experience and x number of years of experience of all of our staff here, when somebody comes back to you with a mould and says 'Look what's happened', it jumps out at you what's happened*" (MD, IJ2)

> "*So I might have three or four projects going at the same time, and during that time, like I say, there is a magical thing that comes [when you have an idea for solving an existing problem]"* (PE, EM1)

> "*You think of a way of doing one job, and you suddenly realise you can incorporate that into jobs you've been doing for years, that saves you money, and that's probably the most interesting part of the job, that's probably the bit that gives me the biggest kick*" (MD, EM2)

While the processes of such intuition appeared difficult to articulate, each of these individuals had to be able to identify the value in their ideas, requiring a certain amount of experience or knowledge of the context. Conversely, individuals who were less willing to accept ideas from external sources appeared less able to see the value in new approaches to operating. Within IJ1, operators were unwilling to accept accountability for altered operational processes, implying they would not accept the risks associated with new approaches to operating.

> "*As soon as they sniff accountability, they don't want to know see, where as if it's to benefit them, 'oh, I'll have that, that'll make my life easier'*" (AOM, IJ1)

Conversely, if individuals were able to adhere to approaches they were familiar with and which would benefit them, they were more likely to accept changes. While the ability to identify improvement opportunities appeared to be an important factor at an individual level, evidence was also related to individual's willingness to proactively pursue improvements and follow them through in order to interpret and integrate individual intuition.

> "*They [management] know that you will see it through, you don't have to be managed, you don't have to be prodded or reminded, and I think it does need to expand, it needs, like I say, all-encompassing [within the] business, to be at the same level, instead of the few individuals*" (ProjM, IJ1)

With operational staff within IJ1 resisting changes, it appeared to be more difficult for the small group of proactive members to affect the organisation as a whole. ED of SI highlighted an important aspect at an individual-level that complemented proactive behaviour: "*I particularly hate for other people to see me fail*" (ED, SI). Within SI, such a perspective was particularly important due to the amount of work that was carried out individually, with numerous opportunities to make mistakes that could only be identified during final inspection and testing.

> "*People who don't have the sort of same aspirations and motivations to constantly try and improve themselves… those certain people are the same ones that would make the ad hoc comment to the person [client] about [a] new technology they don't really understand that it's probably negative, it doesn't put us [SI] in a very good light*" (ED, SI)

This highlights the impact of individual attitudes within SI, and how they had the potential to impact the firm as a whole, in terms of reputation. By viewing the individual as an entrepreneur rather than an expert, appreciation is given to change (and improvement) rather than consistency. However, experience was still valuable within BC, IJ2, EM1 and EM2 (at Director level) to provide important context-specific knowledge, which allowed the potential of ideas and opportunities to be assessed before implementation. Importantly within each exploratory case company, operational procedures (if updated) represented accumulated process knowledge that could potentially substitute personal experience, if adhered to. The important themes identified at an individual level were individuals' ability to identify improvement opportunities from experience and individuals' willingness to pursue their implementation.

6.3.4 Feedback and Feed-forward

Within the Crossan *et al.* (1999) framework, each of the different levels of learning does not exist in isolation. For example, unless individuals used organisational level resources such as procedures, procedures would not affect how individuals behaved. Alternatively, unless those within the system were able to adapt operational procedures to account for new observations, improvements would remain unrealised or errors would not be corrected. These processes represent feedback and feed-forward and reflect how an organisation is able to detect and correct errors across the different levels. The presence of organisational procedures allowed individuals within BC to effectively visualise complex processes to develop understanding before problems occurred on site.

> "*When you turn up on a Monday and you've got three or four trades working in that area, 'oh [no] you'll have to go home, you can go and work over there, and you two are just going to fight it out for the space'*" (MD, BC)

The presence of operational procedures promoted process consistency by allowing previously experienced problems captured in operational procedures to feedback into the behaviour of individuals by informing individuals how to carry out operational activities. The above example could have a considerable impact on project progress if it was allowed to occur regularly on site, due to project processes continually requiring rescheduling. Unless procedures were present, individuals may also not know how to carry out particular activities, being only able to learn from problems they had experienced personally.

> "*Three changes in the business in the last 18 months... there is nothing down there in the first place, nothing to tell you where to find that information… there are no procedures… if you hit on a problem, you experience it, [then] you obviously write it down for the next time"* (ProjM, IJ1)

Without operational procedures, the above highlights how it was necessary for individuals within IJ1 to carry out their own learning, limiting the feedback of organisational experience to the individual. However, in addition to there being a need for organisational procedures to be present it was also necessary for operational members to use them.

> "*Capturing knowledge and then how do you get people to look at that knowledge, has always been very very difficult*" (MD, BC)

> "*50% of our rejects are related to the stores department and it's purely that they've not checked what they're picking. And they've put the wrong label on for the customer [not following procedures], so the wrong product's been delivered to that customer and it's just purely human error*" (MD, IJ2)

Internal auditing represented an aspect of each of the firms (apart from IJ1) that validated the use of operational procedures. However, as the MD of IJ2 highlights, individuals were still able to make errors that procedures were in place to prevent. It appeared to be the attitudes of individuals that determined whether procedures were adhered to, or whether personal experience was considered sufficient. The MD of IJ2 explicitly stated how he supported individuals in accepted the role of operational procedures in managing this issue.

> "*The trick with them [moulding engineers] is not to try and deskill them [reduce the value of their experience], it's to make them understand yes, your skill is you*

set that on day one, you set the standard, you told us that that's the best and it's written down now" (MD, IJ2)

Unfortunately, within other firms, it was difficult, or not considered necessary by management to formalize and enforce the use of procedures.

"*In switchgear, there is only a certain way you can wire it up... you've got personalities in it [software]"(*OD, SI)

Such "*personalities*" could introduce "*oversights or misunderstanding"* (ED, SI), which operational procedures were theoretically in place to reduce. An approach to addressing this issue within SI was to refine procedures, so that they more effectively met the requirements of the individual engineers.

"*Either a general suggestion… it'll do the rounds [around different engineers] and everyone will chip in and we'll end up with a new form. So it'll get registered in the ISO system*" (PE, SI)

While the process of developing solutions could potentially feedback and develop understanding at an individual-level, unless individuals drew from updated procedures, procedures appeared unable to change individual behaviour. A similar situation also occurred if processes were updated and individuals were not informed of changes.

"*When there's an update, the update happens straight away... every time the document's updated, you or I would get an instant email saying certain documents have been updated*" (MD, BC)

While the multi-site nature of BC required formalised systems to feedback information to those affected by updates, within the single site firms where procedures were adhered to, updated procedures could affect individual behaviour without them being explicitly informed of changes.

"*We will get a new drawing, an issue will change, they'll [operational staff] change the card and pass through to programming whatever necessary changes they need to make and the card's updated for next time*" (GM, EM1)

Within BC, IJ2 and EM1, it was also important to identify problems with existing procedures, to implement improvements, even if they had not necessarily resulted in a customer complaint. However, unless individuals identified opportunities for improvement and contributed changes to the system, ideas did not feed forward to the improvement of procedures.

> "*They [operational staff] will just do it the same way all the time, they won't change the packing until they get the problem from packing which gets to production*" (ProjM, IJ1)

> *"'Oh I thought we were doing it this way because BSI [the QMS] told us to'"* (MD, EM2)

While adaptation of operational processes was necessary to account for new insights, unless this process was combined with the use of updated procedures, feed forward was unable to improve operational processes. An example was SI, who appeared to spend considerable time developing procedures, but without them being used by (or applicable to) engineers, the impact of this effort was limited. As a result, it appeared important within the exploratory case companies to use procedures but also balancing between the use of existing procedures and the adaptation of procedures to account for new insight. Within this process, it was the presences of procedures, the support provided by management to use operational procedures and the perceptions (or culture) of individuals that appeared to affect feedback and feed forward processes.

6.3.5 Framework Summary

While the greater structure of the 4I framework would infer that it would be (almost by definition) more applicable than the simplistic learning curve or the Schroeder *et al. (*2002) model, the detail of the framework plays an important role for developing understanding of operational practices. While the structure provides a framework for linking different types of organisational learning activities to organisation-level change, the framework also gives specific attention to how individuals within the system may engage in learning activities. The model also considers how individual behaviour impacts group and organisational-level behaviours. Consequently, compared to the other models of organisational learning, the 4I framework appears to be the most applicable for use within the exploratory case companies. However, the role of experience and external parties included within the learning curve and Schroeder *et al. (*2002), respectively, represent important additional aspects that require inclusion. Building upon the emergent themes presented in Chapter 5, the content of each emergent theme can be developed to account for understanding developed from an organisational learning perspective from discussions within section 6.3. Table 6.1 provides illustrative quotes related to the similarities between the 4I framework and the emergent themes.

Table 6.1: Illustrative interview excerpts related the 4I framework to the emergent themes

Emergent Theme	Organisational	Group	Individual	Feedforward/ feedback
Management Support	*"I'd like to think it's because of my enthusiasm to bring different product types and different industry sectors into the company. And by their own need to change and [provide] different challenges"* (MD, IJ2	*"You've got to have that group discussion... 'look guys, don't blame anybody here; this is the problem and how are we, as a group... [going to] resolve this problem?'"* (MD, IJ2)	*"the idea is get a lot of good lads and pay them quite well, innit [isn't it], but we're bringing them on at the same time... we've got a very, very good work force, not just in their skills, but in their attitudes and performances and things like that*" (GM, EM1)	"*When there's an update, the update happens straight away... every time the document's updated, you or I would get an instant email saying certain documents have been updated*" (MD, BC)
Culture	"*We are all for change, about questioning tradition, think outside the box, 'why are you doing this?' 'well we've always done it like that', 'well why?'*'" (PM, BC)	"*Our designer wasn't familiar with the drainage system they'd used at Dudley, and it was very much, 'ooo… scary', you know, I had to be a bit forceful to push it through [get the changes accepted]"* (PM, BC)	*"when somebody comes back to you with a mould and says 'Look what's happened', it jumps out at you what's happened*" (MD, IJ2)	"*The trick with them [moulding engineers] is not to try and deskill them [reduce the value of their experience], it's to make them understand yes, your skill is you set that on day one, you set the standard, you told us that that's the best and it's written down now*" (MD, IJ2)
Process Improvement	"*So I think they've [senior management] gone through a real pain barrier of wanting freedom [owning their own company] and at the same time recognising that they've got to have structure*" (PE, SI)	"*If it takes a group of you to get together before we found out we've got a problem, I'm sure the group will get together and work it out, and we'll find a solution*" (PE, EM1)	"*I think a lot of it is with manufacturing; for me personally anyway, it's gut feeling*" (MD, IJ2)	"*Either a general suggestion… it'll do the rounds [around different engineers] and everyone will chip in and we'll end up with a new form. So it'll get registered in the ISO system*" (PE, SI)
Benefits realised from process improvement	*"You think of a way of doing one job, and you suddenly realise you can incorporate that into jobs you've been doing for years, that saves you money"* (MD, EM2)	n/a	n/a	n/a

The excerpts in Table 6.1 provide a plausible thread connecting discussions related to the 4I framework with the themes that emerged from discussions on process improvement presented in Chapter 5. Table 6.2 presents an interpretation of the how each of the emergent themes identified within Chapter 5 related to the multi-level nature of organisational learning. The interpretations draw from the within case analysis and discussions related to the 4I framework presented in sections 6.3.1, 6.3.2, 6.3.3 and 6.3.4.

Table 6.2: Summary of Process Improvement and Organisational Learning Findings

Emergent Theme	Organisational	Group	Individual	Feedforward/ feedback
Management Support	Implementation and maintenance of ISO procedures and introduction of new business	Sufficient resources necessary for engaging in group problem solving	Support provided to individuals	Implement systems for updating and notifying those affected by changes and validating changes
Culture	General organisation-level culture and perceptions of change	Perception of and willingness to engage with colleagues and external parties	Individuals identifying improvement opportunities	Perceptions of and willingness to adhere to and update operational procedures
Process Improvement	Policies in place to ensure auditing is carried out to ensure changes are maintained	Discussing problems/ opportunities within a group setting and with customers or suppliers	Identifying issues/ improvement opportunities	Updating existing or introducing new procedures, informing those affected of new procedures/ implementing training
Benefits realised from process improvement	Improved profitability, reduced production cycle times, reduced quality non-conformances, improved customer satisfaction	n/a	n/a	n/a

Due to the benefits realised from process improvement tending to benefit the firm as a whole, they only appeared to relate to organisational level activities. However, due to the interaction between the different levels of organisational learning, engagement in process improvement activities appeared likely to change individual perceptions, which may itself be viewed as a benefit of process improvement (Laforet 2011). If process improvements also resulted in changes in perceptions related to group-level activities, helping to resolve a "*two culture existence*" (PE, SI), that could also be viewed as a benefit.

Reflecting on the analysis presented within Chapter 4 and Chapter 5, the firms who appeared to more effectively engage in process improvement (BC, IJ2 and EM1) had also been able to undergo strategic renewal, where they had been able to change the fundamental nature of the business. Crossan *et al. (*1999) stated, "*Organizational learning can be conceived of as a principal means of achieving the strategic renewal of an enterprise*" (p.522). This implies that firms able to undergo deliberate strategic renewal can demonstrate an ability to effectively engage in organisational learning. Within BC, strategic renewal related to moving from the construction of industrial warehouses to care homes and then onto public sector projects. Within IJ2, strategic renewal related to moving from providing relatively simple injection moulded parts used within the double-glazing industry to providing a wide range of high specification products and services (including tooling manufacturing) to a range of customers. Within EM1, strategic renewal related to developing the company from a traditionally oriented machine shop to one that valued its workforce and focused upon providing design and product improvement services to customers. In comparison, IJ1, SI and EM2 had been unable to change the nature of the business, although in the case of EM2, the Managing Director did not consider a change was necessary.

6.4 Chapter Review

This chapter has presented how the models of organisational learning identified within Chapter 2 were able to contribute to understanding of operational practices within the exploratory case companies. The analytical frameworks highlighted limitations of the existing models of organisational learning and the potential relevance of the 4I framework. The analysis has provided greater detail to the themes identified within Chapter 5, in particular the multi-level nature of organisational culture. The next chapter reports on the confirmatory phase of the research to confirm the findings from the exploratory phase of the research and confirm the relevance of the identified themes to additional case companies.

Chapter 7: Confirmatory Cross-Case Analysis

Chapter 5 allowed the components of process improvements and high-level themes that appeared to impact process improvement within the exploratory case companies to be identified. Chapter 6 analysed the exploratory case companies using the three models of organisational learning identified within Chapter 2. This process allowed the applicability of the three models of organisational learning to be compared and the content of the conceptual model presented in section 5.3 to be developed in order to more effectively reflect the contribution of organisational learning theory (Table 6.2). The refinement of the conceptualisations of the emergent themes also allowed the inconsistencies identified within section 5.3 to be more effectively understood. Rather than culture being conceptualised as a broad organisational level concept, aspects of culture were identified at numerous organisational levels. In combination with the findings from Chapter 5, both process improvement and culture appear to map the multi-level nature of organisational learning, consistent with the structure of the 4I framework (Crossan *et al.* 1999).

The following chapter will aim to confirm the findings of the exploratory phase (RQ1 and RQ2) in terms of the content of process improvement and the applicability of organisational learning to interpreting the framework. Findings suggest that the confirmatory case companies are broadly consistent with the exploratory case companies although management's ability to adapt their behaviour and cognition in order to account for the external environment was identified within the confirmatory case companies. This resulted in a refined conceptual model of process improvement compared to the conceptual model presented in Chapter 5 (Figure 5.2).

7.1 Confirmatory Phase Data Collection

Reflecting Figure 3.1, the interviews conducted in the confirmatory phase of the research were focused upon confirming the findings from the exploratory phase of the research within additional firms with similar characteristics. Through confirming findings within additional case companies, the external validity of the exploratory case findings was improved (Leonard-Barton 1990; Yin 2009). This process also resulted in the refinement and development of the conceptual model presented in Figure 5.2 to account for additional insight provided by the confirmatory case companies.

The confirmatory interview protocol (Appendix 3.5) ensured "*coverage of key topics*" (McCutcheon and Meredith 1993, p.241) that were informed by the themes identified in the exploratory phase and related measurement constructs (see Table 6.2 and Appendix 3.7, Table 1). When combined with the presentation that was given within each interview (Appendix 3.4), it was possible to ensure that interviewees were informed of appropriate definitions of topics before discussions. The emergent themes provided the primary coding framework for the interview data. The greater structure and defined themes of the confirmatory interviews allowed the emphasis given to the emergent themes to be compared across interviews (see Appendix 3.7, Table 1).

The qualitative analysis programme, NVivo9, was used to compare interviews to determine the extent to which the different themes were covered. This process meant it was possible to determine whether all interviews and confirmatory case companies should be included in all areas of the confirmatory phase or whether firms needed to be removed. This process also enabled similarities and differences to be assessed across interviews and across the different themes, helping to build an appreciation of the data as a whole (Crowley *et al.* 2002; Silverman 2007). Table 3 (Appendix 3.7) shows the extent to which excerpts were coded across multiple themes, highlighting the presence of evidence for exploring the connections within the conceptual P6 model. This process allowed the identification of addition connections not included within Figure 5.2 that emerged from the data, resulting in Figure 7.1. Due to the analysis process focusing on the presence of a relationship, compared to the nature of a relationship, the connections are presented as bidirectional.

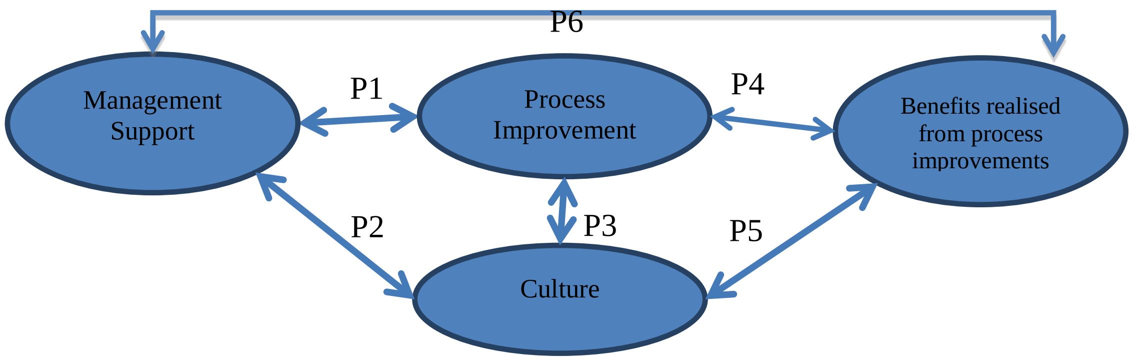

Figure 7.1: Developed model of process improvement

Following the exploration of how the emergent themes were covered within the confirmatory case data, a secondary analysis was carried out to determine how the different themes were related to one another. Figure 7.1 represents this secondary coding framework, with each of the connections between the emergent themes being presented as propositions. While possessing a similar structure to Figure 5.2, propositions P5 and P6 were added to account for additional relationships that emerge during the confirmatory phase. While not identified consistently across the exploratory case companies, propositions P5 and P6 appeared to represent additional factors to consider within process improvement in engineering-oriented SMEs. Table 7.1 presents the definitions of each of the propositions that will be tested within the confirmatory case data.

Table 7.1: Definitions of research propositions

P1	Management support and process improvement are related
P2	Management support and culture are related
P3	Culture and process improvement are related
P4	Process improvement and benefits realised from process improvement are related
P5	Culture and benefits realised from process improvement are related
P6	Management support and benefits realised from process improvement are related

By determining the level of support for each of the research propositions across the six confirmatory case companies, the structure and direction of propositions of a conceptual model of process improvement informed by organisational learning will be confirmed. This process will also allow firms that do not adhere to this model to be identified to assess explanations for the deviation. By exploring process improvement activities alongside themes that are informed by organisational learning, it will be possible to present evidence necessary to address research question 3.

RQ3: How does organisational learning contribute to understanding of process improvement within engineering-oriented SMEs?

The following section introduces each of the confirmatory case companies, in terms of the type of business they were involved in and how they carried out process improvement. This will be followed by the presentation of evidence related to the six research propositions in turn.

7.2 Confirmatory Case Summaries

Injection Moulding 3 (IJ3) was an injection moulding company focusing on moulding high performance materials and the development of tooling capable of moulding such materials. Through close involvement with material suppliers, IJ3 were able to win business by working with suppliers and clients to identify the most appropriate materials for a particular application. Rather than focusing upon series production, where continual cost reduction was an accepted practice and tooling condition declined over time, emphasis was given to the front end of developments (tooling design and commissioning). Such activities were stated as being more difficult to replicate, more difficult to request price reductions on and ultimately more difficult to offshore to lower cost economies. Attention on the development of moulding capabilities had led IJ3 to invest in metal injection processes, a project that had been initiated 10 years ago, required considerable investment (€500,000) and did not have a guaranteed payback. In combination, IJ3's metal injection-moulding capabilities and close involvement with material suppliers had allowed IJ3 to supply materials not available on the open market; therefore they considered themselves unique in the UK.

Systems Integrator 2 (SI2) developed, designed and manufactured industrial equipment for multi-national companies, supplying and installing assemblies globally. Operational practices were focused around individual competence and the delivery of work that had been personally verified as being of an appropriate standard. While emphasis was given to developing experience producing particular types of machines, requests from customers and a recently implemented QMS had supported the documentation of operational processes. Process documentation had promoted process conformity, reduced paperwork while supporting deliberate process changes and improvement. Although a QMS was in place, it was yet to become fully embedded, which resulted in engineers not always adhering to operational procedures or procedures not effectively matching project practices. Such issues appeared to reduce consistency when engineers tended to be professional, but "*very generous*" (SMD, SI2) and over-specifying work. Resolving such changes required rework, as clients could not be expected to pay for such improvements.

Engineering Manufacturer 3 (EM3) used a selection of CNC and mechanical machinery to provide customer-specified components and assemblies to large automotive and automotive-related companies (for example, Land Rover, JCB and Caterpillar). Due to the level of pre-production process and product conformance required by such large customers, it was necessary for EM3 to implement operational systems that promoted conformity to customer defined designs. Following the introduction of new work, customer requirements meant it was not considered possible to adapt operational processes to account for identified opportunities, due to the complex approval process. This resulted in a need to automate processes and specify operational and inspection procedures in greater detail to reduce in-process variations as much as possible. As a result of the reduced opportunities for operators to make improvements, there was a reduced requirement to recruit skilled operators. Unfortunately, the formalisation and prescriptive nature of the operating system appeared to create problems associated with maintaining operators' motivation, as individuals tended to be less engaged with their work, with a greater tendency to skip procedures.

Engineering Manufacturer 4 (EM4) provided the majority of their sheet metal products to the food industry. Investment in the latest technology was considered to assist in maximising process efficiencies, which supported EM4 to compete on price. The latest technology, when combined with manual assembly and 100% inspection ensured that products were aesthetically fault free. EM4 had implemented an ISO system within the past two years that had made it possible to formalise operational processes and promote continuous, systematic, cumulative improvement of organisational processes. Although customers required high standards, if the end product matched requirements, EM4 had scope to adapt operational processes. The formalised operational procedures assisted management in controlling changes and provided traceability for identifying sources of problems. The system also allowed operators to contribute ideas when they identified improvement opportunities.

Engineering Manufacturer 5 (EM5) was made up of four business units, providing a range of metal products and maintenance services. The interview focused primarily upon the architectural installations sector that provided items such as bespoke staircases to private and commercial clients. While experiencing a contraction in demand as a result of the 2008 global financial crisis, with its associated impact on the construction sector, EM5 had implemented a business development plan that had required the re-engineering of the business. This emphasised engagement within and across different levels of the business to align behaviour with the needs to the business. This included defining the strengths of the business that assisted them to further develop and target types of work they were particularly capable of delivering. The plan integrated with operational processes to link daily activities with the strategic aims of the business. Through focus upon delivering exceptional products to clients and deliberately addressing errors, the attitudes of those within the company towards improvement and operational systems were stated as having changed since implementing the business plan.

Engineering Manufacturer 6 (EM6) provided high complexity, machined metal components to, amongst others, the motorsport, nuclear and defence industries. While cost reduction initiatives within the motorsport industry had led to repeat orders, the majority of production was in very small quantities (three or less). As a result of the low quantity of products that were being produced, the ability to effectively and accurately develop quotes was stated as having a considerable impact on the profitability of work. In pursuing internal improvement, management had initiated a number of improvement projects and was mentoring staff to assist them in undertaking improvements themselves. These provided EM6 with a means of promoting contributions from operational staff and improving operational processes. However, the uncertainty of the operating environment had led the Managing Director to postpone investment in new machinery. While operational improvements assisted in improving operational performance in the short term, the gradual aging of machinery was acknowledged as hindering further improvements, as "*we're now two years out of that [investment] cycle, so there is a catch up*".

7.3 Confirmatory Cross-Case Analysis

In-depth within and cross-case analysis of the confirmatory case companies could have provided greater understanding of process improvement practices within additional companies. However, the aim of the confirmatory case interviews was to explore the relationships between the identified themes, allowing the confirmation, refinement and extension of the findings from the exploratory firms within additional companies. For this reason, the analysis of how the emergent themes related to process improvement activities was given primary attention compared to firm specific practices. The definitions of the themes presented in Table 5.2 and augmented by Table 6.2 provided a coding framework that was considered sufficient for confirming the findings of the exploratory case companies.

As a result of the exploratory and confirmatory case company selection criteria being the same, at an aggregate level, there were similarities between the exploratory and confirmatory case companies. These were in terms of the sectors they operated within and the processes that were present within each company (see Tables 3.5 and 3.6). However, variation was present between the two samples, providing both theoretical as well as literal replications of the exploratory case companies (Yin 2009). For example, SI2 had software-writing processes, so had greater process flexibility, but due to products being relatively defined; there were fewer opportunities to engage directly with clients when compared to SI. Conversely, while EM5 operated defined manufacturing processes, the project orientation and client-specific nature of their work meant operational processes had greater similarities with those of BC than other engineering manufacturers. The same was true of IJ3, who focused explicit attention on the development portions of their business, so gave less emphasis to series production than IJ2 and much less than IJ1.

The remaining three companies (EM3, EM4 and EM6) appeared to fit between the approaches to improvement of EM1 and EM2, so could be viewed as literal replications. Reflecting the requirements of their large automotive customers, EM3 considered that operational processes could not be changed without prior client approval, so had limited opportunities for involvement with customers, similar to EM2. While requiring high standards, the clients of EM4 provided more opportunities for process improvements to be carried out, although these were initiated internally and did not appear to result from involvement with clients. Unlike the other companies involved in the research, EM6 was ISO accredited for design as well as manufacture, enabling them to formally redesign customer products. While redesigning products provided opportunities for developing work with clients, the majority of EM6's work was contract-based providing predesigned products, where improvement activities focused primarily on changes to internal processes to reduce cost. While representing differences between the two groups of firms, the similarities allowed the findings from the confirmatory case companies to confirm the findings from the exploratory case companies.

The next section will present data collected from the confirmatory case companies related to each of the research propositions. This will allow each research proposition to be analysed and tested in turn to determine whether each should be accepted or rejected in terms of being included within the conceptual model of process improvement.

7.3.1 Proposition1 - Management support and process improvement are related

Management support for process improvement was, to a degree, implicit, due to the selection criteria requiring each company to possess an accredited QMS. Codification, management and validation of changes to operational processes appeared to assist process improvement, which is consistent with the exploratory case findings.

> "*You have to keep on top of it [the QMS], otherwise you get the snowball effect, likewise with the job cards that come up [to the office] that require action, if you're not careful you can be reproducing it [a problem] when they wanted a change from last time, so you can't go leaving that too long, so the corrective*

action and change control needs to be a priority to prevent the same problems again" (QAM, EM4)

The QAM of EM4 highlighted the relevance of proposition 1, with the management and development of the QMS determining whether process improvement, in terms of reducing quality non-conformance, took place and could be evidenced. By implementing changes at an organisational level, operators appeared able to draw from the improvements made by others, without having had to experience an issue personally. SI2 stated how implementation of a QMS had promoted improvements in internal efficiencies.

"*We are finding we are getting some benefit from it [the QMS], we actually reduced the amount of documentation we were producing during a project*" (SMD, SI2)

As part of the development of new procedures, suggestions of new ideas or identification of operational issues, solutions were developed through discussions between management and operators. Complementing the support given to improving process consistency through resolution of quality non-conformances or improving operational processes, resources were also provided by management to pursue deliberate forms of improvement. Whereas the above quotes related to reducing process variation in order to prevent the occurrence of non-conforming products, each company also introduced variation in the form of new products, systems, structures and machinery, representing step changes in operational processes.

"*I'm going to look at set up times as well, people go to the tool stores, and carry tools back, four, five at a time, so they came up with an idea where they have a trolley and fill it up with the tools and take them all back at once, one trip compared to four trips, the benefit's massive… I push them to it [to initiate further projects], but they came up with the crane idea, that went really well, the extraction [project] was me, I charged them with sitting down, going through it and getting it done, and then paying the bills at the end of it, and unless you're* *willing to pay some money out, then forget it, everything will cost you money*" (MD, EM6)

By providing additional resources, it was possible to develop solutions within group discussions. However, the MD of EM6 highlights the need to provide additional resources to process improvement activities in addition to the operators' time. SI2 also provided examples of introducing new approaches to operating that required resources and could introduce variation into the system.

"*I can tell you that since adopting 3D CAD [computer aided design], the design hours have not changed one iota, we spend the same on design as we used to, but the manufacturing hours, the assembly hours, have gone down, it's more the realisation of what you see in 3D and then the fact that we're not remaking stuff*" (SMD, SI2)

The introduction of new management techniques, such as the implementation of new design software in SI2, or newly implemented QMS within SI2 and EM4, provided new approaches to completing activities. With the improvement projects initiated within EM6, these can be compared to the resolution of quality non-conformances, which relate to improving existing processes. Management within EM4 also provided the necessary resources for the continual investment in new machinery, another forms of process improvement.

"*He [the MD] always had the insight to invest in machinery, which has paid dividends because you often get in the production environment customers, they all talk of cost down, and in this environment, cost down is very difficult and the only way you can get it is by being more efficient, investment insight in the early days paid off*" (QAM, EM4)

Compared to the continual investment in new machinery, management within IJ3 had identified and invested in a new technology, significantly different from existing processes, which formed the basis for the long-term development of the firm.

> "*It's difficult to see when we're going to get a payback if I'm perfectly honest, what we're finding is, we're using the process [metal injection moulding] to make components that we are then producing assemblies from, using both polymer and metal injection mouldings to produce whole products, and those whole products are sold at good margins, and that is, if you like subsidising, I wouldn't say losing money, but I'm not sure we're making money on the metal moulding at the moment, it's a bit too new, most of our efforts in that area are going into introducing the process and explaining how it can be used to designers, and end users, they don't know about it, they've heard about it but don't know how it works*" (CD, IJ3)

Following the investment in the new technology, it was necessary for IJ3 to undergo incremental process improvements to develop the process and work with clients to develop a demand for products from the new process. In comparison to the long-term approach to investing in machinery of EM4 and IJ3, EM6 were postponing investment in new machinery due to uncertainty with their operating environment.

> "*Our biggest problem is we're depreciating all the kit that we've got, which is fine, all of it's paid for, but it's not going to last forever, so if we're going to keep on sitting on it, sitting there, waiting and waiting, we're going to end up with a lot of old kit, and have to replace it all at the same time, which isn't affordable, what we have out there needs to be replaced over a ten-year cycle, and we're now two years out of that cycle, so there is a catch up.... there is a catch up that needs to take place, otherwise we'll lose our capability*" (MD, EM6)

EM6 highlights the potential long-term issues that can result if management chose not to or were unable to continually invest in new production equipment. In addition to management selecting types of improvements and providing resources to process improvement activities, management also appeared to determine how each firm engaged with suppliers and customers. The relationships firms had with suppliers and clients dictated the role of external parties in process improvement. As a result of engaging with large automotive-related companies, there were fewer opportunities for EM3 to engage with clients, and due to process confirmation, it was also difficult to change operational processes once validated by customers.

> "*One of our major customers is [an automotive related company], so we go in, we talk to them, they know what they want, design wise and we know what we need in terms of machining, welding and assembly, so it's really a backwards and forwards thing for us to alter things to suit, but not all companies will let you alter things, they will say make to drawing, but that becomes difficult when there are things in there, that shouldn't be in there, and if you went back to engineering, they would probably change it, but a lot of companies won't do that… when they've issued a set of drawings, and they've done all what they term as their PPAP [Production Part Approval Process] on their drawings, so they know what they're receiving, so they don't like to start changing, so it gets very difficult, once the shutters have gone down, that's the design, so for [another customer] or somebody, they never change it, unless they go through a test process*" (MD, EM3)

The decision to pursue automotive-related work reduced opportunities for EM3 to engage in product redesign and process improvement activities with particular clients. As a result of this, while EM3 invested in new machinery, such as "*two machines down there that are a quarter of a million pounds each*" (MD, EM3), the role of machinery suppliers in process improvement was not discussed. Within other companies, clients and suppliers appeared to play a more important role in process improvement. While EM4 engaged with larger companies, requiring products to defined specifications, EM4 had more opportunities to make improvements.

> "*We kind of have a good relationship from that point of view to make it how we wish, as long as it doesn't change aesthetics, it's very important that the aesthetics to the customer [are right], because although it's for weighing food, you still want it to look like the 'Rolls Royce' of weighing machines*" (QAM, EM4)

In comparison to EM3 and EM4, the low volume and project-oriented nature of IJ3, SI2, EM5 and EM6 required greater involvement in the development of products.

While injection moulding is generally related to high volume manufacturing, IJ3 gave explicit emphasis to the development of new tooling compared to series production, more frequently associated with injection moulding processes.

> "*That's why we're different to other moulders, other moulders mould to a drawing, we mould with a customer to decide what works and what doesn't… continuous development*" (ED, IJ3)

> "*To win the job [high volume work] you've got to have a very sharp pencil [provide competitive quotes] in the first place, and then once the process parameters are set, opportunities to make savings [through process improvement] are limited*." (CD, IJ3)

Through the selection of the type of work IJ3 were involved with, they were able to develop more opportunities to engage in process improvement while developing new tooling. Within SI2, EM5 and EM6, the nature of the work they were involved in also required a level of involvement with customers that provided opportunities for process improvement, illustrated by the design accreditation of EM6. Across the six confirmatory case companies, management support played an important role in facilitating process improvement, in terms of providing the necessary resources for developing solutions and documenting changes to operational procedures. Management support also appeared to indirectly provide support to process improvement, via the type of work each case was involved with. The extent to which each firm engaged in product development appeared to affect the nature of process improvements; process improvement was also affected by the extent to which management invested in new production equipment. Overall, there was insufficient evidence present within any of the case companies to reject proposition 1, suggesting that management support promotes process improvement.

7.3.2 Proposition 2 - Management support and culture are related

While management support for process improvement was, to a degree implicit in the selection criteria, proposition 2 appeared more related to the approach management took to implementing process improvement. Compared to proposition 1, which emphasised operational processes, proposition 2 related to how management engaged with operational staff directly. In combination with the implementation of operational procedures, attention was given to how operational staff perceived operational procedures.

> "*I played it quite crafty, because I thought 'who am I to approve that person for that machinery?' I self-certified initially, those people say, '[I] rate myself as that to use this', within reason obviously, machinery is slightly different, you have to weigh that up if you need training, I started off with the self-certification, then over a period, you get trends that are traceable, you can see if someone is not quite at the level they say they are, so you move them down or up on the [training] matrix, based on their rejects, that's how I do it*" (QAM, EM4)

By engaging with operational staff, there appeared to be a greater potential that new operational systems would be accepted and adhered to. The operational system itself provided data (*"trends")* to justify any further alterations. In comparison to the implementation of the QMS within EM4, the implementation of the business development plan within EM5 appeared to require more fundamental changes of perceptions within the firm.

> "*Everyone in groups of 15 [came] in here [the MD's office], I did presentations to everyone in the business, this is what we're going to be doing, it took a lot of effort, I pretty much lost my voice by the end of it… but it was very important to communicate to them, but it's possibly the most important two hours, and the feedback you get is great, most shop floor can only see next week's wages, I had to look at next year, and to talk to them about next year and the plan, you really have to sell it to them, in an idiot proof way, this is important and this is what we're doing. A lot of the people that have spoken to me afterwards said, 'it's great to know', 'we sit there thinking' 'we're sitting here and we've got no work, we're going bust', you hear on the news it's all doom and gloom. But when somebody tells you, all of a sudden you see a plan and bit of longevity of the whole thing… You get some who have a personal crusade, 'it's about me', 'what about my' and I'll say 'I'm not here to talk about that, I'm talking about the business' and 'I'm talking about collectively what we need to do'. And I'm a big fan, and I don't do*

enough of it, they know me to do it in the bad times… part of this business plan, is to talk to everyone" (MD, EM5)

By directing support to informing all members of staff about the aims of the company, and plans for the future, it appeared possible for management to change perceptions of operational staff to be oriented more closely with those of the firm. Although some individuals appeared less willing to change their views, maintaining support and providing justification could reduce the impact of negative individual perceptions. To varying degrees, this approach to justifying the logic of improvement activities was also present within IJ3, EM6 and SI2. Whether they were "*encouraged*" (CD, IJ3), had issues explained in "*their level of language*" (MD, EM6) or "*involved quite a lot of people in setting it up*" (SMD, SI2), attention was given to how individuals perceived process improvement activities.

"*That's [involving quite a lot of people] been a good mechanism for showing people the importance of the quality system, if they buy into it, if each section of the business buys into it that then pulls everyone up to a better standard*" (SMD, SI2)

The development of the system within SI2 provided a means of changing employees' perception of operational procedures. In comparison, EM3 appeared to take a different view of the perceptions of operational staff. Compared to the newly implemented QMS in SI2 and EM4, the system within EM3 had been in place for nearly 20 years.

"*People's the bit I don't like, I love my engineering bit, if they come in and they're self-motivated, they'll always be self-motivated, unless we've done something to annoy them, but if people come in and you have to be on them [direct supervision], you'll always have to be on them. They'll never change, that's just their personality*" (PM, EM3)

The above highlights a perception of management that considered unless staff were selected appropriately, management were unable to change how staff perceived or approached their operational activities. By emphasising the introduction of procedures to promote conformity for their customers, attention did not appear to be given to the need to engage with operational staff.

> "*We basically do on-the-job training, we tell them they've got to do this, we've now got a definitive spec[ification] sheet that they work to… so we've got to bring a system in, so we part mark every part... you've seen there is a slot there and you mark it, and the operators are told to part mark and I asked the operator, 'do you know why you are part marking that?', 'no I was just told to part mark it' without knowing why you're part marking it... fortunately they had all been machined... he was never told [or asked] why, he was told to stamp [part mark] and that's what he did*" (QM, EM3)

Without giving attention to justifying why particular practices were required, operators appeared less likely to accept the role of operational procedures, so maintained perceptions that may not be oriented towards improvement. Overall, there was support for proposition two from five of the six confirmatory case companies. The nature of the work EM3 engaged in required conformance to agree upon specifications, which led to emphasis being given to adherence to procedures. Unfortunately, this appeared to overlook the role of individual perceptions in determining whether operational procedures were adhered to, and the ability of management to change these perceptions. While evidence provided by EM3 does not support proposition 2, it does not appear to refute the proposition, indicating that management support can promote changes in culture.

7.3.3 Proposition 3 - Culture and process improvement are related

By providing support, management within 5 of the 6 confirmatory case companies appeared able to more effectively orient individuals' perceptions of operational processes towards improvement. Proposition 3 proposes there is a relationship between the culture of each firm and how they engaged in process improvement. As illustrated previously by EM3, unless individuals accepted operational procedures, changes in operational procedures were unlikely to result in process improvements. With activities within each firm relying on individuals completing activities to produce customer-specified items, unless individuals adhered to procedures and made improvements that benefited customers, processes would not improve.

> "*At the end of the day, quality is a state of mind in the individual, if people don't think they should be doing a quality job, that is to the best of their ability, then you've got the wrong person doing that particular function*" (SMD, SI2)

Compared to this general opinion of SMD, the QM of EM3 highlights the importance of the perceptions of individuals on the firm as a whole.

> "*Management don't hold the place together. The shop floor… does that, otherwise we'd just be an office... it's not even monetary, to show that appreciation, would add to building up the culture that does want to improve processes, because you've then got somebody who cares for the company as opposed to somebody who has chips on their shoulders*" (QM, EM3)

Rather than processes and management alone defining how the company operated, the above highlights the role of those within the system (operators). However, the justification for not promoting greater levels of involvement of those within the system was provided in terms of the context of EM3.

> "*It's getting people who can make the correct decisions with processes... we had a problem with a job, and we said what the hell's wrong with that job, you had to weld around this rim, one chap welded clockwise, the other one welded it anti-clockwise, whether it was one way or the other, it was wrong, so you see you can't [allow operators to make changes to operational processes]. We would have to agree the process, [production manager], myself [project manager], or somebody else in our position, agree the process that if it affected our customer, we would have to tell the customer about it, because if we don't, and he [the customer] finds out about it, and he has a problem, he will say well I'm going to withdraw all the machines in the world and you're going to have to pay for it, because you haven't made it, you've changed it without telling me [from] the drawing*" (MD, EM3)

This highlights an issue that was experienced by EM3, but it also highlights the importance of individuals understanding why improvement can or cannot be made and the processes that need to be followed to ensure they do not adversely affect process outputs. Examples were also provided where operators implemented changes that adversely affected product characteristics. This had led to management within EM3 having to "*lock all that back*" (MD, EM3) to prevent any unwanted changes being made. IJ3 provided an alternative perspective to EM3, where improvement opportunities were identified and presented to a client before being implemented.

> "*Some customers, 'oh it's going to be 300 quid', 'yeah but it's going to make your product better', 'oh I don't know about that'… Sometimes we've actually spent our own money, or company money, on slight modifications, that the customer has sanctioned to say yes you can do it, we'll say we'll pay for it, because it makes our processing better, 'oh well, if you get a time saving, can we have a reduction', 'errr, no, if you want to pay for it [the improvement], you can have the time reduction'*" (PM, IJ3)

By exploring the impact of changes proactively, and presenting improvement opportunities to clients, it was possible to ensure there was approval for any changes. By proactively investing in tooling improvements, IJ3 appeared to support the further development of a culture oriented towards improvements, as IJ3 had been able to demonstrate their understanding to external parties that resulted in an internal process improvement. The greater ability to adapt operational processes within SI2, EM4, EM5 and EM6 allowed individuals to make process improvements, with the perceptions of operational processes and clients determining whether improvements were appropriate.

> "*I think one of the areas is the non-conformance side, because it involves everyone in the company, and everybody has different non-conformances, and then there is also the fact of how do you rectify and close them out, which is a bit of a grey area... basically they're closed out by the person who raised... them generally, but they do come up when we've got an audit and they haven't been closed out and we get them closed out*" (TSE, SI2)

Compared to changes being made when the system was being audited, the system developed within EM5 promoted a greater level of proactive improvements, by linking personal rewards with the resolution of issues.

> "*All the divisions have to deliver their portion of the margins, and it's up to them how they do it, so if they're told you've got 200 hours to get this fitted, you've got to bring it in within 200 hours and it's great to hear the different departments talking to each other saying 'I'm going to go over here by 20 hours, so you think you can pull 20 hours back from what you're doing?' and they swap, to make sure they can all bring the margin in together, because the senior managers are all incentivised on that [meeting the margins]*" (MD, EM5)

The above also highlights that as well as culture affecting process improvement activities, by implementing systems that required involvement, process improvement activities also appeared to support changes in culture. Consistent with "*trends that are traceable*" within EM4, the evidence provided from process improvement and measurement could justify and develop understanding of particular decisions. Within EM5, this included a manager that was demoted due to being the "*most criticised manager for non-conformance*" (MD EM5). Compared to the formalised systems present within EM5, EM6 provided an example where general management support promoted greater involvement in process improvement that helped change perceptions

> "*We have a sort of a policy at the moment, where we're encouraging them [operational staff] to work on improvements themselves, and that's going quite nicely… they're doing a lot more programming. Rather than doing all the programme changes ourselves [management and supervisors], we sit there in a chair and talk them through the procedure of how to do it, and their confidence is getting quite high now, they're doing the changes themselves... we're coaches really, they'll be testing their programme, decide what they want to change, come back decide to cut at this point, how do you cut this... they'll make those changes, different speed, different feeds, they're getting quite good at it now*" (MD, EM6)

Through support and involvement with process improvement activities, the perceptions of operators within EM6 were stated as changing. A similar situation was also described within SI2, with involvement with external parties and the recruitment of a graduate, "*we stay involved in some of these research projects, because we do think they change some of the attitudes here*" (SMD, SI2). Consistent with non-conformances being resolved when systems were audited within SI2, improvement activities also appeared to be less proactive within EM6. This appeared to result when process improvement activities do not "*become part of your culture*" (MD, EM6), and follow-up activities were not initiated. This was potentially affected by approaches of particular operators, *"sometimes they don't write it down, just fix the problem and move onto the next job"* (MD, EM6). Unless individuals perceived the need to engage in more systematic process improvement activities, it appeared less likely that subsequent work would benefit from isolated process improvements, limiting organisation learning and continuous improvement.

Overall, support was provided from each of the confirmatory case companies for proposition 3, although EM3 emphasised the need to carefully manage any process improvements to ensure they did not adversely affect product characteristics. The perceptions of those within the firm were stated as affecting whether changes to processes were appropriate. Within other firms, particularly SI2, EM5 and EM6, process improvement activities were also highlighted as affecting culture, as individuals changed how they perceived operational processes as they engaged in their improvement. Consequently, tentative support is also given to this relationship. However, within IJ3, EM3 and EM4, as discussions did not cover how process improvement activities supported changes to culture, support can only be considered tentative.

7.3.4 Proposition 4 - Process improvement and benefits realised from process improvement are related

As a result of proposition 1 determining the level of support provided by management to process improvement, and proposition 3 determining whether those within the firm focused attention and effort upon appropriate process improvement behaviours, proposition 4 appeared strongly influenced by other themes. With the process improvement activities identified within chapter 5 being influenced by the presence of an accredited QMS, SI2 provided evidence of this not being sufficient for firms to realise benefits from process improvement.

> "*You wouldn't believe the number of rubbish businesses we've dealt with that are ISO 9001 and still do, and clearly they aren't following any of this, it's a badge, you can't do business without the badge… on the other hand we are finding we are getting some benefit from it*" (SMD, SI2)

While reducing the amount of paperwork within projects had potential to support improvements in internal efficiencies, these improvements may be difficult to validate and may not directly benefit clients. Across the confirmatory case companies, benefits that were realised from process improvement activities appeared to be strongly influenced by how they were initiated, e.g. management support or opportunities identified by staff, so were influenced by other propositions. However, while unsanctioned and inappropriate changes could negatively affect the outputs of process improvement, by adhering to the framework presented in chapter 5, firms were able to ensure process improvements realised appropriate benefits. For example, unless improvements were documented within EM6 and procedures adhered to, issues in production would only be resolved in the short term.

> "*Well, we're doing a lot of one off, and twos and threes of complex parts, there is not a lot of money in them, even though it may be a couple of thousand pounds a single part... we would be better off making ten of those parts for four thousand pounds, it takes an hour every time, it's all engineering costs... you have to verify what you're doing every time, when we're verifying a programme, we're verifying constantly... the human being slows the whole process right down... it's [the metal] waiting on the spindle doing nothing*" (MD, EM6)

Unless operational systems were systematically developed in a manner that involved clients, which potentially also included quotation processes, it appeared unlikely that consistent benefits would be realised from process improvement activities. Reflecting on Proposition 1, the importance of involvement with clients in process improvement was also highlighted within EM6.

> "T*here was a point a couple of years ago, when it really wasn't worth the risk for them to continue to do [cost reduction]... the material costs had spiralled [increased dramatically], and we haven't been able to continue [with cost downs], they looked like relatively expensive parts, but it wasn't good business... they've [re]laxed their stance on that [cost downs] a bit*" (MD, EM6)

Unless production processes were being systematically improved overtime to accumulate and document operational experience, it was unlikely costs would reduce as a result of repeated orders. A similar situation was also described within IJ3, in relation to series production.

> "*The OEMs will be looking for cost downs all the time, the material suppliers tend not to respond to that, other than with volume discounts, which are not generous… Series production tends to be a lot of hard work for not a lot of return… you reach a peak very quickly of efficiency, then there is a slow decline after that as the tooling wears*" (CD, IJ3)

For IJ3, unless they had opportunities to undertake process improvements, that in general took place during the development phase, they had limited opportunities to improve. With the abrasive nature of materials that were moulded, combined with cost down requests, series production appeared likely to cause issues for IJ3. Although EM3 emphasised the need for consistency during production activities, process improvement during product development was able to provide them and their customers with benefits.

> *"[A potential customer] saying we would like something like that, how can you help us, again that would go to [the project manager] and [PM] to see how they would envisage, it would also go to [the MD], [the MD] is pretty key here on the sort of the development side, he has helped [one customer] in particular to develop assemblies that we have then won*" (QM, EM3)

Through the systematic development of operational processes, by drawing from production knowledge of a range of individuals and formalising this in procedures and part specifications, process improvement supported EM3 in winning work. EM4 and EM5 also outlined how they systematically resolved operational issues, to reduce non-conformances and improve profitability.

> "*If anything is below 30% margin, they'll all have to bring information of why is that below 30%, one bring the reason and [two] bring the corrective action, and then we do the non-conformances after... and the department managers have to put something in place to stop it happening again... what are we going to change in the system, we can't use human error constantly as a reason why*" (MD, EM5)

By systematically resolving operational problems, documenting solutions and using procedures to prevent recurrences, it appeared possible for EM4 and EM5, in particular, to realised benefits from process improvements, which was well encapsulated by EM4, who stated that "*rework is dead money*" (QAM, EM4). Although there was less evidence related to the direct link between process improvement and benefits realised from process improvement due to the indirect impact of management support and culture, some support is provided to proposition 4. By following a systematic, multi-level approach to process improvement, it appeared possible to ensure that before changes were made to operational processes, changes would be confirmed internally by involvement with colleagues and be sanctioned by clients. Inclusion of auditing with the framework also ensured that documented changes influence subsequent operator behaviour, solutions would not be forgotten and the effectiveness of changes were validated. IJ3 and EM6 provided evidence from an alternative perspective related to limited benefits that could be realised from series production if it was not possible to implement process improvements. While this raises questions related to support for proposition 4, if firms pursued process improvement in a systematic manner, they appeared able to realise benefits at an organisational level.

7.3.5 Proposition 5 - Culture and benefits realised from process improvement are related

Across the six case companies, there was considerably less evidence related to proposition 5 than the other research propositions (see Appendix 5, Table 6). Reflecting on proposition 3, with each confirmatory case company tending to provide tangible products produced by operational processes, culture appeared to primarily provide benefits indirectly via process improvement. However, within those activities that were less repetitive and required direct involvement with clients, culture appeared to provide similar benefits to those provided by process improvement.

> "*Maybe three, four times a year, I'll go and see a client who's not happy, you've put a staircase in six months ago and now this has split and this piece of glass is not level, and they're not happy, and I make sure that we go back and sort it, and every single time they're amazed at that, 'I can't believe you turned up', one because the MD's turned up and two because you're going to do it*" (MD, EM5)

This highlights the impact of attitudes and perceptions on customer satisfaction, even if the standard of a product left a customer initially dissatisfied. The MD of EM5 provided examples of how resolving customer complaints effectively could result in further business, and allowed them to charge more, due to the assurance that any issues would be resolved following completion. The perceptions and attitudes of those involved in development work in other confirmatory case companies also appeared to provide similar benefits to those realised from process improvement.

> "*The material suppliers, particularly the ones at the really high end, go to great efforts to cement the relationship between a potential OEM, a potential end user and a first tier or second tier supplier who is manufacturing the components. And that has always been a very important relationship we've had, and a very significant source of profitability of the business*" (CD, IJ3)

Although the relationship was described as being based on the ability to provide the necessary operational processes capabilities, it also appeared to be the willingness of those working within projects to develop solutions with customers and suppliers. The ability to develop and maintain these relationships appeared to represent an important aspect of how IJ3 chose to compete.

> "*Proportionally more development work goes on in the UK than before [globalization], so getting these things [development] right from the start is very important because it may well be that the initial prototype and development work is done in the UK, but production is done in a low cost economy*"(CD, IJ3)

Through the development of relationships with suppliers and customers, IJ3 ensured they were the company that was approached for the development portion of projects. Through working closely with external parties, continually developing their understanding and operational capabilities to develop products that were brought to them, IJ3 appeared better able to secure further, profitable development work. Alternatively, although EM3 appeared to have difficulties in managing improvement activities internally, within development work, the willingness of management to contribute to product development activities provided benefits for EM3.

> "*What we're going to do, we've just got a £300,000 project from [the major customer] that's going in now, and we've thrashed that about so much to get where we are, I've said to them, when we've been running three months, I want to come back and say these are the problems that we're getting, what can we do about that and what are your problems so what can we do about that, again, this is unusual because we know [the customer] so well, we're in the top 80 suppliers, because we go in there and talk to them, VEVA [value engineering, value added] they always come to us, we're one of the only companies that does VEVA for them because nobody else seems to want to do it, we do do that, looking at jobs, to see if we can do it cheaper, we've cheapened a lot of our jobs like that*" (MD, EM3)

Through a willingness to add value to product designs, the involvement with this particular client gave EM3 a means of providing benefits to the clients, which appeared to result from an established relationship. With competitors being less willing to engage in such activities, the culture of the management team appeared to contribute to EM3's ability to secure further development work. SI also provided some evidence of the importance of a willingness to engage with clients and work together to develop solutions.

> "*There might also be some things that the client has asked for which we've not solved and we'll have to go back to the client and say alright sunshine, you're going to have to pay more money if you want that, [what is] very rare is, 'oh that's a complete pile of rubbish' [when it doesn't meet customer expectations]" (*SMD, SI2)

Through a willingness to work with clients to develop solutions, in order to match both SI2's and their clients' requirements, it was possible to ensure that designs could be provided with an acceptable margin, while also satisfying the client's specification and budget. Unless it was possible for SI2 to work closely with clients and share knowledge of designs and application, it would be difficult to balance conflicting specifications. While there was limited support for proposition 5 across the six confirmatory case companies, there was tentative support for culture providing benefits to particular case companies. However, this appeared to be in relation to after sales (EM5) or product development services (EM3, SI2, IJ3), which appeared to support each firm in securing additional business through improving customer satisfaction. In each case, the direct contribution of culture to benefits realised from process improvement also appeared to be complemented by an indirect contribution via process improvement. Consequently, there is inconsistent support for proposition 5, leading to this proposition being rejected.

7.3.6 Proposition 6 - Management support and benefits realised from process improvement are related

Although not present within Figure 5.2, there was considerable evidence related to proposition 6 across all of the confirmatory case companies and within each of the interviews (Appendix 3.7, Table 6). The evidence on proposition 6 appeared to relate to both how management support adapted to account for feedback from the output of process improvement activities, but also those management decisions that provided similar benefits to process improvement without the need for process improvement. While changes had been initiated to account for the recent global financial crisis, those firms that competed globally had to account for longer-term trends that resulted in competition from low cost economies that had increased in recent years (in particular EM3). To account for the difficult operating environment, both EM5 and SI2 stated how important it had been for them to hold financial reserves and demonstrate to clients they were low credit risks.

> "*We work hard on that [financial security], one thing is, if you check us out, we are [a] good credit risk, most companies will do business with us reasonably well, it's winning us business as well, when we've been up against other companies, who are 15, 20% cheaper than us, and when they've come to do the financial checks, where as we weren't in pole position for the project, after they'd done the financial credit checks, we find that we are the most favoured company*" (MD, SI2)

This approach appeared to be affected by the value of work SI2 and EM5 engaged in, where a single project could have a significant impact on a client, where purchasing managers had lost their jobs as a result of poor sourcing decisions (SI2). The same situation was also present for SI2 and EM5, where it was important for them to only work with clients who were in a financially strong position, which determined the payment terms of projects.

> "*With new customers now, we're very strict with payment terms and three weeks ago, I was down in London, because the construction company I was working for were not happy about a bespoke staircase, we expect 90% of the money before we go to site, so this is a 120 thousand pound stair case, they'd already agreed to the terms, but the QS [quantity surveyor] had left, so they were trying to renegotiate it [the contract], I went to see them and said your credit rating is zero, you've accepted the terms, and they said you can't be serious and I said we'll walk away if you don't do it, and these are the reasons... you agreed to these terms, we're not changing... and they're already talking about the next job*" (MD, EM5)

The MD of EM6 described further justification for the careful control of finances, even though he acknowledged the importance of continual investment in new machinery.

"*We haven't had a new machine in here for a couple of years, when all the 'shit hit the fan' [global financial crisis] it was kind of difficult... we were a case in point, they [the news] talk about people not spending their money, that's us, we're not [spending money], we should really now, but there is another round of world recession looming now isn't there, if you read the papers, if people are going to start spending money again, there is a pretty strong research to not [spend money], if we had, we wouldn't be here*" (MD, EM6)

While investment in machinery was previously stated as important to maintain competitiveness, unless a company was able to continue operating during slow periods, investment in new machinery would be of little use. Rather than reducing investment in new machinery, many of the firms stated that they had made staff redundant (EM4, EM5, IJ3) in order to survive. For other companies, the difficult economic climate appeared to direct them to new ways of competing, which included competition from low cost economies: "*we don't make volume parts any more*" (QM, EM3).

"*We've had to change our business model to cater for smaller volumes… We used to make large volume parts and they started to go [overseas], did we lament the loss, or did we move on? We had to change the way we operated, we had to change the machines we operated, things that took two days to set up, but once you'd set them up, just churn churn churn, parts out, but we had no work for those machines so we had to adapt, and we didn't say, 'no we are going to get that big volume work, mark my words', we said look 'we're in a market now where we aren't going to get that work, we need to complement our shop floor capacity with machines with short set up times so we can make smaller volume work'*" (QM, EM3)

The MD of EM5 also described how they moved to smaller volume work, from "*a jobbing shop… towards more project specific, but those projects were one offs*". Reduced opportunities for repeat business meant it was necessary to implement changes to how the business operated; "*we stumbled along for the next two years, never losing money, but not really making a lot of money*" (MD, EM5). The business plan that EM5 had implemented represented how support for process improvement had changed. Following the implementation of systems to promote more effective process improvements, EM5 appeared able to change how they pursued new business, which provided benefits for the firm.

> "*This leaflet that came from [a university]… Business Growth and Development… money back guarantee, 'we guarantee that by the end of the course you'll have got that money back by the decisions you'll make and learn on the course'… every firm got their money back in the first four weeks… And the reputation we've got now, is [EM5] are really good, but God aren't they expensive, and the two come together, and I don't mind… we're trying to get a brand of [EM5] to a point where people say I can afford [EM5], I'm going to use them, for the guy who wants something cheap and cheerful, we're not going to work like that, but pre [the university course] we did [accept cheap and cheerful work]"* (MD, EM5)

Consistent with EM5's approach to moving away from lower margin business, IJ3 had also chosen to increase the focus on development work following the economic slowdown.

> "*About 18 months ago, we decided that certain sectors were not good for us, one of them was the automotive sector, and we actively lost customers, we gave some customers options to stay with us at inflated price levels or not stay with us, the old 'sod off price'… and because of the nature of that business there was no animosity there, they knew what was going on and they said next year we'll come and pick our tools up and we'll be shipping them to company X… then quite often, they'll phone me up three to six months later saying… 'would you like to quote some more work for us, this MIM [metal injection moulding] thing, what's that all about, can we use that', so we've done that [losing the low profit work], and doing that really improved our margins because we could shed some labour and we were then increasing the percentage of high profit business of our turn over… we were losing the low margin stuff… I mean last year we made a larger profit than we've ever made.*" (CD, IJ3)

Consistent with EM5, it appeared necessary for IJ3 to pursue effective process improvement activities to support the development of products, to ensure work that was secured warranted the higher price. While the selection of business represents a relatively high-level activity, evidence related to proposition 6 was also related to operational activities. From analysing completed projects, SI2 began to change the amount of work completed internally, by developing a partnership with a local firm.

> "*It could be that we chose to go down a particular quality route… we'd have spent more buying stuff in but less hours on it [on the project], what we've found is when we get [the local supplier] to put a machine together, they put it together for next to nothing, but then they don't have to get it to work, they do do it very very efficiently… [if we outsource] more stuff can go through here… we flex [the capacity of] our guys downstairs [in the workshop]" (*SMD, SI2)

Through outsourcing particular activities, SI2 were able to focus on those activities they were able to add value to and improve the overall efficiency of projects. This effectively allowed SI2 to realise the benefits from process improvement without having to change internal processes. Feedback from completed operational activities was also presented by EM3 as a potential initiating point for process improvements.

> "*[Until] we've got the thing [a data logging system] rolling, we don't get any information off the shop floor, I went down there and said 'how many parts do you do an hour', 'ooooo lots'... we've got a monitoring system that we've installed, but we're not using, in general terms what I've been talking about this morning is this monitoring… If it's [a particular product] a loser, we then have to look at that job and then improve it*" (MD, EM3)

While this illustrates the potential importance of feedback from operational processes, unless feedback resulted in process improvement, there was less potential for feedback to provide benefits to the firm. Reflecting back on the previous discussions related to EM3, the comments also appear to highlight EM3's emphasis on operational processes rather than the individuals using them. This was summarized well by the quality manager within EM3.

> "*I'd like to say that it's all changed [since the move to lower volume production] and we're looking ahead and looking at poka yoka systems [an aspect of lean manufacturing] and stuff like that, but it's not, this company isn't ready to go down that road yet, we're better than we were ten years ago, but we've still got a long way to go, it's a mind-set change that needs to be realised, in honesty, we're waiting for the old guard to change, and until that happens I don't think there will be a significant improvement in that side [manufacturing approaches]. I wouldn't even consider going for TS[16949]… But I see, we improve our processes, we improve our profitability, so if we get better machines, we have better capacity, so we can put more jobs on, we can start drawing more money in, we get less rejects, we get more money and then that is invested back in to the people to say you've all done a good job, we've all got to this level now. We're not going to say keep up the good work, I'm off down the pub now [with the profit].*" (QM, EM3)

Unless feedback to management resulted in changes in the support provided to operational procedures and how management perceived operational processes, it appeared unlikely that EM3 would be able to make the necessary changes. The MD of EM3 illustrated such a mind-set and view of different approaches to operating.

> "*Job mapping, we don't do that, because there are too many variables, whereas people like [our major customers] are building particular machines, they want to make it that they move the material the least amount of time, but that doesn't work for us*" (MD, EM3)

Without the willingness of management to explore the relevance and implement new approaches to operating, it appeared less likely that they would be able to undergo the necessary changes to meet the needs of their operating environment. Overall, there was considerable support for proposition 6, both in relation to feedback from operational processes changing how resources were directed to process improvement and how management decisions were providing similar benefits to process improvement. The resources provided to process improvement appeared to determine whether firms had been able to change to account for their operating environment. IJ3, EM5 and SI2 appeared to have changed in order for them to be more resilient to their operating environment, moving away from price-based competition. Although EM4 had recently implemented a QMS that had facilitated further improvement, they appeared to be able to maintain their existing approach of investment in technology, supplying to a growing sector. Within this particular case, feedback from operational processes and the environment provided justification that "*cost down is very difficult and the only way you can get it is by being more efficient; investment insight in the early days paid off*" (QAM, EM4). In comparison, EM3 appeared less willing or unable to change, and EM6 appeared to be pursuing a cautious approach to surviving difficult economic conditions. As a result, proposition 6 cannot be rejected.

7.4 Testing the Propositions and Model of Process Improvement

Chapter 5 identified management support and culture as themes that appeared to affect how firms engaged in process improvement and the benefits they were able to realise from process improvement. Figure 5.2 presented a tentative conceptual model related to how these themes related to one another. Drawing from the direct contribution organisational learning was able to make to the conceptualisation of the emergent themes presented in Table 6.2; this chapter has attempted to confirm the findings from the exploratory phase by determining the relevance of the emergent themes and the nature of the relationships between them. Through a data collection process specifically oriented around eliciting data related to these emergent themes, it has been possible to confirm the relevance of the themes presented in Table 5.2. Through presenting each of the connections between the themes as propositions, it was possible to present a refined model of process improvement (Figure 7.1) that included two additional propositions that emerged from the confirmatory data. By exploring the data related to the connections between the different themes, it was possible to determine the structure of a model of process improvement within the confirmatory case companies.

Table 7.2: Testing the research propositions

Propositions	IJ3	SI2	EM3	EM4	EM5	EM6	Decision	Note
P1	✓	✓	✓	✓	✓	✓	Support	Selection of work and investment in machinery
P2	✓	✓	✓	✓	✓	✓	Support	Coaching and mentoring
P3	✓	✓	✓	✓	✓	✓	Support	Process improvement also contributing to changes in culture
P4	✓	✓	✓	✓	✓	✓	Support	Influenced by other themes
P5	✓	✓	✓	×	✓	×	Reject	Contribution made via process improvement
P6	✓	✓	✓	✓	✓	✓	Support	Management support changing to account for feedback and management support providing direct benefits

Overall, support is provided to five of the six research propositions, which provides support for a model broadly consistent with Figure 5.2. However, open discussions within the confirmatory interviews allowed additional topics related to process improvement to be identified. While not fully supported, the direct relationship between culture and benefits realised from process improvement highlights the importance of culture, particularly within those activities that appeared more service-oriented (e.g. product development). For example, within EM5, although the delivered product at times was initially unsatisfactory, a willingness to resolve issues resulted in increased levels of customer satisfaction, which led to repeat business. Within other companies, culture appeared to have an indirect relationship, where benefits were realised via process improvement activities.

The second additional proposition related to the willingness of management to adapt or change their behaviour to account for benefits realised from process improvement or the external environment. While present within the exploratory case companies (in particular BC, IJ2 and EM1), this was considered during the within case analysis. By focusing internally on process improvement activities, the role of external factors was overlooked within the exploratory cross-case analysis (Chapter 5 & 6). The connection was also potentially overlooked due to the theoretical framework of organisational learning, which gives greater focus to the internal creation and distribution of knowledge, rather than knowledge acquisition from external sources.

The third additional aspect of the model was a potentially bidirectional relationship between process improvement and culture. Evidence was identified across a number of the confirmatory case companies related to culture impacting how process improvement was carried out. However, in particular cases (SI2, EM5 and EM6), through effectively engaging in process improvement, the perceptions and attitudes of operational staff appeared to alter, so affecting culture. With both process improvement and culture appearing to occur at multiple organisational levels, this bidirectional relationship is consistent with Crossan *et al.*'s (1999) 4I framework. As process improvement activities gradually progress from individual to group-level activities, perceptions at these different organisational-levels also change. The support for proposition 3 provides further support for the 4I framework of organisational learning being applicable to providing better understanding of process improvement within the confirmatory case companies. Figure 7.2 presents the refined and extended model of process improvement, informed by organisational learning within the confirmatory case companies.

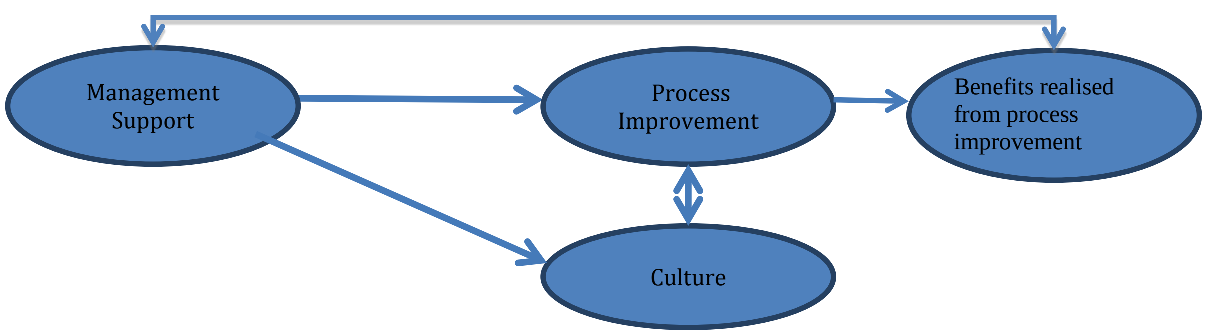

Figure 7.2: Refined conceptual model of process improvement

The confirmatory case company that provided least support for the research propositions was EM3. While inconsistent support was provided to a number of propositions, this appeared to be a result of the industry EM3 operated within, where there were limited opportunities for improvement once production had begun. However, while evidence was inconsistent with some of the propositions, the model provides direction for resolving issues. This may include providing greater justification to operators for the need for consistency or why procedures needed to be adhered to when making process improvements to prevent them adversely affecting products received by the customers. The evidence from the confirmatory case companies would suggest that process improvement may provide a means of developing a culture more oriented towards improvement. Justification was also provided to why EM3 appeared unable to realise more fundamental changes, which were related to the unwillingness of management to critically review and change how they pursued process improvement and conceptualised the business.

7.5 Chapter Review

This chapter has presented evidence from six additional case companies related to the emergent themes that were identified within Chapter 5 and refined within Chapter 6. Following the analysis included within Appendix 3.7, the support provided to each of the connection between the emergent themes was explored and tested. Within this analysis, the importance of supporting individuals to engage with and view process improvement in an appropriate manner appeared to be critical in determining the benefits firms were able to realise from process improvement. The role of management in enabling organisational learning through process improvement and changes in culture was also identified as critical in each firm. Finally, the role of management to provide opportunities for learning and improvement appeared to be an additional factor for promoting organisational learning. Without investing in new machinery or selecting work that required development, it was not necessary for individuals to change how they viewed operational activities. The following chapter will discuss how each of the three research questions have been addressed, which will be discussed by reviewing the findings from this and the previous two chapters. After presenting key research findings, the research as a whole will then be discussed and related to other contemporary research within the field of operations management and wider management literature.

Chapter 8: Discussion

The following chapter reviews the findings of the previous three cross-case chapters in order to address the three research questions. They will be discussed in relation to each question in turn, before presentation of key research findings. The thesis as a whole will then be discussed in terms of the domain of operations management and wider management research before concluding the chapter.

8.1 Addressing Research Question 1

Within Chapter 5, a general structure of process improvement practices within engineering-oriented SMEs was identified. Practices related to the identification of a problem or opportunity to formalising changes within operational procedures. Process improvement appeared to be an important means for each of the exploratory case companies to resolve operational issues and systematically change in a manner that accounted for their operating environment and business opportunities. As a result, engaging in effective process improvement appeared to enable the exploratory firms to meet or exceed customer requirements and supported them in remaining competitive within a highly competitive operating environment. Table 8.1 outlines the operational activities that were identified within Chapter 5 as constituting process improvement within the exploratory case companies and the exploratory firms that engaged in those activities.

Table 8.1: Process Improvement Practices across the exploratory case companies

Company	BC	IJ1	IJ2	EM1	SI	EM2
1. Identifying issues/ improvement opportunities (or receipt of non-conformance notification)	✓	✓	✓	✓	✓	✓
2. Discussing problems/ opportunities within a group setting	✓	×	✓	✓	✓	✓*
3. Discussing problems/ opportunities with customers and suppliers	✓	✓	✓	✓	✓	✓*
4. Updating existing or introducing new procedures	✓	×	✓	✓	✓	✓
5. Informing those affected of new procedures/ implementing training (dependent on the degree of change)	✓	×	✓	✓	✓	✓
6. Auditing following implementation to ensure maintenance of changes	✓	×	✓	✓	✓	✓

*primarily at Director level

Engaging in practices 1, 2 and 3 appeared to allow the exploratory case companies to develop understanding of operational issues or improvement opportunities. By accessing the experience and opinions of both internal and external parties, the exploratory firms appeared better able to understand issues and opportunities. Involving customers meant there was a greater potential that improvements would benefit customers, improving the likelihood that process improvements would benefit the customer. These first three practices are consistent with Browning and Eppinger (2002), who stated that "*process improvement requires process understanding*" (p.428). Without engaging in these activities, those involved in process improvement within IJ1 and EM2 drew primarily from personal experience, resulting in a lower level of process understanding. With a lower level of process understanding, IJ1 and EM2 appeared less able to resolve operational problems that resulted in the recurrence of issues.

Following the formulation of a solution, documenting the solution in new or updated procedures ensured that the developed process understanding was formalised and captured (practice 4). This aspect of process improvement is consistent with Mukherjee *et al.* (1998), who stated that improvement projects resulted in standard operating procedures. By also informing affected operators of the changes, the captured knowledge affected those within the company that were affected by the problem or may benefit from the improvement, even though they were not directly involved in the improvement activity. This activity ensured that individuals knew to use updated procedures, but was also a way of informing others within the organisation of improvement activities (practice 5). Finally, the auditing of operational procedures (practice 6) ensured operational procedures were used following changes. Unless operator behaviour was changed following process improvement activities, improvement opportunities would remain unrealised and customers would continue to experience issues. Auditing also provided a means of validating whether implemented changes had the desired effect on operational processes. If changes did not have the desired effect, information from auditing could provide an initiating point for further improvement activities.

Compared to discussions presented on Six Sigma within section 2.2.2, with the exception of IJ1, there was a notable lack of formal problem solving methodologies within the exploratory case companies. Within IJ1, the process improvement intervention employed a formal problem solving methodology, similar to that presented within Bateman and David (2002). Rather than using formal validation mechanisms, less formal processes appeared to be sufficient within the exploratory case companies (measuring internal rejects, returns or non-conformances). The use of less formalised process improvement techniques is consistent with the findings of Antony *et al.* (2005). They found that only a small proportion of SMEs within their sample used the structured methods of Six Sigma. However, amongst the exploratory case companies, limitations of the informal approach to process improvement were identified. Where informal approaches did not result in sufficient process understanding (EM2) or procedures were not adhered to (SI), greater formalisation appeared necessary.

While formal quality management tools or problem solving methodologies were not employed or discussed within the exploratory interviews, practices listed in Table 8.1 could be augmented by the use of formal quality management tools and techniques. For example, group discussions could draw from measurement data and problem solving tools (e.g. Pareto analysis or tally charts) to help create knowledge about a problem (Anand *et al.* 2010). Statistical process control and measurement systems analysis could be introduced into process auditing in order to formally validate the effectiveness of changes to operational processes or provide direction to where improvements were needed. With some customers of IJ1, IJ2, EM1 and EM2 requiring measurement data to be supplied with products, there was potential to increase the formality of the process improvement practices within the exploratory case companies, with only limited changes to current practices.

While Six Sigma acknowledges that not all improvements require a formalised improvement methodology (Linderman *et al.* 2006), it has been identified that improvement activities benefit from being strategically aligned (Schroeder *et al.* 2008; Zhang *et al.* 2008). Within the exploratory case interviews, while many examples resulted from the identification of non-conformances, other process improvements appeared to be aligned with the longer-term aims of the companies. With management tending to own, or hold equity in, the exploratory case companies (BC, IJ2, SI, EM1 and EM2), large-scale process improvement activities tended to be initiated to promote the long-term success/ survival of the company. Although there were no formal process improvement project selection processes, management's role in initiating process improvements ensured activities worked to achieve the aims of the company. Management involvement in the selection process thus implies a degree of strategic alignment. Active involvement in company activities also allowed management to informally validate whether improvements contributed to the strategic aims of their business.

Within the exploratory case companies, management also played an important role by implementing and maintaining the QMS that appeared to play an important role in process improvement. By facilitating deliberate changes and ensuring that changes were documented, management provided the necessary mechanisms for engaging in process improvement. In addition to the implementation, management also played an important role in supporting individuals in using procedures. This included not only funding accreditation, but also providing sufficient resources for staff to discuss problems in group settings away from operational activities and resourcing internal process audits. While resources directed towards these process improvement activities ensured adherence to operational procedures, management support also provided resources for changing how individuals perceived process improvement activities. Resources were provided in terms of training and direct support to effectively persuade operators of the value procedures could have within operational practices (e.g. IJ2).

The actions and role of management identified within the exploratory case companies in relation to process improvement appear consistent with Samson and Terziovski's (1999) definition of leadership. Leadership was stated as promoting organisational learning, individual development and improved organisational performance. Within the exploratory case companies, resources provided to process improvement and changing individual perceptions, which included training (a form of personal development), appeared to contribute to the benefits realised from process improvement (elements of organisational performance (Samson and Terziovski 1999, p.407)).

Personal perceptions of operational processes oriented towards improvement appeared to provide two benefits in relation to process improvement. Firstly, operational staff appeared more willing to adhere to operational procedures without direct supervision. Through accepting the role operational procedures played in informing individual behaviour, procedures were not seen as replacing the value of individual experience or expertise. Secondly, individuals appeared more willing and able to engage in process improvement activities by identifying and actioning improvement opportunities. Rather than blindly following procedures (as was at times the case within IJ1 and EM2), operators would notice issues as they used existing procedures and if not actioning improvements personally, were willing to inform others of their observations (e.g. EM1).

The perceptions of operators also provided a secondary means of validating the effectiveness of changes that resulted from process improvement activities, in addition to auditing. From this perspective, if operators found that changes to operational procedures did not have the desired effect or caused additional problems, they may revert to previous versions of procedures or initiate further improvement activities. When successful improvements were accepted by those using procedures and became part of their approach to operating, process improvements could be viewed as becoming embedded in how a firm operates (part of their culture (Csikszentmihalyi 1996)). While the small size of EM2 allowed management to monitor the effectiveness of process changes directly, within larger firms, culture appeared to play a greater role in validating completed improvement activities. This was particularly important within BC and SI, where operational activities took place across multiple project sites.

The perceptions of individuals not only appeared to affect how individuals engaged with operational processes, but also how they engaged with others (both internal and external to the firm). Within those firms where staff appeared to have negative perceptions of operational procedures (IJ1, SI, EM2), attention was focused upon personal experience, which appeared to result in individuals being less willing to accept information from other parties (both internal and external). As a result, the perceptions of individuals affected the type of process improvement practices IJ1, SI and EM2 engaged in, which in turn appeared to affect the benefits these firms were able to realise from process improvement activities. An unwillingness to accept information from external parties resulted in individuals rejecting new approaches to working (IJ1) or not changing personal behaviour to reduce the occurrence of errors (SI). Focusing on personal experience alone meant that process improvements were based on a lower level of process understanding, which in turn appeared to result in efforts directed towards process improvements being less effective or even ineffective.

In summary, process improvement within engineering-oriented SMEs was identified as a range of operational practices that translated individual behaviour to organisational-level change. While similar process improvement activities were identified across the exploratory case companies, the identified themes of management support and culture appeared to play an important role. Management provided sufficient resources and culture oriented towards improvement appeared to affect the benefits firms were able to realise from process improvement. Consequently, while process improvement could be defined in terms of operational practices, the current research indicates that process improvement is a more complex organisational activity. In addition to operational practices, process improvement requires active resourcing and direction by management, commitment from individuals and, where appropriate, involvement with customers and suppliers. Within the firms that appeared more effective at translating process improvement into benefits received by customers (BC, IJ2 and EM1), management provided greater levels of support compared to those firms that could not carry out process improvement as effectively (IJ1, SI, EM2). The exploratory case findings were confirmed by the confirmatory case studies, in terms of the content of process improvement, role of management support, impact of culture and benefits firms were able to realise. The confirmatory case companies did, however, highlight a potentially more critical role of suppliers within the SME context compared to the exploratory case companies, which is explored further within Matthews *et al*. (2013b).

By addressing research question 1, the findings suggest that there are specific operational practices that constitute process improvement within engineering-oriented SMEs. While these practices may be less formalised when compared existing process improvement methodologies (see section 2.2.2), by accounting for other emergent themes, they appear appropriate for the context of SMEs. Consequently, the current findings could refute the requirement for a formalised, structured process improvement methodology within engineering-oriented SMEs. By combining the roles of management with the contributions of individual operators to validate the effectiveness of changes and to identify further opportunities for improvement, the proposed framework does not necessarily forfeit rigour. However, if process improvement activities required formalising, at the request of a customer for example, or were too complex for informal problem solving approaches, quality management tools and techniques could be integrated into the proposed framework, and map formalised improvement framework more closely.

8.1.1 Research Question 1 Theoretical Contributions

While the research has not been explicitly focused upon particular improvement methodologies, by conducting the research in firms with ISO 9001 accredited QMS, the findings of the research can be considered in relation to the improvement frameworks discussed in Chapter 2. By interpreting the identified components of process improvement from a Six Sigma perspective, the external validity of the findings of the current research is potentially extended. Through the exploration of an identified problem, individually and within a group setting, the subsequent implementation of process improvements allows benefits to be realised, consistent with the DMAIC improvement cycle (Schroeder *et al.* 2008). The identified practices are markedly different, however, to existing conceptualizations of process improvement (Powell 1995; Wolff and Pett 2006) and process improvement related activities (Samson and Terziovski 1999; Kaynak 2003; Tu *et al.* 2006).

The refined conceptualization may indicate there is a different relationship between process improvement and benefits realised from process improvement than previously identified. Powell (1995), Samson and Terziovski (1999) and Wolff and Pett (2006) were unable to demonstrate a significant relationship between process improvement and firm performance. The current research would suggest this may have been the result of construct validity (not measuring process improvement). However, while the current research did not attempt to measure firm performance, within all case companies (exploratory and confirmatory), the support and direction provided by management appeared to have a considerable impact on the benefits firms were able to realise from process improvement activities. By ensuring process improvement activities were in line with the aims of the firms, it appeared more likely they would positively affect firm-level performance.

Conversely, unless process improvement activities were directed in a manner that was consistent with the aims of the firm, while benefits may be realised from individual process improvement activities (reduced cycle time), they may negatively affect other process improvement outcomes (increased levels of scrap). This finding could be viewed as consistent with Zhang *et al.* (2008), who found that strategically selected improvement projects positively impacted firm performance, whereas adherence to formalised improvement methodologies did not. As a result, the findings of the current research are consistent with this and related research (Kaynak 2003; Zu *et al.* 2008) that required quality management activities to be coordinated, with process improvement, in isolation, not being directly related to firm performance. However, within discussions on proposition 4 in Chapter 7, by explicitly involving customers in improvement activities, it was possible to ensure process improvements provided them with benefits. Improvements in customer satisfaction were stated by a number of firms to assist in securing repeat business from existing customers (for example, BC, IJ2, EM1 and EM5), so indirectly related to many conceptualisations of firm performance (Roth *et al.* 2008).

While none of the case companies employed formalized process improvement selection tools, management played an important role in selecting those improvements that met the needs of the company. This would also infer that the relationship between management support and benefits realised from process improvement is mediated by process improvement. While Samson and Terziovski (1999) found a significant direct relationship between leadership and firm performance, process improvement, or more specifically organisational learning, may actually mediate this relationship. This issue was effectively explored by Shaver (2005) and Evans and Davis (2005), highlighting the need for further exploration of existing research. Lyon *et al.* (2000) took an alternative perspective to the need to identify mediating variables, in terms of the organisational-level at which constructs reside. From this perspective, it is difficult to logically relate leadership (measured at an individual-level) to firm-level performance, without theoretically or logically connecting individual and organisational-level behaviours. With process improvement acting as a mediating variable between management support and benefits realised from process improvement thus extends existing research in this area.

These findings also suggest that individual perceptions oriented towards improvement promote process improvement. For example, if individuals are willing and able to identify improvement opportunities that reflect the requirements of customers (identified through involvement), process improvements are more likely to realise benefits that improve customer satisfaction. Building upon individual perceptions of personal activities, colleagues and external parties, if they are shared across an organisation (Radnor 2001), they can be considered to constitute an organisational culture (Schein 1990). Considering individual perceptions as an element of organisational culture provides a connection with existing literature, where Zu *et al.* (2010) found that culture affected the type of quality management practices carried out by a firm. Although it was more difficult to determine from the exploratory case data, literature also suggests that process improvement activities have the potential to effect organisational culture. The process improvement activities identified within the exploratory case firms include practices that promote the development of process understanding. The development of process understanding can change how individuals perceive processes that can in turn impact on organisational culture (Bititci *et al.* 2006; Zu *et al.* 2010). Through providing support to process improvement activities, management support was able to indirectly change individual perceptions of operational processes and process improvement activities, so indirectly changing organisational culture.

Within IJ1, SI and EM2, without management supporting effective group problem solving activities, individuals being unwilling to adhere to procedures or having limited involvement with customers and suppliers, process improvement activities appeared to have less impact on organisational culture. Conversely, providing support across all the areas of process improvement, BC, IJ2 and EM1 appeared able to support the development of a culture oriented towards process improvement. This final insight provides direction for firms that may not possess a culture oriented towards improvement. Without this insight, firms may focus wholly on changing operational processes, which may result in resistance to changes (e.g. IJ1, SI and EM2). This resistance is a result of what Crossan *et al.* (1995, p.351) termed "*forced learning*", that has a greater potential to revert over time. To account for this, the current research suggests that management direct attention to process improvement and culture together in order to realise benefits from process improvement. The research also suggests that it may be possible to change culture by supporting process improvement in isolation, although there is a need to maintain support until a sufficient level of process understanding has been developed in order to change individual perceptions of process improvement.

The above findings related to addressing research question 1 contribute to theory on process improvement, particularly within engineering oriented SMEs. Drawing from the definitions of process improvement presented within section 2.2.3, additional process improvement definitions can be proposed that account for the theoretical contributions of the work.

> *Process improvement within engineering-oriented SMEs is a multi-level activity requiring the development, capture and application of process understanding.*

Within engineering-oriented SMEs, alignment of process improvement activities within organisational aims impacts the benefits firms are able to realise from process improvement.

Individual perceptions within engineering-oriented SMEs determine whether operational procedures are adhered to and whether further improvement opportunities are identified and actioned through process improvement without direct supervision.

Within engineering-oriented SMEs, management support is necessary to resource operational systems as well the changing individual's perceptions of operational systems.

8.2 Addressing Research Question 2

The results of the systematic literature survey that was presented in section 2.4 identified the learning curve, internal and external learning and the learning organisation as the most frequently used models of organisational learning within operations management research. Crossan *et al.*'s (1999) 4I framework was identified as a model of organisational learning that had a stronger theoretical underpinning than the learning organisation, so was more relevant for analysing operational practices than the learning organisation. While components of the 4I framework had been used within operations management research, the 4I framework was yet to be employed in its entirety. Chapter 6 presented evidence collected from the exploratory case companies related to these three models of organisational learning. The applicability of the three models of organisational learning to practices within engineering-oriented SMEs will be discussed in the following three sections.

8.2.1 The Organisational Learning Curve

The learning curve represented the most established model of learning, having been observed and objectively measured on multiple occasions across numerous industries over many years (Wright 1936; Yelle 1979). Previously conducted research focused upon the relationship between the number of items produced and its resulting impact on process cycles times or product costs. Consequently, with the current research not employing objective process measures, it was difficult to compare findings directly with this model of learning. However, interview discussions, stories and anecdotes were often consistent with aspects of the learning curve, in particular the accumulation of production experience.

Rather than defining experience as the number of completed items resulting in improvements in cycle times, customers of the exploratory case companies used the learning curve as a means of gauging firm competence or demonstrating that firms can "*deal with those special circumstances*" (MD, BC). This view is potentially more consistent with the learning organisation conceptualisation of organisational learning (Senge 1993), where the accumulation of organisational experience has been stated as improving organisational competence (Ahire and Dreyfus 2000; Rosenzweig and Roth 2004). Unless firms had been able to complete a number of projects, or produce similar products, a number of the exploratory case companies stated they would have difficulty securing work with new customers (in particular BC, IJ1). To move across sectors, it was also necessary for BC to accumulate related experience, and demonstrate the similarity of completed projects to prospective customers.

While the accumulation of related experience appeared to be important within the exploratory case companies, Zangwill and Kantor (1998) highlighted the difficulty in relating process-level improvements to firm-level improvements. This was due to errors within measurement and reporting systems making it difficult to confidently attribute operational improvements to particular organisation-level outcomes. To address this, Zangwill and Kantor (1998) suggested focusing the measurement of improvements on specific processes, to allow the benefits of changes to be measured more accurately. Within the case companies, many operational improvements took the form of operators identifying opportunities for improvements while manufacturing products. EM1 and EM2 described other forms of improvement as resulting in tangible and measureable improvements in cycle-time and reductions in product cost. However, within EM2, such improvements were not always documented, making their contribution more difficult to validate. This form of learning appeared to be primarily driven by the individual's attitudes and experience, which enabled them to identify and action improvement opportunities, respectively. By occurring primarily at the level of the individual, this form of learning was made difficult to research, making the learning processes a "*black-box*" (Barkema and Schijven 2008) and "*autonomous*" (Li and Rajagopalan 1998). The impact of individual perceptions on this form of improvement was illustrated by Uzumeri and Nembhard (1998). They demonstrated that rates and direction of learning could vary across individuals, dependent on whether individuals were quick learners, or whether their output degraded over time. Combined with the current research, Uzumeri and Nembhard (1998) make it difficult to argue that it is possible to represent organisational learning as a single mathematical function as presented by Wright (1936) or Yelle (1979). This also reflects Barkema and Schijven's (2008, p.596) comment, that the learning curve was "*largely devoid of theory*", highlighting the need to contribute additional aspects to this model of organisational learning.

Within the majority of the exploratory case companies, individual-level learning and changes to practices were connected with the organisation through updating operational procedures. The autonomous nature of the classic learning curve resulted in it not considering formalised and documented learning activities. For each of the exploratory case companies, operational procedures were necessary for validating processes, ensuring consistency and facilitating the deliberate resolution of non-conformances identified by customers. Consistent with Benner and Veloso (2008), repeated use of procedures promoted learning, with measurement assisting with the management and coordination of improvement activities (Mulhaney *et al.* 2004). Without documenting processes or improvements, there was a risk that practices and improvements would be forgotten between batches. The problem of forgetting within the learning curve conceptualisation of improvement has been acknowledged (by amongst others, Jaber *et al.* 2010; and Teyarachakul *et al.* 2011), highlighting the need for documentation as a limitation of the classic learning curve.

This limitation was further emphasised by the time frame of projects BC worked on, increasing the likelihood site-level improvements would be forgotten. The introduction of formalised procedures allowed management to capture improvements made at a site-level so they could be transferred to subsequent projects, and used by other project managers. By having systems in place that prevented solutions being forgotten, operational procedures provided each firm (apart from IJ1) with a means of demonstrating to customers there was a reduced risk errors would be repeated across projects or batches.

Finally, the codification of procedures allowed the exploratory case companies to critically review and optimise procedures when implementing changes. This resulted in improvements not necessarily being the result of learning undertaken during production, correcting problems once they had occurred or ‘learning by doing’. For example, before production began, IJ1 and IJ2 carried out pre-production trials to optimise machine settings, reducing or removing the need for subsequent refinement. BC also focused improvements in this way, to effectively maximise the learning from initial projects, to “*minimise the learning curve on any [subsequent] job*” (MD, BC). However, within IJ1, changes to process parameters made after optimisation resulted in reductions in process performance. To reduce the risk of changes being made following optimisation, the MD of IJ2 gave explicit attention to preventing individuals from making unauthorised changes to operational processes. Similar situations were also present within BC, EM1 and EM2, where adhering to procedures prevented changes being made that would not benefit the end user or result in a non-conformance.

While it was not possible to collect objective measures or evidence of a form consistent with previous research (Wright 1936; Yelle 1979), this was not the aim of the current research. Evidence was broadly consistent with aspects of the learning curve, such as the accumulation of experience at a company level or operators gradually making changes that resulted in improvements to operational processes. However, the aim of the second research question was to explore the applicability of the learning curve to engineering-oriented SMEs. Evidence has thus been presented that would indicate the learning curve is not applicable for operational activities within engineering-oriented SMEs. Consistent with previous research (inparticular Uzumeri and Nembhard 1998), the accumulation of production experience may not result in improvements in operational performance. The learning curve also does not account for the presence, use, refinement or optimisation of operational procedures. Within the exploratory case companies, the use of externally validated procedures played an important role in allowing the majority of firms to deliberately and systematically document learning from experience of producing particular parts. Within the exploratory case studies, it was also observed that the perceptions of individuals influenced whether improvements were identified. Depending on how operational processes were perceived, individuals who perceived problems as opportunities for improvement were more likely to initiate improvements.

In order to be able to identify improvement opportunities with existing procedures it was also necessary for operational procedures to be used consistently, which was also determined by the perceptions of the individual. As a result, the exploratory case companies provided evidence that tended to refute the “classical” learning curve as defined by Wright (1936), which suggests the learning curve is not applicable to engineering-oriented SMEs. The form of the data collected is considered appropriate for making this statement (Yin 2009; Miller and Tsang 2011). However, while the learning curve was not consistent with operational improvements, the role of general production experience at an organisational level was found to be important within the exploratory case companies, highlighting a degree of applicability of the learning organisation. Consistent with Kantor and Zangwill (1998), it does not appear appropriate to attempt to relate operational level improvements with firm level changes, which more developed models of organisational learning are able to do.

8.2.2 The Schroeder *et al.* (2002) Model of Organisational Learning

While the Schroeder *et al.* (2002) model of learning was not explicitly identified within Figure 2.6, it provided an appropriate approximation for the models of organisational learning that were neither the learning curve nor more developed models of organisational learning. March (1991) and Levinthal and March (1993) emphasized the need to appreciate both variation increasing and variation reducing forms of learning. While March (1991) conceptualised this process as the introduction of new organisational members and Levinthal and March (1993) related these topics to innovation, Schroeder *et al.* (2002) accounted for these forms of learning and was grounded within manufacturing, so was considered appropriate for the current research. While the learning curve focused upon gradual improvement, refinement and reductions of errors (variation reduction), within these alternate models, attention was also given to variation-increasing behaviour. Williams *et al.* (2000) stated that process improvement within quality management was primarily in the form of variation reducing activities. However, March (1991) presented risks associated with the over-exploitation of existing organisational knowledge, which is consistent with only focusing on variation reduction. This highlights further limitations of conceptualising organisational learning wholly in terms of the accumulation of experience such as the learning curve where variation continually reduces.

The Schroeder *et al.* (2002) model accounts for this limitation by acknowledging that learning activities take place both internally across organisational functions (instead of just individually), and externally with customers and suppliers. This conceptualisation of learning ensured that firms operating more consistently with this model engaged in improvements that drew from the knowledge of suppliers and accounted for customer requirements. This process meant that following refinement of operational processes, involvement with customers and suppliers ensured that returns of improvement activities did not diminish over time, which was experienced by those firms which had less involvement with external parties (particularly EM2). The bidirectional relationship between internal and external learning, presented in Figure 2.6, implies that the two forms of learning are mutually supporting. This acknowledges a third model presented in Figure 2.5, absorptive capacity (Cohen and Levinthal 1990), that states that a base knowledge (internal learning) is required in order to appreciate the value in related knowledge (external learning).

Within the exploratory case companies, findings were broadly consistent with the structure of Schroeder *et al.*'s (2002) model. Firms that cross-trained operational staff and implemented suggested improvements were able to engage more effectively in external learning (BC, IJ2, EM1). These firms worked closely with external parties (both customers and suppliers) to develop products and processes, which in turn appeared to improve manufacturing performance (e.g. scrap rate, on-time deliveries). Within these firms, management implemented internal processes and supported external engagement that facilitated the accumulation of internal resources that were valued by their customers. As a result, adherence to the Schroeder *et al.* (2002) model could be viewed as how BC, IJ2 and EM1 pursued their manufacturing strategy that supported them in developing a competitive advantage.

However, while the bidirectional relationship between internal and external learning would infer that external learning would promote internal learning, this was not apparent with firms that engaged in internal learning less effectively. Within IJ1 and SI, involvement with external parties did not appear to promote internal learning, which was reflected in them having difficulty in implementing improvements that were identified from involvement with external parties. For example, operators within IJ1 were unable to see the value in improvements introduced as part of the improvement intervention, so resisted or rejected new approaches to operating. Consistent with this perspective, unless improvements, suggested by customers, can be effectively implemented internally, involvement with customers may actually have a negative impact on performance (at a project level). SI provided an example where involvement with customers that resulted in the frequent adaptation of project specification could result in "*death by a thousand cuts*" (PE, SI) and projects being delivered late.

Not being able to realise value from external involvement without implementing changes internally implies there is not a direct relationship between external learning and the accumulation of resources. Levinthal and March (1993) stated that following exploratory learning (potentially with external parties), firms needed to refine ideas internally in order to realise value from them. However, due to IJ1 and SI emphasising the accumulation of individual experience, operators or engineers appeared less willing or unable to accept new knowledge from external sources so were unable or unwilling to refine them for use internally.

The last of the six exploratory case firms provided a third perspective on the Schroeder *et al.* (2002) model. Within EM2, there was only a limited level of involvement with customers and suppliers, due to the nature of relationships with customers combined with products being relatively simple, being produced on standard machinery. Within EM2, there was also a low-level of cross-functional training and few suggestions from operational staff, inferring a low-level of internal learning. However, involvement with customers tended to result in improvements in product designs and processes that had a measureable impact on manufacturing performance. This appeared possible within EM2 due to its small size (ten employees, and five operational staff) and it being possible to codify improvements in procedures. The Managing Director and Works Director were able to ensure adherence to operational procedures through direct supervision.

While the approach in EM2 allowed the implementation of small-scale, incremental, product design-based improvements, without greater involvement of operational staff, there were risks that larger-scale improvements (introduction of new machinery) would cause problems. The need for direct supervision also resulted in procedures being skipped if direct supervision was removed, for example, when orders were being rushed. Without operational staff taking ownership of operational procedures and viewing them as a means of promoting consistency, without supervision, internal learning also did not appear to directly impact on manufacturing performance.

Within IJ1, SI and EM2, while attention was given to engaging with external parties, less attention was given to internal learning processes. In light of the findings from BC, IJ2 and EM1, IJ1, SI and EM2 were not pursuing or implementing a resource-based manufacturing strategy, to translate internal learning and involvement with external parties into the accumulation of internal resources that were valued by their customers. Instead, they focused on the pursuit of particular customers (automotive for IJ1 or projects with greater scope for SI) or were not pursuing a strategy at all (EM2), which appeared unable to translate developments into a competitive advantage for these firms. This observation is consistent with the findings of Lee and Klassen (2008) and Rosenbusch *et al.* (2011), who highlight the importance of smaller firms developing internally, before pursuing involvement with external parties.

The Schroeder *et al.* (2002) model of learning and improvement provided considerably greater structure to observations compared to the learning curve. While not present within the models of organisational learning identified within Figure 2.5, the model provided a means of conceptualising a number of models of learning that were present. This included both variation-increasing and variation-reducing activities (March 1991; Levinthal and March 1993). However, the findings from the exploratory case companies were, in places, inconsistent with the Schroeder *et al.* (2002) model, implying that the structure of the model may benefit from refinement. These findings, which are consistent with related organisational learning theories (Cohen and Levinthal 1990), argue that the benefits realised from external learning increase following the pursuit of internal learning activities. While the findings from the exploratory case companies provide some support for the Schroeder *et al.* (2002) model, the findings would provide more consistent support if the Schroeder *et al.* (2002) model accounted for absorptive capacity (Cohen and Levinthal 1990). The requirement to balance exploitative and exploratory learning provided by March (1991) and Levinthal and March (1993) also assists in the development of the Schroeder *et al.* (2002) model. While the model provided some direction for the balanced pursuit of internal and external forms of learning, the structure of the model limited insight for poorer performing firms unable to benefit from involvement with external parties.

While the learning curve considered the role of experience at an individual and organisational-level, the Schroeder *et al.* (2002) model emphasised cross-functional knowledge of the individual and cross-functional behaviour of the firm. This resulted in a focus upon group-level activities that impacted on the accumulation of resources. While the model gave attention to facilitating group-level activities, attention was not given to whether individuals were willing to engage in cross-functional problem solving activities or engage with external parties (individual perceptions). Consequently, the model appeared to have only moderate applicability within engineering-oriented SMEs.

8.2.3 The 4I Framework of Organisational Learning

The Crossan *et al.* (1999) framework was the third model identified from the analysis of operations management literature that drew from organisational learning. Within Figure 2.5, the 4I framework represented a model of organisational learning that accounted for the major contributing sources (Crossan *et al.* 1995). While the learning organisation was the primary contributor to Figure 2.5 (Table 2.3), consistent with Tsang (1997), the learning organisation was considered an idealised form of organisational learning, giving insufficient detail to the specific learning mechanisms and processes. The Crossan *et al.* (1999) 4I framework addressed this limitation, drawing from the learning organisation and also other relevant and influential literature within Figure 2.5 (which included

Argyris 1977b; Fiol and Lyles 1985; and Nonaka and Takeuchi 1995). Amundson (1998) stated that operations management activities took place at numerous operational levels, suggesting that the selected model of organisational learning needs to map multiple organisational-levels. Crossan *et al.* (1999) represents one of the only models that explicitly maps the learning process across multiple organisational-levels (Crossan *et al.* 1995).

Within the exploratory case companies, organisation-level assets of procedures, culture and firm strategy provided a foundation for exploring each firm's ability to undertake organisational learning. As stated within the previous section, IJ1, SI and EM2 did not appear to be pursuing explicit development strategies, and while SI and EM2 had procedures in place, as a result of the perceptions of individuals within these companies (culture), they were not necessarily adhered to. In comparison, BC, IJ2 and EM1 appeared to possess organisational-level assets more consistent with the 4I framework, in terms of explicit development strategies, procedures to record organisational learning and cultures oriented towards learning and improvement (Bontis *et al.* 2002).

Organisational-level resources were considered to direct group and individual behaviours through processes of feedback. Strategy and procedures appeared to inform or guide group and individual behaviour within the exploratory case companies to ensure they were consistent with the aims of the organisation. Organisational culture also appeared to inform how individuals approached operational activities and how they engaged in their own and group-level activities. Individual perceptions of work and group-level activities within IJ1, SI and EM2 appeared to affect individuals' ability (or willingness) to engage in improvement activities. The lack of strategy, combined with a lack of, or unwillingness to adhere to procedures resulted in these firms not being able to effectively draw from knowledge or experience that had been accumulated by the firm. Combined with an unwillingness to engage in effective group-level activities meant that problems within IJ1 and EM2 could not be resolved within group-level discussions and feed forward into the alteration of procedures. SI provided an alternative perspective, where problems were discussed and developed within group-level activities that resulted in adaptations to operational procedures. However, as individuals did not consider it necessary to adhere to procedures, changes to procedures did not affect the behaviour of individuals.

Within BC, IJ2 and EM1, the more explicit firm strategy and operational procedures, combined with cultures that appeared to be more oriented towards improvement resulted in more effective organisational learning activities. The organisational strategy ensured that operational procedures were oriented towards adding value to the firm and accumulating resources. Operational procedures also directed individual and group behaviours to ensure they reflected previously accumulated organisation-level knowledge and experience. The organisational culture of BC, IJ2 and EM1 also ensured individual perceptions were oriented towards identifying improvement opportunities within existing operational procedures. Finally, the organisational culture supported individuals in engaging in group-level activities, in which they focused on problem solution, rather than apportioning blame and appeared less likely to withhold information. Such activities appeared to result in procedures being updated, that because they were the result of group discussions, individuals appeared more willing to accept. Such perceptions of group-level discussions appeared to transfer to engagement with suppliers and customers, where problems were approached collaboratively, facilitating the development of solutions with customers and suppliers. Consequently, BC, IJ2 and EM1 developed products and processes with customers and suppliers that would, in turn, contribute to the refinement of organisational procedures, culture and strategy.

The 4I framework thus provided an effective structure for analysing operational practices within each of the six exploratory case companies. Those firms that adhered less closely to the framework had greater difficulty in undertaking organisational learning. Those firms that adhered more closely were able to adapt or deliberately change to account for their operating environment. The emphasis given to strategic renewal and change of the 4I framework resolved issues associated with the gradual refinement, variation-reducing emphasis of the learning curve. The 4I framework also explicitly acknowledges the limitation of the learning curve that did not consider individual perceptions of processes that may determine whether improvements occurred over time. The 4I framework also addresses the limitation of the Schroeder *et al.* (2002) model by considering how individual perceptions may affect interactions within groups and with external parties. Consequently, the 4I framework's primary strength over the two previous conceptualisations of learning is that it considered organisational learning as changes in both behaviour and cognition at multiple organisational levels. These findings were broadly consistent with the findings of the confirmatory case companies. The greater structure of the data collection and analysis processes enabled the exploration of the relationship between process improvement and culture. With both topics relating to numerous organisational levels (Table 6.2), the applicability of the 4I framework to process improvement activities was further emphasised within the confirmatory case companies

A secondary strength of the framework, which is specifically relevant for the context of the research, is that operational procedures and processes are a primary focus of learning activities. By using the 4I framework, it was possible to analyse organisational learning behaviours within normal business practices. Without explicitly employing the 4I framework, previous research into organisational learning within SMEs has required learning behaviour to be linked with the development of competences (Chaston *et al.* 2001). Alternatively, organisational learning was defined in terms of changes in organisational-level behaviour, which may require explicit learning triggers to initiate organisational learning behaviour (Jones and Macpherson 2006; Zhang *et al.* 2006; Noke and Hughes 2010). Interestingly, learning triggers may overlook views that consider organisational learning as a proactive activity (Fiol and Lyles 1985). Learning triggers imply a reaction to a stimulus or adaptation, rather than learning (Weick 1991). Without requiring learning triggers, the 4I framework located organisational learning behaviours within operations management practices, demonstrating that the framework is applicable to operations management in general. Orienting learning activities towards revenue generating activities also made the 4I framework applicable for use within SMEs. Due to SMEs having to focus their attention on revenue generating processes (Hudson *et al.* 2001b), a conceptualisation of organisational learning that requires separate learning activities, such as research & development, developing new products or specific identifiable process that enable change (Eisenhardt and Martin 2000), would potentially be less relevant. Many of the SMEs involved in the research had insufficient resources to direct towards learning activities that did not directly affect revenue-generating processes.

8.2.4 Research Question 2 Theoretical Contributions

Building upon how process improvement was carried out within the exploratory and confirmatory case companies (addressing RQ1), organisational learning appeared to provide an appropriate theoretical framework to interpret findings. Organisational learning was presented as an appropriate theory for use within the current research in section 2.3.1 and considered a relevant theory for use within operations management in general (Amundson 1998). Section 2.4 identified three models of organisational learning that are most frequently used within operations management research related to organisational learning. The focus given by these models provided a means of exploring the applicability of each model in turn.

The need to explore specific models of organisational learning within operations management is well illustrated within the most highly cited organisational learning articles presented in section 2.4 (specifically Ahire and Dreyfus 2000; Hult *et al.* 2003; Rosenzweig and Roth 2004). Within each of these articles, organisational learning was primarily defined in terms of the learning organisation. As a result, organisational learning was defined in terms of the accumulation of experience in quality management (Ahire and Dreyfus 2000), a culture oriented towards learning (Hult *et al.* 2003) or the accumulation of production know-how (Rosenzweig and Roth 2004). Such definitions overlook the process-oriented nature of organisational learning that makes it relevant for use within operations management (Amundson 1998) and thus overlook the mechanisms of learning (Tsang 1997). Consequently, this use of organisation learning is potentially more inline with the learning curve, where learning processes represent a black box that does not effectively draw from the underlying theory (Barkema and Schijven 2008). By viewing organisational learning in a manner similar to the learning curve, existing research overlooks important limitations. By exploring the applicability of the learning curve, the current research is able to make the following theoretical contributions in relation to the learning curve.

Unless changes to operational processes are documented within operational procedures, learning curve improvements cannot be validated and may revert overtime.

When processes are optimized or customers require the validation of operational processes, learning curve improvements may adversely affect the output of operational processes.

The learning curve conceptualisation of learning does not acknowledge the impact of individual perceptions in relation to whether improvements are made and documented.

Consistent use and improvement of operational procedures can provide new customers with a proxy for organisational experience and competence, more appropriate that the learning curve conceptualisation of experience.

The Schroeder *et al.* (2002) model of learning provided additional insights, introducing the important role of external parties within engineering oriented SMEs. However, consistent with the resource based view underpinning of this model, limitations were identified, providing a number of theoretical contributions from the perspective of the Schroeder *et al*. (2002) model.

Internal learning is required for engineering-oriented SMEs to benefit from external learning.

Unless involvement with external parties results in the implementation of internal changes, involvement with external parties is unlikely to improve operational performance.

Without internal learning, high levels of external learning can adversely affect operational performance of internal operations.

Perceptions of operators determine the extent of internal learning, whether external learning was accepted internally and whether internal processes were adapted.

While the selection of three models of organisational learning did limit the scope of the research, the rigorous approach to identifying and selecting each model presented in section 2.4 provided justification for the choice of each model. In particular, the selection of the Crossan *et al.* (1999) 4I framework over alternative conceptualizations (such as Fiol and Lyles 1985; Levitt and March 1988; or Seely-Brown and Duguid 1991), did at least limit the impact of this, due to the 4I framework drawing from other influential models (Crossan *et al.* 1995). By interpreting operational activities through the lens of the 4I framework, two theoretical contributions can be made to operations management research drawing from organisational learning.

Operational improvement activities within engineering-oriented SMEs are largely consistent with the structure of Crossan et al.'s (1999) 4I framework of organisational learning.

Organisational learning in engineering-oriented SMEs involves activities a numerous operational levels, resulting in changes in behaviour and cognition that can help firms change to account for a changing operating environment.

Addressing the second research question provided a solid foundation of context-specific understanding of organisation learning and theoretically underpinned understanding of operational activities and emergent themes that were identified while addressing research question 1.

8.3 Addressing Research Question 3

The confirmatory case studies had two primary purposes: the first was to extend the external validity by confirming the exploratory phase of the research presented in Chapter 5 and developed within Chapter 6. The second was to address research question three, by further exploring how organisational learning contributes to understanding of process improvement within engineering-oriented SMEs. This was realised by administering a more tightly defined interview protocol to additional firms with similar demographics from the same geographic regions as the exploratory case companies. Compared to the exploratory case studies, where themes were the result of interpretations of discussions related to process improvement, definitions were explicitly stated within confirmatory interviews. This process enabled the use of a more defined coding framework, which assisted analysis and comparison of the confirmatory case data. The analysis process (Appendix 3.7) helped validate the relevance of the emergent themes to discussions on process improvement and relationships between the themes. Consequently, the external validity of the exploratory case findings was extended, inferring the emergent themes were potentially relevant to firms other than those involved in the research but operating within similar domains with similar characteristics.

In order to address research question 3, it is necessary to consider the origins of the emergent themes employed as the coding framework within the confirmatory case interviews. The themes were identified as a result of analysing process improvement activities, resulting in the presentation of a conceptual model of process improvement (Figure 5.2). Within Chapter 6, the 4I framework was identified as an applicable framework for analysing engineering-oriented SMEs, which provided theoretically underpinned justification for elements of the conceptual model. Combining these two perspectives of analysing the exploratory case data, the emergent themes were representative of organisational learning in the context of process improvement within engineering-oriented SMEs (Table 6.2).

The confirmatory interview data provided evidence related to the need to emphasise changes in culture in order for firms to realise benefits from process improvement activities. This is consistent with Crossan *et al.* (1999), who defined organisational learning as changes in both behaviour (process improvement) and cognition (culture). This indicates that if organisations carry out process improvement while supporting changes in individual perceptions (culture), they can be considered to have undergone organisational learning. Section 7.3 explored the support provided to the connections between each of the emergent themes and how they related to the processes of process improvement within the confirmatory case companies. Without attention on changing individual perceptions or culture, improvements did not become embedded in the firms and firms appeared less able to realise benefits from process improvement.

As process improvement activities were carried out, it appeared necessary for there to be changes in perceptions at different organisational levels (from individual, to group, to organisational). This finding is consistent with the 4I framework (Crossan *et al.* 1999) and illustrates how process improvement activities are related to organisational learning. This finding is also consistent with Anand *et al.* (2010) who illustrated how different types of process improvement behaviours could result in different learning outcomes. The finding is also consistent with Bontis *et al.* (2002), who demonstrated the importance of relating different levels of learning together, for example, developing individual understanding as a result of group-level discussions.

Also consistent with Crossan *et al.* (1999) was the role management played in supporting and directing process improvement activities. Compared to the literature reviewed within section 2.2 where process improvements tended to result from the receipt of non-conforming products, management also directed deliberate process improvement activities. This consisted of selecting to work on product development activities or introducing new manufacturing techniques as forms of process improvement. These represented step changes or breakthrough improvements mentioned in section 2.2 compared to the incremental refinements resulting from the receipt of non-conformances. This meant that process improvement was no longer defined in terms of organisational adaptation, making it more consistent with organisational learning (Fiol and Lyles 1985). Organisational learning thus provides justification for process improvement behaviour as conscious, deliberate activities based upon the choices of individuals within the firm.

By introducing new products and new manufacturing techniques into the firms, process improvement resulted in increases in process variation, that required subsequent refinement, consistent with Bayus (1995). The role of learning activities when introducing new technology was illustrated by IJ2. A new process had required considerable refinement before the process could supply production parts - "*it's complicated… it took 15 weeks until we were actually confident with it*" (MD, IJ2). This moves away from the adaptation of operational processes on receipt of non-conforming products that focus wholly on reducing process variation (Williams *et al.* 2000). Organisational learning provides theoretically underpinned justification for this type of behaviour, as over-emphasis of variation reduction can limit a firm's ability to change (March 1991; Leonard-Barton 1992; Benner and Tushman 2002), reduce the occurrence of double loop learning (Argyris 1977a; de Treville and Antonakis 2006) and lead organisations to reject new information (Cohen and Levinthal 1990). Within the context of engineering-oriented SMEs, based primarily on interviews with managing director, management were able to take risks by investing in processes with unknown payback periods. While it was acknowledged this introduced risk into the operations, such investments provided these firms with the potential for long-term improvements in performance (IJ3), or improve the chance of survival (EM6).

While research has explored process improvement activities in depth, as presented in section 2.2, it has not effectively drawn from organisational learning theory. For example, Bateman and Rich (2003) identified culture as an inhibitor of process improvement, without acknowledging proposition 2, where management support has the potential to change organisational culture. Within Bateman and Rich (2003), this addition could assist in sustaining improvements realised from process improvement interventions. Alternatively, other research has explored how organisational culture may change as a result of the engagement in particular quality management practices (Zu *et al.* 2010) or through management implementing a performance measurement system (Bititci *et al.* 2006). While this second area of research at least implicitly acknowledges the role management can take in changing culture, the current research builds upon and adds to these findings with a strong theoretical underpinning by exploring proposition 3. In addition to presenting process improvement and culture as interrelated, the insight provided by organisational learning gives theoretically underpinned justification for management to direct attention towards both process improvement and culture.

Consequently, findings from the confirmatory case companies indicate that process improvement activities consist of more than the implementation and maintenance of operational procedures. While these provided a foundation for process improvement, it appeared necessary for those engaging in process improvement activities to develop process understanding. This process could be facilitated by direct support from management via training, mentoring, coaching or incentives oriented towards process improvement and validated by measuring the outcomes of process improvement. This finding is consistent with Done *et al.* (2011), who stated the importance of supporting and rewarding involvement in best practice interventions in order to realise long-term outcomes. Without a culture (or individual perceptions) oriented towards adhering to operational procedures and engaging in process improvement, operational staff may not accept process improvements implemented by external parties or by management. This highlights the need to define process improvement and culture together, to ensure that individuals accept changes so that they are not rejected, process improvement is sustained over time and further improvements are initiated. Without an appropriate culture, process improvements appeared to require direct supervision (EM2) and may revert over time (IJ1 and EM3), so consequently would not provide firms with benefits. In this situation, it would be difficult to argue that process improvement (defined in terms of organisational learning) had taken place, compared to a temporary change or adaptation.

Although firms where management directed attention to both changes in behaviour and cognition appeared to be more effective at realising benefits from process improvement (SI2, EM4, EM6), those firms that initiated more deliberate, breakthrough changes appeared able to realise higher-level improvements (IJ3, EM5). Consistent with the exploratory phase of the research, specifically section 6.3.5, those companies that actively engaged in product development activities (IJ3, SI2, EM5) appeared to have greater potential to undergo organisational learning that resulted in strategic renewal (Crossan *et al.* 1999; Crossan and Berdrow 2003). For example, IJ3 had pursued metal injection moulding that required large-scale process improvements across the company in order to bring the technology to market. Following this form of process improvement, it was IJ3's ability to implement changes in behaviour and cognition across the firm that assisted new processes to become embedded into the company and support close involvement with external parties.

Finally, proposition 6 related to how management changed the resources they provided to operational activities, to account for feedback from previously implemented changes. By defining their business in terms of supplying automotive customers, EM3 gave less emphasis to pursuing work that provided them with opportunities to engage in process improvements. The management decision to remain within the automotive sector appeared to limit process improvement opportunities within the company, thus removing opportunities for engaging operational staff that may assist in changing how they perceived operational processes. Without a willingness to critically view the business and the customers EM3 worked with, EM3 continued to pursue business in a highly competitive and controlled sector. Evidence from the other case companies (both exploratory and confirmatory) highlighted that by critically reviewing their operating environment, management could select business that could realise benefits for the firm without engaging in process improvement (losing less profitable series production within IJ3). While driving process improvement and organisational learning, proposition 6 appeared to relate primarily to managerial learning and knowledge acquisition, so was considered outside the scope of the research.

In summary, organisational learning theory provides theoretically underpinned justification for the identified practices of process improvement. Organisational learning also provides justification for the need to conceptualise process improvement in terms of both changes in behaviour (operational practices) and cognition (individual perceptions/ culture). Finally, organisational learning theory was also able to provide justification for conceptualising process improvement in terms of deliberate, step change and breakthrough behaviours that were initiated by management as well as the correction of internal errors. In combination, organisational learning theory has provided three perspectives to process improvement that have enabled the development of greater understanding. These are the content of process improvement, how individual perceptions affect process improvement practices and the requirement for management to deliberately select and provide support to practices that constitute process improvement. Without attention to these three areas, engineering-oriented SMEs appeared to be less able to realise benefits from engagement in process improvement activities.

8.3.1 Research Question 3 Theoretical Contributions

By developing understanding of how organisational learning theories relate to operations management practices, the current research highlights the need to question a selection of existing research related to the role of culture within process improvement. Hult *et al.* (2003) found that culture oriented towards learning provided firms with positive performance consequences. Anand *et al.* (2010) also found the creation of knowledge (an element of process understanding) related to process improvement was related to process improvement project success. However, within SMEs, Chaston *et al.* (2001) found that similar aspects of learning were not directly related to improved performance. Terziovski (2010) was also unable to find a direct relationship between culture and SME performance. The current research suggests that process improvement potentially mediates the relationship between culture and benefits realised from process improvement (similar to performance consequences, project success and SME performance). This is consistent with the potentially mediating role of process improvement between management support and benefits realised from process improvement presented in section 8.1. This argument can be supported by organisational learning theory, due to the need to translate individual, group and organisational cognition (components of culture) into changes in operational behaviour in order for organisational culture to impact the benefits firms are able to realise from process improvement. The confirmatory phase was able to make the following theoretical contribution to process improvement, informed by organisational learning.

> *Effective process improvement requires attention on both changes to operational processes and changes to individual perceptions of processes in order to realised benefits from process improvement that are sustained over time.*

While the research suggests that process improvement mediated the relationship between management support and benefits realised from process improvement, the confirmatory phase identified and explored the nature of the direct relationship (proposition 6). By interpreting their operating environment, management appeared able to select business that provided greater opportunities for process improvement and benefits realised from process improvement. While this has been stated as being related to managerial, rather than organisational learning, this represents an important theoretical contribution to research on process improvement.

> *Management's ability to change their perceptions of the business determines whether they pursue new types of business and change how they support process improvement.*

Interestingly, consistent with the support provided to proposition 6 for a direct relationship between management support and benefits realised from process improvement, there was some support for proposition 5. This provides evidence that in certain contexts, which appeared to be related to product development services and customer relations, culture could provide similar benefits to process improvement. These benefits were related to securing repeat business and improving customer satisfaction.

Drawing from sections 8.1, 8.2 and 8.3, organisational learning could be considered as making a notable contribution to understanding on process improvement. Attention is given to both behavioural and cognitive changes necessary for benefits to be realised from process improvement, accepted by those in the firm and subsequently maintained. Organisational learning provides theoretically grounded and logically justified mechanisms for explaining the role of the themes that have been identified in existing process improvement research but have not been explored. Instead of presenting aspects of management support and culture simply as inhibiters and enablers (Bateman and Rich 2003), direction is given to examining the mechanisms through which they exert influence and affect firm-level behaviour.

While such inhibitors and enablers may explain why problems occur, without exploring the underlying mechanisms, understanding is not developed related to how these factors affect firm-level outcomes. Without understanding how success factors relate to improvements, less direction is given to managers, meaning they may remain uninformed on what management need to do or how culture exerts influence. The process orientation of organisational learning is able to provide greater understanding of process improvement, providing practitioners with the necessary understanding to pursue process improvement more effectively. This limits the risk of research presenting *why* particular companies are unable and others are able to improve, without offering actionable solutions that relate to *how* firms can begin to resolve their shortcomings, a noted strength of case-based research (Yin, 2009). By interpreting the impact of management support and culture from an organisational learning perspective, the following theoretical contributions can be made.

By pursuing new types of business and introducing new types of process equipment, management are able to provide more process improvement opportunities and can facilitate strategic renewal.

Management are able to change operator perceptions of process improvement activities through training, mentoring, coaching or incentives, to ensure they were aligned with the aims of the company.

The following section will summarise the findings that result from addressing the three questions and will present them as key research findings.

8.4 Key Research Findings and Definitions

By undertaking exploratory research into process improvement in the context of engineering-oriented SMEs from an organisational learning perspective, the research has been able to make a number of key practical and theoretical contributions. Firstly, the research has been able to build upon existing literature on process improvement to define how process improvement is carried out within engineering-oriented SMEs. Compared to existing definitions, the current research shows that process improvement is a multi-level practice that requires involvement from a range of individuals within an organisation.

Definition 1: Process improvement is a multi-level practice that relates identified issues or opportunities with changes in operations procedures

Definition 2: Process improvement requires support and direction from management to ensure those within the company engage with process improvement and ensure benefits realised from process improvement are in line with the aims of the company

Definition3: Process improvement provides engineering-oriented SMEs with a mechanism for organisational learning to allow them to deliberately adapt to the requirements of their operating environment

Definition 4: Organisational learning within engineering oriented firms relates to deliberate changes to products and processes that are reflected in changes in *individual, group and firm-level cognition of the types of work the company engage in*

The process improvement practices need not require the use of formalised improvement tools, techniques or methodologies that define much of the existing literature on process improvement (Section 2.2.2 and 2.2.4). This is consistent with contemporary perspectives on Six Sigma, stating that it "*is not just about statistics*" (Kumar *et al.* 2008, p.882). Drawing from an organisational learning perspective, process improvement behaviours were initiated at an individual level, before being developed within a group setting and then being formalised in operational procedures. The proposed conceptual model and definitions ensures process improvements draw from the knowledge of those within the organisation, but also that improvements are formalised.

Combined with the theoretical contributions made in sections 8.1.1, 8.2.1 and 8.3.1, the above definitions emphasise the relationship between process improvement and organisational learning. In addition to these definitions, there are further key research findings that related to aspects of these definitions. These relate to the interplay between process improvement and culture discussed within section 7.3.3, included within definitions 1, 2 and 3 to ensure process improvement results in organisational, rather than operational learning. The final key research finding is the critical role of management, not only to provide resources for engaging in and developing commitment to process improvement but also to interpret the operating environment. This key finding relates to deliberate changes included within definition 4, providing the necessary opportunities to those within the firm to engage in process improvement and if appropriate, allow a firm to undergo strategic renewal to reflect the requirements of their operating environment.

In combination, these key research findings show the need for different approaches to researching process improvement that are able to appreciate the role of individual perceptions as well as objective measurement of changes in process characteristics. The research thus highlights the value of interpretive research within operations management that can draw from subjective interpretations of practitioners to develop greater understanding of operational processes and their improvement.

8.5 Discussion

Through addressing the three research questions and presenting the key research findings, the research has been able to approach operations management research from two perspectives (organisational learning and process improvement) that could be drawn together. Combining these different analytical perspectives within empirical research, it has been possible to develop a more complete picture of process improvement practices within engineering-oriented SMEs. A potential weakness, however, is the limited exploration of the literature behind the emergent themes. Schein (1990) provided support for the relevance of culture, while also providing independent justification for the observed connections between management support, culture and operational processes. Innovation culture was considered relevant due to the context in which it was developed (manufacturing SMEs) and culture being considered an "*impediment to the implementation of innovation [a form of process improvement]*" (Terziovski 2010, p.895). While the related topics of organisational context (Choo *et al.* 2007a; Nair *et al.* 2011) and psychological safety (Choo *et al.* 2007b) provide alternative means of conceptualising similar topics, Arumugam *et al* (2013) stated these topics were not the same as organisational culture.

While management support was included within the conceptual model, the role of leadership appeared to be critical, to identify opportunities at a firm level and lead the firm in order to take advantage of them. Leadership theory was a second area in which further literary exploration could have been conducted, however, Samson and Terziovski's (1999) construct was selected due to it being related to providing a context that promoted organisational learning (p.396). From this perspective, although there may be a "*leadership theory*" (see Antonakis *et al.* 2003), Samson and Terziovski's (1999) conceptualisation of leadership was considered appropriate for directing analysis within the confirmatory phase of the research. Alternate conceptualizations of leadership could have provided alternative analytical frameworks, such as identifying transactional and transformational approaches to leadership, that were explored by Vera and Crossan (2004). Even withstanding these opportunities for revising the current research, Chapter 2 drew from literature most related to the topics of interest, within the context of operations management, with the emergent themes assisting analysis and informing subsequent data collection.

Section 2.4 provided justification for the selected models of organisational learning used within the research. By drawing from different models of organisational learning as discussed in section 8.1, this could be considered single loop learning (Argyris 1977a), where an alternative but similar theory may be more efficient at explaining observations. Rather than exploring different models of organisational learning, different theories could also be considered as perspective from which to analyse the research, representing double loop learning (Argyris 1977a) in relation to the selected theories. This allows theories, other than organisational learning, to be considered to determine whether they are more or less appropriate for researching process improvement. Although numerous theories could be considered, only a small selection will be covered due to space limitations. Each has been selected due to similarities in the context in which they have been employed and their relevance to the topics under discussion.

The first of these is memetics, a concept based upon evolutionary theory that relates how ideas and concepts can grow, evolve and become embedded. Secondly, institutional theory will be considered that emphasizes the establishment of routines that help justify particular actions within an organisational context. This particular perspective will also be extended with the use of institutional logics, as a means of establishing new institutionalised practices, which will be considered in terms of the use of an externally accredited QMS. Thirdly, the findings will be related to research on empowerment, in order to relate the research as a whole to alternative perspectives that build upon particular perspectives to process improvement discussed in section 2.2.

O'Mahoney (2007) presented an ethnographic study exploring how the establishment and evolution of BPR (Hammer and Champy 1993) can be better understood by viewing the concept through a lens of memetics. Individuals who selected to pursue or were trained in BPR were considered advocates of the approach. Within the current research, this was in the form of Directors accepting and believing the value a QMS could bring to the organisation (this occurred within BC, IJ2, EM1, SI, EM4 and SI2). In specific cases, implementing a QMS required the involvement of Directors with consultants (BC and EM1), which could be seen as a form of training that changed how Directors and operators viewed the initiative. EM5 then represented an example where operational processes and business as a whole were actually re-engineered, following the thesis of Hammer and Champy (1993) very closely. O'Mahoney (2007) outlined how extended training helped embed perceptions of improvement activities, which was important within the case companies, to ensure support was maintained if initial results were not positive. This finding is consistent with research on Six Sigma (Schroeder *et al.* 2008), highlighting the similar origins it shares with BPR. The connection with evolutionary theory was also made by Harry and Schroeder (2000) who stated that "*Six Sigma is very Darwinian- only the strong survive*" (p.181).

A number of case companies (including BC, EM2, EM3, EM4, SI and SI2) described the necessity to pursue ISO 9001 accreditation in order for them to be able to secure particular types of business. However, particular firms (BC, EM1, EM4, EM5 and SI2) approached the implementation process as a means of supporting business development, with operational improvements related to the system being connected to organisation-level performance metrics. O'Mahoney (2007) thus provides insight to the current research as well as existing literature on process improvements (for example Bateman 2005). By considering how members of a firm view operational initiatives provides a useful framework for assessing why certain initiatives become embedded into the culture of one firm and not in others. Within IJ1, as process improvement intervention training did not hold value outside the intervention, there appeared reduced motivation to pursue further improvements once external support and pressure was removed. Without linking further achievements to personal development goals, individuals were able to return to previously held roles that were not related to process improvement. Memetics thus provides a framework through which to view the establishment, replication, adaptation and subsequent success of a process improvement initiative, an alternative perspective to the cognitive changes described within the current research.

Institutional theory outlines how social structures form within organisations and industries that can determine how firms operate and compete (Meyer and Rowan 1977). Established, societal institutions inform the formal structure of an organisation, such as the presence of particular functions (marketing and finance) that assist firms in gaining legitimacy (Scott 1987). Such institutions can also affect individual behaviour by directing them away from pursuing efficiency-oriented goals in favour of maintaining the legitimacy of their actions. Meyer and Rowan (1977) presented "*myth and ceremony*" (p.340) as the primary mechanisms through which new institutions form within an organisation or society at large.

While providing legitimacy for individual actions, institutions may also tend to resist changes when actions are inconsistent with accepted institutional behaviour. An example of this within quality management would be individuals using outdated procedures even though they know they were wrong and resisting changes being made to them (e.g. IJ1, EM2 and EM3). To address this, institutional entrepreneurs can attempt to create new institutions by matching the needs of a particular venture or opportunity with those of established institutions (Tracey *et al.* 2011). Whether these new institutions match with the requirements of the wider society can determine their relative success (Hamel and Prahalad 1994; Garud *et al.* 2002; Greenwood and Suddaby 2006) in terms of being established and replicated. As a result, viewing the acceptance of a QMS and the pursuit of process improvement through the lens of institutional theory could provide enlightening insight on how new processes become "*institutionalised*" (Crossan *et al.* 1999) within an organisation. Interestingly, within work by the developers of Six Sigma, explicit attention is given to institutionalising new operational processes, which appears overlooked in the more recent interpretations of the approach (Harry and Schroeder 2000, p.111).

A QMS (particularly ISO 9001) represent an institution that is developing in legitimacy as an accepted standard at a society level (Benner and Veloso 2008). As a result, firms may choose to implement such a system to improve company image, because customers demand it or as a response to competitors implementing similar systems (Lo and Chang 2007). Drawing from Meyer and Rowan (1977), these business arguments provide an established logic that management can buy into. However, Lo and Chang (2007) found that where motivation for adoption was related to improving internal processes, firms perceived greater benefits. Institutional theory provides a means of balancing justification for the conflicting needs of process and business-level improvements. Within the case companies, ISO enabled companies to win business (BC, EM4, SI1, SI2) but also assisted them in becoming "*much more managed*" (MD, BC). This can be compared to the MD of EM2 who implemented ISO at the request of customers. This had led to the MD of EM2 questioning whether it was possible to justify the cost of maintaining accreditation.

Within EM2, established links with customers and less formalised process measurement meant the direct impact of certification was more difficult to determine. The greater level of competition experienced by other firms meant that they needed the "*same badges on your arms*" (MD, BC) just to be able to tender work. An institutional logics perspective on process improvement may provide an interesting viewpoint on how justification for particular initiatives can be established and subsequently embedded in the culture of a firm. The logic of the MD in IJ2 for undertaking process improvement was consistent with this - "*everything is done to make things better for all of us… we all want a wage increase, it's as simple as that*". Process improvement was presented as one of the primary means of improving the profitability of work, so enabling wage increases. This was carried out more formally within EM4 and EM5, where measurement data related to costs was used to illustrate the need to focus on process improvement. This is consistent with De Leeuw and van der Berg (2011), who demonstrated how performance measurement could affect individual perceptions of improvement, which in turn contributed to firm-level benefits.

Management gurus Peter Drucker (1955; 1999) and W. Edwards Deming (1994), who were major contributors to work on process improvement, emphasised the need for pride of workmanship and self-management to reduce the need for direct supervision. Both gurus stated that this could be realised through the empowerment of staff. Within their insightful mapping of empowerment research across a number of decades, Bartunek and Spreitzer (2006) highlighted how the use and meaning of the term empowerment had evolved. By acknowledging the role of the concept within a range of contexts, which included TQM, empowerment's relevance to the current research can be appreciated. Through processes of behavioural and cognitive changes, operational staff appeared to be provided with mechanisms that allowed them to undertake improvements without direct supervision and personally validate the effectiveness of changes. Anand *et al.* (2012) presented autonomy (an aspect of empowerment) as an important area of research and found there was a significant relationship between trust in management and commitment of individuals to continuous improvement. Commitment to improvement initiatives combined with sufficient autonomy was found to empower individuals within their day-to-day work. Empowerment could be viewed as an alternate means of assessing the effectiveness of management support directed towards process improvement. Alternatively, individual perceptions of empowerment may provide an alternative means of assessing the necessary cognitive changes for promoting process improvement through operational-level staff.

While there are many other, potentially relevant theories from which the research could have been taken, the above provide some insights on how each alternative theoretical perspective could contribute to the current research. Each provides an insightful lens through which to view the acceptance, maintenance and improvement of operational systems. However, compared with organisational learning, each gives greater emphasis to specific aspects affecting operational processes, rather than the processes themselves, so is potentially more relevant for extending the current research. For this reason, organisational learning appears to be a more appropriate theoretical lens through which to view operational processes and explore their impact on the benefits firms are able to realise from their improvement. The use of organisational learning theory to explore operational practices and in particular process improvement has been able to question, support and contribute to existing research within the domain of operations management. However, consistent with Schmenner *et al.* (2009), dependant on the aims of further research that build upon the current research, organisational learning theory may be discarded, to focus on particular areas of interest that may require the use of alternative theories.

8.6 Chapter Review

This chapter has presented how each of the three research questions was addressed by drawing from the previous three cross-case chapters to present the contributions made by the current research. The findings were discussed within the context of existing research, highlighting where the current research diverges from existing research and where it is consistent. Where findings diverged represented where the current research was able to contribute new knowledge to operations management. These were presented as key research findings. The organisational learning theoretical underpinning of the research was then critically discussed, to explore the relevance of alternative theoretical perspectives. The next chapter will conclude this thesis, presenting managerial implications, limitations, areas for further research and concluding remarks.

Chapter 9: Conclusions

Following the presentation of how the three research questions were addressed and discussing them in relationship to contemporary literature, this chapter will present managerial implications, explore limitations of the research and approaches to addressing them in further research. The chapter (and thesis) will conclude by stating how the research aims were addressed with conclusions.

9.1 Managerial Implications

Rather than attempting to wholly build theory about operations management, the current research specifically set out to explore operational practices and determine the applicability of an existing theory to engineering-oriented SMEs in order to develop a better understanding of practice. Research methods were selected that allowed the development of understanding related to practice, while being informed by a sound theoretical underpinning. Consequently, the research does not attempt to present completely new frameworks, theories or models, but instead to give direction to how practitioners perceive, understand, engage in and provide support to process improvement activities. As stated by McCutcheon and Meredith (1993), case research provides an important tool for refuting previously held assumptions (p.251) or, drawing from the section 8.5, to question established logics. The current research provides direction to managers in a number of ways.

Firstly, managers selecting to pursue process improvement, with the aim to improve operational performance, may benefit from conceptualising process improvement in a manner consistent with the current research. Compared to process improvement being defined in terms of the application of statistical tools, process improvement is defined as a combination of mechanistic (document-based) and social (group-based) activities that reflect more enlightened views on process improvement methodologies (for example, Antony 2007). The conceptualisation of process improvement, by drawing from organisational learning, also provides managers with a framework for relating individual-level behaviours to organisational-level changes, which are then sustained over time. By drawing from the knowledge of a range of individuals within a firm and capturing that within operational procedures, firms may have greater potential to integrate (Grant 1996) and realising value (Wiklund and Shepherd 2003) from the knowledge-based resources of the firms. Defining the SMEs involved in the research as engineering-oriented then ensured there were the necessary capabilities within the each company to interpret, capture and apply accumulated knowledge. This highlights the importance of the proposed definition of engineering-oriented SMEs, ensuring the development of engineering capabilities that appeared to allow firms to undergo process improvement and move away from price based competition.

Secondly, although research question 1 focused upon the practices that the case companies engaged in, when undertaking process improvement, in isolation they do not necessarily capture the full essence of process improvement within engineering-oriented SMEs. In addition to providing support for engaging in particular process improvement practices, the current research highlights the role of individuals' perceptions of process improvement practices. Without providing support to ensure individual perceptions and understanding is aligned with the aims of improvement activities there appeared to be a greater likelihood that changes in operational behaviour would be rejected or may revert to previous practices over time. Such support may take the form of training, but may also take the form of coaching, mentoring or incentives, to assist in aligning the aims of individuals with those of the firm. Drawing from the organisational learning perspective, the role of perceptions can be appreciated as occurring at multiple organisational levels. In addition to the need to support individual changes in cognition, attention also needs to be directed to how individuals perceive external parties (customers and suppliers), engage in group-level activities and use operational procedures. The research thus provides management with practical and actionable strategies for changing organisational culture that can promote more effective process improvement. Such strategies may include structured training programmes before initiating process changes combined with on-going support for all those responsible and involved in process improvement initiatives.

In addition to management providing direct support to changing individual perceptions, maintaining support for process improvement practices identified by the research allowed the development of process understanding at an individual-level.

Process understanding could then assist in changing perceptions related to improvement opportunities, group-level activities, external parties and the role of operational procedures. This provides managers with understanding of the mechanisms that result in improvement initiative becoming embedded in a firm, highlighting the need to maintain support for improvement initiatives. Combined with direct support to changing individual perceptions, the current research thus provides two perspectives for embedding process improvement behaviours within a firm.

Finally, in addition to focusing internally on operational processes and the perceptions of operational staff towards process improvement activities, the research highlights the need for managers and directors to adapt their behaviours and perceptions to account for their operating environment. Within the case companies, unless management pursued business that provided opportunities for improvement, there were fewer opportunities for process improvement to provide benefits. While this insight is logical, in combination with providing support to process improvement and changing perceptions of process improvement activities, the firms involved in the research appeared able to deliberately change the nature of their business from within to account for their external environment.

By providing support for both process improvement and changing the perceptions of operational staff, firms appeared able to undergo strategic renewal, to allow those within particular firms to account for and accept their changing operating environment. Within both exploratory and confirmatory case companies, this allowed firms to move into and perform well in new markets that helped them reduce business risk or account for increasing levels of competition in existing markets. However, other firms were also able to pursue process improvement and redefine their business, while continuing to engage with existing customers and improve their competitiveness in their existing markets. This final insight highlights the need for management to pursue a business level strategy that provides opportunities for process improvement, with the current research providing a framework for realising value from process improvement. The current research thus provides practising SME managers with a framework to pursue operational development through process improvement appropriate for a difficult operating environment.

9.2 Limitations and Areas for Further Research

The primary limitation of the research, which is often a limitation raised in relation to interview and case study based research in general, is the data that it draws from (Kvale and Brinkman 2009; Pratt 2009). Unless research is able to draw from a strong base of rigorously collected data, questions can be raised in relation to the reliability and validity of findings. However, the nature of the current research acknowledges these issues and has addressed them in relation to the type of research that was conducted. Section 2.2.3 outlined the wide range of definitions and perspectives taken to process improvement research, suggesting that qualitative, exploratory, interpretive research was necessary and appropriate to address exploratory research questions (Handfield and Melnyk 1998; Yin 2009). While the collection of objective data may have provided data to assist in validating process improvements, such forms of data while validating changes in behaviour are unable to capture individual perceptions, so were not wholly relevant for the current research. For example, while Antony (2000; 2001) and Kumar *et al.* (2006) could demonstrate and confirm process improvements objectively, that could be realised from the application of quality management tools, understanding related to process improvement, more generally was not provided by this work. Unless such data were integrated with interview data, the “black box” of organisational learning (Barkema and Schijven 2008) would remain unopened.

The number of interviews conducted is a second area the research could be questioned. However, the aim of the research was to develop theoretically underpinned understanding related to operational practice, compared to the presentation of generalizable, normative theories, meaning reaching theoretical saturation was considered of primary importance (Yin, 2009). As a result, further interviews, while potentially providing additional support for identified themes, would be less likely to significantly change the nature of the findings. Although further interviews were pursued at each of the exploratory and confirmatory case companies, the resource drain of further interviews was difficult for small firms to justify, particularly within a difficult operating environment. This issue was particularly relevant due to the research being conducted between 2010 and 2012, with banks offering limited support for smaller firms (IJ2 and SI2) and uncertainty about further deterioration (EM6). Fortunately, both Laforet (2011) and Lumpkin and Dess (1996) considered owners and technical managers of small firms as having a good working knowledge of a firm as a whole, giving justification that single interviews conducted within certain firms provided appropriate data (EM2, EM4, EM5, EM6). However, additional interviews with operational staff would have provided additional and valuable perspectives on process improvement, to validate that the perceptions of management were in line with how operational staff engaged with operational processes. The diversity of firms involved in the research helped to address the number of firms involved in the research, due to them providing a range of contexts, helping develop more robust theoretical insights (Siggelkow 2007; Miller and Tsang 2011).

Although the scale of the data may be, to a degree, limited, the research has been able to draw from 34 interviews in 14 companies resulting in over 54 hours of interview data and nearly 900 pages of transcriptions. While interviews were the primary form of data collection, further insight of the case companies was provided in the form of project meetings, site tours, observations of practice, company websites and personal experience of working within similar companies and with one of the firms (see Table 3.5, Table 3.6 and Chapter 4). Consistent with an interpretive perspective to the research, the primary data collection, while not objective, was used to develop the richness of how each firm was presented, in addition to confirming and validating topics that were discussed within interviews (Radnor 2001). The additional sources of data, in particular the professional experience of the author, allowed the relevance of interview discussions to be considered from a range of perspectives and subsequently reinterpreted during the analysis process (Reimer 1977; Radnor 2001). Consistent with Reimer (1977), the author's professional experience also provided motivation for initially exploring process improvement within SMEs as a topic of practical relevance.

The interpretive perspective and experience of the author also assisted in addressing issues related to the potential limitations of the data collection tools (Appendix 3.1 and 3.5). Consistent with an interpretivist perspective, the interview protocol emphasised the elicitation of broad discussions on focal topics (McCutcheon and Meredith 1993; Radnor 2001; Kvale and Brinkman 2009). The interview protocols were not meant to act as scripts with the interview emulating an aurally administered questionnaire, as stated in section 3.3.2, such a form of data collection is inappropriate within exploratory research. Within the exploratory phase, presenting definitions of areas of interest before interviews were conducted may have confined the topics of discussions, reducing the ability for themes to emerge from discussions on process improvement. The confirmatory phase of the research, while employing a more structured data collection tool, still relied heavily on the author's experience and interview craft to translate focal topics into discussions the interviewee would be interested in and willing to contribute to. Although the very nature of the data collection instrument limits the ability to validate its reliability, the transparency of the analysis process (Table 3.4, Table 3.7, Appendix 3.7), presenting numerous excerpts of interview data and returning case reports to case companies represents alternative means of validating findings from an interpretive perspective (Radnor 2001; Noke and Hughes 2010). Returning to the exploratory case companies (Section 5.3) and sharing findings with a range of academics and practitioners further assisted in addressing questions related to the reliability and validity of the current research (Table 3.6).

To address these limitations, further case-based research could be conducted that draws from interviews with a larger number and wider range of organisational members, which could be combined with objective measures of process improvement activities. In combination, interview protocols could be developed in order to be more positivist in nature, that promote the repeatability of topics covered to improve repeatability and validity of interview data. To address the limitations of interview-based data collection methods, building upon the exploratory nature of the current research, further research could take the form of qualitative surveys to allow the exploration of process improvement practices across a larger number and range of firms. Macbryde and Paton (2013) demonstrate how such forms of research can provide insight into practices within a large number of firms that can be effectively combined with follow-up interviews. This process would support the further extension of the external validity of the current research. Alternatively, also building on the findings of the current research, quantitative research instruments could be developed that draw from existing measurement constructs (Roth *et al.* 2007). Using linear, non-linear or multivariate analysis techniques it would be possible to test the support for the different propositions across a wide range of firms (Hair *et al.* 2006). Alternatively, using variation or co-variation forms of structural equation modelling (Reinartz *et al.* 2009), the specific structure of the model relating process improvement, management support, culture and benefits realised from process improvement could be confirmed. Integrating such forms of subjective data with objective data (such as firm growth, profitability or other measures of performance) could further assist in extending the validity of the findings.

9.3 Conclusion

In conclusion, the research has presented process improvement as a multi-level practice that considered multiple levels of perceptions, reflecting the requirements of organisational learning theory. Anand *et al.* (2010), the only article identified within Chapter 2 that drew from both organisational learning theory and process improvement as central terms, considered "*process improvement is central to operations management*" (p.304). This statement is consistent with the findings of the current research, with the current research providing greater detail in relation to what such a statement implies. Within the current research, centrality to operations management represents how management provide resources (management support), how those within the organisation perceive such activities (culture) and how process improvement is able to provide benefits to the firm. The current research also provides direction for practising managers towards the important internal and external stakeholders affected by, involved in and benefitting from process improvement. Reflecting back, the objectives, aims and proposed contributions of the research presented in section 1.4 were addressed as follows:

1. While organisational learning is frequently drawn from within operations management literature, the use of organisational learning theory is limited
2. The learning curve, the Schroeder *et al.* (2002) model and more developed models of organisational learning, primarily the learning organisation, are the major models of organisational learning employed within operations management research.

3. The current research identified process improvement as a multiple-level practice that relates isolated operational level improvement to organisational level change.

4. The current research assisted in developing understanding of the role of management in selecting and supporting operational process improvement activities in order for them to be aligned with organisational-level aims. Understanding of the role of individual perceptions of process improvement was developed in terms of their effect on how individuals identified improvement opportunities, engaged in group-level activities and engaged with organisational procedures. Understanding of how management support directly and indirectly affected culture was also developed.

5. While used within operations management literature, the learning curve conceptualisation of learning provided limited direction to understanding operational practices within engineering-oriented SMEs. The Schroeder *et al.* (2002) provided some insight into the nature of internal and external learning activities, but was inconsistent with some findings from the current research. The Crossan *et al.* (1999) 4I framework was found to be the most applicable for developing understanding of operational activities within engineering-oriented SMEs.

6. Organisational learning theory provides justification for the role of individual perceptions within process improvement activities, as requiring understanding to promote the acceptance of changes. Organisational learning also highlighted the importance of management support in directing process improvement behaviour in order to promote deliberate changes, compared to adaptation in terms of resolving or correcting errors. Management support enabled changes that were both incremental (variation reducing) and breakthrough/ step change (variation increasing), which appeared to assist firms in undergoing strategic renewal.

This thesis has attempted to address three research questions that were systematically formulated within Chapter 2. By drawing from the population of operations management research between 1991 and 2011 (over 20,000 articles from 11 operations management journals), the literature review provided a solid foundation for the need and relevance of research within the domain of process improvement and organisational learning within the SME context. Conducting the research has addressed an important gap within operations management research in relation to how to conceptualise process improvement. The research has also re-emphasised organisational learning as an appropriate theory for use within operations management (Amundson 1998), and proposed Crossan *et al.*'s (1999) 4I framework as particularly appropriate within the context of process improvement. Combining the first two research questions with the third provides practitioners with theoretically and logically argued justification, supported by empirical evidence for factors affecting firms' ability to engage in and realise value from process improvement. Consequently, the research may assist practitioners in overcoming barriers and inhibitors to process improvement that can result in improvement activities being rejected by operational staff.

Overall, the thesis has provided a theoretically justified argument, grounded in practice with results oriented towards benefiting operations management practitioners while simultaneously contributing to operations management research. An appreciation of cognitive changes that were related to pride in workmanship and empowerment introduced in section 8.4 highlights how certain companies have emphasised the development of an appropriate organisational culture to promote improvement. Rather than individuals misbehaving (Ackroyd and Thompson 1999) or resisting change, they appeared more willing to accept process improvement as an important and (at times) enjoyable aspect of their work. The companies involved in the research that directed attention to process improvement and supported the development of operations staff, appeared better able to operate, and even thrive, within a difficult economic climate. The findings of the research are thus particularly relevant for an economy emerging from a severe recession and small firms operating in a high cost economy with global, low cost competition.

9.4 Critical Reflection

Although answering research questions posed by identifying gaps within the literature, these are not seen as the primary contributions of the current research as perceived by the author. Operations management frequently presents itself as a practically oriented subject, however, at times, research is largely devoid of practice (Meredith 2001, p.326; Voss 2010; MacCarthy *et al.* 2013). From this perspective, the primary audience of operations management research is other operations management researchers. In an effort to increase the perceived legitimacy of operations management research to other management fields, organisational theory has played an increasingly important role (Schmenner *et al.* 2009). The current research has attempted to provide an alternate means of addressing this double hurdle of relevance to practice with academic rigour (Starkey and Madan 2001). Grounded within operations management practice, integrated with practical experience of the author and informed by organisational theory this issue has, at least partially, been addressed. The practical experience of the author also ensured the topic of the research as a whole is related to issues experienced by practising operations management.

As a result of the above observation, stakeholders other than other operations management researchers are introduced. Firstly, the research subjects or practitioners represent the primary stakeholder that the research is oriented towards. Rather than simply representing a client with the research being a consultancy project, the relationship could be seen as more nuanced. The research subject does not pay for the time of the researcher, but the participant contributes their valuable time. However, the researcher is not obliged to provide a report or suggest actions that will improve performance, but they the research still needs to honour the resources provided by the research subject. The author then represents another stakeholder, with the validity of the findings reflecting on their professional credibility as a researcher. Providing research subjects with independent, critical analysis of collected data, whether positive or negative, contributes to the research subject's ability to understand their operations and potentially improving their capacity to pursue effective process improvements. Finally, the introduction of organisational theory provides credibility and rigour to the analysis process. Alternate frames of reference provided by organisational theory are able to provide practitioners with new ways of viewing practical issues, so moving away from their established "*theories in use*" (Argyris 1977a, p.122). As a result, operations management research has the potential to be grounded within practical issues, drawing from organisational theory that in turn contributes to practice. This represents the researcher managing relationships with research subjects, to ensure the primary stakeholders benefit from their involvement in operations management research. This was something the author of this research was commended on by the MD of EM1.

The final point of reflection on the current research, is to address comments made by Teece (2007, p1345), accusing operations management as having undergone very little innovation in the previous 60 years. The author views this opinion as a damning indictment of operations management research in general. However, this does raise questions related to the final stakeholder, which must be the students of operations management that operations management research educates. Transfer of operations management research into practice is effectively made during the education of students that need to be informed of current thinking and practice. Undertaking research informed by organisational theory could then reduce the risk of course syllabi continually changing to account for the latest management fashion (Thawesaengskulthai and Tannock 2008) or courses content becoming outdated in a "*post-lean age*" (MacCarthy *et al.* 2013). Teaching then represents the final test of relevance and creditability of operations management research, as to whether or not one is willing to teach what one researches. From this perspective, there is a need to combine focus on undertaking interesting, practically relevant research, with a willingness to release new ideas into the field. The outcome of this practice can be future operations manager implementing operations management thinking into practice, with results representing the true acid test of research. Brian Squire, former Reader of the University of Bath, speaking at the University of Cambridge (Squire 2011) then presented such informed, enthused students of operations management as candidates for further operations management research. IJ2 commented on the author's enthusiasm for contributing to operations management teaching, a likely prerequisite for creating a virtuous circle that links research and practice. This will allow teaching within operations management to move away from teaching "*widely diffused*" (Teece 2007, p.1345) tools and techniques, towards developing the skills necessary for developing understanding of context specific operational practice.

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Appendix

Appendix 3.1 Exploratory Research Protocol

Nature of Research

I am a research from Nottingham University Business School. I am researching operations management and process improvement. My research generates academic journal articles and a dissertation on issues of process improvement. The research involves conversations with people who work in the organization and analysis of operational procedures.

I have permission from …… to speak with staff and ask them about their work. I would like to talk to you for around one hour and tape the interview.

Confidentiality

These interviews will be taped and fully transcribed by a professional audio typist or myself. The only people to see the transcripts will be myself and the typist. No real names will be used in the transcript – even where names are used in the interview the typist will replace them by pseudonyms and/or initials. If there are things you would prefer not to be taped I will switch off the reorder.

Do we have your permission to proceed?

Demographic

What is your title?

Could you describe the nature of your job, with details of the different activities it involves?

General

What continuous improvements initiatives are you undertaking at the moment?

Training

What training programmes do you have in place?

How do you maintain training standards?

How do you manage new/agency workers?

Process Improvement

Is there a structured approach to problem solving?

Can you describe the quality control processes of some of the parts you produce?

Are there specific work procedures (moulding and tool acquisition)?

Are there similar procedures for maintenance of machines?

Are these procedures reviewed?

How would you go about identifying route causes (new and existing tooling)?

How do you involve suppliers and customers in this process?

How is the performance of corrective actions measured?

New Product Development

Are there procedures in place for developing new products?

How do you communicate these issues with the client?

How do you go about new product developments?

How is the performance of new products measured?

Process Review

How are new product developments and process improvements documented?

Personal Development

How is employee performance assessed?

How is this process used?

General

What is the general perception about the continuous improvement program among employees?

In relation to return on investment, customer satisfaction, number of defective parts, waste and other measures of performance that are important to you, how does process improvement affect firm performance?

Appendix 3.2: Exploratory Firm Contact Letter

Dear MD,

I am conducting research on process improvement in manufacturing companies as part of my PhD studies at Nottingham University Business School.

Research shows that firms have difficulty in maintaining progress and sustaining change after the initial enthusiasm for a new process improvement initiative wears off. With my supervisors, Prof. Bart MacCarthy and Dr. Christos Braziotis, I am studying this phenomenon within Small and Medium sized Manufacturing Enterprises. The aim is to develop a framework that allows smaller firms to use process improvement approaches more effectively to enhance long-term competitiveness.

The research consists of interviews with small and medium-sized manufacturing enterprises engaged in process improvement activities. Process improvement activities may consist of reducing variation in a manufacturing process or re-engineering an order processing procedure to reduce throughput time. The aim is to develop a better understanding of the processes in place that support improvement activities. In particular, the role of project management in process improvement is of interest, as it has been identified as an important skill to structure and learn from improvement activities.

The immediate output from involvement in the research will be a case report for each participant company presenting observations, findings, and suggestions. This will contribute to the larger project that is analysing the process improvement experiences of a range of firms (confidentiality will be fully respected and anonymity guaranteed in all cases). Participants in the project will also receive summaries of the overall research findings in due course.

We very much hope that you will be interested in participating in the research. If you are, please contact me on 07812 602567 or alternatively my email address is lixrlm1@nottingham.ac.uk. If you would like to find out more about the work, I am very happy to meet with you to discuss it or to answer any questions you may have by email or telephone.

I look forward to hearing from you,

Yours sincerely,

Rupert L. Matthews

Appendix 3.3: Summary Case Report: Systems Integrator

OD (Director), Rupert Matthews 14.00 24-11-2010

Formed in 2002, the aim was to provide high specification, client specific system integration solutions, that were not being addressed by the firms dealing with the board members when they held prior roles. Systems Integration consists of the logic and control systems that enable a selection of different, automated machines (such as material handling, processing or inspection) to operate together. To do this, there was a "*need to know a little about a lot*", so that a range of a machine could be brought together in a range of different situations. In addition to this, it was also important to be able to effectively demonstrate to clients an ability to transfer existing experience to new contexts. An example was given of work with Rolls Royce, where although the details of the inspection process were unknown, Systems Integrator (SI) were still able to appreciate requirements for the system. Within this process it was important for engineers to be able to quickly grasp project details and communicate this effectively to clients.

Operating with such large clients (which also included Mars and Toyota), at times it was necessary for SI to be contracted by intermediaries, who were contracted by the end user. Although getting as close as possible to the end user was an aim of SI, such contract work was necessary due to the operating capital involved in certain projects. While limiting the direct involvement with the end user that enabled access to unarticulated needs (an important avenue for future business) the structure buffered SI from particularly demanding clients. The structure also ensured SI only had responsibility for their part of the system, reducing the associated risks of other subcontractors not delivering and jeopardizing entire projects. The effect of this situation was a limited ability to build client relations, which was emphasised as important both in the interview and on the website. After building a relationship, SI stated how it was possible to co-develop solutions with clients around specific operational problems. The result was an ability to add more value to solutions compared to tightly defined solutions that had already by decided upon. The following report is based upon a discussion about Systems Integrator with the operations director, which is structured according to the different areas of the [initial] conceptual framework, with the report concluding with further research opportunities.

Training

The technical nature of the work and close interaction with clients required those working within SI to have a high level of technical competence. This consisted of degree level (or equivalent) formal qualifications from a range of backgrounds, which were supported by mentoring of less experienced staff. This was highlighted as particularly important when university educated recruits may not have practical experience of working with actual systems. Further training was carried out in relation to the (relatively) recently implemented quality management system. This had been developed by a project engineer from assessing current processes, who was responsible for training all those in the organization in how the new procedures would affect them. Although the process had been difficult, the process had been able to develop this project engineer's understanding of quality management. A system was also created that conformed, but required further tailoring to simplify for use.

The above two examples represent making use of internal knowledge (mentoring) and formalising operating systems (QMS). Neither considers the need to access information from outside the firm, which is particularly necessary when dealing in a technology driven environment with very knowledgeable customers. To resolve this issue, directors were charged with accessing various sources of knowledge including seminars, trade shows given by equipment manufacturers and new legislation. Such information would then contribute to internal seminars to present new ideas and developments. This allowed the whole firm to accumulate knowledge about the industry without having to release all members. Although there may be a risk of the directors only importing certain types of information, informal discussions could help elicit information that may have been noticed but not presented by the director. In addition to this, electronic documents associated with seminars were stored upon internal databases for subsequent access.

Technical System

The development of an ISO accredited quality management system (a requirement of some customers) enabled SI to promote consistency and continuous improvement. One of the difficulties that had been experienced was overly prescriptive procedures, which were not appropriate within an environment requiring flexibility. With a degree of structure helping to promote continual learning, a balance between the two was the aim. Within this, an acknowledgement of the craft nature of software writing processes was necessary to draw from individual skills, while still promoting consistency. Reaching the right level of structure within procedures may then assist in component integration, or alternatively modification, if only particular modules of code required changing post implementation. Developing the correct procedures was stated as important, due to similar procedures being in place for measuring and logging specification errors. Although more effective at identifying issues, the associated costs of bill of material errors was negligible when compared with reworking errors in coding. Finding the correct balance between these two types of problems may potentially allow a consistent system wide solution to be developed.

Social Systems

Emphasising skilled professionals with relative autonomy, social systems appeared to dominate the working processes. This was demonstrated by the strong emphasis given to the development of experience in writing software and the flexibility of staff to form and transfer between teams. This process was important within projects, especially those requiring differing levels or types of resources throughout their life cycle. To support learning across projects, project management reviews were undertaken to identify opportunities for improvement. These consisted of both in project processes and the overall project design. With a variety of backgrounds within SI, such activities may have benefited from a number of different perspectives, limiting the risk of organizational blind spots. This may occur if everyone within a firm has a similar background and sees problems in similar ways. Although increasing coordination costs associated with new groups, requisite variety represented an important attribute for creating new knowledge and supporting long-term firm health.

Improvements Activities

Improvement of software consistency represents an area that SI intended to improve, and an area that individuals within the firm were planning on looking at. A possible solution may be to move towards modularity to configure solutions rather than truly customized products. Although representing a degree of deskilling, SI would be able to emphasis the integration and optimization portion of their work, which was likely to be the work that added most value to clients. An example given of this was the reuse of a particularly successful piece of “three pump” code, which may lead to a library of software modules that could be selected during specification meetings. By emphasising program stability and standard interfaces, the ease of configuring solutions may increase. The result could be greater emphasis given to managing risks (stated as an area that could be improved) or alternatively, more resources available to pre-installation, system optimization. Unfortunately, emphasising reuse of old code may reduce variation within the system, and in a worse case lead to new ideas being rejected, an issue that would need careful monitoring.

Improvement projects represent a particularly interesting proposition for SI, due to the cyclical nature of the demand for systems throughout the year. With consistently busy periods in January and quite periods in August, there were periods where slack resources were present. By supporting those in the firm to initiate improvements or undertake self-directed learning, such as new programming techniques, SI could accumulate an array of new knowledge. Following such activities with company-wide forums, new ideas could be interpreted as a group, and possibly then formalised into revised organisational procedures. In addition, these activities could also form the basis for training programs, in the form of both direct (software skills) and indirect (researching techniques) to support further learning. These activities could then compliment the technical information brought into the firm from equipment seminars attended by the directors. A further output of these internally initiated learning activities may be the development of documents, not only for internal use. By presenting ideas related to developments in the industry in professional and practitioner journals, it may be possible to generate demand for new products or techniques. An example of this was the “secure trace” process that had been developed by a consortium to trace pharmaceuticals and prevent contamination. By publicising the system, or aspects of the system (depending on consent of other partners), SI may be able to benefit from the investment made into this technology. Currently, the approach taken to commercialising such knowledge was through informal discussions with clients, to identify opportunities for certain developments. Publication of ideas, although potentially seen as releasing the valuable resources of the firm, may help create more, higher value demand, that may in turn help SI grow.

Further research

SI represents a particularly interesting candidate for further research, due to their knowledge and project-oriented nature. Particular emphasis was given within the interview to the value of knowledge-based resources within the firm. On a continuum from mass production to fully project oriented, SI represents an interesting alternative to other firms that have been involved in the research [to this point]. Interviewing actual project workers would allow the identification of actual drivers of knowledge creation and how they relate these to the value offered to the client. Discussing similar issues with the member responsible for the quality system would then allow a perspective of how easily new ideas could be implemented into the system. Involving a range of individuals could also allow perspectives of actual project work to be added, such as the processes involved in reviewing completed code, or agreeing on standards. Understanding of such processes is likely to represent important elements of the knowledge creation process. Together, this could allow the initial discussion with OD to be developed into a form more representative of SI as a whole, promoting the acceptance of ideas that are proposed.

In addition to the above benefits associated with further involvement in the research, SI may also be able to benefit from research carried about within operations management. The implementation of advance manufacturing technology (AMT) and its effect of firm performance is a subject that has been written about at length. Research with SI could then draw from this literature to help build appreciation of particular drivers of end user performance, for example the level of initial end user knowledge's effect on post implementation innovation. This process may provide SI with a framework for determining the appropriate level of involvement they need to have with clients to promote in process development, balances again the delivery to schedule.

Appendix 3.4: Confirmatory Case Presentation

Supporting Continuous Improvement Initiatives through Learning

"most companies have failed to grasp a basic truth: continuous improvement involves continuous learning" Harvard Business Review

"Although simple to define, the achievement of such continuous improvement(CI) activities and its maintenance over the long term is a major source of difficulty." *Technovations*

A Typical company's approach to continuous (quality) improvement

- None conforming product returned from customer
- Identify route cause based on experience and knowledge of those within the system
- Change procedures
- Implement training for operators to prevent repeat problems

But what happens if there wasn't knowledge in the system and the problem was not solved?

- Reoccurring quality faults
- Solving the same problems continually
- Dissatisfied customers
- Wasted investment in problem solving and training
- Problem solvers run out of answers for clients

My Research to explore process improvement in SMEs

Case Firm Summary

Company Name	Employees	Industry	Case Type	Number of Interview	Position Held	Total time
Building Contractor	49	Construction	Pilot	**3**	MD, Quality Consultant, Project Management	**7h**
Injection Moulding 1	73	Injection Moulding	Exploratory	**2**	Production manager, project manager, process engineer	**3h30m**
Engineering Manufacturer 2	10	Compression Plastics	Exploratory	**2**	Managing Director	**2h40m**
Injection Moulding 2	35	Injection Moulding	Exploratory	**2**	MD, production manager	**4h30m**
Systems Integrator	25	Advanced Manufacturing Equipment	Exploratory	**3**	Directors and Process Engineer with responsibility for quality	**7h20m**
Engineering Manufacturer 2	23	Sheet Metal	Exploratory	**2**	Director, Product Manager, Project Engineer	**3h30m**

- Emergent themes of leadership and culture identified as connecting process improvement and performance

4

Culture and Leadership's role in Process Improvement

- Process improvements that are driven through staff commitment to improvement (culture)
- Resources are made available for process improvement activities (leadership)

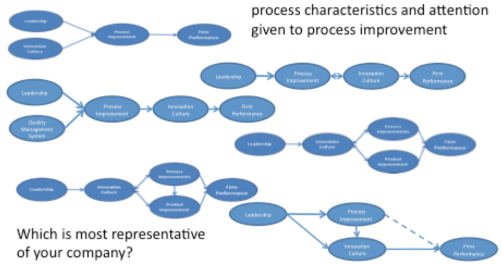
- These aspects then allow organisational learning to take place by transferring individual insight into organisation level changes in behaviour

What is Process Improvement?

1. Having an idea, seeing an opportunity or receiving/identifying a non-conformance
2. Discussing such insights with colleagues to develop a better undertaking and then formulating a solution
3. Developing new operational processes to support solutions and inform those affected
4. Implement and then audit processes to ensure new procedures are maintained
5. Return to step one, if solution was not satisfactory

Models of process improvement identified within case companies

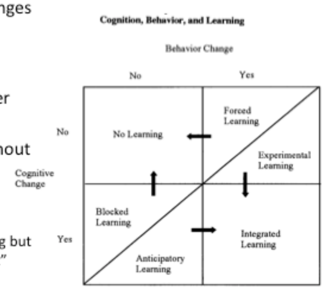
Models that account for environment, process characteristics and attention given to process improvement



Which is most representative of your company?

Relating models to organizational learning theory

- Without cognitive changes (culture), behavioural changes (process improvement) will be resisted and revert over time
- Cognitive changes without behaviour change will not be able to impact performance
  - "we know what's wrong but we aren't going to fix it"



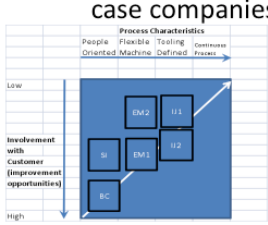
Culture is not necessarily fixed

- Process improvement activities can provide justification for changing how processes are viewed by those in the system
- Process improvement activities can provide staff with opportunities to solve operational issues, helping them engage with the system
- Process improvement activities can provide opportunities for cross functional problem solving, helping reduce organizational barriers that can hamper learning

Why Is Learning Important?

- New concepts are more easily accepted by relating them to prior knowledge (ASQ)
- If firms do not continually learn about their operating environment, may focus on developments that aren't valued by end users (e.g. Kodak versus Canon)
- Learning organisations can more effectively adapt to new opportunities and threats

How has this been observed in the case companies?



- Firms more engaged in process improvement and learning could more effectively engage with customers, so create more value

Impact on Performance

- Able to adapt customer products to account for process knowledge
  - Parts made more cheaply, more quickly, with higher quality and at lower cost
- Willingness of customers to explore new product ideas
  - Secure new business through developed relations
- Staff more engaged in operational processes through involvement in their improvement

Appendix 3.5: Confirmatory Case Research Protocol

Research Protocol

Nature of Research

I am a research from Nottingham University Business School. I am researching operations management and process improvement. My research generates academic journal articles and a dissertation on issues of process improvement. My research involves conversations with people who work in the organization and analysis of operational procedures.

I have permission from …… to speak with staff and ask them about their work. I would like to talk to you for around one hour and tape the interview.

Confidentiality

These interviews would be taped and fully transcribed by a professional audio typist or myself. The only people to see the transcripts will be myself and the typist. No real names will be used in the transcript – even where names are used in the interview the typist will replace them by pseudonyms and/or initials. If there are things you would prefer not to be taped we will switch off the reorder.

Do we have your permission to proceed?

Questions

Management Support, based upon Terziovski and Samson (1999) construct

What role do management play in process improvement?

How does that impact the organization as a whole?

Are individuals given responsibility for process improvement?

What is their role within the firm?

Innovation Culture based upon Terziovski (2010) construct

What is the general perception of process improvement?

What responsibility is given to employees for process improvement?

Are employees willing to try new ideas (knowing they are supported even if they fail)?

What role do group meetings, internally and with customers and suppliers play in these?

Process Improvement, based on a range of constructs,

When a product is returned or a customer complains, how are issues addressed?

How do you gain ideas and implement improvements to operational processes?

What is the role of group activities within these activities?

Benefits Realised from Process Improvement based upon Beltran-Martin *et al. (*2008)

How does process improvement affect operational performance as perceived by the customer?

What factors of process improvement contribute to improving customer satisfaction?

Appendix 3.6: Confirmatory Case Introductory Letter

Dear MD,

Process improvement represents an important, if not essential activity for firms to engage in if they are to remain in business in the long-term. It provides firms with a means of continually adapting their operations to meet the needs of demanding customers while simultaneously accounting for a continually changing operating environment.

Building upon 4 years of practical experience as an engineer, for the past 3 years I have been carrying out research on firms engaging in process improvement. This has included close involvement with primarily small and medium sized manufacturing enterprises operating in a range of sectors. This has provided me with a unique insight into how these firms approach process improvement but also the wide range of benefits they are able to realise from it.

To assess the relevance of my findings to a wider range of firms, I am currently looking for additional firms to be involved in my research. This will involve a small number of meetings, about three, not lasting more than one and a half hours each, with yourself and other personnel involved in process improvement activities. Meetings will take the form of interviews on topics related to process improvement and include a short presentation related to my research. Following completion of the interviews, I will be able to provide you with a third party perspective on operational activities in the form of a short case report. This will explicitly identify aspects of good practice as well as potential areas in which improvements can be made. Confidentiality and anonymity will be respected at all stages of the research.

I very much hope you are interested in this research and would like to be involved, please see my business card attached for contact details. I will also be emailing and telephoning you directly in the next week. Firms that have already been involved in the research have found it to be a valuable process, giving them a chance to reflect on their own business processes and gain a third party perspective of their operations.

Yours sincerely,

Rupert L. Matthews

Appendix 3.7 Confirmatory Case Interview NVivo9 Analysis

Interview Process and Theme Definitions

Within the confirmatory case interviews, while each interview were structured around a research protocol and presentation, interviews were tailored to reflect the specific interviewee and the case company. For example, if an interviewee gave greater emphasis to the benefits they may receive from the research, this was a major topic that was covered within the interview (EM3). Other interviewees were more willing to discuss process improvement practices in general, which resulted in them speaking freely about operational practices (EM5). Informed by the cross case analysis of chapters 5 and 6, Table 1 presents the definitions of each emergent theme, these are informed both by Table 6.2. The definitions from Chapter 6 were refined to account for further research into each theme and informed by associated measurement constructs identified within literature. The definitions and constructs were then informed the development of the confirmatory research protocol (Appendix 3.5).

Table 1: Emergent Themes and Definitions

Theme	Definition
Management Support	Management provides resources for organisational learning, personal development and improved organisational performance (Samson and Terziovski 1999)
Culture	Individuals perceive process improvement activities in a positive light and are willing to engage with colleagues, supplier and customers to realise improvements (Schein 1990, Terziovski 2010)
Process Improvement	Identifying issues, developing solutions within groups and with customers and suppliers, altering operational procedures and confirming the effectiveness of improvement through auditing (Chapter 5, Anand *et al.* 2009)
Benefits realised from process improvement	Products produced more cheaply, delivered more quickly, improved quality, improved profitability, securing repeat business and improved customer satisfaction (Beltran-Martin *et al.* 2008)

Following the collection of data, each recording was listened to, to identify portions of discussions that related to the above emergent themes. These portions of discussions were transcribed verbatim and coded to particular themes. When exerts related to more than one theme simultaneously, they were coded across multiple themes simultaneously. Following the assignment of portions of text to specific themes, recordings and transcripts were listened to and read through repeatedly to ensure exerts had been interpreted logically and assigned to appropriate themes.

Once the interview data was prepared, transcripts were imported into NVivo9 and formatted. As a result of the formatting of the transcriptions, it was possible to use the autocoding function of NVivo9. Following the repeated reviewing of the raw interview material, the autocoding process reduced errors that may occur during manual coding where exerts are assigned to the wrong code. The following section explores the interview data to determine the extent to which each of the emergent themes was covered within each interview.

Interview Content Assessment

Table 2 shows the results of a matrix-coding query conducted in NVivo9 between the emergent themes and the different interviews. A matrix-coding query identifies the number of exerts related to a particular node across the different interview transcripts. The variation across the interviews is a result of the variation within the interviewing process and the differing emphasis given to different topics within particular interviews. This reflects the approach to interviewing described in Chapter 3, where interview were not defined by tightly scripted interview protocols, but also the differences between the different companies. The numbers in Table 2 represent the number of codes (exerts of text) that relate to each theme within a particular interview. These have been normalised to account for the differing lengths of the interviews to assist comparison.

Table 2: Interview/Emergent theme Matrix Query Results (no. Codes)

	Management Support	Culture	Process Improvement	Benefits realised from process improvement
1 : EM3 QM	24	19	24	15
3 : EM3 PM	22	29	24	8
4 : EM4 QAM	17	12	18	14
9 : IJ3 PM	11	15	15	12
12 : SI2 TSE	22	24	20	16
Average	19	20	20	13
Standard Deviation	5	7	4	3
2 : EM3 MD	21	23	29	9
5 : EM5 MD	40	32	17	21
6 : EM6 MD	14	11	12	11
7 : IJ3 ED	36	34	24	6
8 : IJ3 CD	27	15	15	24
10 : SI2 SMD	17	14	18	13
11 : SI2 SMD	22	11	15	15
Average	25	20	19	14
Standard Deviation	9	10	6	6

The data in Table 2 have been divided into interviews with managers/engineers and interviews with directors allowing comparison between the two groups. Table 2 shows that only management support is notably different between the two groups, but this difference is not significant. This difference is logical due to directors emphasising their impact on operational processes. The highlighted areas of the table are interviews in which the number of codes was more than one standard deviation different from the mean. Apart from EM5, firms in which only one interview was conducted were within one standard deviation of the mean (EM4, EM6). The greater emphasis given by EM5 was likely to relate to the discussions focusing upon a strategic initiative the managing director had driven over the past year.

The only other interview where more than one theme highlighted was the interview with the Engineering Director (ED) at IJ3. This can be explained by the attention given to improving tooling through involvement with customers being the focus on his role, with how this impacted performance being more the responsibility of the Commercial Director (CD). Overall, each interview warrants inclusion within the confirmatory phase of the research, although due to the different nature of the interview within EM5, it will not be included within the preliminary analysis that assesses the content of each interview.

Thematic Analysis and Model Development

Chapter 5 identified management support and culture as themes that appeared to play an important role in relation to supporting or inhibiting the conversion of process improvement activities into benefits realised from process improvement. This observation was then validated by the theoretically underpinned findings of Chapter 6. This provided theoretical as well as empirical justification for potential components of the emergent themes (such as the availability of resources and perceptions of operational processes). The following section explores the extent to which themes were simultaneously coded across multiple themes. This will be carried out by first determining the total number of interview exerts that were coded across the different themes. Following this, sequential matrix queries allowed the identification of the number of exerts coded across two, three and all four themes simultaneously. Table 3 presents the number of exerts coded on particular themes (the sum of columns in Table 2) and the number of exerts coded across multiple themes.

Table 3: Number of exerts coded at multiple nodes

	Management Support	Culture	Process Improvement	Benefits realised from process improvement
Management Support	242			
Culture	140	213		
Process Improvement	210	146	242	
Benefits realised from process improvement	132	**59**	119	174
Management Support & Culture			*109*	55
Management Support & Process Improvement				<u>94</u>
Culture & Process Improvement				59
Coded on all nodes				45

Table 3 shows that across the 11 interviews, there is a considerable number of exerts that were coded across more than one theme. This provides tentative evidence that the themes are related to one another within the context of process improvement in engineering-oriented SMEs. Of the exerts coded across two nodes, the direct link between culture and performance appears to have received the least support (highlighted in bold). This result is consistent with the findings of chapter 6, where culture did not appear to be directly related to benefits realised from process improvement within engineering-oriented SMEs.

Of the exerts coded across three nodes simultaneously, , there is a higher level of support for a relationship between leadership, process improvement and benefits realised from process improvement (underlined). Consistent with findings from chapters 6, this provides evidence related to management providing support to direct process improvements in a manner that more effectively contributes to the needs of the end user. Management Support, Culture and Process Improvement also received considerable support (italic). Building upon the inconsistent evidence for the relationship between culture and process improvement presented in section 5.3, the data collected from the confirmatory case interviews will allow this relationship to be explored further.

To assess the similarities between the different themes in relation to the words within exerts, a Pearson correlation word similarity cluster analysis was conducted on the different nodes using NVivo9. This provides additional evidence related to the similarities between the different nodes and how the different nodes may be related to one another.

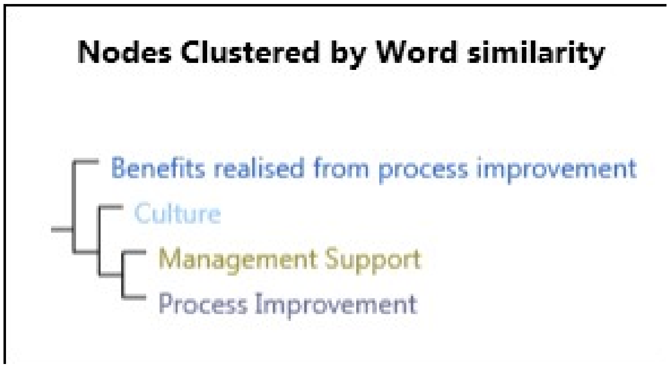


Figure 1: Nodes Cluster Analysis by word Similarity.

Table 4: Pearson Correlations of Node Work Similarity Analysis

	Management Support	Culture	Process Improvement
Culture	0.987873		
Process Improvement	0.993247	0.991506	
Benefits realised from process improvement	0.988543	**0.975885**	0.985872

Table 4 highlights how the different themes can be related to the same phenomenon, using very similar words. This analysis also shows that the discussions related to process improvement are highly similar to discussions related to culture and management support. Consistent with Table 3, this analysis also shows that culture is least similar to exerts related to benefits realised from process improvement (highlighted in bold). The analysis is also consistent with Table 3 in relation to how management support, culture and process improvement are extremely similar (>0.99). However, Table 4 shows the high level of similarity between the different nodes. As a result, from this data, it is not possible to infer that one theme is more strongly related to another; only they are highly related to one another and further qualitative exploration is necessary. Due to this method of analysis only demonstrating the presence, rather than the direction of a relationship, when exerts were coded across more than two nodes, the nature or direction of relations cannot be determine. Consequently, it was not possible to assess the relevance of specific relationships from the evidence in Table 3.

While demonstrating that within the analysis of cross-coded items, the four topics appear highly related, there is a need for more in-depth analysis. To explore the data in greater depth, the individual relationships between the themes were defined as nodes within NVivo9 allowing the level of support for specific relationships to be identified.

Figure 2 builds upon Figure 5.2, but also includes the emergent relationship between culture and benefits realised from process improvement. Figure 2 also included a second emergent connection presented in Table 3, where management support directly contributes to benefits realised from process improvement. Figure 2 presents all the connections between the emergent themes. This will provide a second perspective on how the different themes relate to one another. Figure 2 presents each connection as a proposition, which are presented in Table 5. Due to the nature of the analysis, the direction of the relationship cannot be inferred until exerts are analysed individually. Overall, this analysis process will allow the results presented in Table 3 to be assessed in relation to specific connections.

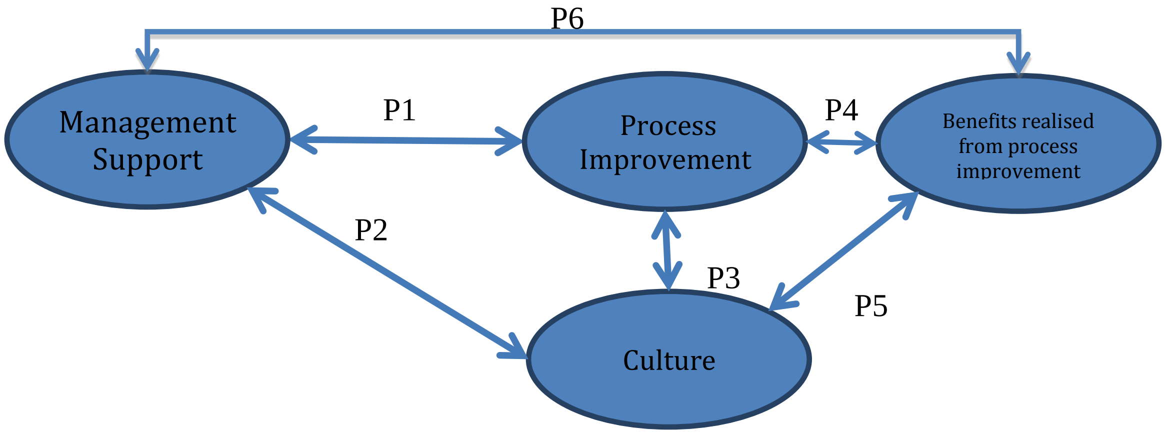


Figure 2: Developed model of process improvement

Table 5: Research propositions

P1	Management Support is related to process improvement
P2	Management Support is related to culture
P3	Culture is related to process improvement
P4	Process improvement is related to benefits realised from process improvement
P5	Culture is related to benefits realised from process improvement
P6	Management support is related to benefits realised from process improvement

The following section reports of the analysis conducted in relation to the different propositions.

Preliminary Analysis of Research Propositions

While each of the themes were covered within each of the interviews, due to the propositions being related to how specific themes relate to one another, the propositions provide a finer grained analysis framework. Recordings and interview transcripts were reanalysed using the refined coding framework of Figure 2 and Table 5. Within this process, portions of interview discussions were assigned to particular propositions and again analysed using the autocoding function of NVivo9. Although covering the same themes, the finer grained analysis meant that certain exerts were split into more than one node within the second coding. As a result, the total number of exerts related to the themes contained within Table 5 are not exactly the same as those in Table 3. To aid comparison between interviews, consistent with Table 2, the number of exerts have been normalised to account for the different length of interviews.

Table 6: Codes related to the research propositions across interviews

	P1	P2	P3	P4	P5	P6
EM3 QM	26	9	13	25	0	9
EM3 MD	22	4	24	19	2	10
EM3 PM	28	8	20	15	2	16
EM4	22	7	10	21	1	11
EM6	17	7	8	16	1	11
IJ3 ED	36	12	20	9	0	6
IJ3 CD	11	5	11	16	3	5
IJ3 PM	24	2	21	26	6	12
SI2 SMD	19	4	13	23	3	9
SI2 SMD	17	9	9	16	2	9
SI2 TSE	26	10	20	6	0	14
Total	**248**	<u>77</u>	**169**	**192**	*20*	**<u>112</u>**
Average	23	7	15	17	2	10
Standard Deviation	7	3	6	6	2	3

Consistent with Table 3, the direct relationship between culture and benefits realised from process improvement, proposition 5 (italic), received least support within the confirmatory interview. It was not covered within 3 interviews and the lowest average number of occurrences. The interviews in which it was not mentioned were those that focused attention primarily on operational processes, rather than direct interaction with clients (EM3 QM, IJ3 ED, SI2 TSE).

Broadly consistent with Chapter 5, P1, P3 and P4 received greatest attention within the interviews (highlighted in bold). The large emphasis given to these propositions provides further evidence of the role of the emergent themes within process improvement practices.

In comparison to P1, P3 and P4, P2 received considerably less attention across the interviews (underlined). This suggests that while managers involved in the research may focus attention on process improvement activities, they gave less attention and so potentially fewer resources towards developing individual's perceptions of process improvement.

A relationship that was not identified within Chapter 5 but emerged within the confirmatory interviews that received considerable support was the direct relationship between management support and benefits realised from process improvement (P6) (bold underlined). This potentially related to both the impact managerial actions could have on benefits realised from process improvement but also how managerial support may change to account for benefits realised from previously initiated process improvements.

Overall, there appears to be evidence within the confirmatory case interviews to explore each of the propositions. At this point, it should be noted that employing the qualitative analysis tool, NVivo9, should not be used as a means of substituting "*words for numbers*" (Crowley *et al.* 2002, p.193). Across the 11 interviews, the similarity of the words used and how each theme was covered within each interview shows that the data collection method was applied with some consistency. However, while providing some evidence related to different connections, this form of analysis in not appropriate for interpretivist research, as it does not explore the meanings associated with each exerts. This is consistent with an interpretivist perspective, where it is necessary to assess what the interviewees are "*trying to say*" (Stuart *et al.* 2002, p.427). To address this limitation, Chapter 7 explores how the exerts related to each proposition in order to determine the level of support is received. This process will allow each of the propositions to be tested in turn, in order to confirm, refute, refine or development the conceptual model (Figure 5.2) following the confirmatory phase of the research.