An investigation into the effect of lean new product development on learning behaviours within routines: A practice-based perspective

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Abstract

The discipline of Operations Management has made significant impacts on both Academia and Industry by individuating unique operational practices that lead to superior organisational performance. Predominantly research has assessed the impact of operational techniques at the organisational level. Micro-economic theories have then been utilised to explain how operational practices result in unique capabilities, and so derive organisational outputs. However, scholarship has identified an issue with this method of explanation. By assessing operational techniques at the organisational level, research has assumed how operational techniques operate at the micro-routine level. Furthermore, under this logic operational practices are often conceived as a 'black box', which are actioned unproblematic on a day-to-day basis within organisational routines to achieve these outputs. New research in other management disciplines have shown that organisational features present at a macro-level often have vastly different properties when viewed from a micro-routine dynamic perspective. As such, it is unclear how operational techniques work at the micro-level within routines, and the performance benefits that they engender.

To address the issue this research takes a novel approach within OM by utilising a practice-based routine perspective. This perspective analyses individual's actions in naturalistic settings, as such, it details how operations management techniques affect peoples' behaviours as they enact their work within routines. An operations management technique called lean new product development is studied within a single case setting to understand the effects it is having on individuals' learning behaviours within organisational routines. The impact lean new product development has on learning was chosen given its prominence in explaining superior performance at the organisational level within the lean literature. Critically the practice-based perspective allows learning to be operationalised via specific behaviours within the routine, and so assess the impact of lean new product development at the micro-level.

This research details a mechanism of how techniques such as lean new product development result in stimulating learning. It was shown that wider social dynamics affect how these techniques are utilised within routines. Contrary to prevailing research indicates that the performance benefits of operational techniques are subject to dynamic, complex, and often fragile social processes occurring at the micro routine level, not apparent at the macro, organisational level. As such, the research contributes to the literature as to how operational techniques can improve routine performance and result in capability formulation.

Declaration

No portion of the work referred to in the thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

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Chapter One: Introduction

Traditionally, Operations Management (OM) techniques have been assessed by their impact related to organisational objectives (Peng et al., 2008). These include multiple objectives at the business level such as speed, flexibility, cost, quality, and dependability (Boyer and Lewis, 2002; Ferdows and De Meyer, 1990; Flynn and Flynn, 2004; Noble, 1995). Furthermore, by using this method to measure impact, unique practices are generally identified as causally relevant in determining weak or strong performance outcomes (Ward et al., 1998). However, significant scholarship has questioned this aggregated measure of operational performance, which eschews what is occurring during the actual operational activity level of an organisation (Peng et al., 2008; Lewis, 2002; Lamming, 1993). They argue that operational capabilities which lead to organisational objectives are formulated from operational routines (Clark, 1996; Hayes and Pisano, 1994), which are an underutilised analytic resource within the OM literature, given this is where OM work is actually realised (Peng et al., 2008). To understand how operational capabilities are formulated, one needs to understand how OM techniques shape routines performance in which they are utilised (Peng et al,. 2008).

This research utilises practice-based routine theory (Feldman and Rafaeli, 2002; Pentland and Feldman, 2005) to determine the effect an operational technique has on a key driver of business performance, namely learning, within routines. Specifically, the research looks at how an OM technique 'lean NPD' shapes a routines' micro dynamics such that it affects the abilities of individuals to engage in reflective learning. Scholarship has argued that learning is a key capability through which lean and lean NPD result in superior organisational objectives (Morgan and Liker, 2006; Spear, 2004). These studies often appeal to macro-organisational phenomenon, such as unique OM practices, combined with positive organisational outputs as evidence of how a learning capability is generated. However, no study has been conducted from a practice-based routine perspective which demonstrates the micro-mechanisms as to how lean NPD practices results in learning within a routine, which ultimately results in capability formation. That is, no previous research has utilised the analytic resources of the practice-based perspective of routine dynamics which deconstructs organisational phenomenon into what people say and do in the presence of OM techniques as they engage in routine activity, that results in learning outcomes. This research therefore aims to investigate how the micro-mechanisms of lean NPD practices results in learning within a routine from a practice-based routine perspective. Research in other disciplines has

discovered that routines and practices which appear stable and unproblematic from a more macro perspective, have the converse properties when viewed from a micro dynamic routine perspective (Feldman, 2003; Pentland and Feldman, 2008). That is, they are dynamic, subject to a variety of social forces which affects their performance (Feldman et al., 2016). However, no such routine micro study has been conducted within the OM discipline to understand how seemingly stable macro-practices are enacted at the micro-level, and how these practices may lead to behavioural outcomes which shape operational capability formation. This research addresses this research gap, by detailing the mechanisms of how lean NPD techniques affect routine dynamics, and their behavioural outcomes within the routine. In doing so it exposes how OM work leads to new behaviours within routines, and the dynamics around such work. As such, it contributes to the literature as to how lean NPD routines can cumulatively result in a superior learning capability at a macro-level.

This research takes the perspective that lean NPD techniques *can* result in learning at the routine level. This is because organisations known for their high utilisation of operations management techniques, such as Toyota, are able to produce innovative products, which, assuming a link between learning mechanisms and product innovation (Benner, 2003), is suggestive that these techniques can foster learning. However, further evidence is required to understand *how* these techniques affect learning processes at the micro-level to formulate these capabilities. This is because it is possible that although companies which utilise lean NPD to produce innovative products, these outputs may not be based on, or related to, organisational learning processes (Salvato and Rerup, 2011). Current literature *assumes* that micro-learning is occurring which would result in innovative products derived from an innovation capability (Adler et al., 2009). Thus, evidence of a mechanism is required to provide a 'strong inference' (Guide and Ketokivi, 2015) as to how these innovative outputs and capabilities come about. Relatedly, scholarship has questioned the ability to correctly identify organisational outputs with a level of innovation. This is because the degree of innovation of a product may be based on one's perspective (Adler et al., 2009; Lamming, 1993). This is possibly indicative of the fact that products and operational objectives are problematic indicators of underlying organisational learning activities. Others have suggested that causally relating OM techniques to organisation outputs is challenging (Lewis, 2000). As such, to demonstrate that operational routines can foster learning, a mechanism needs to be proposed and tested regarding how this might occur at the routine dynamic level.

Consequently, this research proposes a novel conceptual mechanism that occurs within organisational routines, one which details how OM techniques can result in learning. New innovations within routine theory, called practice-based routine theory, are utilised (Feldman and Pentland, 2003). This theory is suitable to understand *how* activity within routines is achieved (Parmigiani and Howard-Grenville, 2011; Pentland and Feldman, 2005).

Stemming from practice-based routine theory, this research utilises a practice-based perspective as a lens for the research (Schatzki et al., 2001). This theoretical lens has had a significant impact on disciplines such as strategy (Seidl and Whittington, 2014), organisational theory (Nicolini, 2012), and learning (Gherardi, 2009b). The practice-based perspective is concerned with what people 'do', for it argues that organisational features are talked (Boden, 1994), or enacted into being (Gherardi, 2012b) on an ongoing basis. For instance, management hierarchy, organisational functions, are not enduring structures of an organisation, but determined and constituted by people's behaviours. As such, the perspective argues, in order to study organisational features, we need to study how people do things within organisations that actively constitute these features (Corradi et al., 2010; Gherardi, 2009a). Since the perspective focuses on how organisational activity is actually achieved, practice-based studies have utilised methods such as ethnomethodology (LeBaron et al., 2016; Samra-Fredericks, 2010), the analysis of interaction (Balogun et al., 2015; Dittrich et al., 2016), direct observation , and shadowing (Czarniawska, 2014) in micro-studies of behaviour (Nicolini, 2012). Drawing on previous practice-based studies, this research uses this lens to understand how lean NPD affects the ability of individuals to learn within a single case, utilising the method of ethnomethodology supplemented by the analysis of interaction and shadowing.

Lean NPD was chosen as the OM technique to study because previous research indicated that it produced innovative products, indicating possible underlying learning processes (Clark and Fujimoto, 1991; Ward et al., 1995). Significant scholarship has argued that lean and lean NPD fundamental strategic advantage is the ability of these techniques to accelerate organisational learning, and so create a learning capability (Clark et al., 1987; Spear, 2010, 2004). However, these bodies of research lack a micro-analysis of how this is achieved at the fundamental levels of capabilities; routines. Furthermore, research has shown NPD is a context where learning is abundant (McCarthy et al., 2006). Hence, by studying an OM technique in a context characterised as 'learning rich' should provide the greatest

opportunity to witness how lean NPD can result in learning behaviours, and so provide abundant data to answer the research question and propositions.

This research makes several contributions to the literature as summarised in the **addendum part B**. Firstly, it demonstrates learning occurs as a direct consequence of using lean NPD practices within a routine, and thus indicates how these techniques result in a learning capability. Secondly, it answers calls from within the OM field for methodological innovations (Singhal and Singhal, 2012a, b) by utilising ethnomethodology (Garfinkel, 2002), interaction analysis (LeBaron et al., 2016) and shadowing (Czarniawska, 2014). Thirdly, the research, uniquely for OM, brings a practice-based perspective to the subject (Corradi et al., 2010), which details the actual content of doing OM work (Jarzabkowski et al., 2016). Fourthly, utilising the unique lens of the practice-based perspective and its resulting methodology, gave rise to a distinctive understanding of lean NPD as 'cognitively shaping' organisational members' behaviour (Powell et al., 2011). Finally, insights from the study detail features of lean practices that change behaviour; this provides insights into how features of routines such as artefacts operate (D'Adderio, 2011), as well as to the mechanisms of reflective learning (Jordan, 2010). Furthermore, the research highlights practical contributions in relation to key techniques, management issues, and strategy, in lean NPDs application.

1.1 Chapter overview

The aim of this chapter is to set-up the research problem, and give an overview of the strategies that will be used to answer it. To do this there are three main sections. The first section presents research from OM which shows that lean, and lean NPD in particular, create organisational performance through achieving multiple performance objectives simultaneously (Morgan and Liker, 2006), such as cost, efficiency, quality (product and project), flexibility, and dependability (Chavez et al., 2013; Clark and Fujimoto, 1991; Hayes and Wheelwright, 1984; Hill, 1985; Rytter et al., 2007; Swink et al., 2005). Arguments are introduced which state a key driver of these organisational performance metrics is the ability of these techniques to foster learning. Next, it is argued that although the literature stresses the ability of lean NPD to derive a learning capability, there is no explanation as to how this occurs within the building blocks of capabilities; routines. At this point, the innovations from the practice-based perspective are introduced, where it is argued that this lens is particularly apposite in answering the aims of the research; that is, it provides a conceptually and

methodologically robust theory to determine how lean NPD affects individuals within routines. Finally, a short thesis overview is given.

The next section (1.1.1), gives a brief overview of lean, followed by a discussion of how OM scholars believe lean and lean NPD result in organisation performance. This is followed by evidence from research regarding the performance benefits of lean (section 1.1.2), and lean NPD (section 1.1.3).

1.1.1 Lean overview

This section shows how OM scholars seek to illustrate that the exceptional performance of a group of companies, with the exemplar being Toyota Motor Corporation, in the latter part of the twentieth century to the present day is largely based on a series of practices known as the Toyota Production System (TPS) (Monden, 2011; Ohno, 1988; Womack et al., 1990). From research funded through the Massachusetts Institute of Technology, called the 'International Motor Vehicle Program', scholars coined these practices as 'lean' (Womack et al., 1990). Significant influences on the formation of the TPS include the work of quality movement pioneers, such as Crosby (1979); Feigenbaum (1951) and Deming (1986), who focused on the cost of quality and the elimination of waste. Also influential were the international visits to Germany where a Toyota delegation saw the Focke-Wulff aircraft factory and learnt the idea of a 'takt' time to level production (Holweg, 2007). Other overseas visits influenced the formation of the TPS such as a visit to General Motors and Ford production plants (Cusumano, 1985). These plants focused on mass production techniques, which, although Toyota managers were impressed by, they simply could not utilise, due to a lack of demand, with low volumes in Japan, and financing constraints which prevented the necessary level of inventory and capital equipment (Holweg, 2007).

Furthermore, Taiichi Ohno, a highly influential founder of the TPS, argued mass production had two major issues. Firstly, it had large inventories which were costly, and secondly, it could not vary production to tailor to all customer's tastes (Ohno, 1988). That is, mass production lowered cost but sacrificed flexibility. Indeed, he characterised mass production as comprising of seven wastes: overproduction, waiting, conveyance, processing, inventory, motion, and correction (Ohno, 1988; Ohno and Kumagai, 1980). To try to compete with these mass produced cars, Toyota had to produce a vehicle at mass production prices, but with less 'waste', and lower capital equipment cost, and shorter production runs (Ohno,

1988). In response, Toyota removed all the waste they could from their production system via two main methods, known as the two pillars of the TPS (Cusumano, 1985; Ohno, 1988). Firstly, instead of holding large inventories and pushing parts through the production system irrespective of demand, Toyota would only 'pull' parts when they needed them, as demand required (Ohno, 1988). They labelled this 'Just in Time' (JIT), which was apparently conceived from seeing how a supermarket conveyer worked (Spear, 2010). To enable JIT, Toyota utilised small batch sizes, and altered equipment quickly to cope with variation. They did this with the aid of a consultant, Shingo, who introduced the concept of 'Single Minute Exchange of Dies' (SMED), such that they could alter capital equipment set-ups with minimal down time (Shingo, 1983). The second pillar of lean was called 'Jidoka' or 'autonomation'. This means that as soon as there is a quality issue, production is stopped to fix it. Defective products are not produced irrespective of a quality issue, and then fixed later in the assembly line (Ohno, 1988). Rather, those involved looking to solve the root cause of any product defect to prevent it occurring once again, and so improve the process. These 'two pillars' culminated in the main techniques which resulted in a reduction of the seven 'wastes', previously listed. These techniques culminated in a production system which was low cost, high quality, flexible, and hence appeared to achieve multiple objectives simultaneously. Fujimoto (1999) notes that the TPS did not come fully formed in a single event, but was a mixture of learning and borrowing ideas from within and across industry, as well as through personal experience. Since Ohno and the two pillars of lean, subsequent research listed more techniques that could be used to eliminate waste and, at the same time, increase end-customer value. Highly influential in this view was the work of Womack and Jones (1996). They argue that other major factors, such as the creation of end customer value, standardisation, involvement, and stability, worked in a system to produce the positive effects associated with lean practices.

Although Womack et al. (1990) describe how the TPS has been applied to all functions within Toyota, and subsequently, Womack and Jones (1996), how it can be applied 'strategically', the majority of lean research has been applied to traditional manufacturing operations (Hines et al., 2004; Jayaram et al., 2010b). Either explicitly or implicitly, OM scholars argue that a large part of Toyota's continued economic performance is based on the unique production capability, 'lean', which enables it to pursue multiple operational objectives simultaneously; these are traditionally thought of as, cost, efficiency, quality, flexibility, speed, and dependability (Chavez et al., 2013; Hayes and Wheelwright, 1984; Hill, 1985; Rytter et al., 2007; Swink et al., 2005). Utilising the same logic, the lean NPD

literature (less developed than lean applied to manufacturing (Hines et al., 2006)) implies that a part of Toyota's economic success is also based on its ability to pursue multiple operations objectives simultaneously in product development (Morgan and Liker, 2006). This in turn, scholars argue, is based on a unique set of practices, used in product development (Morgan and Liker, 2006; Womack et al., 1990). Definitions of lean NPD and NPD more generally will be given in section 1.1.3 and Chapter Two.

1.1.2 Lean and performance

Toyota Motor Corporation, the paradigmatic lean organisation, came to prominence through its ability to displace high profile industry incumbents within their established automotive markets (notably displacing Ford and General Motors in the USA) (Womack et al., 1990). As the above section describes, significant bodies of research argue that this was fundamentally based on its ability to pursue multiple objectives simultaneously (Schomberger, 1986). Toyota provided a counterpoint to the residing logic that operational performance is solely based on focusing on a single primary objective such as cost, and trading this off at the expense of other operational objectives, a manufacturing strategy known as, 'focused factories' (Skinner, 2007). Lean organisations provided products that were simultaneously more cost effective, higher quality, and more varied than focused factories (Hayes and Pisano, 1996), thus providing evidence that multiple operational objectives *could* be achieved simultaneously. Research also provided a differential to explain this ability to eschew a trade-off in performance, it resided in operational capabilities coined 'lean', which were counter intuitive to the dominant Taylorist and Fordist logics (Dosi et al., 2000). For example, Toyota seemed unconcerned with maximum asset utilisation, with its use of short manufacturing runs; furthermore, it ordered material well below the economic order quantity (Fujimoto and Shimokawa, 2009; Womack et al., 1990).

Although the link between operational practices and performance is notoriously complex (Lewis, 2000; Skinner, 1969; Swink et al., 2005), research has generated numerous studies to support this link in regard to lean manufacturing (Callen et al., 2000; Chavez et al., 2013; Fullerton et al., 2003; Ketokivi and Schroeder, 2004; Lawrence and Hottenstein, 1995; Nakamura et al., 1998; Sakakibara et al., 1997). However, throughout the lean canon there are some studies which question the ability of lean to increase organisational performance (Callen et al., 2000; Sakakibara et al., 1997). Where the link is questioned, some scholars have offered an explanation, arguing that lean and performance are contingent on external

factors which are not universal (Browning and Heath, 2009; Cua et al., 2001; Hines et al., 2004; Shah and Ward, 2003). Others (Liker and Convis, 2011; Monden, 2011; Spear, 2010), argue that the difficulty in ascertaining a link between lean and performance is due to the fact that the definition of lean is open to interpretation (Hines et al., 2004; Holweg, 2007), and adds to the complexity of making assertions (Anand et al., 2009; Chavez et al., 2013; Najafi Tavani et al., 2013). Irrespectively, throughout lean research, evidence has strongly favoured the efficacy of lean in increasing organisational performance, by lean's ability to produce functions which simultaneously achieve multiple operation strategy objectives.

1.1.3 Lean NPD and Performance

Ward et al. (1995) labels lean NPD as the second Toyota paradox (the first being found in manufacturing). This paradox is based on research showing that Toyota employed counter intuitive practices which increased NPD performance relative to their competitors. For example, Toyota was seen to create a high number of prototypes, to front load the development cycle with resources, as well as to delay design decisions until the last moment; all contrary to the methodology of competitors (Morgan and Liker, 2006; Sobek et al., 1999). Scholars argued that these practices resulted in superior NPD performance (Clark and Fujimoto, 1991; Ward et al., 1995; Womack et al., 1990). Like lean in manufacturing, there is much controversy over what lean NPD is (Baines et al., 2006; Leon and Farris, 2011). Broadly, some scholars define it as a set of tools (Hines et al., 2006), some as processes (Sobek et al., 1999), principles (Staats et al., 2011), or a combination of the three (Morgan and Liker, 2006). What constitutes lean product development will be explored in greater detail in Chapter Two.

The seminal book, *The machine that changed the world* (Womack et al., 1990) contained a chapter dedicated to Toyota's product development capabilities, which reportedly contributed to its economic performance (conceived in terms of market share, profitability, and market capitalization rate). The ability of lean NPD to increase organisational performance has also been supported by other research (Clark and Fujimoto, 1991; Morgan and Liker, 2006; Spear, 2010; Ward et al., 1995). In parallel to the arguments made in favour of lean in manufacturing, these scholars argue that economic performance is dependent on Toyota's ability to achieve multiple operations strategy objectives simultaneously within NPD. Here, authors have used the following types of metrics to determine operations strategy objectives: quality and design surveys, monetary and labour resources used in a

development project, the number of weeks a development project lasts, the number of new models launched in a specific time period, and average vehicle age (Clark and Fujimoto, 1991; Kennedy, 2013; Morgan and Liker, 2006; Ward et al., 1995). They also point to evidence that Toyota has performed favourably along all these dimensions in comparison to other automotive manufacturers, such as GM or Ford. Replicating the logic of findings from research on lean manufacturing, they state Toyota's unique development practices explain these performance outputs.

More recent scholarship on Toyota (Morgan and Liker, 2006), and developments within the industry, have shown that it is at the forefront of some of the most innovative designs within the industry. Most notably the 'Prius', the 'Lexus', and now the 'Mirai', can all be defined as radical products. Radical innovation has been defined as using technologies that are not closely related to the current firm technologies (Dosi, 1982; Green et al., 1995) or current customers' requirements (Abernathy and Clark, 1985; Christensen and Bower, 1996), and involve architectural innovations rather than components or module innovation (Henderson and Clark, 1990; Iansiti and Clark, 1994). Both the Prius, Lexus, and Mirai appear to fit this definition. For instance, for the Lexus, Toyota developed a whole new engine, combined styling and performance in a way previously thought inconceivable, targeted luxury consumers for the first time with a new dealer network, and had to develop a whole new architecture to support current and future innovations (Morgan and Liker, 2006). To date, the Lexus is one of the most successful and highest quality luxury brands. The Prius, the first ever diesel electric hybrid, clearly has technical and architectural innovation, as well as arguably creating a new market, and continues to be successful to the present day (Morgan and Liker, 2006). The Mirai is the first commercial hydrogen fuelled car. This shows that recently lean NPD has produced radical innovations, if not the most radical innovations within the automotive industry.

Although the majority of research has been conducted on Toyota, a handful of scholars have looked at lean NPD outcomes in other companies, and found mixed results. For instance, Al-Ashaab et al. (2013) states that users of a lean product development tool called 'Set Based Concurrent Engineering' increased the level of innovativeness and lowered the risk of rework in a Rolls Royce helicopter engine project. Whilst others have recorded less positive outcomes. Chen and Taylor (2012) used an interpretation of lean NPD as a set of techniques such as; design standardisation, designing to current manufacturing capabilities, and design simplification. They argued that lean NPD hindered radical innovation capability, whilst part

integration increased an organisation's radical innovation capability. Lewis (2000) defines lean in terms of techniques and principles derived from previous scholarship, based on lean in manufacturing (Schonberger, 1986; Womack et al., 1990). Inferring that these principles affect product development, he reports that lean resulted in reduced development time but low innovation; with lean atrophying skills that were more exploratory. In contrast to research done at Toyota, these scholars show that lean NPD involved a trade-off along the dimensions of efficiency and innovation. Other mixed performance outputs include Staats et al. (2011) who used a principled approach to lean NPD and argued that the use of lean increases project 'on time' and 'effort', but has no impact in terms of quality. Again, this performance output is contrasted with that of Toyota. More negative findings include Browning and Heath (2009) who argued that Lean hindered learning in situations of high novelty, increasing the resources consumed in new product introductions of the Lockheed Martin F22 Raptor. Whether these non-Toyota examples impact the notion that lean NPD results in achieving multiple performance objectives is moot. What it may indicate, much like lean in manufacturing (Holweg, 2007), is the difficulty of transporting these practices outside of Toyota. The next section looks at a key explanatory mechanism which scholars use to understand how lean results in these performance objectives.

1.2 Lean and learning

Scholars attribute the ability of lean systems to produce superior organisational processes which result in multiple organisational performance objectives based on their unique practices (Spear, 2010; Womack et al., 1990). However, within this scholarship, a key explanatory mechanism as to how this is achieved is predicated on the ability of these practices to create a learning capability, which in turn drive these organisational outcomes (Spear, 2010). Scholars have argued that organisational learning plays a key role in explaining competitive advantage, in fact, it may be the unique capability through which firms compete (Grant, 1996; Kogut and Zander, 1992; Senge, 1990). Learning, which leads to knowledge, is important since it allows an organisation to change and adapt when an organisation experiences inevitable environmental turbulence; indeed, it is its very definition; *"...organizational learning is a change in the organization that occurs as the organization acquires experience*" (Argote and Miron-Spektor, 2011:1124). Moreover, theories of learning, such as the 'SECI' model by Nonaka and Takeuchi (1995), contribute to strategic theories. For instance, strategic advantage explained through theories including

the resource based view (Barney, 1991; Wernerfelt, 1984), dynamic capabilities (Eisenhardt and Martin, 2000; Teece et al., 1997), and evolutionary theories (Nelson and Winter, 1982), rely on a theory of learning to provide an underlying mechanism as to how change occurs within their framework (c.f. Zollo and Winter (2002)). That is, theories of learning provide a key explanatory element within strategic management (Argote et al., 2003; Hayes and Pisano, 1996). The theorems explain how firm capabilities can be dynamic: for knowledge can be gained, lost, and transformed, which helps explain changes in firm performance (Argote et al., 2003).

It has been argued that lean practices accelerate learning (Spear, 2010), balance different type of learning activities (Adler et al., 2009), and enable participants to engage in unique learning experiences such as reflective or "deutero-learning" – which is the ability to "learn how to learn" (Bateson, 1972). Indeed, work by Ohno (1988) relates how he altered the production system, based on his ability to think differently about how production systems work as described in section 1.1.1. Furthermore, continuous improvement, a central theme of lean has been explained through theories of learning; "the process of improving action through better knowledge and understanding" (Fiol and Lyles, 1985, p. 803), and so, "more than anything, it is this 'dynamic learning capability' that is at the heart of the success of TPS" (Holweg, 2007). However, although learning is cited as key capability which drives performance, derived from the use of lean practices, no scholarship has conducted a micro study as to how these practices actually do in fact change behaviours. For instance, taking John Paul MacDuffie as an exemplar of a macro perspective on lean in Adler (2010:107) he states:

> *Toyota bypasses this particular dichotomy by relying on five mechanisms for continuous learning. Learning at Toyota is ubiquitous (across the entire organization and all the time), automatic (occurring without direct management intervention), iterative (following a disciplined movement between phases of standardization and experimentation), gap-driven (where the gap is defined by the space between the ''current situation'' and the ''ideal state''); and framed around ''problems as opportunities'' (stimulating positive cognitive biases and legitimizing difficulties and failures as valid inputs to the learning process).*

Although the above quote makes an important contribution to research, what is missing is how these processes work in people's daily activity as they utilise lean practices to produce these learning outcomes. If competitive advantage is realised in OM by performing similar routines to the competition more efficiently and effectively (Clark, 1996; Hayes and Pisano,

1996), then how do lean systems actually do this from a routines perspective in relation to learning? However, to understand this, lean NPD must be incorporated into routine theory, to show how lean NPD affects learning within routines (Guide and Ketokivi, 2015). As Peng et al. (2008) note, the OM literature often neglects the routine perspective, which makes it unclear how performance and capabilities related to OM techniques are generated. As such, the strategy for this research is to propose a mechanism within routines, which can explain how lean NPD results in learning. This can then be tested. However, before this is done, recent conceptual and methodological innovations occurring within the routine literature and in the business management discipline generally need to be considered. These innovations will shed light on how routines work and offer insights into new methods of capturing how people behave within routines. As such, they provide a better position from which to understand how lean NPD affects learning.

1.3 The need for a practice-based view of routines

The notion of routines has recently received increasing popularity amongst academic circles (Parmigiani and Howard-Grenville, 2011). Routines have traditionally been defined as a *"consistent, learned stable body of activity"* (Nelson and Winter, 1982:14) and are generally thought to be the most basic building block of organisations (Cyert and March, 1963). Routines have a heterogeneous conceptual heritage with the first mention by Stene (1940) that routines were important in organisations for coordination and were identified by their non-deliberative action. The Carnegie school (Cyert and March, 1963) subsequently utilised the conception of routines. Much like Stene's (1940) conception, organisational routines represented conditioned forms of action that required little cognitive input, thus they acted as time and attention saving devices, based on habit (Cyert and March, 1963; March and Simon, 1958). The seminal work of Nelson and Winter (1982) on evolutionary economics utilised the conception of routines as a key explanatory device of how organisations adapt. They developed the conception of routines where individual skill was a metaphor for how routines functioned; that is, routines were related to knowledge of how to do things and make choices, and where innovation was based on new combinations of whole, or parts of routines.

Whilst the work of Nelson and Winter (1982) remains ambivalent to the level of intentionality and thus cognitive input in carrying out routines, scholars with this view of routines have tended to emphasise that, much like the Carnegie conception, routines reduce cognitive input from participants, and thus sacrifice learning for the increased efficiency of

carrying out routines; which results in increased stability and variance reduction (Adler et al., 2009; March, 1991). Activities based on routines may only equate to experiential or incremental learning patterns; or, indeed, routines may be thought of as a consequence of these stable learning patterns (Argote, 1999; Gilbert, 2005). Through this lens, routines can be seen as analogous to heuristics or standar operating procedures (Feldman and Pentland, 2003). Some authors have argued that the use of the word 'routine' has automatically led scholars to reify them into objects which have associations with inertia (Feldman and Pentland, 2003). Parmigiani and Howard-Grenville (2011) called the above descriptions of routines, the 'economic', or 'capabilities' view of routines. They identified three major themes running through this 'capability view'. These were: routines as genes that induce inertia, (Aime et al., 2010; Gilbert, 2005; Knott, 2003), routines as the micro-foundations of capabilities (Abell et al., 2008; Teece, 2007; Zollo and Winter, 2002), and routines as stores of knowledge (Gavetti and Levinthal, 2000; Huber, 1991; March, 1988; Zollo and Winter, 2002). Consequently, these views often presented routines as black boxes and as entities, and were predominately interested in explaining why they led to organisational performance.

Within routine theory that has been what D'Adderio (2011) describes as a 'Copernican' revolution as to the nature of routines. Feldman and Pentland's (2003) seminal article reoriented the routines literature from organisation economics to organisational theories, most notably a 'practice-based perspective'. This 'practice-based' conception is more interested in… "*how they operate and how they are reproduced or changed as people enact them*" (Parmigiani and Howard-Grenville, 2011:414). By doing so this conception showed that routines could be flexible, adaptive and highly intentional. This view opened up the 'black box' of routines, and began to outline a theory of 'how' routines actually functioned. Which included showing that routines have different aspects that allowed them to be both flexible and sustained. In brief, there is an ostensive part, which is considered to be the name of the routine or its abstract codified form (Cohen and Bacdayan, 1994) and a performative aspect, which is the actual performance of the routines, what people do when going through the routine in real time (Pentland and Feldman, 2008). These authors argue that routines are affected by the internal dynamics of artefacts (objects within routines), people's agency, and how the routine is embedded in organisational understanding. The overall differences between the two views are presented in **Table 1.3**.

Table 1.3: table showing the differences between the capabilities and practice perspective of routines, taken from Parmigiani and Howard-Grenville (2011:418).

	Capabilities Perspective	Practice Perspective
Main interests	What routines do (coordinate, create, change) and how they lead to firm performance	How routines operate; internal dynamics
Focal level of analysis	Firms (the firm is the structure for governing, collecting, creating and maintaining routines)	Routine itself
Unit of analysis	Routines as "entities" (whole routines, "black boxes")	Routines as "parts" (internal structure of routine, what's inside the "black box")
Empirical attention to	Firm-specificity of routines How they create value and thus lead to differential performance How they build to form capabilities Complementarities between routines Transferability within and between firms (tacitness and stickiness)	Actors' influence on routine performance Artifacts' influence on routine performance How routines change and remain stable over time; role of agency and artifacts in this How routines are created or changed When and how routines break down
Behavioral assumptions	Bounded rationality Organization-specific foresight Potential self-interest Agents act as expected	Human action is "effortful" (not mindless) Human agency/everyday activity constitutes social life Agents are not replaceable; have different intentions, motivations, and understandings
Analogies	Genes Repository of memory Microfoundations of capabilities	Grammars Repertoires Generative systems
Stability and change	Acknowledge that routines can change, but more interested in stability Routines provide for stability or change	Change and stability always possible Same mechanisms (agency, artifacts) underlie change or stability

Parmigiani and Howard-Grenville (2011) state that these two views of routines are not diametrically opposite, but instead have different conceptual tools to solve different problems concerned with routines. Given that this research is concerned with how lean NPD affects the way people behave and learn within routines, it appears that a practice-based view of routines is better suited in achieving these aims. Thus, if lean NPD is going to be combined with routine theory, the practice-based view of routines is one better suited to understanding the problem. As such, in postulating a framework for how lean NPD results in learning within routines, it needs to adhere to a practice-based routine requirement. Such a conception

of routines needs to be utilised which incorporates the features of routine dynamics found within this literature. This literature takes into consideration endogenous factors that occur within routines, which *interactively* constitute the routine's micro-dynamics, and so, *how* the routines works (Pentland and Feldman, 2005). This analytic perspective provides ways of understanding macro organisational phenomenon by breaking them down into what people say and do, as well as what materials they use (Feldman et al., 2016). For instance, people may use materials such as whiteboards, or pieces of paper within the routine which under this analytic is labelled an 'artefact' (Howard-grenville et al., 2014). While how people behave in the routine has been labelled 'agency', of which they are 'actors' (Feldman et al., 2016). If lean NPD practices are present within the routine, then they must embody a factor which constitutes the routine, and so influence how the routine is performed.

1.3.1 Practice-based methodologies

Recent scholarship in other management disciplines has utilised the practice-based approach to analyse performance. Such an approach takes the view that organisations exist through practices, and that practices constitute enduring features of the organisation. Thus, organisations are talked, or enacted, into being. Examining what people do or say as they go about their activity has produced very different results of what organisations are like as things are done, compared to what people assume is the case, or say is occurring within the organisation. For instance, the strategy as practice-based view provides evidence that doing strategy may not be like some rational plan that involves intellectual thinking and then a practical implementation (Jarzabkowski and Kaplan, 2015). In some studies, less than fifteen minutes of each day was spent by a senior strategy analyst doing 'strategy', the majority of the time was spent in conversations within the organisation (Mintzberg, 1973; Whittington, 2003).

Practice-based perspectives have led to important insights across various topics including, strategy (Jarzabkowski, 2004; Seidl and Whittington, 2014; Whittington, 2006), learning (Brown and Duguid, 1991a; Gherardi, 2000, 2009; Tsoukas, 1996; Wenger, 1998), technology (Orlikowski and Scott, 2008; Suchman, 1987), workplace studies (Atkinson and Drew, 1979; Garfinkel, 1967; Heath and Luff, 2000; Hindmarsh and Pilnick, 2007; Llewellyn and Hindmarsh, 2013) and routines (Feldman and Pentland, 2003; Jarzabkowski et al., 2012; Pentland and Feldman, 2007). A practice-based approach is apposite for this research because it provides a methodologically and philosophically sound theory in which

performances can be analysed within routines in response to lean NPD. Thus, it can be robustly determined if learning is occurring. The approach used to analyse practice for this study employed methods including the analysis of interaction, shadowing, direct observation and ethnomethodology. Given the impact that this approach has had in other business management disciplines, and the opportunity it provides in answering this research problem, a practice-based perspective will be assumed, with the corresponding methodological basis throughout this research.

Notably there are no practice-based studies conducted within this area which focus on OM, however, one could argue that studies such as those by MacDuffie (1997); Von Hippel (1994) and Von Hippel and Tyre (1995) are prototypical practice-based studies in their level of detail, and in their methodology of capturing the performative aspects of work. This said, since OM is concerned with changing the everyday activity of organisations to make them more efficient, and practice-based studies provide an alternative perspective to what everyday activity consists of, it would seem that OM could only benefit from a practice-based perspective analytic.

Moreover, some research suggests that actors engage in ex post rationalisations and sense making (Weick, 2012). As such, if a retrospective methodology was employed, these activities, such as post rationalisations, may obscure the actual details of what happened. This echoes recent concerns from organisational theory scholars that traditional methodologies are somehow deficient, "…*our explanation would look like a "post-mortem dissection" (James 1909/1996, p. 262); it would not be fine-grained enough to show how change was actually accomplished on the ground—how plans were translated into action and, by so doing, how they got modified, adapted, and changed*" (Tsoukas and Chia, 2002:568). Focusing on more micro level processes would enable learning to be measured in direct relation to an actor's actions and avoid the issues of scepticism relating knowledge and innovation type described above. This addresses concerns expressed by Adler et al. (2009) of conducting macro level studies on the topic of knowledge and change. Hence, to determine if lean NPD techniques are affecting peoples' performance, it appears that we need a method to examine performances 'directly', in real time, and in situ. Using such an approach with associate methodologies also answers calls from within OM for more innovative methodologies (Singhal and Singhal, 2012).

1.4 The research questions

The introduction has substantiated a gap in OM research which this research seeks to address. That is, OM research has utilised organisational objectives as evidence to access operational capabilities. However, there is significant research which questions the use of organisational outputs as a measure of OM practices. Furthermore, accepting capabilities are constructed from routines, and that OM practices are utilised to execute routines more efficient and affectively, then the context of routines is an apposite setting to study the effect of OM practices, since it should explain how OM capabilities arise. Moreover, the context of routines has been neglected within OM research (Peng et al., 2009). Innovations within routine theory which utilise a practice-based perspective have shown how practices which appear stable at a macro organisational level, often have converse properties at the micro-level. Such a perspective is utilised to reveal the micro mechanisms of how organisational processes occur (Jarzabkowski and Spee, 2009). Hence, to understand how OM techniques result in capabilities, a micro-level analysis of how they affect routines dynamics will be conducted. Given the importance learning plays in the strategic and OM literatures in achieving organisational outputs via practices, this relationship will be investigated through a focussed case study. Lastly, lean NPD is the OM technique which has been chosen to study since such a technique operates in a context characterised as 'learning rich'. This should provide the greatest opportunity to witness how lean NPD can result in learning behaviours, and so provide abundant data to answer the research question and propositions.

To determine how lean NPD results in learning outcomes within routines a testable framework will be established. The testable framework needs to be based on the analytic of a practice-based routine perspective, such that lean NPD practices have to be understood as to how they are constituted by routine theory in order to reveal their micro mechanics. Furthermore, a measure of learning needs to be determined at the routine dynamic level so that it can be identified if learning is a consequence of lean NPD interacting with these routine dynamics. Hence, the framework requires the resulting two features which will be argued for in chapter three:

1. A measure of learning at the micro-level
2. A practice-based routine requirement

Given the framework the following research question and propositions are generated:

Research Question (RQ)1: Does the interaction between lean New Product Development (NPD) practices and people within organisational routines lead to reflective learning behaviours?

Research Proposition (RP) 1: *Interaction with lean actors increases the 'willingness' of people to engage in reflective behaviours within routines.*

RP 2: *Interaction with lean artefacts increase the 'capability' of people to engage in reflective behaviours within routines*.

RP 3: *Interaction with lean artefacts combined with lean actors increases the 'willingness' and 'capability' of people to engage in reflective behaviours within routines.*

1.4.1 Thesis structure

These insights from the literature regarding how a testable framework should be constructed, result in the following overall thesis structure:

Chapter two: Before the framework can be constructed a full understanding of lean NPD needs to be garnered. This understanding is needed so that lean NPD can be cogently synthesised into the practice-based routine theory, and, as such, a testable framework. Furthermore, insights need to be sought regarding what characterises lean NPD can be used for, and for understanding through what mechanisms it results in NPD performance. These can then be incorporated into the framework. To do this, a systematic meta-synthesis literature will be used. This is the first time this method has been used in a literature review for lean NPD.

Chapter three: The purpose of chapter three is to use routine theory, as well as theories of learning, combined with insights from the literature review, to create a testable framework for a possible mechanism as to how lean NPD could result in reflective learning. As per the insights above, the framework needs to incorporate the two requirements of:

1. A measure of learning at the micro-level
2. A practice-based routine requirement

Chapter four: A case study methodology is used to study behaviour within routines. Taking inspiration from practice-based studies, uniquely for OM, ethnomethodology is used to study practice which is augmented with the analysis of interaction, direct observation and shadowing. This allows behaviour to be studied as a direct consequence of interaction with lean NPD techniques within routines.

Chapter five: In this chapter a Gioa analysis is performed on each routine type recorded in the case (Gioia et al., 2013). This results in three descriptive analytics of behaviour occurring within each routine, some of which are occurring as a direct consequence of interaction with lean NPD. This behaviour is then analysed theoretically to determine if it can be characterised as reflective learning.

Chapter six: Within this chapter all the routines are considered holistically to determine if emergent meanings are derived from this analysis. Moreover, such a technique details the exact interactional context in which lean NPD results in specific behaviours. This gives answers to the framework, ultimately detailing that lean NPD can produce reflective behaviours as a consequence of people interacting with it within routines.

Chapter seven: Finally, chapter seven concludes the research, highlighting its contributions, limitations, and a path for future work.

1.4.2 Conclusion

Given the evidence from the organisational outputs which are attributed to lean NPD, the position of this research is that lean NPD *can* result in learning. However, the mechanisms regarding how lean NPD achieves this at the routine dynamic level are not well understood. In particular, there is no evidence of how they affect people within routines as they use lean NPD techniques. As such, it is argued that a framework needs to be proposed that details the mechanism of how lean NPD affects learning, which can then be tested. This needs to utilise innovations from within the Business Management discipline; specifically, it was argued,

that a practice-based perspective provided the correct lens through which to study the problem, and as such will be adopted by this research.

The next section conducts a metasynthesis literature review on lean NPD so that the framework can be informed by the most cogent understanding of lean NPD.

Chapter Two: Metasynthesis literature review

Chapter overview

This chapter uses historical data contained within the literature to ascertain if there is a coherent phenomenon called lean NPD. It can be interpreted into Routine theory in chapter three. Descriptions of lean NPD from within the literature will be used to inform the framework regarding how lean NPD might result in reflective learning within routines. To do this a literature review methodology is employed. This chapter is constructed as follows. The first section of this chapter argues for a type of literature review methodology known as a *metasynthesis*, which is derived from a systematic literature review. The second section describes the methodology and the steps taken in the thesis. The third section presents the results of the *metasynthesis*, and the final section discusses these results in light of the chapter's aims.

2.1 Choice of Literature review methodology – metasynthesis

Literature review methodologies usually take the form of a background review where a topic is introduced, gaps are highlighted, and relevant literature streams proffered that may be brought to bear on the research gap in preparation for the primary research (Doyle, 2003). Sandelowski and Barroso (2007) argue that these reviews are generally not utilised as a line of scientific investigation in themselves, but provide the grounding for one. This usually consists of performing a narrative discussion, where topics are brought together, however, Sandelowski and Barroso (2007) state the analysis is rather limited. While a background methodology literature review is appropriate for some research questions it does attract some general criticisms. For example, it involves biases such as focusing on work that has been published in widely accessibly outlets (Petticrew and Roberts, 2008), and often only seeks literature which has a confirmatory role to the researcher's views (Chan et al., 2004). Since there are no explicit and comprehensive search procedures in such a review, scholars can inadvertently present a partial history of the phenomenon, negatively affecting the scope and depth of their investigation (Dixon-Woods et al., 2004).

A type of review labelled a systematic review reduces the bias inherent in literature selection, screening, analysis, and synthesis of the results. This is achieved by providing a transparent,

objective, replicable, and all-inclusive method (Saini and Shlonsky, 2012). The systematic review originally was a tool developed within the medical sciences to bring together large amounts of disparate studies on a single phenomenon into a format that practitioners could use as part of evidence based practice (Dixon-Woods et al., 2004). As such it traditionally involved bringing together results of experiments into a statistical model.

While this approach is relatively straight forward for quantitative studies within the hard sciences, for qualitative studies this methodology has a number of drawbacks (Dixon-Woods et al., 2004). The main drawback is that epistemological and ontological perspectives each individual researcher brings to their study can entail different methods and research designs. Hence, researchers exhibit their own preferences about what data reveals about social reality, and so what counts as 'good' research (Noblit and Hare, 1988). A form of systematic literature review called qualitative synthesis recognises these drawbacks and has developed a methodology to try and alleviate them (Denyer and Tranfield, 2006; Major and Savin-Baden, 2010; Saini and Shlonsky, 2012). In these studies, evidence is not simply aggregated and combined as in meta-analysis reviews. Instead, qualitative synthesis involves an interpretation of the original primary data so that it is synthesized to form new conceptions of the phenomenon under study (Noblit and Hare, 1988). Unlike meta-analysis this process is not simply an aggregation and then an analysis of data, it involves an active, synthesising component.

In understanding the lean NPD phenomenon this chapter's research aims are to abstract descriptions of lean NPD from the literature to develop a definition, it will necessarily involve, almost exclusively, scholars and practitioners experience of lean NPD, and so, qualitative data. Accepting that qualitative synthesis offers the advantages of the systematic review and addresses concerns of using qualitative data with this method, this genre was used. Within the genre a *metasynthesis* method was chosen because this type of qualitative synthesis is suited to the chapter's research aim, in that such a methodology can form a holistic understanding of the lean NPD phenomenon. This can be interpreted into Routine theory, and shed light on the nature of lean NPD.

In choosing a metasynthesis, the research aligns itself to certain epistemological positions; this is because the method involves looking beyond the text, reading between the lines, and constructing new meanings which are generally associated with more post-modern positions (Sandelowski and Barroso, 2007). The epistemological position of this thesis will be

explored in chapter four. Here it is sufficient to say that the thesis is sympathetic to post-modern concerns and the socio-historical context an important factor in the production of knowledge (Foucault, 1972). On the other hand metasynthesis is still conducted within the envelope of evidence based practice (Denyer and Tranfield, 2006). Indeed, Saini and Shlonsky (2012) states that it is epistemologically neutral. Hence, any inference that goes beyond the immediate text in order to penetrate the findings of a particular author will be grounded in empirical findings. The appropriateness of this position was confirmed during this metasynthesis review, where, by looking at evidence surrounding the production of research in the lean NPD literature, cogent environmental explanations of the interpretations scholars utilised within their research were discovered.

2.2 The metasynthesis methodology

There are a number of possible descriptions in the literature of a qualitative synthesis and so metasynthesis (Major and Savin-Baden, 2011). Given that there is no general consensus the method was based on a combination of the methodology described in Saini and Shlonsky (2012) and the work of Sandelowski and Barroso (2007). This was due to their clarity of exposition, the contemporary nature of their work, and the consistency of their description. Generally the process follows that of Saini and Shlonsky (2012) , however for the actual metasynthesis stage greater emphasis is put on the work of Sandelowski and Barroso (2007) because these authors provide a high degree of practical detail whereas for this crucial stage Saini and Shlonsky (2012) provide relatively little. The overall method provided by Saini and Shlonsky (2012) include the following steps: 1) determine the research question, 2) determine breadth and scope of the review, 3) complete information retrieval searches for potential studies, 4) screen based on the substantive focus of the question, 5) classify by study type, 6) complete separate second screen for each study type, 7) complete separate extraction for each study type, 8) complete separate quality assessment for each study type, 9) complete separate synthesis for each study type, 10) assess the potential for integration across synthesis and synthesizing where possible, and 11) dissemination of results. Their process description is geared toward the integration of quantitative and qualitative data. However, after a pre-review reading of the literature, only qualitative data is being used to answer this chapter's aim, so this process has been adapted to five steps as Saini and Shlonsky (2012) recommend in their book. These were: determining the research aim, determining the breadth and scope of the review, information retrieval, screening, and then complete extraction. A short overview of each step will now be given:

1) Determining the research aim

This step requires little discussion, chapter one argued for lean NPD to be interpreted into Routine theory so that a testable framework could be established, one that reveals the mechanism of how lean NPD affects learning behaviours within routines.

2) Determining the Breadth and Scope of the review

The time frame of the literature review includes 1986 – 2016 since initial scoping showed literature connecting lean organisations with innovation in early studies (Imai, 1986). The breadth of the study was also increased to include not only peered reviewed data bases, but also grey literature (defined below), as per a qualitative synthesis methodology (Saini and Shlonsky, 2012), as well as future recommendations from the previous systematic reviews (Leon and Farris, 2011).

3) Completing information retrieval searches for potential studies.

The search strategy for the literature review followed a two part process, the first was based on the search strategies of Leon and Farris (2011), which in turn was based on Baines et al. (2006), with the caveat that this research involved a larger timeline, 1986 - 2016. Four databases were searched: Engineering Village (Compendex), EBSCO (Inspec), Emerald, and ProQuest (ABI/INFORM), using a key word search of twelve search strings of source text data. As Baines et al. (2006: 1541) state, these databases provide a wide range of journals and a far ranging search, journals included; *Journal of Product Innovation, Journal of Construction Engineering and Management, Journal of Operations management, and Proceedings of the Institution of Mechanical Engineers*.

The second part of the literature review differed in search strategy from the previous reviews in that a grey literature search was conducted. Grey literature is defined as literature that is hard to find using standard search strategies (i.e. electronic databases), and is often non-peer reviewed work aimed at practitioners or policy makers; multiple media types were also included in this search (Saini and Shlonsky, 2012).

4) Screening based on the substantive focus of the question

In accordance Saini and Shlonsky (2012) this review includes three levels of screening, an initial screening, a strict screening, and screening at data extraction. These screening levels moved from the use of a coarse quick level of at the initial stage, to a more refined and

extensive look at the literature at the final stage. The key to an inclusion criteria was that research only included primary research, and on paradigmatic lean organisations.

5) Completing extraction

Of the remaining screened books, media, articles and dissertations were read and watched, and an initial written report on each source (see **appendix A table 8.1**) (Sandelowski and Barroso, 2007). The initial report was relatively general and included type of source, publication date, setting, research questions, theoretical orientation, sampling size and procedures, method of data collection and analysis, and major findings (Saini and Shlonsky, 2012). Here the last level of screening took place. Research was excluded where it was found that some research was just reinterpretations of more original research, even though it was presented as primary. For instance, Morgan and Liker (2006) which initially appeared a key text, was excluded because it was largely based on the research of Morgan (2002), Itazaki (1999), and Liker (2004).

This resulted in the following sources of **table 2.1**. (see **Appendix A table 8.1** for full analysis of these sources)

Table 2.1: The key sources in chronological order of publish date

Author, Title, Source
Imai, M. (1986). "The key to Japan's competitive success." McGraw-Hill/Irwin.
Graves, A. (1987). Comparative trends in automotive research and development, International Motor Vehicle Program.
Womack, J., Jones, D., Roos, D (1990). The Machine That Changed the World. New York, Rawlinson Associates.
Clark, K. B. and T. Fujimoto (1991). Product development performance: Strategy, organization, and management in the world auto industry, Harvard Business Press.
Lamming, R. (1993). Beyond partnership: strategies for innovation and lean supply. New York, Prentice Hall.
Whitney, D. E. (1993). "Nippondenso Co. Ltd: A case study of strategic product design." Research in Engineering Design 5(1): 1-20.
Cusumano, M. A. (1994). "The Limits of Lean"." Sloan Management Review 35: 27-27.
Kamath, R. R. and J. K. Liker (1994). "A second look at Japanese product development." Harvard Business Review 72: 154-154.
Ward, A., et al. (1995). "The second Toyota paradox: How delaying decisions can make better cars faster." Sloan Management Review 36: 43-43.
Sobek, D. K. (1997). "Principles that shape product development systems: A Toyota-Chrysler comparison." PhD thesis
Cusumano, M. A. and K. Neboeka (1998). Thinking Beyond Lean: How Multi Project Management is Transforming Product Development at Toyota and O, Free Press.
Muffatto, M. (1998). "Reorganizing for product development: Evidence from Japanese automobile firms." International Journal of Production Economics 56: 483-493.
Sobek, D. K., et al. (1999). "Toyota's principles of set-based concurrent engineering." Sloan Management Review 40(2): 67-84.
Itazaki, H. (1999). The Prius that shook the world, Nikkan Kogyo Shimbun Limited.
Thomke, S. and T. Fujimoto (2000). "The Effect of "Front-Loading" Problem-Solving on Product Development Performance." Journal of Product Innovation Management 17(2): 128-142.
Morgan, J. M. (2002). High performance product development: a systems approach to a lean product development process, University of Michigan. PhD Dissertation.
Liker, J. K. (2004). The Toyota Way. New York, McGraw-Hill. Chapter 5.
Mehri, D. (2006). "The darker side of lean: an insider's perspective on the realities of the Toyota production system." The Academy of Management Perspectives 20(2): 21-42.
Horikiri, T., et al. (2009). Oobeya – Next Generation of Fast in Product Development QV Systems MIT Sloane.
Tanaka, T. (2011). Learning from Toyota's Management System. L. S. 2011.

What follows is an analysis of each sources interpretative lens. The function of **Table 2.1**, and the following analysis is to make the reader aware of the basis and possible influences

on each source, and so let the reader critically engage with the text during the following metasynthesis results, and discussion. This lets readers judge for themselves the weighting of the different sources. An analysis of the interpretative lenses of the lean NPD field shows three major themes within the chosen literature. The first theme mentioned by Clark and Fujimoto (1991); Lamming (1993); Whitney (1993); Womack et al. (1990) and Graves (1987) focused on the ability of lean NPD to give the benefits of both mass and craft, that is to give high variety low volume products at low cost with short lifecycles. Here it is argued that lean NPD creates novel low cost products through a holistic synchronisation with other organisational departments, such as manufacturing and the supply base. However, these themes appear to lose prominence after 1993. A potential explanation is that the theme expressed a strategy that was in place during the time of the research, but has since declined. Indeed, the work of Muffatto (1998) and Cusumano (1994) describes how lean organisations changed their development strategies to one of simplification due to part proliferation and overwhelming complexity caused by the high variety strategy of the preceding years.

The second theme is present in the work of Sobek (1997); Sobek et al. (1999); Ward et al. (1995). They argue that lean NPD is a way of exploring design space to reduce rework and so NPD cost and time. In their work, integrating NPD with other aspects of the organisation become less prominent. The concept of producing a novel product concept too becomes less of a research focus, and as will be discussed subsequently, this group of scholars focus on a particular practice called ‘Set Based Concurrent Engineering’ (SBCE). These works are explicitly influenced by the preceding research of Ward and Seering (1993), in which theoretical simulations predicted SBCE to be the most efficient NPD practice. Utilising a predominantly deductive, or a prior method , they found what they thought to be the physical manifestation of the work of Ward and Seering (1993) at Toyota. However, this thesis will argue in the following results section that these findings are unlikely to be novel, or frame essential practices to lean NPD.

With the publication of Morgan (2002) another explanatory theme comes to the fore. That is, lean NPD can be explained through Lean tools used in manufacturing and by using lean concepts of value and waste. This is a step change in interpretation that the author explicitly states is an interpretive framework for his research. While previous scholars have discussed aspects of lean manufacturing in NPD, like JIT, they have been ambivalent at best regarding the efficacy in the application of these concepts (Clark and Fujimoto, 1991; Sobek, 1997). Furthermore, from the key sources no subsequent work uses the lean manufacturing

paradigm to explain lean NPD. Indeed, Horikiri et al. (2009) explicitly states that it is not applicable in NPD. The work of Morgan (2002) appears to be highly influenced by an understanding of lean as a concept that can be universally applied across the organisation, as portrayed in work such as Womack and Jones (1996) and Liker (2004)[1]. Interestingly, Morgan (2002) goes beyond using the lean manufacturing paradigm as an interpretative lens and engages in action research to test a tool called 'Value Stream Mapping' in the NPD process; this is concerned with removing any wasteful activities. The reason why this individual work is chosen as a theme in itself is because the idea of transferring lean tools from manufacturing into NPD has had such a large influence on the wider lean NPD literature, and tools such as Value Stream Mapping in NPD have become part of the wider discourse. However, it should be noted that, out of this thesis' sources, such work represents more of an outlier in lean NPD interpretation.

Lastly, with the lean NPD literature there is a theme of the efficacy of lean NPD based on its ability to effectively and efficiently solve problems, with the assumption that NPD represents a design problem writ large, based on numerous smaller design problems. While this theme is present across all the literature, and even within the themes discussed above, it comes to prominence in the work of Thomke and Fujimoto (2000). Moreover, such an interpretation has no contrasting examples within the key sources. With the reader now fully aware of the subtext and historical influences of the various sources within the metasynthesis, the next step is to perform a 'targeted comparison' along the taxonomic categories, which comprise the results section.

2.3 Metasynthesis results

Below the results for each category are shown. Stated by the target comparison methodology the results are displayed under 'common themes', 'contradictions', and 'absences' of the category within the literature. This is followed by a discussion for each category, and represents the synthesis part of the metasynthesis. Once this is shown for each category, an overall synthesis for every category is performed in order to answer the research questions.

[1] Clearly Liker (2004) is after the publication of Morgan (2002). However, given that Professor Jeffry Liker was his supervisor and they are published relatively simultaneously, it can be stipulated that his thoughts would have had a bearing in the development of Morgan's ideas. Further, in their future co-authored works there is explicit reference to this link c.f. Liker, J.K., Morgan, J.M., 2006. The Toyota Way in Services: The Case of Lean Product Development. The Academy of Management Perspectives 20 (2), 5-20

General category

1. The identity of lean NPD companies

Common themes: All sources in the literature review referred implicitly or explicitly to a company as an exemplar, the majority of these references were made to just Toyota (ten out of the twenty sources). Nine referred to lean Japanese automotive manufactures, of which Toyota was inclusive; of that eight, different companies were used as lean exemplars, for instance, Honda, Mazda and Nissan. The one source that used an automotive supplier was a case based on Nippon Denso.

Contradictions: Interestingly the group of Michigan-based authors (Ward et al., 1995) explicitly state that in their research only certain practices were encountered at Toyota and not in Mazda or Nissan. This research was looking for a particular practice which they labelled Set Based Concurrent Engineering (SBCE); this practice will be explained and analysed later in this section.

Absences: None

Discussion: The discussion revolves around whether the title of 'lean NPD exemplars' depends on whether SBCE is considered essential to lean NPD, as some authors have argued (Khan et al., 2011; Ward, 2007). In the section on SBCE it will be argued that the literature indicates that SBCE is in fact non-essential to lean NPD. Moreover, accepting the seminal works from Womack et al. (1990) and Clark and Fujimoto (1991) would suggest that there is a group of Japanese companies with extremely high product development performance and unique practices called 'lean', and not just Toyota.

Physical assets, materials and technology

2. Common parts strategy (utilising common parts across multiple product types)

Common themes: Although most of the literature displayed contradictions as to whether companies utilised common parts, there were clusters of research that offered a similar explanation of what lean is, and so described similar common part strategies: For instance, the earlier work by Clark and Fujimoto (1991), and that of Lamming (1993) argue for a low number of common parts, this is connected to their explanation of lean that it provides the benefits of both mass production and craft production, hence new parts at low cost.

Contradictions: The literature is divided on how lean NPD uses common parts in their development projects. As stated, the earlier work by Clark and Fujimoto (1991) and by

Lamming (1993) clearly shows that lean NPD creates new parts. Indeed, this is related to these works understanding of lean, that it is designed to produce high variety items in small batches, at low cost. These authors stress that the newness of parts is not just superficial, there is genuine novelty in parts so that customers are not confused. Whitney (1993) states that Nippon Denso utilised standard interfaces in a modular product to match the requirements of Toyota's high variety strategy. Here Nippon Denso used the modular interfaces in a postponement strategy to meet Toyota's demand. This postponement strategy was linked to a product innovation strategy, whereby Nippon Denso ensured standard products exceeded customer requirements for long time horizons (10 years). As such, they could utilise a highly automated manufacturing base to maintain low cost. Clearly this contrasts with the automotive manufacturers' manufacturing strategy, but its effects, of high variety, low volume, are identical. This view of unique parts for lean companies (bar Nippon Denso) goes largely unchallenged until research in 1995, (although Kamath and Liker (1994) refer to using standard parts for routine items, such as bolts). The major change comes with the work of Ward et al. (1995), who state that lean NPD development teams try to keep subsystems and components the same as new product models are developed, in clear contradiction to earlier research. This view is then modified by work that builds on this publication. Sobek (1997) states that for items that require long development times, such as engines and transmission, standard parts are utilised. However, for parts with lower development times Sobek (1997) states that they utilise modular systems with standard interfaces. This is a subtle yet major difference from the work of Ward et al. (1995) since, in theory, standard interfaces would still allow for new parts. Muffatto (1998) describes a historical context whereby the complexity from new parts within automotive OEMs was at such a high level that they had had to reduce it around the time the article was written (1998). Sobek et al. (1999) state that Toyota utilises a common parts strategy as does the work by Thomke and Fujimoto (2000) but only refers to product platforms (the broad structures underlying a product), so that learning is enabled between projects. Lastly Liker (2004) describes the process of developing the Lexus and Prius as developing entirely new components. However, he then goes on to state that this went too far at Toyota so that a common platform strategy had to be employed latterly to cope with the increased complexity.

Absences: The omissions can be put down to differing research questions, one notable exception is the work of Womack et al. (1990) where there is no explicit description of how

lean NPD affects part choice even though there is a large discussion on the explanation of lean NPD as a low cost form of craft production.

Discussion: The above analysis gives a confusing picture of lean NPD parts strategy. However, there are some possible explanations for the differences in the literature. The work of Clark and Fujimoto (1991), Lamming (1993), and Sobek (1997) show some similarities. For instance, these literatures talk about the creation of new parts developed within manufacturing capabilities. In the work of Sobek (1997), manufacturing capability (i.e. what is producible) is defined by the interfaces between components, where no such assertion is made in the earlier work. Under this interpretation, the earlier work also brings in manufacturing performance as a key explanatory factor in lean NPD performance, since as manufacturing capability is constantly being improved due to Kaizen (continuous improvement), this results in new abilities to create new products in a dynamic situation. This is contrasted with the relatively static understanding provided by Sobek (1997), where it is not clear how modular interfaces which define manufacturing capability are updated. This interpretation would also allow for the finding at Nippon Denso, where new but modular products are created. However, this interpretation is based on the role of lean to extract the benefits of both craft and mass production. Accepting that lean NPD utilises common platforms and components to reduce complexity and increase learning would suggest that the logic of lean, as the best of craft and mass production, ceased to be an overriding factor, and that issues of complexity control started to become more of an issue, as described by Muffatto (1998). However, the work of Itazaki (1999) and Liker (2004) then states that as Toyota felt its development had become stale, it instigated the development of the Lexus and the Prius; this resulted in an explosion of complexity which once again had to be tempered. It should be noted that with the introduction of these new cars, irrespective of standardisation efforts, there appeared to be a step change in complexity hence, the need for new practices, such as the Oobeya room (an Oobeya room is a large project room discussed below).

In conclusion, it appears that to accommodate the findings of the literature, one needs to posit a dynamic ability of lean NPD to adapt to both external and internal conditions. Also, under this interpretation, the ability of lean NPD to adapt appears highly dependent on manufacturing capabilities and research and development capabilities. This, which is largely absent from research post Clark and Fujimoto (1991) and Lamming (1993), will be discussed below.

3. Design for manufacture

Common themes: Nine of the sources describe practices which relate to design for manufacture. This is where the product is specifically engineered with processes in manufacture in mind so that it is easy to make, with high quality of conformance; this also means productivity is reached quickly after product launch. There is a high degree of focus on process engineering in lean NPD relative to other automotive companies. In latter developments in the literature, design for manufacture is expressed in check sheets and standards where parts are reviewed to determine their fit within the current manufacturing capability. Obviously, this has strong links with the previous category of parts strategy.

Contradictions: While all sources state design for manufacture is important, the mechanisms as to how it is achieved vary slightly across the literature. For instance, while Clark and Fujimoto (1991) and Graves (1987) assert that it is achieved via intense communication and experience, Morgan (2002) and Sobek (1997) state that this is done through loose specifications. This is where, rather than stating to assembly all specifications, non-essential specifications are left for manufacturing to decide. This speeds up development time and consequently facilitates manufacturing in production.

Absences: Where design for manufacture is not mentioned, it can be put down to research questions.

Discussion: Whether the contradiction expressed above is real or not again depends on the reading of 'intense communication', since it could be argued that this communication concerns what specifications are necessary and which are not. One aspect that was particularly emphasised in Clark and Fujimoto (1991) is that design for manufacture cannot be given overall precedence since it may reduce the impact of the product concept. This theme is tacitly present in the description of the development of the Lexus; here the chief engineer challenged production to make a car that was initially considered impossible (Liker, 2004). Hence, emphasis of how strictly parts are designed to *current* capabilities differ somewhat depending on the source, which in fact may reflect the reality that design for manufacture requirements change in line with the aims of the development project.

Intangible Assets, relationships and Information

4. Relationship to innovation / technology

Common themes: The oldest literature first states that lean organisations are only concerned with small continuous incremental changes (Imai, 1986), however, sources that follow it remain agnostic to this view. For instance, Womack et al. (1990) state that the reason why lean companies have not engaged in 'epochal' innovation (a paradigmatic change in technology) is because the automotive industry, where most of the studies had been conducted at that time, was relatively stable, hence it was not needed. They postulate whether lean companies would have the ability to engage in self-drive cars or hybrid technology; interestingly, just six years later this was shown to be verified by the arrival of the Prius. Clark and Fujimoto (1991), in a similar tone, describe how lean firms try to link technology with development through long term development cycles, and that lean companies utilise constant incremental jumps in technology to stay ahead of competition. This is closely tied with part strategy described above. A theme within the literature is that current technology assets are reconfigured to a high degree in order to achieve innovations before new investments in technology are made (Graves, 1987). This results in increased flexibility (Lamming, 1993) and contributes to lower product lifecycles. Again this points to the logic of lean incorporating the best of mass and craft production. Moreover, while lean companies have been described as conservative at adopting new technology they clearly do it. Again descriptions of this practice involves utilising more mature developed technology and basing developments on the innovative use of this relatively well-established new technology (Itazaki, 1999; Liker, 2004). For instance, the development of the Lexus utilised relatively well-established technology but Toyota's understanding of that technology allowed it to design and produce it against such tight tolerances that resulted in a somewhat inimitable product (Liker, 2004).

Contradictions: Nippon Denso pursued the opposite strategy of incremental improvements, they sought breakthrough innovations and used a highly automated robot technology to produce their goods. That said, the company produced robots in-house to extract maximum flexibility from the technology. Furthermore, a radiator is a much simpler product than an automotive vehicle. Hence, the description of Nippon Denso is in some ways commensurable with the idea of utilising skill in technology to get the most out of current assets. Mehri (2006), who engages in a polemic against lean practices, states that often innovative solutions were sought outside the lean organisation, usually in the form of benchmarking. Further, he states that while the company was poor at innovation, it was

always interested in new technology, but only in technology that had been tried and could be shown, in practical terms, to have an effect.

Absences: There are no real absences within the literature given the different research aims amongst scholars

Discussion: While this section has highlighted some possible contradictions, it could be argued that they actually fit within an abstract development pattern of technology use in lean companies. Nippon Denso utilises and develops technology assets based around understandings of them so that they can be utilised in unique ways (whether this differs from non-lean companies is unclear). Mehri (2006) describes the importance that lean organisations place on concrete non-abstract understandings of technology; this differs from the more principled theorising of western cultures, which may explain how lean organisation utilise technology assets in a unique manner. This will be discussed below.

5. The Chief Engineer

Common themes: Out of the selected literature, fourteen out of the twenty sources mention the Chief Engineer or heavy weight product manager (the term chief engineer, *susha* in Japanese, has come to predominate over the term 'heavy weight product manager' so this thesis will use the term chief engineer). These descriptions are remarkably consistent across the sources. The most comprehensive discussions of this role are present in the work of Clark and Fujimoto (1991), Sobek (1997), and latterly, Itazaki (1999) and Liker (2004). They detail interviews with chief engineers to give more concrete descriptions. Broadly, the chief engineer is responsible for the entire NPD project. This person has a small, dedicated, cross-functional team, and draws project personnel from functional units on an as needed basis. Chief engineers have no formal authority over the functional units but they possess much informal authority. They are highly competent engineers, usually with twenty years of experience, and display a rare but valued skill set. Below is the list that Clark and Fujimoto (1991: 256-257) accumulated of key characteristics of chief engineers:

- *"Coordination responsibility in wide areas, including production and sales as well as engineering*
- *Coordination for the entire project period from concept to market*
- *Responsibility for concept creation and championing as well as cross functional coordination*

- *Responsibility for specification, cost target, layout, and major component choices*
- *Responsibility for ensuring that the product concept is accurately translated into technical details of the vehicle*
- *Frequent and direct communication with designers and engineers at the working level as well as through liaisons*
- *Maintain direct contact with customers (PM's office conducts market research independently of marketing group)*
- *Possess multilingual and multidisciplinary abilities in order to communicate effectively with marketers, designers, engineers, testers, plant managers, controllers and so forth*
- *Role and talents in managing conflict surpass those of neutral referees or passive conflict managers; they may initiate conflicts to prevent product designs or plans from deviating from the original product concept*
- *Possess market imagination and the ability to forecast future customer expectations based on ambiguous and equivocal clues in the present market*
- *Circulate among project people and strongly advocate the product concept rather than do paperwork and conduct formal meetings*
- *Mostly engineers by training, they possess broad (if not deep) knowledge of total vehicle engineering and process engineering"*

The chief engineer is generally explained as being beneficial through a series of concepts, such as aiding communication, in that they provide a way to articulate difficult to describe and vague styling concepts. Furthermore, the literature often describes the authority to communicate these concepts being derived from the chief engineer attaining knowledge through direct acquaintance or 'Gemba' (which means 'the real' in Japanese), as well as through their own skill.

Contradictions: At first there appears to be a contradiction contained in the work of Womack et al. (1990), set against the rest of the literature, in that they describe the chief engineer as possessing formal power with dedicated collocated teams, contrary to the informal power and small teams common to other research. However, in the afterword section (2007) of their book they correct this, and revert back to a description more consistent with the rest of the literature. Sobek (1997) states that his findings differ from those of Clark and Fujimoto (1991) in that they see the chief engineer as more personally involved in the day to day activities of the project, such as writing the concept description. While this may be the case,

it could be argued that such a subtle difference is highly dependent on the interpretation of work, and a moot point. Bigger differences are present though in the expertise that the chief engineer has. While Clark and Fujimoto (1991) state that the chief engineer has a broad set of skills, authors such as Sobek (1997) and Morgan (2002) state they have more deep expertise in a particular functional area. However, this difference may be accounted for by latter accounts of chief engineers. For example, authors such as Liker (2004) recall how in different projects different types of chief engineers were chosen to reflect the felt need of the particular projects. For instance, in the Prius (the world's first hybrid car), the chief engineer lacked any real depth of expertise and was relatively young, but this brought a 'fresh look' to the development process. This indicates that the skill sets of chief engineers are relative to particular projects and that while the chief engineer's role is pivotal, it changes as development conditions change. The last major contradiction is the way the chief engineer communicates with his staff; however, this will be discussed under the category of communication (page 68).

Absences: Most of the absences within the literature can be put down to differing research aims; they were not all concerned with describing lean NPD activities. One notable difference is the work of Whitney (1993) who describes much more strategic and high level consensual development planning at Nippon Denso. However, this difference in project management may be put down to Nippon Denso having a much more functional product, as it is a component supplier, compared to an automotive manufacturer. It can also be attributed to the vast differences in product strategy, in that Nippon Denso introduced products with long life-cycles spanning over a ten-year period, comparable to the relatively short product introductions described at Toyota.

Discussion: As previously stated, this category appears to be relatively consistent in the descriptions that the literature gives of the chief engineer. Differences have been explained by the fact that the chief engineer has a role that adapts to the changing product requirements. The Prius development project provides an interesting case since, due to the complexity of the project and the relative inexperience of the chief engineer, new practices were developed, such as the Oobeya room (which will be discussed on page 68).

6. The role of the supplier in lean NPD

Common themes: The role of suppliers in lean NPD is remarkably consistent throughout the literature, with small refinements throughout the historical development of the lean research.

Essentially, lean NPD companies use their suppliers to a greater extent, get them involved earlier in the NPD process, give them more responsibility over design, have a longer-term and closer relationships, and utilise a delegated sourcing strategy in comparison to non-lean NPD companies. Moreover, personnel are shared between the buying and supplying companies, with guest engineers. They take part in open book pricing policies. As well as buyers at lean companies expect to be allowed access at any time to their suppliers and readily share sensitive information.

Contradictions: The only contradictions that are present, within this topic, is the nature of communication between the OEM and its supply base. Clark and Fujimoto (1991) state that lean NPD involves a high degree of intense communication with its supply base, whereas Ward et al. (1995) describes fewer but more effective communication events between the OEM and their supply base. This tension may be resolved since Clark and Fujimoto (1991) state that the communication has a largely tacit dimension, indicating that they may take a more relaxed view on what communication refers to. Obviously whether this contradiction is real or not depends on the definitions of 'intense', moreover it is unclear exactly what each author means by 'communication'. For instance, Dyer and Hatch (2006) describe numerous communication events within a lean supply base, from trade associations to formal meetings.

Absences: While not an absence as such, Clark and Fujimoto (1991) are the only authors to use the supply base as an explanation of product development performance; this allows the OEM to reduce the scope of the development project, while the OEM requires the suppliers to have a high level of development capability to produce novel products. As such, Lamming (1993) argues that lean NPD demands unique requirements from the supply base in its development capabilities. Again, it is worth noting that these early works on lean NPD show a holistic understanding of how performance is created, which is largely absent in later works. Supplier relationships are only mentioned in eight of the twenty sources which is relatively brief considering the importance it is given by some authors.

Discussion: As stated above, the role of the supplier is relatively consistent within the lean NPD literature. Lean NPD appears to require the supply base to have development capabilities so that it can input unique designs into the development process. However, the topic is conspicuous by its absences in some sources. Furthermore, the performance increases of the supply base appear to be premised on lean NPD's long term holistic focus

and communication ability, suggesting supplier relationships and capabilities are sufficient yet not necessary in lean NPD performance.

7. Front loading in lean NPD

Common themes: Twelve of the twenty sources mention front-loading as a key driver in lean NPD performance, and this is closely linked with the discussion on SBCE and Concurrent engineering below. Front loading is where resources are used to try to detect problems early. This avoids late changes which are costly and difficult to reverse due to the investment in production time and assets.

Contradictions: There are no contradictions in the literature as such but Thomke and Fujimoto (2000) show that Toyota did not always use front loading in its development, but experimented with the degree of problem solving and the effect it had on project time and cost, from the 1980's to the mid-1990s.

Absences: There are no real absences given their research questions.

Discussion: It appears that front loading the process is not a prerequisite of lean NPD but is something which has evolved and been described by Thomke and Fujimoto (2000).

8. Set based concurrent engineering / concurrent engineering

Common themes: Some authors argue that set based concurrent engineering (SBCE) is the defining aspects of lean NPD (Khan et al., 2011; Ward, 2007). Indeed, it has created a significant literature of companies using the tool in different environments (Al-Ashaab et al., 2013; Inoue et al., 2011; Kennedy, 2013). An exposition of the practice of SBCE is found within the work of Morgan (2002); Sobek (1997); Sobek et al. (1999) and Ward et al. (1995). This forms the major discussion point of their research. References are also made within Mehri (2006) and Whitney (1993). What follows is an explanation of SBCE.

Sets within SBCE are each explicit product concepts which contain design requirements (Sobek et al., 1999). These sets are considered in parallel where Toyota purposely tries to explore each concept as fully as possible thus delaying design 'freeze' for as long as possible (Sobek et al., 1999). Solutions to design requirements which are feasible across the sets specify the design space; this design space is gradually reduced through testing, customer inputs, information across functional areas, and looking at trade-offs in performance of

design options (Sobek et al., 1999). Sobek, Ward et al. (1999:73) describe the method of SBCE like this:

Principles of Set-Based Concurrent Engineering

1. Map the design space.
- Define feasible regions.
- Explore trade-offs by designing multiple alternatives.
- Communicate sets of possibilities.

2. Integrate by intersection.
- Look for intersections of feasible sets.
- Impose minimum constraint.
- Seek conceptual robustness.

3. Establish feasibility before commitment.
- Narrow sets gradually while increasing detail.
- Stay within sets once committed.
- Control by managing uncertainty at process gates.

This slow convergence and consideration of multiple designs is argued to increase overall project effectiveness and efficiency, with a number of stated benefits:

1) Communication within SBCE is dependable since design space only converges (although this is admittedly an ideal (Ward et al., 1995)). Hence, any information that is communicated, as long as it currently falls within a department's feasibility range, it can utilise. This is regardless of whether it is the final specification, since the final specification will only be within the current design space due to the principle of convergence. This allows work to start early, reduces rework, and provides a basis for increased efficiency of communication (Sobek et al., 1999; Ward et al., 1995).

2) Communication within SBCE explores the design space, increasing decision effectiveness (Sobek et al., 1999). This means that instead of giving specifications for a component or process within NPD, information is communicated through physical artefacts, such as prototypes or drawings, tolerances or parameters, open-ended tolerances, trade off curves and performance charts (Sobek, Ward et al. 1999). This allows departments to understand relationships between systems and sub systems, thus optimising design, reducing the chance of reiterations, and understanding what is possible under current technical conditions. Interestingly, SBCE can be seen to provide just enough information at a boundary between different knowledge areas, and even more so, it shows the relationship at the

boundary through the methods described above. This is also relevant to the supply base since the supplier also keeps Toyota up to date with developments so Toyota can understand how the design space is changing from its suppliers (it seems plausible that only long term relationships would encourage such behaviour, as found in partnership suppliers to Toyota in its keiretsu) (Liker et al., 1996). Communication with the supply base is made more efficient with methods such as practical demonstrations, min max trade-offs, bulls eye specifications and the use of *gurai* (about) targets which provide a map of the solution space (Liker et al., 1996). Indeed, evidence points to Japanese suppliers being more likely to explore design space than their US counterparts (Liker et al., 1996).

3) Communication within SBCE is more efficient. There are two arguments for this statement. Firstly, having each department communicating a range of possibilities rather than whether it can meet a single specification, allows all involved parties to see design solutions that are commensurable. This is in contrast to concurrent engineering (CE) or point based NPD where the project is passed from one department to another (Pugh, 1991; Ulrich et al., 2011). These design processes are problematic as they can create iterative cycles due to unknown constraints in the subsequent departments, and often never reach a satisfactory total solution, yet are fixed due to time constraints (Yassine et al., 2003). The second argument is that (SBCES)s communication method is also resource light. For instance, each department has a lessoned learned book that provides the current state of possible designs. Using the lessons learned book, an audit is conducted to determine if a solution falls outside of current possible designs. If absolutely necessary (since no design is within current possibilities), a new process / technology is devised, and the new possibility is written within the lessons learned book. The lessons learned book covers all areas of a function / component, such as government regulations, manufacturability, where bolt hole positions are, what can and cannot be economically produced, and past problems (Sobek, Ward et al. 1999). This book reduces the need for meetings, hence, reduces time and cost. Secondly, by performing an audit and seeing where the actual work lies in creating a solution no specific NPD team is created, and there is no colocation of NPD actors (Sobek et al., 1999).

A careful reading of the above will show that there is some ambivalence as to what SBCE is. Initially, authors such as Ward et al. (1995) consider SBCE as a formal tool and this is how it is conceived in much of the subsequent literature. However, other authors such as Mehri (2006) and Sobek, (1997) and, indeed, on occasion Ward et al. (1995), point to SBCE as a way of thinking or communicating. This ambivalent reference to SBCE highlights an important historical basis for SBCE, the original authors Ward et al. (1995) were looking for evidence of SBCE in companies, inspired by theoretical work they had done on modelling product development in the research of Ward and Seering (1993). As noted by Hoppmann et al. (2011), this may have heavily influenced their work.

Contradictions: Of the descriptions of SBCE there are no specific contradictions, although there is some ambiguity as to what the concept refers to. However, there is a possible contradiction in findings since Ward et al. (1995) state that Nippon Denso utilise SBCE whereas Whitney (1993) states that he found no evidence of this during his research. Of course this could be down to sampling issues.

Absences: There are notable absences for such a key practice. Seminal research from Clark and Fujimoto (1991), Womack et al. (1990) and Lamming (1993) do not mention SBCE, instead they describe concurrent engineering, where engineering stages are overlapped. Ward et al. (1995) state that SBCE differs from concurrent engineering in that concurrent engineering does not communicate 'sets' but 'points', essentially these points are solidified specifications that cannot be changed, hence there is no gradual convergence within concurrent engineering development which may lead to rework and a longer development time. However, a close reading of Clark and Fujimoto (1991) clearly shows that two conditions of concurrent engineering are 'intensity of communication' and 'bi-directional information flows', which could be interpreted as very close to SBCE. Further, they state that doing this communication work upfront reduces rework and considers development downstream issues up front. Also, much like SBCE, they describe high bandwidth communication and a drip feeding of information rather than batch communication across development stages.

Other evidence which suggests that SBCE is not unique or subsumed under different practices, such as communication, comes from the latter descriptions of lean NPD. For instance, Tanaka (2011) in a very detailed presentation of Toyota's current NPD practices, does not mention SBCE. Furthermore, within the very work of Ward et al. (1995) they state

they did not find SBCE in many Toyota factories, and more specifically SBCE does not apply to the development of all parts; contrary examples were given of the powertrain and gearstick development.

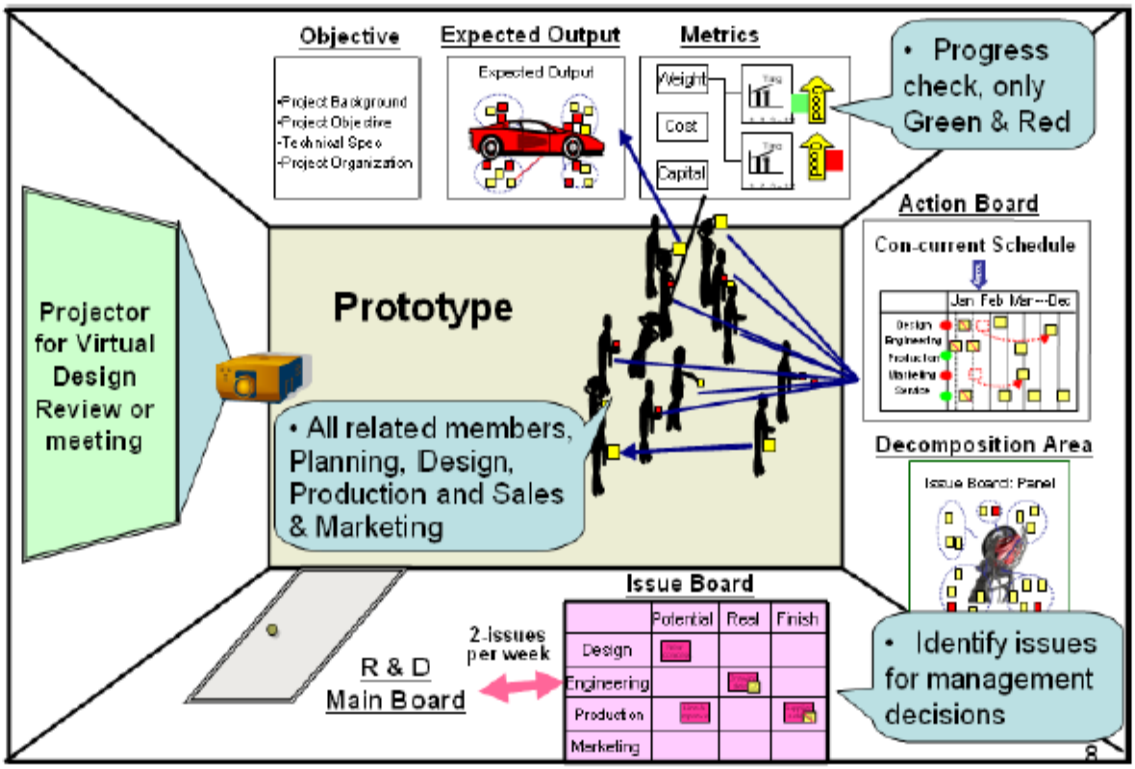
Discussion: Given the arguments made above, it appears that SBCE can be subsumed into different practices and, in fact, does not relate to a unique practice. Moreover, if SBCE does exist as a unique practice, it would appear to be relatively minor, and only specific to a particular type of development parts, like the body chassis. Given these findings, it is relatively surprising that it has had such a large impact on the subsequent literature.

9. The role of communication

Common themes: Communication is a major theme in the literature, with sixteen sources explicitly referring to it. As can be seen in the discussions above, it plays key explanatory roles in a number of categories, such as the chief engineer, supplier relationships, and SBCE. For instance, the literature consistently describes the chief engineer as a communication point between different functions, such as styling, the customer, and top management. Further, the chief engineer plays a role in communicating hard to define concepts as discussed above. SBCE, also explained above, illustrates the importance of ambiguous or broad band width communication. Communication is also described as related to information structures (discussed below), since the A3 report provides systematic ways of representing information and so gives a common language through which different functional areas can communicate. It is not only information structures that aid communication but also communication types. For, where possible, there is a constant theme within the literature of bringing people together around physical artefacts to aid communication. Essentially, communication is used to explain how lean NPD identifies and solves issues early on in the process, thus reducing rework later on. The work of Itazaki (1999) described a new practice that was created during the Toyota Prius development which then became a key practice at Toyota (Tanaka, 2011), and is mentioned in subsequent literature; this is the Oobeya room, or large project room. The Oobeya is a room arranged as in **Figure 2.1** below. It is a place where the development team comes to review progress and discuss issues. On the walls the organisation puts a story logic of how the development team will reach its goals. This practice helps by clearly assigning tasks to specific personnel, what they need to do, and where they are in the schedule, so that any issues can be identified and appropriate responses made. Again, information structure and type (see below) plays an

important role, with a physical model or picture of the development object being designed placed centrally within the Oobeya.

Figure 2.1 – A layout of the Oobeya room taken from *Horikiri et al. (2009)*



Contradictions: Within the literature there is tension between descriptions of the best way to communicate in lean NPD projects. Bar the work of Sobek (1997); Sobek et al. (1999); Ward et al. (1995) the majority of sources state that face to face is the best way to communicate development ideas. These named authors describe how Toyota prefers written communication, then if this is not sufficient, a face to face meeting. If there is then still an issue, this gets moved up the management hierarchy so that the chief engineer becomes involved in a face to face meeting. A possible solution is that the majority of research has only considered issues that cannot be solved easily, and so, face to face communication is necessary. Another possible resolution is that written communication is only appropriate for solving certain types of problems, for instance, technical ones, yet problems of coordination need to be solved face to face like in the Oobeya room. That said, later reports on how the Oobeya room is organised state that, although they use face to face communication, a structured way of communicating is still utilised; for instance, attendees only present two problems at a time, and are asked to talk for less than two minutes on each problem (Tanaka, 2011).

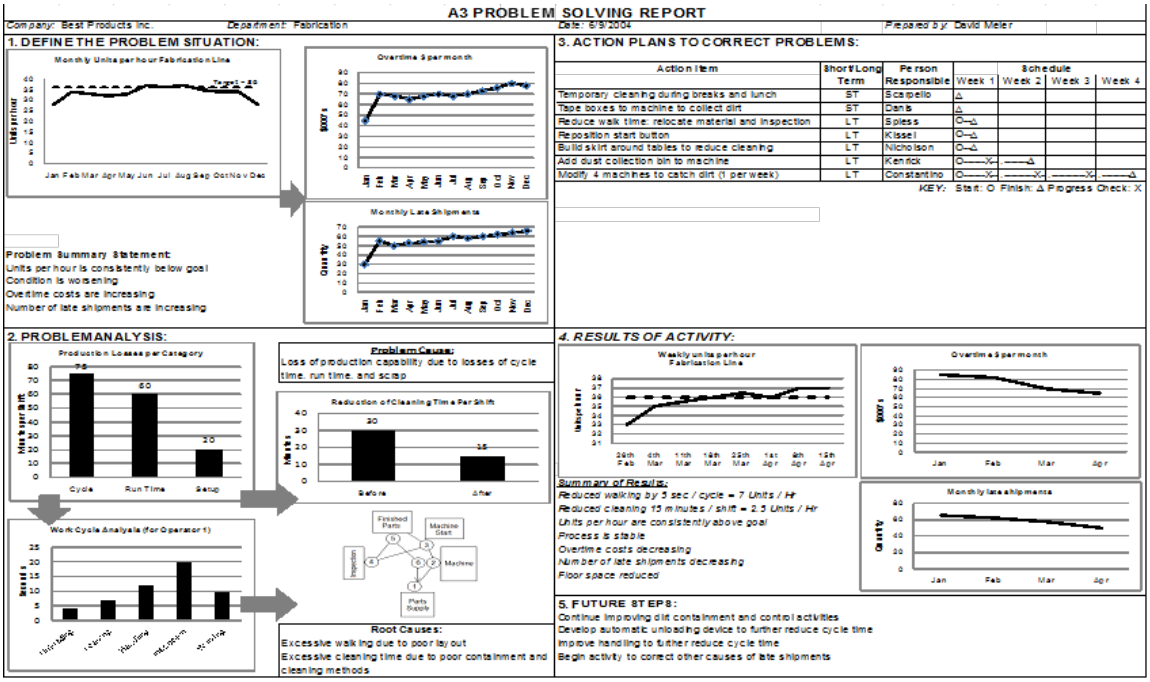
Absences: There are no absences due to the research aim's within the literature

Discussion: The way lean companies communicate is clearly a unique feature of their development system, and although there is a tension in the descriptions it clearly is a major factor in understanding the lean NPD phenomenon. Communication activity is structured in its timing at a macro level (front loading), and at a micro level (turn taking in the Oobeya room). Communication is also structured around its location, the Oobeya room, and around how facts are communicated via the A3 report or intense face to face meetings. It appears that such a method is utilised to identify problems and opportunities in the most expedient manner across the development cycle.

10. Practices related to information structure and type

Common themes: There is a number of related but discreet themes within the category. The first is the structure through which information is gathered. This theme runs from the first source (Imai, 1986) to the last (Tanaka, 2011), and is represented in sixteen of the sources. There are consistent descriptions of how lean companies consider the way information is gathered as being just as important as the result the information brings. These processes of information structuring include instilling the right attitude on information retrieval (e.g. to question purportedly held beliefs), and, if necessary, creating conflict between different viewpoints in order to generate ideas. While the earlier literature cites the chief engineer (described above) as pivotal in this activity, the later literature states that as well as this, practices such as A3 reports are also required (Morgan, 2002; Tanaka, 2011). The A3 represents a systematic way of organising information which needs to be available to the organisation. Traditionally this is for solving problems but it has a variety of functions, from making proposals to providing status updates on change processes. Scholars have argued that A3 reports express the manifestation of Plan Do Check Act (PDCA) thinking, first pioneered by Deming (1982) but utilised in lean companies (Liker, 2004). PDCA is a methodology for solving problems encountered within an organisation which scholars in lean NPD categorise as a 'scientific method' (Morgan, 2002). While such ascriptions to PDCA as a scientific method could be highly questionable given the significant debate about what constitutes a scientific method (Bird, 2006). PDCA and, so, A3 reports do express a logic which favours a, '*logical thinking process, objectivity, results and process, synthesis, distillation, and visualisation, alignment, coherence and consistency across, systems view point*" (Sobek II and Smalley, 2008: 12). Each quarter of an A3 piece of paper represents one part of a PDCA cycle, as shown in **Figure 2.2**:

Figure 2.2: Source: Sobek II and Smalley (2008:156)



The above theme of how information is structured is highly related to the information type that lean NPD companies are described as utilising. The type of information that lean companies use is described as 'highly detailed', and 'concrete'. By concrete the literature refers to actually physical results rather than theoretical inferences, indeed one could describe lean companies' information preferences as atheoretical. Again, this is present from the first research by Imai (1986) to the last paper by Tanaka (2011) and is present in sixteen of the sources. This theme is expressed in different ways, for instance, by the fact that Toyota engage in much more physical prototyping than non-lean competitors within their NPD. Also, the literature describes how lean organisations engage in large amounts of testing so decision can be made based on data rather than theory. This is combined with the notion that if there is a problem the personnel responsible should always go and see, through direct apprehension, the nature of the issue themselves, rather than accept reports by others. This theme is closely linked to the previous one of information structure, since A3 reports, in their systematic presentation of information, require the user to input data that is based on actual results and as detailed as possible, that is, based on direct acquaintance of the issue. Lastly, it should be noted that lean organisations adapt their physical test assets to increase the speed and flexibility of the test facility, so that data can be produced quickly. Clark and Fujimoto (1991) describe a process much like that portrayed in manufacturing in which there is through, detailed and rigorous analysis of test assets, and they are recombined to minimise set up time.

Contradictions: A tension can be seen in the way lean companies like their information structured in comparison to what type of information they prefer. Since, if information is correctly structured in an A3 report, it is by necessity no longer information from direct acquaintance. However, it appears that while for the person responsible for writing the A3 report, it is necessary to see and understand the problem first hand, during their communication efforts it is important to show everyone the logic that has been used in reaching the conclusion of the report.

Absences: The only omissions can be put down to the differing research questions of the sources.

Discussion: Clearly, this category plays a fundamental part in lean NPD given the prominence and consistency with which it is represented within the sources. The performance benefits of utilising this kind and structure of information are generally stated as improved problem solving capability. While this explanation is somewhat of a gloss, detailed descriptions of responses to issues that this method give are more illuminating. For instance, Whitney (1993) stated how Nippon Denso's ability to tailor an automating solution to assembly was found, after reconceptualising what the issues were. It was its focus on detail that enabled it to reinterpret the problem, which in turn proffered new possibilities. This echoes the discussion above on technology concerning the development of the Lexus; through detailed and concrete analysis, issues were reconceptualised and engineering trade-offs dissolved. This ability or method appears to be a key explanatory factor in lean NPDs ability to achieve some of the outputs described within the other categories, such as technology utilisation, parts strategy, and changing communication basis. This ability to structure information in a certain way, and seek the correct type of information appears to be a tacit skill of the chief engineer. Meanwhile the physical practices, such as the use of A3 reports, appear to be present to enforce the development of skill in less experienced personnel. Increases in performance appear to give lean NPD companies the ability to dissolve trade-offs, solve problems at the root cause, and utilise assets in novel ways, resulting in NPD performance.

2.4 Discussion of the results

The research aim of this chapter was to determine if there is a coherent phenomenon found within the literature and grey sources so that it can be interpreted through Routine theory in

the next chapter. By ‘coherence’ this thesis means a property of lean NPD that is consistently displayed on all occasions of lean NPD recorded. Looking at the physical manifestations of lean it would appear that they do not fit the coherence criteria. Lean NPD organisations are inconsistent in their use of novel parts, they have different views about the priority design for assembly plays in the development of products, and there is even some controversy about exactly what a lean NPD organisation is. If we then turn to practices to define lean NPD again, there appears to be little continuity. The literature describes how ‘front loading’ has evolved over time and, as such, cannot be essential to lean NPD. Moreover, SBCE, if different from Concurrent engineering, is not consistently used across all development activities or lean NPD organisations. This point may be levelled against concurrent engineering too, since certain technologies, like the powertrain, resist the ability to engage in them concurrently due to their long development times.

Defining lean NPD through the relationships it engenders appears a more coherent approach. Throughout the literature, where supplier relations are mentioned, it appears that they are integral part of lean NPD. However, if supplier relations were such an essential part of lean NPD, one would expect the theme to be more prominent in the literature. Furthermore, in explanations of supplier relationships in lean NPD, the literature emphasises that the efficacy of lean NPD is premised on its ability to integrate suppliers effectively in the NPD process. As such, structural elements, such as, few suppliers, long term relationships and early involvement, may be sufficient, but not necessary, conditions of the role of suppliers in lean NPD. This point is made by Dyer and Hatch (2006), who state that Toyota’s ability to extract greater value from its supply network was determined by the internal flexibility the organisation exhibited to its supplier base rather than the shared supply base structures with competitors. The pattern of relationships of lean NPD to technology also seems to be premised on a similar ability to integrate it in unique ways. Here this manifests itself in the ability of lean NPD to repurpose mature technology assets for novel uses. Hence, these two aspects of lean NPD: its supplier relationships and use of technology, appear to point to a deeper phenomenon.

The chief engineer characteristics are premised largely on their ability to communicate with a diverse number of stakeholders and maintain overall project responsibility which aids integration and so, performance. This aspect appears important, especially when it is concerned with products that contain the notion of aesthetics, since these qualities are generally hard to communicate. In looking for an explanation for their integrative and

communicative abilities, it seems to be premised on the ability to use a particular information type which gives them authority (direct apprehension or the 'gemba'), and to have informal authority over functional areas. However, it is unclear how the chief engineer alone can display consistent performance results across a multitude of projects, and coordinate long term activities, such as supplier relations and technology development. There must be some logic which they work to, in the development projects, which makes performance consistent within lean organisations. While the unusual communication patterns displayed by lean organisations might also be a factor in explaining a unique aspect of lean NPD, they too vary broadly. For instance, the development of the front loading process, and of the Oobeya room are both communication patterns that have developed, either in response to market requirements for contracted development times, or to increasing complexity, respectively. What these communication patterns do highlight is the way they are used to bring about problem identification, this, in turn, points to a problem solving basis for lean NPD.

Problem solving in lean NPD is based on the way it engenders information structuring and information type preferences to allow it to reconceptualise problems, dissolve trade-offs, and produce a systems wide, optimal solution to issues at hand. This process would explain the varied, dynamic, and evolving manifestations of lean NPD, while still maintaining the property of being a coherent phenomenon. As such, categories like SBCE, front loading the NPD process and A3 reports represent tools to maintain this thought process where breakdown may occur. For, if such information structuring / activity was a natural occurrence, the need for practices to stimulate behaviour would cease. As such lean NPD can be seen a way of organising information or knowledge to produce results that may not come naturally to practitioners in development projects (hence, lean organisations unique performance characteristics). As internal and external environments change, practices will need to change in order to create the desired thinking where new breakdowns occur, or where this type of learning is required; hence the multiple manifestations and evolutions. Chapter three will propose that this thinking, stimulated by lean NPD practices, equates to second order learning (Argyris and Schon, 1978). This is where individuals learn by questioning assumptions, bringing in varied viewpoints, engaging in a 'good dialectic', which results in new conceptions of the world (Schön, 1983).

2.4.1 Conclusion

In summary this chapter has sought to answer the following question; is there a coherent phenomenon called lean NPD so that it can be interpreted into Routine theory (in chapter three)? It has been argued that lean NPD is a coherent phenomenon if conceived as a way to influence a certain kind of thinking in development personnel, by changing their behaviour through practices. As such, this interpretation can explain the various manifestation of lean NPD and its evolution. This chapter represents an original piece of research in its own right, since a metasynthesis methodology has not been applied to this topic before. Furthermore, these results offer a new interpretation of lean NPD, and the research highlights some important contradictions and tensions within the literature, such as those concerning the uses of SBCE, and of the manufacturing paradigm of lean within lean NPD.

The next chapter utilises the conclusions from this chapter concerning the basis of the lean NPD phenomenon and places it within practice-based routine theory. As such, it argues that lean NPD consists of two categories which constitute the practice-based view of routines, called ‘agency’ and ‘artefacts’. ‘Agency’ is expressed in lean NPD in the form of the chief engineer, while artefacts can be seen as practices like use of Oobeya room and the A3 report. In lean NPD the two components of these routines are utilised in a way that affects how personnel carry out their *organising* (Weick et al., 2005), or practices. It will be argued in the next chapter that this change in practice results in reflective learning (Dewey, 1925; Miettinen, 2000).

Chapter Three: The generation of the research questions

Chapter overview

This chapter seeks to provide a testable framework which can establish how learning can emerge from OM techniques such as lean NPD. Consequently, there are three aims to this chapter. Firstly, to provide a framework which details the mechanism of how lean NPD might, *ex ante*, result in learning. The proposed framework needs to incorporate new innovations within the business management discipline which are pertinent in answering questions of *how* performance is changed due to lean NPD (Jarzabkowski and Spee, 2009). This is done by incorporating insights from the practice-based perspective. Furthermore, learning needs to be conceptualised at the micro-level so it can be measured as an outcome of routine dynamics. Secondly, given the framework presented and the findings of chapter two concerning what lean NPD is from the literature, this chapter aims to describes how lean NPD *could* function within such a framework. In particular, a mechanism is proposed which details how lean NPD could possibly affect routines, resulting in learning. Lastly, based on the proposed framework, an overarching research question is generated, with conjoining research propositions. This question, and related propositions, can then be tested and discussed in the remainder of this research. The following section briefly discusses each aim, providing the central arguments of this chapter.

3.1 Central arguments overview

Building on the argument in chapter one, to understand how lean NPD results in learning within operational routines the two below criteria need to be met:

(a) A measure of learning at the micro-level

A theory of learning needs to be proposed, which measures learning at the individual, rather than the organisational level. This will tie learning to participants *within* routines, and so avoid the criticism, and scepticism, related to the operationalisation of learning at the organisation level, detailed in chapter one (Adler et al., 2009; Lamming, 1993a).

(b) A practice-based routine requirement

A practice-based conception of routines needs to be utilised which incorporates the features of routine dynamics found within this literature. This literature takes into consideration endogenous factors that occur within routines, which *interactively* constitute the routine's micro-dynamics, and so, *how* the routines work (Pentland and Feldman, 2005). If lean NPD is present within the routine then they must embody a factor which constitute the routine, and so influence how the routine is performed.

The first section of this chapter will address these two criteria respectively. An 'individual learning requirement' will be met by arguing for learning as reflective learning, commonly labelled 'double loop learning' (Argyris and Schon, 1978). It will be argued that different theories of reflective learning consistently describe similar behaviours involved in reflective practice (c.f. Argyris and Schon, 1978; Dewey, 1925; Schön, 1987). However, due to the perspicuity of the description of the reflective behaviours, and the overall consistency with the theoretical assumptions of this research, Dewey's reflective learning cycle is utilised as a model for this type of learning (Dewey, 1925). Dewey's learning cycle states that there are five consecutive stages, or behaviours, (stated below) which result in reflective learning.

1. The first stage occurs when there is a breakdown in normal or expected habitual responses, this is a non-cognitive experience of resistance which involves back-talk (Koschmann et al., 1998).

2. The second stage furnishes the experience of resistance with conceptual apparatus to intellectualise the problem, and define what is going wrong. This definition of the problem provides the basis for what the solution will look like.

3. The third stage involves the formation of a 'working hypothesis' where possible solutions are proffered given the total set of condition which are constraining the solution.

4. The fourth stage involves iterative thought experiments to rework the working hypothesis in light of current understandings.

5. The last stage involves testing the hypothesis through practical action as it is only though practical action that a hypothesis can be verified. This in turn leads to an

understanding of the assumption under which the hypothesis was constructed, and so learning.

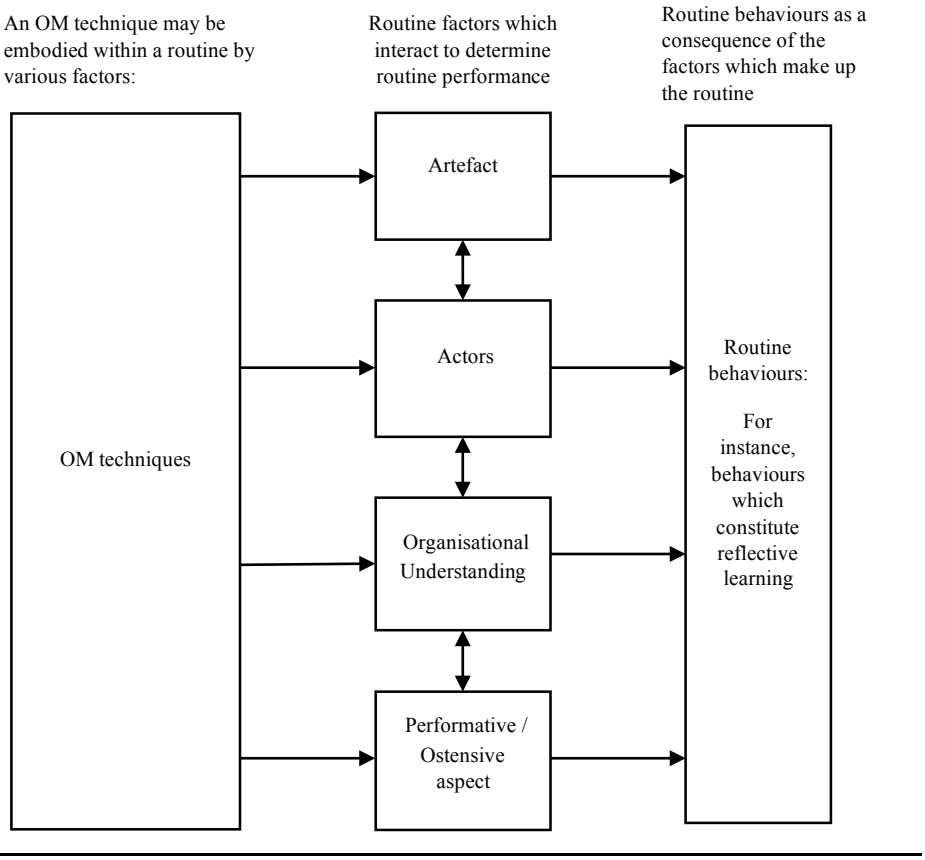
This research focus is trying to determine whether learning is occurring within routines in response to lean NPD. Therefore, Dewey's reflective learning cycle needs to be a consequence of interacting with these techniques to answer this question. Reflective learning theories have the advantage over other theories of learning by offering an explicit method and criteria to identify reflective learning when it is occurring (Elkjaer, 2004). Moreover, this type of learning occurs at the level of analysis of individuals and groups (Schon; 1983). This ties learning to the spatiotemporal activity found within the routine, thus avoiding questions of the appropriateness of indirect measurements, such as organisational outputs (Adler et al., 2009).

The individual learning requirement is followed by discussion from the practice-based routine literature to satisfy 'A practice-based routine requirement'. Practice-based routine theory identifies four features that affect a routine's interactive internal dynamics, and so how routine behaviours are created, resulting in the routine being performed (Parmigiani and Howard-Grenville, 2011; Pentland and Feldman, 2005). The first factor is the ostensive and performative aspects of the routine, where the ostensive is defined as the 'abstract representation' of the routine such as 'make a purchase order', and the performative is defined as the 'actual doing' of the routine 'making a purchase order' (D'Adderio, 2011; Pentland and Feldman, 2005) Hence, the ostensive part of the routine is seen as relatively fixed, since in abstract, 'making a purchase order' appears like a fixed method as to how the routine *should* occur. Whereas, in reality, the actual performative aspect of the routine changes every time due to contextual contingencies. For instance, the paper for the purchase order may need replenishing on one routine occurrence. The next routine enactment may require a new pen to be sought, and so on. The next major factor which affects behaviour within routines is how the participants of the routine relate their understanding of the routine relative to its function within the organisation (Feldman and Rafaeli, 2002; Howard-Grenville, 2005; Pentland and Rueter, 1994). This is where the person doing the routine interprets what is required from the routine, relative to how they understand the whole function of the organisation (Lazaric and Denis, 2005). This factor has a strong relationship to the next factor, which is: how the people actually doing the routine shape its performance- the literature refers to this as 'agency' (Feldman, 2003). This is a key factor within the practice-based view since it defines the routines as person-centric, or "effortful

accomplishments" (Pentland and Rueter, 1994:488), in contrast to the capabilities view. Lastly, the literature identifies factors called artefacts which affect routine behaviours (Pentland and Feldman, 2008). These are material aspects involved in the routine, that shape how it is performed. These include things like standard operating procedures, prototypes, and more platitudinal aspects, such as contextual features, including office layout (D'Adderio, 2011). During actual routine performance these factors combine, and interact, to constitute the routine's behaviours, and so how the routine is performed (Parmigiani and Howard-Grenville, 2011). It should be noted that these factors are analytically distinct rather than practically distinct, and have been derived from emphasis by authors on a particular factor (D'Adderio, 2011; Parmigiani and Howard-Grenville, 2011). As such, behaviour should be conceived as *emerging* and interacting between the milieu of factors (Feldman, 2000). With these criteria briefly outlined, frameworks can now be discussed which detail possible mechanisms of how OM techniques could affect learning within routines.

3.1.1 An alternative framework

Figure 3.1: Overall generic framework for how OM techniques could embody routine factors, which would interact with individuals within the routine to improve routines behaviours



Synthesising the two requirements, (a. A measure of learning at the micro-level, and b. a practice-based routine requirement), with our concern of how OM techniques affect routine behaviours leads to the framework in **Figure 3.1**. That is, if OM techniques are affecting routine behaviours, then using practice-based routine theory they must be identified as being embodied by an endogenous factor that constitute routine enactment (the central column of **Figure 3.1**). They must be synthesised into the practice-based routine literature (as denoted by the right hand arrow from 'OM techniques' column to, 'Endogenous routine factors that determine routine behaviours' column in **Figure 3.1**) For instance, OM techniques could place a unique actor, which is specially trained in a certain technique, or a unique artefact, such as a particular representation of a standard operating procedure, within a routine. Furthermore, by characterising learning as individual behaviours, means that it may be possible to tie these behaviours to specific endogenous routine factors. Moreover, by looking at what behaviours are formed as a consequence of *interacting* with these endogenous routine factors, it may be determined what effect they are having within the routine on behaviours. For instance, if an OM technique places a specially trained actor within the routine, interacting behaviours of participants within the routine can be observed, and then determined if they correspond to learning in response to this factor (as denoted by the right hand arrow from 'Endogenous routine factors that determine routine behaviours' column to 'Routine behaviours' column in **Figure 3.1**). That is, **Figure 3.1** provides the framework whereby a relationship *can* be established between OM techniques, and learning, occurring within routines. However, **Figure 3.1** is a *generic* framework. To situate lean NPD into the framework requires further argument; to establish lean NPD practices as embodying parts of factors which interact to contribute to routine behaviour. This is the topic of the next section.

3.1.2 Lean NPD mechanism that result in routine reflective learning

The second half of this chapter incorporates lean NPD into **Figure 3.1**'s framework by proposing lean NPD practices (detailed in chapter two) are placed within the 'OM technique' column, resulting in **Figure 3.2**. Each lean NPD practice is identified with the four factors that interact to affect the behaviours within a routine. Specifically, synthesising lean NPD into the practice-based routine literature, it is argued that lean NPD practices either embody artefacts or actors of the factors which constitute routine behaviour, as is shown in the first column in **Figure 3.2**. Hence, the unique way lean NPD embodies a routine's factors can be labelled a 'lean actor' (as in the case of the chief engineer) and several specialised 'lean artefacts' (as in the case of practices such as A3 reports, check-sheets, multi-prototyping,

etc.). By incorporating lean NPD into the framework, it provides an understanding as to how lean NPD could embody routine factors, and so affect routine behaviours. Again, using the 'individual learning requirement', means that Dewey's learning behaviours can be tied in close spatiotemporal location to lean actors and artefacts, establishing if they do in fact have a relationship to learning within routines, when individuals interact with them (the furthest right-hand-side column in **Figure 3.2**).

Figure 3.2: Overall framework as to how lean NPD practices are embodied in routines, and a proposal as to how their attributes could result in interactions that are defined as reflective behaviours.

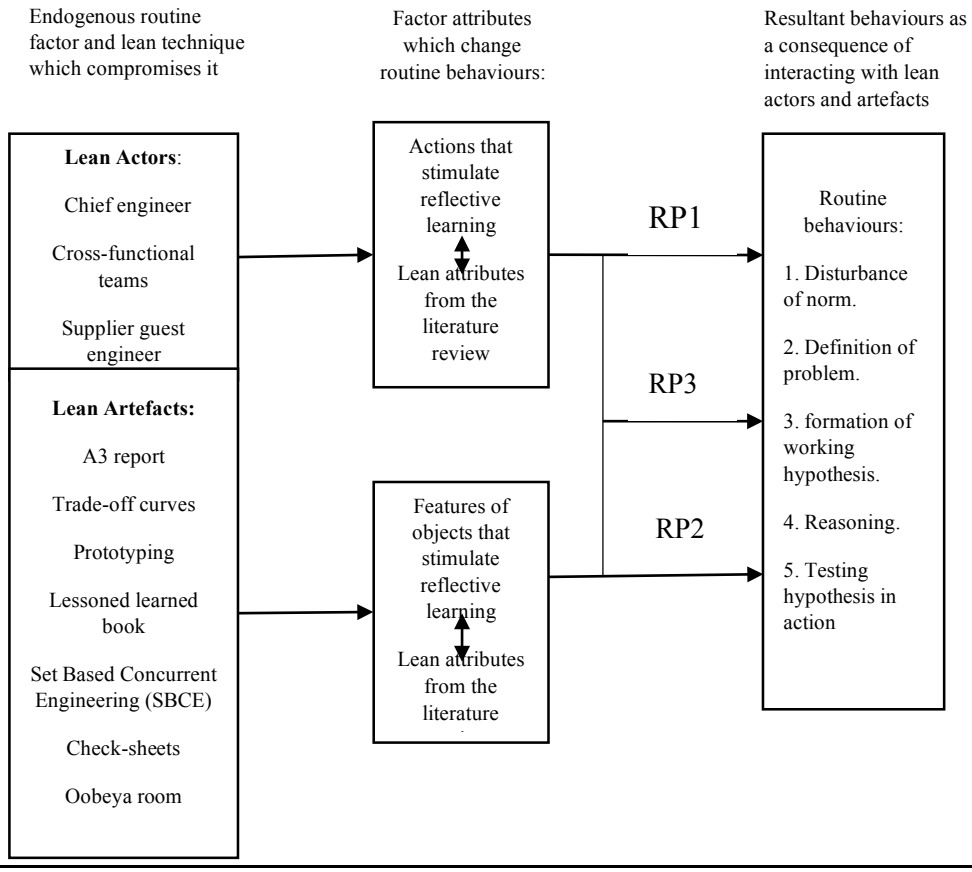


Figure 3.2 also includes more information than **Figure 3.1**, situated under 'Factor's attributes which change routine behaviours'. This information is introduced to try and understand the exact features of lean actors and artefacts that result in reflective behaviours, answering calls from recent scholarship to explore the precise details of routine factors which lead to behaviour (c.f. Nicolini et al. (2012); Seidel and O'Mahony (2014) and D'Adderio (2011)). To do this, the 'Factor's attributes which change routine behaviours' column represents insights from reflective theory on how reflective behaviours are engendered through both personal action (agency), and material objects (artefacts). These insights are combined with the inductive results from the literature review in chapter two. That is, a

mechanism is conjectured to how reflective learning may arise from lean NPD which fits both the unique aspects of lean NPD detailed in the literature, and corresponds to the most plausible mechanism from reflective theory (as denoted by the two-way arrow in the attributes section in **Figure 3.2**). This explanation culminates in **Figure 3.2** which expresses the overall framework as to how lean NPD *could* result in reflective learning.

3.1.3 Research questions

The overall aim of the research is to establish if there is a positive relationship between learning and lean NPD within routines, and how this relationship operates. This aim addresses a significant gap in the OM literature which has not been explored; the effect of lean NPD on learning behaviours as these techniques are being used within NPD routines. As such, the main question proposed by this research is:

RQ1: Does the interaction between lean NPD practices and people within organisational routines lead to reflective learning behaviours?

A possible mechanism is also proposed as to *how* features of lean NPD actors and artefact results in reflective behaviours based on **Figure 3.2**. This aspect of this research answers a general, and recent call within the OM field to understand the theoretical basis of causal relationships, rather than assume it exists because of the co-presence of inputs and outputs (Guide and Ketokivi, 2015). Using the framework from **Figure 3.2** three research propositions are generated which correspond to possible mechanisms through which the attributes of lean actors and artefacts could stimulate reflective learning. Firstly, it will be proposed that lean actors such as the chief engineer have an attribute which affects people by engendering an attitudinal response called a 'willingness' to engage in reflection (Jordan, 2010). This is defined by a set of behaviours such as 'a passionate humility', an ability to take in multiple view-points, and accept multiple truths (Contu and Willmott, 2003; Jordan, 2010). These behaviours stimulate and encourage reflective learning behaviours (Schön, 1987). Hence, the first research proposition:

RP1: *Interaction with lean actors increases the 'willingness' of people to engage in reflective behaviours within routines.*

Secondly, it is conjectured that lean artefacts such as A3 reports, check-sheets and Oobeya Rooms all have the attribute of increasing the 'capability' of people within routine to engage in reflective learning. A 'capability' to carry out reflective learning is defined as the ability to garner questioning and feedback, and engage in experimental activities (Jordan, 2010; Yanow and Tsoukas, 2009). This capability is thought to increase the ability of people to engage in reflective learning (Schön, 1987). This results in the second research proposition:

RP2: *Interaction with lean artefacts increase the 'capability' of people to engage in reflective behaviours within routines*.

Lastly, in routines where there are both lean actors and artefacts, on the aforementioned logic, they should combine to increase both the 'willingness' and 'capability' to take part in reflective learning. Thus, the third research proposition:

RP3: *Interaction with lean artefacts combined with lean actors increases the 'willingness' and 'capability' of people to engage in reflective behaviours within routines.*

These central arguments will now be expanded in the sections below, culminating in the generation of the research propositions which can be tested in the remainder of this research.

3.2 Learning as reflective learning

Seminal research had referred to reflective learning as the critical learning process at the micro-level which results in endogenous routine change (Feldman and Pentland, 2003). Feldman (2000:625) utilises the work of Argyris and Schon (1997) to explain what learning is:

> *From my observations, organizational routines involve people doing things, reflecting on what they are doing, and doing different things (or doing the same things differently) as a result of the reflection. Thus, organizational routines can include the ''double loop learning'' that Argyris (1976) and Argyris and Schon (1978) have identified.*

The work of Argyris and Schon (1978) argued that learning could be divided into 'Single Loop' and 'Double Loop' learning. Single loop learning they contend is akin to a

thermostatic learning cycle where learning takes place within known boundaries. Double loop learning involves the questioning of those very boundaries in situations that are novel, uncertain and complex. For radically new knowledge to occur, personnel have to engage in double loop learning. This is described as "… when error is detected and corrected in ways that involve the modification of an organization's underlying norms, policies and objectives" (Argyris and Schon, 1978: 3). That is, double loop learning can be identified by a change in schema, or base assumptions. Scholarship has characterised double loop learning under the broad category of 'reflective learning', such that assumptions are reflected upon and altered (Argyris and Schön, 1997; Feldman, 2000; Jordan, 2010; Tsoukas and Chia, 2002). Reflective learning is also described as playing a key part in lean systems. For instance, the work of Spear (2010, 2004), Browning (2009), and Morgan and Liker (2006), all refer to reflective learning as critical to how lean achieves performance. As such, given the prominence reflective learning plays within the OM lean literature, and the practice-based routine literature, it will be utilised as a measure of learning at the micro-level. However, using reflective learning as a definition of micro-learning is problematic. The reason being that although reflective learning is widely cited as occurring, the literature is relatively silent on what the measurable behaviours which constitute reflective learning are. This includes recent scholarship specifically concerned with understanding how reflective talk changes routine enactment (Dittrich et al., 2016). However, for this research, clear behaviours need to be identified with reflective learning, such that the relationship between these behaviours and features of lean NPD practices can be determined. What follows is a discussion on what the appropriate operationalisation of reflective learning is for this research.

3.2.1 The definition of reflective learning

Work from Yanow and Tsoukas (2009) and Jordan (2010) has re-conceptualised a form of double loop learning called reflection-in-action (Schön, 1983). Reflection-in-action details how a change in tacit beliefs occurs 'during' action (conceived as close spatial-temporal location). This differs from Argyris and Schon (1978) account of reflection who viewed it as occurring after the event. Reflection-in-action is particularly apposite for the research of this study since the focus is on how learning is occurring in the midst of routine action, not after the event. If OM techniques are affecting behaviour as they are being utilised, then learning must be affected 'in-action'. Schön (1983) argued that in situations of high novelty and uncertainty participants need to engage in reflection 'in action' in order to cope effectively with dynamic break-down situations. This theory has had a huge impact on a

variety of disciplines such as strategy (Liedtka and Rosenlum, 1996), nursing (Bulman and Schutz, 2013), education (Eraut, 1994), management (Ciborra, 1999), and of course, organisational learning (Raelin, 2001, 2007). Schön (1987) states that reflection in action occurs through a five step process:

1. normal ways of responding to the environment are disrupted by an event that is contrary to expectation.
2. This then leads to the experience of surprise.
3. Surprise then leads us to focus on the phenomenon of surprise, which in turns leads us to question our current understanding of the situation, or knowing in action.
4. This then results in on the spot experiments,
5. Experiments lead to reflection in action, and a reformulation of the assumptions under which the problem is conceived.

Problematically for this research, Schön (1987) utilises a cognitivist theory of mind. As will be discussed in chapter four, a practice-base analytic requires the rejection of cognitivist theories (Gherardi, 2009a), hence, to be consistent, a non-cognitivist theory of learning needs to be presented. A non-cognitivist approach is achieved by agreeing with the behavioural criteria which Schön (1987) identifies as occurring during reflection-in-action, but by denying that this means that there is any need to posit a cognitive process. Hence, a change in our assumptions through reflection is not a change in base beliefs in one's mind, but rather a new ability to act in a new way within the world (Yanow and Tsoukas, 2009). This creates a theory of learning that both provides a behavioural process as to how learning occurs, and at the same time connects it intimately with the context of learning, since activity (what learning is premised on), is limited or enabled by the contextual features where the learning takes place (Yanow and Tsoukas, 2009). The non-cognitive re-conceptualisation of Schön's (1987) work is faithful to the actual methods that Schön (1987) himself uses, since to identify the five stage process of reflection-in-action, he looks at interactions of behaviour within a design studio (c.f. Schön (1987:Ch3)). Hence, ultimately like the non-cognitivist view, Schön (1987) operationalises reflection-in-action based on discrete behaviours. Schön's (1987) initial insights have been extended in the literature through other non-cognitive theoretical approaches (Keevers and Treleaven, 2011; Yanow and Rethymnon, 2007; Yanow and Tsoukas, 2009). For instance, Yanow and Tsoukas (2009) have theorised this process utilising a phenomenological perspective, arguing that under such a view the notion of reflection-in-action can be extended and illuminated. They use Heidegger's (1962) notion of

'modes of being' to elucidate different types of surprise and coping mechanisms that may result in different reflective responses. As such they argue that reflection in action can be extended through four ways. Firstly, it consists of alternative explanations other than the most expedient to hand, which opens up epistemological authority into the reflective situation. Secondly it requires an attitudinal response that is receptive to new ideas irrespective of how this affects the perception of one's identity concerning authority. A point echoed by Yanow (2009) where it is argued that an attitude of 'passionate humility' and a 'language of inquiry' is required to stimulate reflection. Thirdly, having a receptive attitude requires making the logic through which you see the situation transparent and open to questions, regardless of egoistic impulses. Lastly the individual needs to pay attention to the situation surrounding them and allow themselves to be surprised via a sensitivity to events. These extensions listed correspond to what Jordan (2010) states is a critical antecedent to reflection-in-action; an attitude of a *willingness* to engage in reflection-in-action. The other antecedent being a *capability* to carry out reflection-in-action. She argues that two aspects limit or enable the ability of individuals to engage in reflection-in-action, defined below (Jordan, 2010:41):

1. "Willingness: Willingness to engage in reflection-in-action, the need for passionate humility: recognition of multiple 'truths', scepticism about one's own ways of thinking and acting.

2. Capability: Capacity to reflect-in-action, the ability to experiment, engage in backtalk (this is an unexpected non-rational activity of having a conversations with materials, so that they indicate what is possible (Yanow and Tsoukas, 2009)) or , an interactive practices of informing and questioning."

Jordan (2010) draws on situated learning theory (Lave and Wenger, 1991) to state that the *capability* of individuals to engage in reflective learning is increased via participation in working contexts. She lists several activities which increased both the 'willingness' and 'capability' to reflect found in her study: the use of multiple perspectives, public questioning, job rotation, 'on the job' training, an alternation between full and peripheral participation in activities, a reconstructing of abstracted rules, and case base teaching. Aspects that inhibited reflection included identity struggles within practice, strict division of responsibilities, low formal teaching, and inflexibility caused by external perceptions of what practice should entail. These findings are somewhat corroborated by Tucker et al. (2002) which indicated

that institutional, organisational, and psychological factors all negatively affected reflective abilities of front line staff in a hospital.

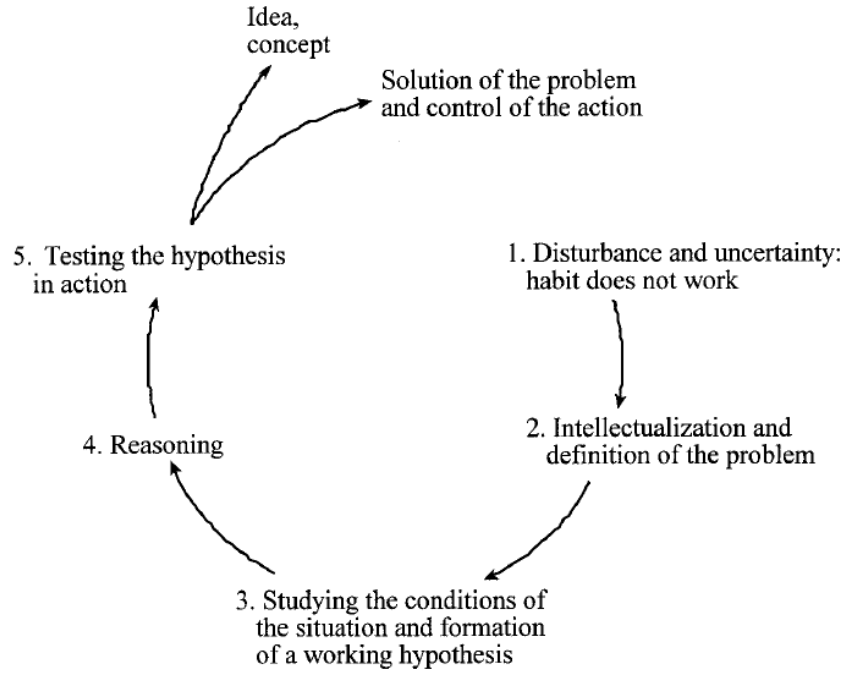
Previous research has focused on the primary description of the process of reflection-in-action provided by Schön (1987), and in particular the attitudinal dimension of a 'willingness' to engage in reflection-in-action. However, some aspects of his work have drawn little attention which correspond to Jordan's 'capability' dimension (Jordan, 2010). Schön (1987) explicates the efficacy of reflection in action through the use of frame experiments. Frame experiments is where our 'knowing-in-action' (our ability to carry out a highly skilled action in a state of non-awareness), is brought to conscious awareness. Here, it can be viewed under differing assumptions, to determine what might occur if a change in the assumptions were made, through which we have been carrying out the activity. To do this however, the relationship between the practitioner and the external world needs to be 'transactional'. Transactional situations provide a context where we can do frame experiments, such that we can have 'backtalk' from the environment. That is, 'backtalk' are contexts where reality provides resistance to required change, and indicates what is and what isn't possible within the frame experiments. Schön (1987) states that such contexts where frame experiments occur can be virtual worlds. Virtual worlds provide a representation of reality such as a map, or a drawing. The efficacy of the frame experiments is determined by how well the virtual world represents the real one. Schön states the more empirical content, the more representation of reality the virtual world will be, and the greater the backtalk (Schön, 1987).

Reflective theories based within the pragmatist tradition also offer important insights too into the nature of reflective behaviours. The work of John Dewey is considered a key theory (Miettinen et al., 2009) based within the pragmatist school of learning (Dewey, 1925; James, 1902; Mead, 1934; Peirce and Ketner, 1992). Scholars have argued that pragmatism, with its focus on behaviour, and its critique of a purely abstract focus on thinking, is consistent with the principles of the practice-based perspective (Elkjaer, 2004; Gherardi, 2009b; Jordan, 2010; Miettinen et al., 2009). Furthermore, pragmatism takes into account the environment surrounding learning, while also detailing *how* learning occurs. This is described in the following account of the behaviours which constitute Dewey's learning cycle (see **Figure 3.3**). Dewey (1910:200) states that learning occurs via these five phases:

> *. . . as states of thinking, are (1) suggestions, in which the mind leaps forward to a possible solution; (2) an intellectualization of the difficulty or perplexity that has been felt (directly experienced) in a problem to be solved, a question for which the answer must be sought; (3) the use of one suggestion after another as a leading idea, or hypothesis, to initiate and guide observation and other operations in collection of factual material; (4) the mental elaboration of the idea or supposition as an idea or supposition (reasoning, in the sense in which reasoning is a part, not the whole, of inference); and (5) testing the hypothesis by overt or imaginative action. (p. 200)*

Learning has a double outcome for (Dewey, 1925), firstly if understandings are verified, the immediate troubling situation is resolved, assumptions are either verified or changed depending on outcome (Miettinen, 2000). Secondly, the reasoned outcome is added to the repertoire of knowledge for use in future situations (Miettinen, 2000). Crucially, and analytically distinct from the reflective processes from Schön (1987), the overall environmental features play a key role in the process. The application of what was learnt, and how reflective learning occurs, is determined by contextual features that 'allow' past experiences to bear on the current situation (Elkjaer, 2004). "*For Dewey it is always the situation – consisting of concrete participants, objects and mediating factors (e.g. language, technology), which override the individual participant. Thus, one can have had experiences as an individual, which one cannot in a concrete situation gain access to – either because one has 'forgotten' them, or because the situation does not permit it*." (Elkjaer, 2004:425). Echoing practice-based theory (c.f. Orlikowski (2006)), thinking is not an abstract activity, but occurs through the interaction of individuals and the environment, hence a change in these variables, leads to a change in thinking (Fineman, 2003; Vince, 2002). Elkjaer (2004) states that this idea links to Argyris and Schön (1996) concept of the 'undiscussable' – a context within an organisation which will not allow some things to be mentioned. Thus, using Dewey (1925) indicates that there may not be just contextual antecedents to whether reflective learning occurs or not (like those of a 'willingness' and 'capability' from Jordan (2010)), but, that the very content of that learning will alter with a change in the contextual features depending on where the learning is occurring.

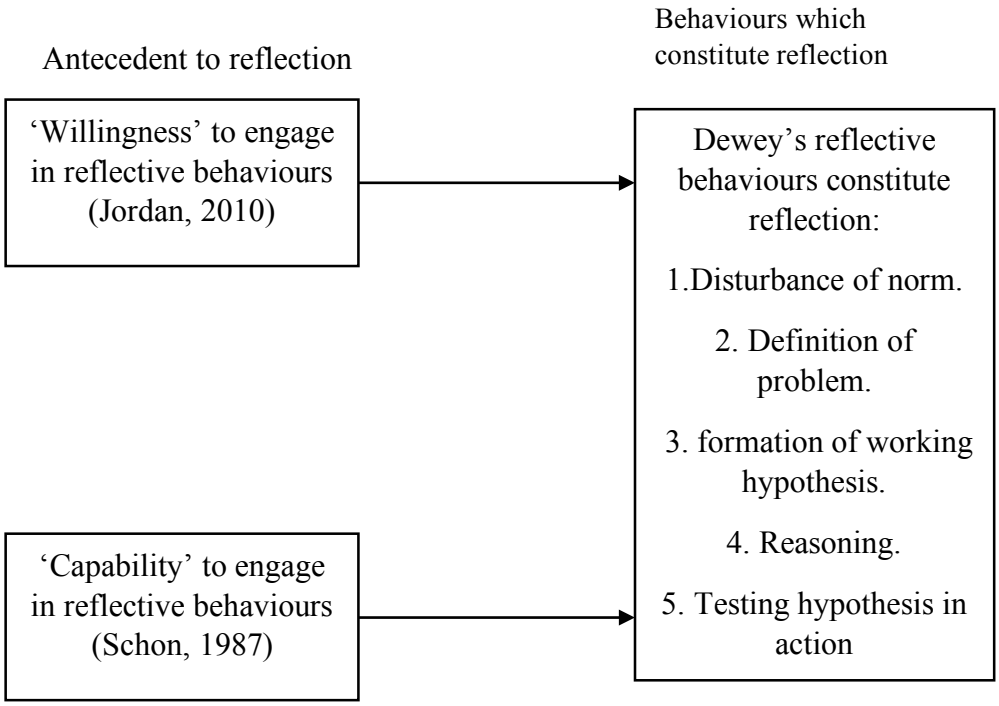
Figure 3.3: taken from Miettinen (2000: 65) a representation of Dewey's reflective learning cycle



Clearly both Schön (1987) and Dewey (1925) theories of reflection describe similar behaviours that result in reflective learning. Both have a five step process which constitute reflection. Using these models of reflective learning, combines the best of the acquisition and the participatory models of learning. That is, they detail how learning actually occurs, while taking into account how contextual features affect the learning process. Moreover, the theories identify learning with a change in base beliefs at the individual level. As such, reflective theories will be utilised as the basis of how learning occurs at a micro-level. However, there are differences between the two conceptions. The notions of willingness and capability appear as an antecedent, or an enabler, to reflective behaviours within Schon's (1986) and Jordan's (2010) conception of reflection, rather than behaviours which constitute reflection itself. Furthermore, these antecedents are missing from Dewy's (1925) conception. That said, Dewey (1925) highlights the important role of context in reflection. While both theories of reflective learning can be drawn on, Dewey's (1925) account of the actual behaviours which constitute reflective learning will be utilised. The rationale for this is that choosing one will avoid ambiguity within this research. Furthermore, Dewey's (1925) original argument has its assumptions in line with this research's practice-based perspective, and Dewey (1925) provides greater clarity on what behaviours constitute reflective learning, in contrast to Schon (1988); Schön (1987); Schon and Rein (1995) who's writing is relatively diverse. However, insights from both theories will be utilised. Particularly, the importance of antecedent factors of willingness and capability which lead to reflection present within

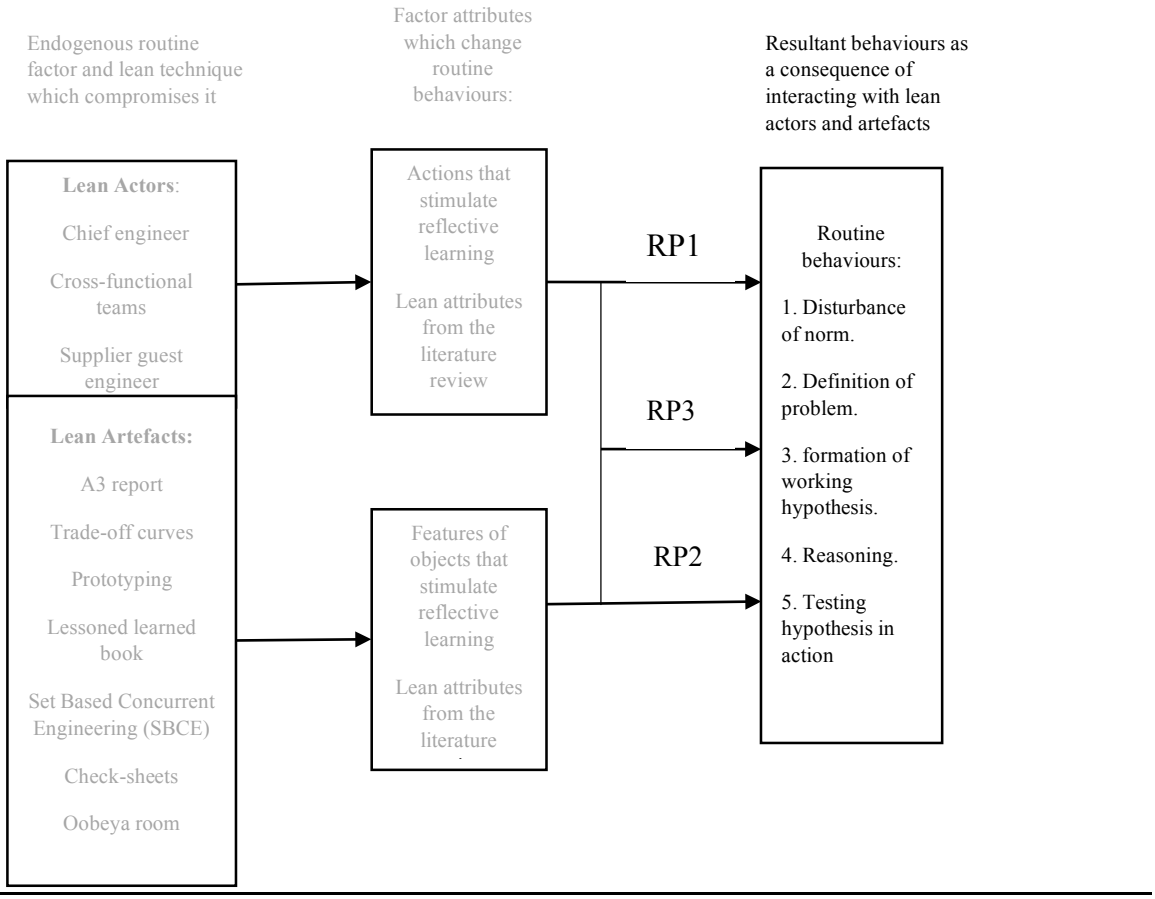
Schon's (1987) and Jordan's (2010) work. **Figure 3.4** below gives a possible formulation about how these insights on reflective behaviours can be combined:

Figure 3.4: A suggested formulation as to how theories of reflection of Schon (1987) Jordan (2010), and Dewey (1925) can be combined.



In the parlance of more positivistic work, this section gives the reader the dependent variable. That is, by using Dewey's (1925) definition of reflective learning we have a set of behaviours that could be identified within routines as reflective learning. As such, adapted from **Figure 3.2** this section has argued for the right hand column, of what routine behaviours we need to measure highlighted in **figure 3.2.1**.

Figure 3.2.1: Highlighted area depicts the area this section has argued for, that learning within routines can be identified as reflective behaviours



However, these behaviours need to be a consequence of interactions with OM techniques. In developing the argument, the next section surveys the literature to describe how the practice-based perspective on routines understand endogenous routine factors that determine routine behaviours. Once these factors are identified it can be argued which factors lean NPD embodies within routines. As such, this will ultimately result in a proposed framework for how lean NPD might result in reflective behaviours. Prima facia, if lean NPD created antecedents to reflective behaviours within routines, then this may explain a mechanism as to how they result in explorative learning.

3.3 A practice-based theory of routines

This section utilises the ideas of the practice-based view of routines. Furthermore, if we are interested in determining how people's learning behaviour is effected by their interaction with OM techniques within routines, then we need a conception of routine that looks at *how* routines function; which is the research focus of the practice-based view of routines

(Parmigiani and Howard-Grenville, 2011). While this theory still utilises the original definition of routine as "*repetitive and recognizable patterns of interdependent actions, carried out by multiple actors*" (Feldman and Pentland, 2003: 95), it argues that routines are effortful, and endogenous routine change can occur (Feldman and Pentland, 2003). This conception has been termed the 'Copernican revolution' in routines theory, since it built on the economic view of routines pioneered by Nelson and Winter (1982), but argues for the key role of human agency (D'Adderio, 2011). The practice-based perspective has utilised a variety of studies which investigate standard operating procedures (D'Adderio, 2003; D'Adderio, 2001, 2008; Lazaric and Denis, 2005; Pentland and Feldman, 2008). It could be argued these studies with the research focus on standardisation are related to lean NPD and improvement techniques, and may provide insights. However, there are few studies which look into NPD (Cacciatori, 2012; D'Adderio, 2001; Salvato, 2009) and Om techniques at the same time. Moreover, there are no studies which look at lean NPD, or routines from an OM perspective more generally (Peng et al., 2008). Hence, the practice-based view of routines should provide novel insights into how lean NPD may function within routines.

By utilising the findings of this view this section will provide an overview of the factors which govern behaviours within routines. The general features of the practice-based view of routines utilise four key concepts when explaining what affects routine behaviour (Parmigiani and Howard-Grenville, 2011). These are:

- the ostensive and performative aspects of a routine
- artefacts used in the routine
- the organisational context through which the routine is enacted
- people's actions within the routine.

A discussion regarding each concept now ensues in the following sub-sections.

3.3.1 The ostensive and performative aspect of the routine

Research into routines identified a paradoxical aspect to all routines. That is, to be routines they need to have the qualities of being "*repetitive and recognizable patterns of interdependent actions, carried out by multiple actors*" (Feldman and Pentland, 2003: 95), yet being based in action, every new instance of a routine is somehow different, due to changing contexts (Edmondson et al., 2001; Feldman, 2000; Pentland and Rueter, 1994). That is, a routine such as 'making a purchase order', has the quality of being repetitive and recognizable, since it is an action that an organisation may routinely carry out. However, as

alluded to in chapter one, each time someone makes a purchase order, there are contingencies that change the actual actions within a routine. For instance, the actors within a routine may have to alter their fulfilling of the routine due to absent employees, wrong paperwork, a break-down in IT systems etc.

As a solution to this paradox, the seminal contributions from Feldman and Pentland (2003) and Pentland and Feldman (2005), utilised the language of Latour (1987). They stated that routines have dual aspects: the mainly unchanging abstract part which they labelled 'ostensive', and the actual act which they labelled 'performative'. The ostensive they argued is largely, but not exclusively represented in formal organisational procedures such as, 'how to make a purchase order'. It by no means needs a physical representation, for instance, in some organisations with low levels of documentation, verbal acceptance of a routine called 'make a purchase order' is all that functions as an ostensive aspect (Pentland and Feldman, 2005). The performative aspect of a routine 'make a purchase order' is the actual doing of that task. Scholars argue that depending on which aspect of the routine one is researching, results will be vastly different (Pentland and Feldman, 2005). For instance, data collected on a singular routine may indicate it is changing under the performative aspect, while stable under the ostensive, or vice versa (Pentland and Feldman, 2005). Research has also shown that these two defining aspects of routines are by no means unproblematic. For instance, what counts as the ostensive or abstract representation of the routine may differ between organisational members (Feldman and Rafaeli, 2002), whether this be a simple misunderstanding, such as the incorrect revision on a standard operating procedure, or a result of organisational hierarchy having different perspectives on a routine (Adler et al., 1999). This situation is obviously made worse by the fact that routines involve multiple actors and are distributed over time and space, which include inter as well as intra-organisational contexts (Pentland and Feldman, 2005; Rerup and Feldman, 2011).

Further research shows that the ostensive and performative aspects of the routine affect each other, and the performance of the routine as a whole (Turner and Rindova, 2012). For instance, the actions taken during the performative aspect of a routine leads to the constitution of the ostensive part; if the performance is entirely separate from what people say the routine is, then it is likely that the ostensive part needs changing (Feldman, 2000). Furthermore, the ostensive part is said to constrain and enable the performative aspect since the ostensive, or the abstract part, sets a criteria on what sort of behaviour the routine requires (Feldman, 2003: 303). At the same time this ostensive aspect also legitimates and prescribes

the type of performative behaviour required (Turner and Fern, 2012). It has been argued that the amount of divergence or convergence between the ostensive and the performative may be indicative of the way the work place is organised (Pentland and Feldman, 2008). For instance, if there is convergence between the two aspects then this may indicate a very authoritative work system, alternatively it may show that standard operating procedures are updated regularly, as in features of lean manufacturing (Pentland and Feldman, 2008). Divergence may mean that Management has a poor understanding of what actually occurs (Hales and Tidd, 2009). This can have dangerous consequences as described by Weick (2003), where through a process of 'practical drift', peoples actions slowly begin to differ from those prescribed by the routine, which hampered coordination, and resulted in friendly fire incidents. Conversely, there is the idea of 'routine as target', derived from the original work by Nelson and Winter (1982). Here, divergence between the ostensive and performative aspect is seen as a necessary condition for organisations performance. Where there is divergence between the actual and intended performance, individuals tend to engage in behaviour to strive to meet that target, to repair that routine, or use the unintended consequence of action to expand the future performance of that routine (Feldman, 2000).

3.3.2 The role of agency in routine behaviour

A central tenet of the practice-based view of routines is that routines are 'effortful accomplishments' (Pentland and Rueter, 1994:488). Agency covers the aspect of the routine that is concerned with how people influence the performance of the routine. Traditionally, these scholars have utilised agency under a cognitive model of understanding (c.f. Cohen and Bacdayan (1994)). This has led to implicit models of how agency occurs within routines. For instance, Feldman (2000) refers to agents 'repairing', 'striving' and 'expanding' depending on the outcome of the routine. Interestingly, Feldman (2000) describes the engine that drives routine change as learning, and particularly double loop learning (Argyris and Schon, 1978), however the details of this process occurring within the routine are never discussed. Furthermore, research indicates that how people act is shaped by how the routine is embedded in an agent's wider organisational understanding about what is a legitimate course of action within such a setting (Feldman and Rafaeli, 2002; Pentland and Rueter, 1994). This wider organisational understanding has meant that routines are not always performed according to Management's expectation (Feldman, 2003). For instance, agents have purposefully frustrated change within routines if they perceive a new routine as a threat to their organisational understanding of how work should be conducted (Lazaric and Denis,

2005). Research has shown that it is difficult to execute a routine according to an exact specification when people hold different expectations and understandings of that routine (Pentland and Feldman, 2008; Turner and Rindova, 2012). Although the role of agency has been stated as critical within routines, the empirical evidence shows mixed results on how it affects routine performance. Routine actors can either change the routine via reflective learning, or create stability in the routine despite a requirement to change (Feldman, 2003).

3.3.3 The role of organisational understanding in routine behaviour

Scholars have argued, and empirically shown that the way in which an organisation is perceived by the employees affects routine behaviour (Feldman and Pentland, 2003). This has been labelled as how the routine is 'embedded' either within the organisation as a whole, or within socially similar groups (D'Adderio, 2009). For instance, these groups may share a common identity forged around work practices labelled 'communities of practice' (Brown and Duguid, 1991). Authors which stress organisational understanding as a factor in routine performance claim that it is not just the immediate task of the routine which determines its behaviour, but how the routine's contents sits within the holistic web of routines that entail some sort of organisational purpose as to why the routine is important (Feldman and Rafaeli, 2002). This legitimates action and provides actors with a normativity about what actions are sanctioned or appropriate (Bourdieu, 1990). Embedded understanding of the routines also controls who is involved in them, and the connections that each routine has with the wider organisation (Feldman and Rafaeli, 2002). Controlling who interacts within and adjacent to the routine, it is argued, sends messages to organisational members about how important such a routine is to the organisation (Westley 1990). As such, who is in the routine and who the routine is connected to within the organisation is related to aspects of power and identity, and ultimately routine performance (Feldman, 2003).

3.3.4 The role of artefacts in routine behaviour

The term 'artefacts' has been used to denote any physical material utilised within the routine (D'Adderio, 2011). Artefacts include standard operating procedures, prototypes, posters on walls, written communication, computer program interfaces (D'Adderio, 2011; Parmigiani and Howard-Grenville, 2011). Despite some recent publications (c.f. Cohen, 2007; D'Adderio, 2011; D'Adderio, 2008, 2009; Pentland and Feldman, 2005, 2008; Schulz

2008)), the role of artefacts in routines is much under-researched, with D'Adderio (2011); Pentland and Feldman (2008) calling for increased research activity in this area.

Extant research has shown that artefacts play a complicated role since they may occupy different aspects of the routine simultaneously (Miner et al., 2001; Pentland and Feldman, 2005). For instance, a standard operating procedure might be an ostensive part of the routine, yet it could also be central in the performative aspect of the routine (Pentland and Feldman, 2005). Scholarship has argued that artefacts have become central to many routines, for instance, research has shown that artefacts can perform between 11%-85% of routine work (Orlikowski and Scott, 2008). Artefacts can embody the physical traces of routine once the routine has been performed, as well as be the outcome of the routine (Lee and Amjadi, 2014). D'Adderio (2003) has highlighted how artefacts can have negative consequences on routine performance. The reason being is that artefacts can encode behavioural responses so much so that they become unquestioned and automatic (D'Adderio, 2003), so that behaviour becomes locked in and the routine effectively becomes fixed or 'dead' (Pentland and Feldman, 2008). Artefacts within routines may also control who participates, and prioritise certain individuals' claims within a routine over others, affecting what understanding are brought to bear in routine enactment (Cacciatori, 2008; Kaplan, 2011). Hence artefacts may stimulate some courses of actions over others (Cacciatori, 2012; D'Adderio, 2003). Furthermore, artefacts within routines can help cross knowledge communities, where communication and understanding can prove difficult, whether this be due to language use or differing expectations as to what environmental signals mean (Leonard-Barton, 1992). This is done via coordination and understanding across different knowledge communities (Lee and Amjadi, 2014). These artefacts have been labelled 'boundary spanning objects', and provide mutual points of understanding between these different communities (Bechky, 2003; Carlile, 2002; Hargadon and Bechky, 2006). Predominantly research has focused on the role boundary spanning objects play between routines, and not within routines (Cacciatori, 2012; Ewenstein and Whyte, 2009).

While such examples show how artefacts can have a large impact on routine performance, other research suggests that sometimes these artefacts do not seem to affect routine behaviour. For instance, Hales and Tidd (2009) shows that the encoding of design routine in a software wizard led to it being completely ignored. This points to other factors that influence routine performance (Parmigiani and Howard-Grenville, 2011). As such, there is general agreement that objects have multifaceted roles within organisations (Engeström and

Blackler, 2005; Nicolini et al., 2012), yet there needs to be greater understanding for the exact features of artefacts which affect behaviours (Nicolini et al., 2012).

As Cacciatori (2012) states, although there has been some research on artefacts within routines, the research is nascent when focusing on the actual *features* of an artefact which influence behaviour. The routine literature has focused on how artefacts have been used within routines (D'Adderio, 2008; Howard-Grenville, 2005; Pentland and Rueter, 1994; Rerup and Feldman, 2011; Salvato, 2009; Turner and Fern, 2012), yet there is no framework, or understanding, as to how the actual properties of those artefacts affect routine performance. There is, however, a vast and complex literature on how artefacts affect individual action, that lies outside the research carried out in routine theory. Disciplines such as Science and Technology studies (Pickering, 1992) and human computer interaction (Suchman, 2005), have explained the role of artefacts under various theories. For instance, these include: Boundary spanning objects (Carlile, 2004), epistemic objects (Ewenstein and Whyte, 2009), and Affordancy Theory (Gibson, 1977). To investigate each theory is beyond the scope of this research. However, they are predicated on two competing views of human behaviour. The first, using a cognitive model, states that artefacts provide a template which programs participants to act according to that template (Cohen and Bacdayan, 1994). Variance in performance is determined by variance in cognitive assumptions of the participants, resulting in different interpretations of what the artefact means (D'Adderio, 2011). The second explanatory model draws more on phenomenology, and is researched principally under the concept of sociomateriality (Orlikowski, 2007; Suchman, 2005). Sociomateriality utilises an understanding of human experience as 'embodied' (Merlau-Ponty, 1962), and a 'knowing in action' that is suffused with materiality (Ingold, 2000; Suchman, 1987, 2005). Such an understanding blurs the line between material and non-material objects… "*to signal this ontological fusion. Any distinction of humans and technologies is analytical only, and done with the recognition that these entities necessarily entail each other in practice*" (Orlikowski and Scott, 2008: 456). Barad (2014) uses the metaphor of 'entanglement' to describe this relationship between human and artificial action.

In conclusion, the major interest of this study is in the performative aspect of routines, that is, how routines are actually carried out (Pentland and Feldman, 2005). By identifying lean NPD with practice-based routine theory will situate lean NPD within routines, and so provide a mechanism that determine how lean NPD affects routines. As the discussion on practice-based routines has shown above, the way artefacts and actors affect routine

performance is under-researched (D'Adderio, 2011). Interestingly, there is a growing interest in how micro processes of routines are enacted, and cumulatively contribute to macro—organisational phenomenon (c.f. Balogun et al. (2015)). As such, studying the mechanisms of routine behaviours through lean NPD may provide a fertile perspective that contributes to practice-based routine theory more generally. However, for this research, the focus is on a particular way lean NPD affects routine behaviours, specifically whether in fact they do result in reflective learning. To integrate lean NPD into practice based routine theory, the practices of lean NPD are considered in light of these four features of the routine, where it can be determined what parts of the routine lean NPD embodies.

3.4 Identifying lean NPD with practice-based routines

This section synthesises the findings of chapter two, from the systematic literature review of the lean NPD phenomenon, with the four factors discussed in **section 3.3** that affect practice-based routine behaviours. Firstly, however, the major practices of lean NPD need to be identified before it can be argued which endogenous routine factors each embody. **Table 3.1** identifies practices found within each of the major themes generated in chapter two, that are integral to lean NPD. Practices can be defined as the specific and discrete activities (sometimes described as tools (c.f. Morgan and Liker (2006)) that lean NPD utilises. For instance, while 'common parts strategy' is a theme from chapter two, the actual practices through which lean NPD achieves this phenomenon include check-sheets, Oobeya rooms, and cross functional teams. The practices for each theme is identified in **Table 3.1** and are generated by reviewing the literature included in the metasynthesis for the major practices related to each one.

Table 3.1: Identifying lean practices contained within the metasynthesis of chapter two

Themes from the metasynthesis chapter 2	Practices found within each theme
1. The identity of Lean NPD companies	Non-applicable
2. Common parts strategy	Check-sheets, Oobeya rooms, cross functional teams.
3. Design for manufacture	Check-sheets, Chief Engineer, cross functional teams, SBCE, lessoned learned books, Oobeya rooms,
4. Relationship to innovation / technology	Chief engineer, cross functional teams, check-sheets, SBCE, experimentation
5. The Chief Engineer	Chief engineer
6. The role of the supplier in Lean NPD	Trade-off curves, targets, supplier guest engineer
7. Front loading in Lean NPD	SBCE, Oobeya rooms, check-sheets, lessoned learned books, prototypes, cross functional teams, targets, trade-off curves
8. Set based concurrent engineering / concurrent engineering	Oobeya rooms, check-sheets, lessoned learned books, prototypes, cross functional teams, targets, trade-off curves
9. The role of communication	A3 reports, Oobeya rooms, face to face meetings, Chief engineer, prototyping
10. Practices related to information structure and type	A3 reports, Oobeya rooms, Chief engineer, prototyping, experiments, direct apprehension of the problem

Condensing the practices from the table above, results in the left-hand column of **Table 3.2.** **Table 3.2** shows these eleven major practices, and the corresponding factor of the routine they embody. Each identification of a practice with a routine factor will now be argued for.

Table 3.2: Identifying how the major practice from **Table 3.1**, correspond to routine factors which they embody

Major practice found within lean NPD	Factor of the routine they embody
Chief engineer	Actor
Cross-functional teams	Actor
Supplier guest engineer	Actor
A3 report	Artefact
Trade-off curves	Artefact
Prototyping	Artefact
Lessoned learned book	Artefact
Set Based Concurrent Engineering (SBCE)	Artefact
Check-sheets	Artefact
Oobeya room	Artefact

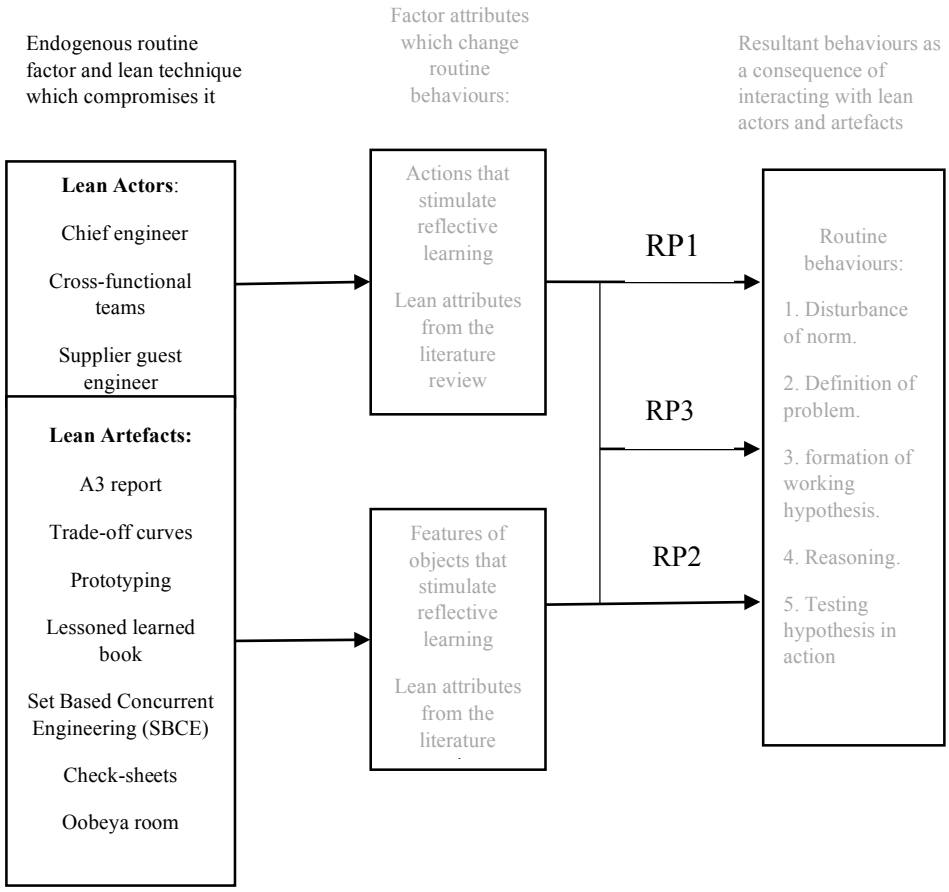
An actor would be a specific person or persons which lean NPD uses in a determinate way within lean NPD. Of this characterisation there are three practices which are based on specialised actors, the chief engineer, cross functional teams, and a supplier guest engineer. Conversely, an artefact is a physical inanimate object, generally used in a representational capacity. Within lean NPD A3 reports, lessoned learned books, trade-off curves, check sheets, and prototypes clearly meet this criterion. Also SBCE uses artefacts during concurrent engineering. They are utilized to convey possible designs to multiple actors (Ward et al., 1995). However, such an identification as the main aspect of routine performance is difficult to ascertain. Although artefacts are necessary in such a technique, wider organisational understanding may play a key part. That said, without the use of artefacts as a controlling and communication mechanism within this understanding, such a process would be extremely difficult to maintain. As such these processes can be identified as utilising artefacts to alter routine performance. The classification of Oobeya rooms could also be seen as problematic. Yet, Oobeya rooms are constituted by an array of artefacts placed on the walls of the Oobeya. The physical arrangement of these artefacts also shapes the routine since the routine is enacted in the sequential order of the artefacts on the wall. As such, this technique can be best described as an artefact, even though it is a tool to amalgamate smaller artefacts in a sequential manner.

3.4.1 Conclusion

The identification of lean NPD techniques above, with aspects of routine factors demonstrates that, on the whole, lean NPD techniques can be identified as embodying the

parts of routines labelled artefacts or actors. This identification is of course simplistic. While the factors that affect routine performance have been analytically separated, in practice, this may not be the case. For instance, artefacts may play various roles at once across the routine, incorporating both performative and ostensive aspects (Pentland and Feldman, 2005). Moreover, the use of agency must be instrumental in all routine actions, if routines are indeed "*effortful accomplishments*" (Pentland and Rueter, 1994:488). However, what the above identification has done is highlight the most salient features of lean NPD practices, and how they fit into factors that affect practice-based routine behaviour. That is, lean NPD individuates itself within routines by its unique use of actors and artefacts. As such, from now on, the research will refer to lean NPD techniques as either utilising lean actors or lean artefacts as the major determinants of how they affect routine behaviour. The conclusion from this section is populating of the first left hand columns in **Figure 3.2** within the framework highlighted in **figure 3.2.2**.

Figure 3.2.2: Highlighted area depicts the area this section has argued for, that lean practices can either be identified with actors or artefact which constitute a routine's internal dynamic



3.5 Possible attributes of lean actors and artefacts

Insights from reflective learning theory are combined with those from the metasynthesis review to formulate how lean actors and artefacts attributes could result in reflective behaviours. It may be conjectured that theory should be used from research previously done on how particular features of routine actors and artefacts lead to specific behaviours. For instance, those mentioned in the 'artefacts' section above, such as boundary spanning objects, epistemic objects, affordance theory, may provide understanding as to how particular features of lean artefacts could result in reflective behaviours. However, this literature streams is not utilised for the three following reasons: Firstly, the majority of this literature is directed at the use of artefact between routines, while the focus of this study is within routines (Ewenstein and Whyte, 2009). Secondly, as stated, these theoretical mechanisms all are deeply based on a particular philosophical position, consequently the literature base is diverse (Cacciatori, 2008). Furthermore, such literature has had little impact within routine theory, as such it is still in its infancy (Seidel and O'Mahony, 2014). Thirdly, they do not relate these theories to OM techniques such as lean NPD.

Given these issues, insights from reflective theory will be utilised. Although the language of 'artefacts' and 'actors' is alien to this theoretical perspective, it does provide details as to how features of actions (actors), and features of objects (artefacts) can enable reflective learning. Particularly, the antecedents to reflection discussed, such as the 'willingness' and 'capability' to reflect, seem apposite for determining attributes of lean NPD actors and artefacts which lead to reflective learning. Furthermore, the literature in this area is relatively stable and consistent about the character of reflective learning, and features which affect it. Lastly, since the research is focused in trying to determine reflective behaviours within routines, it makes sense to use reflective theory as a literature base, since it's primary concern is learning, rather than the more general issue of how artefacts and actors affect behaviour.

Data from the metasynthesis in chapter two is important in proposing a mechanism since previous descriptions of lean NPD detail specific characteristics of lean NPD actors and artefacts. By producing a mechanism that is consistent with these historical descriptions increases the likelihood that such a mechanism is capturing the essential features of lean NPD.

Table 3.3: How the lean NPD literature associates particular attributes with lean actors and artefacts

Lean NPD routine factors	Attributes associated with the lean NPD factor found within the literature
Lean Actors	Excellent communicators across all functions (Clark and Fujimoto, 1991), diffuse conflict situations, demand to reconceptualise problems, focus certain 'atheoretical' data, brings together differing view-points, not just focused on results but demands people to follow a process as to how they achieved a particular result (Morgan, 2002; Tanaka, 2011), requires information to be structured in a specific way.
Lean Artefacts	The conclusion of the metasynthesis from chapter two was that lean NPD favoured a certain information structure and type. Although, this preference was expressed by lean actors such as the chief engineer, it was within artefacts that the information was collected and displayed. Thus, a key attribute of these artefacts appears to be they type of information contained in them, and the way it is structured.

It could be argued that these behaviours which lean actors engender stated in **Table 3.3**, and specifically the chief engineer, correspond to what Jordan (2010) referred to as willingness to engage in reflection-in-action. Key behaviours for this dimension which enables reflective behaviours are a 'passionate humility', a recognition of multiple truths, and the ability to hear multiple view-points. The behaviours associated with lean actors appears to fit these criteria. For instance, as **Table 3.3** shows, they try to hear multiple view-points (multiple-view-points (Yanow and Tsoukas, 2009)) they ensure data is collected that is based on actual events, rather than their own understandings on what they think should be occuring (a passionate humility (Contu and Willmott, 2003)) they understand inputs from all different functions (a recognition of multiple truths (Schön, 1987)). Furthermore, this correspondence between description of lean actor's behaviours and a willingness to reflect obtains if the criteria from Yanow and Tsoukas, (2009) are included too. Lean actors seek alternative explanations other than the most expedient to hand, as in their focus on the process of information collection (Liker, 2004). They open up epistemological through the bringing together of multiple view-points, as they coordinate cross functional activities (Sobek, 1997). Lean actors are described as being receptive to new ideas irrespective of where the idea comes from (Liker, 2004), for instance, the concept of 'jidoka' (stopping as soon as there is a problem) came from a sewing loom (Spear, 2010). Furthermore, they communicate the logic through which they see the situation in a transparent way, which is open to

questions (Clark and Fujimoto, 1991). Stories of chief engineers spending time with young couples living the 'Rav 4 lifestyle' show how they pay attention to the situation surrounding them, and allow themselves to be surprised via a sensitivity to events, and hear new ideas (Liker, 2004).

On the other hand, it may be conjectured that lean actors increase the dimension of a 'capability' to engage in reflection-in-action too. For instance, activities such as 'questioning and informing', that are part of the definition of a capability to engage in reflection, may be present in how the Chief engineer questions people within the Oobeya room. Furthermore, guest engineers may provide more 'backtalk' about their own company's part within the organisation which is hosting them. However, there is a real lack of experimentation based solely on the activities of the lean actors. Neither a Chief engineer, a guest engineer, or a cross functional team, could engage in experiments without the aid of any artefacts. Moreover, backtalk is normally associated with a conversation with materials, rather than between people (Koschmann et al., 1998). Thus, it appears more cogent to state that lean actors engender a 'willingness' to engage in reflective behaviours rather than a 'capability'. As such, it is proposed that an attribute of a lean actor which could result in reflective behaviours, is how they promote a willingness to reflect within routines, producing the first research proposition:

RP1: *Interaction with lean actors increases the 'willingness' of people to engage in reflective behaviours within routines.*

Information type and structure are key attributes of lean NPD artefacts found within the literature review as **Table 3.3** shows. These attributes possibly correspond to the concept of 'virtual worlds' in reflective theory. That is, they provide a representation of the real world where participants can explore and engage in 'frame experiments' without having to engage in the cost of actually doing these actions for real Schön (1987). It appears that by having a high empirical context (information type), they have the ability to more fully represent the world, thus increase the amount of backtalk such artefacts can have, making them 'fully transactional' (Jordan et al., 2009). While the issue of information structure does not play a role within concept of virtual worlds, it could be plausibly suggested that such formats help users experiment via the orderly representation of information, reducing search costs. It could be argued that these artefacts, which contain varying logic and multiple truths also increase the willingness to engage in reflective behaviours. However, their main feature

demonstrated by the metasynthesis is based on information structure and type. As such, this leads to the second research proposition as to how artefact engender reflective behaviours:

RP2: *Interaction with lean artefacts increase the 'capability' of people to engage in reflective behaviours within routines*.

Lean NPD is described as using both artefacts and actors simultaneously. For instance, the chief engineer acts within the Oobeya, and constructs A3 reports with other participants. Based on the above logics lean actors and artefacts should combine within routines, which gives the third research proposition:

RP3: *Interaction with lean artefacts combined with lean actors increases the 'willingness' and 'capability' of people to engage in reflective behaviours within routines.*

These research propositions express the proposed attributes which lead to reflective behaviours, and can be seen pertaining from the central column of **Figure 3.2**. The research proposition detail potential mechanisms in the overall framework which can be tested in the remainder of the thesis. It should be noted that the research proposition deal with lean actors and artefacts at a *generic* level. The reason being is that the theory is not developed enough to determine specific features of actors or artefacts which result in specific behaviours, hence they can only be ascribed to actors and artefact in abstraction. While the research propositions express a mechanism as to how lean NPD might result in reflective behaviours, there is a more central problem of whether lean NPD does actual result in reflection. As such the main research question of this research is:

RQ1: Does the interaction between lean NPD practices and people within organisational routines lead to reflective learning behaviours?

These propositions and the research question are expressed in the framework of **Figure 3.2**. The framework can be tested to determine how lean NPD leads to reflective behaviours (RP1, RP2, and RP3), and whether in fact it does result in reflective behaviours (RQ1).

3.5.1 Conclusion

This chapter utilised new innovations within the business management literature to explore how behaviours in routines occur, and how to study learning at the micro-level. Using these innovations, a framework was constructed which detailed a mechanism as to how lean NPD might positively affect learning behaviours within routines. Such a mechanism incorporated the following features:

1) Utilise a practice-based conception of routines that incorporates the features of routine dynamics found within this literature, which details *how* routines work.

2) A measure of learning at the micro-level.

It was argued that learning at the micro-level needed to be conceived in the form of reflective behaviours as identified by Dewey (1910). Then, using the practice-based routine literature, four factors were identified and described that affect internal routine dynamics (Parmigiani and Howard-Grenville, 2011). Using the findings of chapter two, lean NPD techniques were identified with two of these factors; actors and artefacts. However, within the routines literature, recent articles have stated that it is not enough merely to state aspects of routines which affect behaviours, the actual attributes of these factors need to be understood (Cacciatori, 2012; Nicolini et al., 2012). As such, it was argued for two potential attributes of lean NPD actors and artefacts which resulted in reflective learning: lean NPD actors increase the willingness of individuals to engage in reflective behaviours. While lean NPD artefacts increase the capability of individuals to engage in reflective behaviours. This results in the framework of **Figure 3.2**. from which three research propositions were derived that refer to a possible mechanism as to how lean NPD may engender reflective behaviours. Moreover, a research question was generated which sought to determine if there is an overall relationship between lean NPD and reflective learning.

Given the framework of **Figure 3.2** the next chapter argues for the kinds of data and appropriate methods needed to test it. Utilising a strong practice-based perspective it will be argued that practices need to be identified that link, in real time, how lean actors and artefacts affect routine participant's practices during their interactions. Moreover, it states that to understand these practices, we need to use an ethnomethodological perspective, so that we can determine what they mean from an insider's view point (Rawls, 2008). These practices can then be compared and contrasted to Dewey's (1925) description of reflective learning, so answering the research propositions and question.

Chapter Four: Research Methodology

Chapter overview

This chapter has three main sections: a discussion on research design, a description of data collection, and a discussion on design quality. Cumulatively these sections argue for the kind of data which is appropriate to answer the research questions, the methods needed to acquire the data and how it was actually achieved. Furthermore, through a consideration of the topic of quality, it is argued that the design, methods, data, and analysis, were conducted to ensure robust and reliable answers to the research propositions and question.

To establish if reflective learning occurred around lean actors and artefacts, a single in-depth case study was used to research the practice of micro-behaviours within routines, in the context of an NPD project (Balogun et al., 2015; Hindmarsh and Pilnick, 2007; Samra-Fredericks, 2003). Single cases have been the predominate research method within lean NPD scholarship (Morgan, 2002; Sobek et al., 1999), as well as a currently dominant approach within the operations management literature (Ketokivi and Choi, 2014). Hence, the case was an illustrative case (Yin, 2008). The case was a small European robotics firm, which had been using lean NPD since 2008. Within the case three main routines were encountered; those that created lean artefacts, those that used lean actors and artefacts, and those that did not use any lean techniques. To study the micro-behaviours within these routines, ethnomethodology was used as a basis (Rawls, 2008), augmented by the analysis of interaction and shadowing (Czarniawska, 2014). These methods were used to establish *how* behaviour changed in response to lean techniques. Behavioural interactions could then be compared and contrasted with the behaviours which constitute reflective learning, and so answer the research propositions and question.

A case method was chosen since ultimately it fitted the duality criteria proposed by Ketokivi and Choi (2014). This criteria states that a case study is needed when the questions require the research to be 'situationally grounded', but also seeking a 'sense of generality'. For this research, situational understanding had to be garnered of how participants behaved within routines, in response to lean NPD. The answer to the questions also have a sense of generality, in that they contribute to theories of how endogenous routine change occurs in

response to OM techniques. Specifically, a mechanism will be revealed about how OM techniques function at a micro-level.

Although this research fits within these new criteria within OM for what warrants a case method, there are some significant modifications from the techniques prescribed by Ketokivi and Choi (2014). This is due to the fact that the data, and so methods which are used to become 'situationally grounded', to determine what behaviours are occurring within routines, differs from traditional OM methods. This research, uniquely for OM, takes a practice-based perspective (Gherardi, 2009a). Taking inspiration from articles that call for radical innovations in research methodology within OM (c.f. Fynes et al. (2015); MacCarthy et al. (2013); Singhal and Singhal (2012a, b)), and subsequent articles which have taken up this call under different topics (Marshall et al., 2016), this research utilises an understanding of situationally grounded imported from other disciplines such as organisational theory, called the practice-based perspective. This perspective will now be briefly discussed to provide context for the method discussion.

Within other management disciplines there has been a distinction within research concerning that which focuses on 'structure' as opposed to 'practice' (Whittington, 2006). These two views entail fundamentally different theoretical underpinnings, and subsequent methodologies (Tsoukas and Chia, 2002). A 'structural' view takes descriptions of an organisations as referring to an abstract property which that organisation has e.g. resources, capabilities, and functions. The organisation is generally conceived as a homogenous unit, rationally constructed, and stable. Furthermore, the details of the activity of what people do on a day to day basis are largely ignored. Exemplars of research in this tradition include, Barney (1991); Porter (1996); Williamson (1998). The assumptions underpinning this structural view have generally informed the OM field (Singhal and Singhal, 2012b). The practice-based perspective on the other hand, most forcibly stated by Gherardi (2012b); Nicolini (2012); Schatzki et al. (2001), and Feldman and Orlikowski (2011) assert that descriptions are not abstract properties of organisations, but based on what people do in-action. As such, this view focuses on what people do which makes up an organisation's day-to-day activity. Thus, unlike the structured view, organisations are heterogeneous, constantly changing, and in a constant state of 'becoming' (Tsoukas and Chia, 2002). Such a view is emphasised by the application of the gerund (-*ing*), which is added to organis*ing (Corradi et al., 2010)*, or know*ing* (Orlikowski, 2006); pointing to the constant activity that individuals engage in which constitute organisations.

The purpose and aims of this research can be viewed as emanating from the logic of a practice-based perspective. Significantly, the practice-based perspective is missing from the OM literature. This is surprising, since OM's focus on process efficiency and effectiveness, should result in a central concern with what individuals are doing within these processes (Marshall et al., 2016). This research explicitly takes a practice-based perspective, which is an original contribution to the OM field. Furthermore, uniquely for the OM field this research utilises ethnomethodology with the case method, and specifically shadowing and the study of interaction. Fundamentally, mirroring other management disciplines influenced by this perspective (c.f. (Orlikowski, 2002; Whittington, 2003), the essence of the research question and propositions emphasise how lean NPD affect one's everyday organis*ing,* a perspective which has been missing from the OM field (Marshall et al., 2016).

The next section focuses on the research design, with a discussion of the variables which led to the choice of methods. These will be considered in the light of the research question and propositions:

RQ1: Does the interaction between lean NPD practices and people within organisational routines lead to reflective learning behaviours?

RP1: *Interaction with lean actors increases the 'willingness' of people to engage in reflective behaviours within routines.*

RP2: *Interaction with lean artefacts increase the 'capability' of people to engage in reflective behaviours within routines*.

RP3: *Interaction with lean artefacts combined with lean actors increases the 'willingness' and 'capability' of people to engage in reflective behaviours within routines.*

4.1 Research Design

This section's main focus is in developing the logic which determines what sources of data and corresponding methods will answer the research question; that is it explains the research design (Yin, 2008). Building on the discussion in the introduction, this section will argue for the philosophical position that underpins the practice-based perspective, and subsequently

how this affects the approach, strategy, and methods utilised. Furthermore, the research design is considered in relation to contemporary discussion occurring within the OM field based upon research objectives, and their relationship to theory (c.f. Ketokivi and Choi (2014)).

4.1.1 Research Philosophy

Traditionally, the broad question of research philosophy has been typically expressed in terms of questions regarding ontology, ('What sorts of entities is reality constituted of?') and epistemology, (How do we know such entities?). These questions are pertinent to research design since the answers will determine what objects our theories refer to (ontology), and what sort of evidence gives us access to these objects (epistemology). As Sartre (1956 xxvi) eloquently states *"If every metaphysics (read ontology) in fact presupposes a theory of knowledge every theory of knowledge in turn presupposes a metaphysics"*; that is, the concepts are logically connected. Within the Social Sciences the relationship between these two concepts is often represented along a spectrum with a realist ontology and positivist epistemology at one end, and an anti-realist and interpretivist epistemology at the other, for example Cunliffe (2011 : 8). Some scholars take a more relaxed stance regarding the exclusivity of different philosophical positions. They argue for inclusivity and an acceptance of different philosophical view-points, no matter how incommensurable they appear to be (Symon and Cassell, 2012). This is done in order to, potentially, create a richer picture of reality, and the approach is termed a multi-paradigmatic perspective on theory building (Gioia and Pitre, 1990).

A practice-based perspective takes a particular standpoint on the questions of epistemology and ontology, based on the ideas that constitute it. Nicolini (2012) provides a historical narrative outlining the ideas that inform the practice-based perspective. He states that authors such as Heidegger (1962); Merlau-Ponty (1962); Schutz (1967); Wittgenstein (1953), Dewey (1988), and Nietzsche (1927), have had a major impact on the ideas that found a practice-based perspective (Schatzki et al., 2001). To this he adds the influence of social theorists such as Giddens (1979), Bourdieu (1978), Latour (1987), and Garfinkel (1967). Scholars such as Schatzki et al. (2001) have endeavoured to synthesise these various influences under the banner of 'practice theory'. An understanding of what a practice-based perspective entails has gained more interest recently as evidenced by the work of authors such as Nicolini (2012), Corradi et al. (2010), Miettinen et al. (2009) and Gherardi (2012b).

The following sections will argue for a particular reading of the practice-based perspective. To do this I will draw on the social and philosophical theories which inform the practice based perspective as well as the more recent interpretations of 'practice theory'. This interpretation will be made clear during the following discussion of the epistemological and ontological exposition of practice theory.

Epistemologically, a practice-based perspective entails a reversal in epistemic priorities relative to traditional scholarship (Suchman, 1987). That is, practice scholars argue that looking at what people say and do in everyday situations reveals social reality, rather than any theoretical preconceptions about how the world is constructed (Garfinkel, 1967). They focus on detailed human interaction, which traditional perspectives had either assumed or ignored, to reveal the mechanisms through which people organise themselves (Gherardi, 2012b). In contrast, traditional theory often focuses on words that it assumes are referring to deep structures or properties. With this rejection of a deeper structure occurring behind reality, practice theory is anti-essentialist (Nicolini, 2012). Practice-based studies argue that before we have our 'theoretical' understanding of the world, the world is intelligible to us, we can interact with it in meaningful ways. Therefore, we need to examine how we engage intelligibly in the world, in everyday situations, to reveal how we know and use concepts, rather than to take on theoretical view of the world of what is 'really' occurring. For instance, if we ask the question what is knowledge, traditional theory will form an abstract 'ideal' or 'essence' of what 'knowledge' looks like, and then what sort of things will denote knowledge; this could be, justified true belief, or some correspondence to a state of affairs (Kirkham, 1992). While practice-based studies may not disagree with these theoretical definitions, its proponents would argue that we need to look at how people use the concept of knowledge in their normal, everyday, 'pre-theoretical' usage of the term, to reveal truths about the concept (Brown and Duguid, 1991; Orr, 1996). For instance, this may reveal that we use knowledge on occasions where there is possibility of doubt (Wittgenstein, 1974), when we know how "to go on" (Wittgenstein, 1953), and knowledge may refer to colloquially accepted acts of expertise, like story-telling (Orr, 1996). For practice based scholars the true way to understand concepts is through their naturalistic settings in practice. It argues that traditional theory generally assumes concepts refer to some ideal object, mental or physical, and then constructs means to test these ideal theories. These assumptions of the ideal, practice scholars argue, automatically distort the meaning of the concepts (Shotter, 2012).

Rouse (2001) notes two usages of the term 'practice' which lead to differing ontological groundings. The first is where scholars use the term 'practice' instrumentally. This corresponds to an epistemological understanding of practice, through which theoretical entities can be understood. Here, a focus on practices become the means to understand some deeper process going on *behind* practice. The second term is where practice is conceived of in a normative sense. This is where concepts are expressed in and through practice, hence a flat ontology; what exists is only present in the manifestations of practice. For instance, instrumental views of practice would argue that to understand psychological concepts we need to posit cognitive processes going on *behind* practice. Conversely, a normative view would argue that aspects going on behind practice do not play a role in our understanding of them; feelings, emotions, and desires are all expressed in and through practices (Rouse, 2007). In this sense practice-based theory is anti-foundationalist, there is nothing metaphysical that experience depends upon (Nicolini, 2012). This does not mean that 'normative' practice-based theorists deny the occurrence of cognitive processes, just that to understand the concepts we do not need to posit these theories. A normative reading therefore rejects dualism: everything is displayed in practice (Nicolini et al., 2003). Moreover, since practices occur in time, this view is consistent with a process view of the world where events are in a state of unfolding, or becoming (Tsoukas and Chia, 2002). Hence, scholars which utilise this view talk of ascribing concepts to people only on the basis of their being displayed in practice on an ongoing basis (Orlikowski, 2002). Significantly, other theories which utilise a 'process view', use an instrumental view of practice. For instance, Weick et al. (2005) uses an idea of 'cognitive rules' to underpin the mechanisms going on behind practice. Following the argument above, such a view is inconsistent with the very notion of practice, since behaviour gets it's meaning from the 'cognitive rules' rather than the behaviours in context. Given the contradiction present in the instrumental view of practice, in that it seeks to use practice but then utilises explanations 'behind' those practices, this research will use a normative reading of practice, as it is more consistent with the philosophical theories that inform it (Nicolini, 2012). Such a reading expresses the key tenets of a practice-based view; a rejection of dualism, and a flat ontology, where practices go 'all the way down' (Gherardi, 2012b).

Accepting a normative understanding of practice means that to comprehend what practices are we need to recognise what they mean for the people doing the practice, that is, from the perspective of people inside the practice (Gherardi, 2012b). This concern for understanding practices from 'the inside' is most prevalent in the social theory of ethnomethodology

(Rawls, 2008). Pioneered by Garfinkel (1967), ethnomethodology's focus is to elucidate the indigenous methods of how a group create ordered social reality (Sharrock and Randall, 2004). As Samra-Fredericks (2010 :2148) states, "*Ethnomethodology's distinctive focal analytical interest is in explicating the methods and reasoning procedures or inferential practices for accomplishing a social–moral order*". As such, this thesis will take a distinctively ethnomethodological reading of the practice-based perspective (Nicolini, 2012). Furthermore, consistent with ethnomethodology, a normative conception entails that all aspects of organisational phenomenon are expressed within and through practices. In Nicolini's (2012) terms, this is a 'strong programme' of practice, where we do not just describe what people are doing in an a 'theoretical way' but accept that practices are, *"... are fundamental to the production, reproduction, and transformation of social and organizational matters"* (Nicolini, 2012: 14).

Some authors have argued that a practice-based perspective lends itself to social constructivism on the one hand (Schatzki et al., 2001), and realism on the other (Nicolini, 2012). Social constructivism states that concepts are socially defined largely irrespective of any external reality, whereas realism argues that there is a mind independent reality 'out there' (Bird, 2006). There are two arguments that reject these positions from a practice-based perspective. Firstly, realism is rejected because to determine if there is a reality behind social practices one would have to come to grips with the external world, which by definition would require an understanding of an essentially external reality. Here, we would have to posit a reality behind practice, breaking the premise of the normative understanding (Dreyfus, 2001). Social constructivism is rejected since to conflate all reality to our concepts again would require an understanding of an essentially external reality (in order to make such a claim), again breaking the premise of the practice-based perspective (Dreyfus, 2001). Thus, the debate between what is and is not really real is undercut. This has led scholars to argue that practice-based perspectives are "post epistemological" (Gherardi, 2012b : 3). Moreover, these questions on the nature of reality only become problematic in very unique circumstances – generally, when we are doing philosophy or particle physics (Barad, 2014). It is argued that by taking words or concepts and extracting them from their normal contexts, where they are unproblematic, and then placing them in an unusual context, generates these philosophical problems (McGinn, 1997). Thus, by understanding the correct context or application of the word, questions concerning reality dissolve, they are in a sense 'pseudo questions' (McGinn, 1997).

Practice-based studies, through the observation of practice, highlight some key aspects of human nature. Firstly, when action is functioning smoothly it is generally transparent to the individuals performing it, that is, they are unaware of their own activity (Hindmarsh and Pilnick, 2007; Nicolini, 2011). For instance, take the often cited example of Heidegger (1962) and his hammer. Heidegger states that he only becomes aware of a hammer in his hand once there is a malfunction or 'breakdown'; what once was invisible to him he then becomes aware of, because reality no longer functions as smoothly as it should. This fact of human nature clearly has important methodological consequences, since it questions the ability of people to report on practices that are functioning smoothly. Secondly, people rationalise action post hoc once they encounter a state of affairs they find pleasing, and use phrases to reorientate their past action with phrases such as 'all along . . .'(Fox, 2006; Garfinkel, 1967). Thirdly, language and actions get their meaning from their use in context, and hence are indexical (Orlikowski, 2007). This does not mean that content is redundant; rather content and context result in meanings. Fourthly, it is argued that a fact of practice is that it is generally mutually intelligible or understandable despite the fact that context, which determines meaning, is constantly changing (Suchman, 1987). That is, our understanding is based on a context that is constantly changing, but we somehow manage to produce rational intelligibility in our everyday actions. Lastly, in practice-based studies a full range of psychological concepts can be ascribed to human beings. Humans can be rational, irrational, optimising, or satisficing; but these psychological ascriptions can only be made if they are consistent with patterns of action understood from within the practice (Gherardi, 2012b).

Practice-based studies stress the embodied and physical aspect that produce practices (Gherardi, 2009a). They argue that action and practice is intimately linked with our physical bodies and our surroundings (Carlile and Langley, 2013). Materiality, our own, and the context in which we act, has a critical part to play in practice based studies (Feldman and Orlikowski, 2011). This is because our experience, or how we experience, is shaped by our own and others embodiment; we are not unattached, 'godlike' perceivers but a part of the world (Merlau-Ponty, 1962). Since practices take place in the material world, objects have a significant role to play, and are intrinsically linked to meaning, or, as Nicolini (2012:4) puts it, *"objects make practices durable, they bring in connections of others which in the past have created these objects, they fix practices in space and time"*. These objects once created, then generate new practices. For instance, a space rocket is a complicated amalgamation of practices, this then allows new activity: to go into space.

Given these concerns and priorities it is no surprise that practice based studies share a common set of methodologies. These include a unit of analysis that is based on behaviour, both verbal and non-verbal, indeed organisations are conceived as *"…a texture or a web of practices…"* (Gherardi, 2012b:2). Further, due to the fact that practices are indexical, liable to *post hoc* rationalisation, and transparent, practice based scholars seek to observe and record action as it happens (Nicolini, 2012). Thus, methodologies that are particularly prevalent include conversation / interaction analysis (Llewellyn, 2008), direct observation / ethnography, interviews of the double, ethnographic interviews, and shadowing (Czarniawska-Joerges, 2007). These methods are not just used to produce 'thick' descriptions but are used to reveal an aspect of the social world that would otherwise remain hidden, revealing very different aspects of organisational activity (Nicolini, 2012). For instance, these methods have been involved in work place studies to reveal how people actually interact with computers in their day to day activity, in such settings as the London underground, and air-traffic control rooms (Heath and Luff, 2000).

To reveal how lean actors and artefacts affect learning within routine dynamics during NPD this thesis will look at the practice of participants within the routine to determine what is occurring, that is individuals practices within routines are the unit of analysis. These practices may constitute concepts such as learning, which is a focus of the thesis. Taking the concept of Dewey's (1925) reflective learning cycle from chapter three, each stage can be determined through practice.

For instance, what it means to form a 'working hypothesis' can be identified through what people actually say and do. Although sometimes utilising differing philosophical basis, scholars working in reflective theory have previously identified reflection through practice, expressed in linguistic and non-linguistic behaviour (Argyris and Schon, 1978; Dewey, 1925; Dittrich et al., 2016; Elkjaer, 2004; Jordan, 2010; Miettinen, 2000; Schön, 1987). Additionally, under this view lean can be understood through practice; it will be expressed through what people say and do when engaged in 'lean work'. As stated, to determine what these practices are actually doing in the social setting we need a method to understand them from the inside. For instance, are the practices we are seeing from a member's point of view forming a working hypotheses or doing some aspect of lean NPD? To ensure that we are understanding practices from 'the inside' the thesis will utilise a reading of practice that draws predominately on ethnomethodology as its basis. Moreover, ethnomethodology is consistent with the central tenets of the practice-based perspective (Pleasants, 2002), and

sophisticated in terms of explicating 'members methods', which is what practices mean for those doing them (Rawls, 2008).

Returning to the OM field, practice-based studies potentially offer a theory to focus on practice, finding a middle way between a need to be theoretical *and* be relevant to practitioners (Fynes et al., 2015; MacCarthy et al., 2013). As Fynes et al., (2015) state, 'go and see' a lean practice, should play a bigger role in OM studies. The practice-based perspective provides a theoretical basis for the 'go and see' logic, in that it is a theory that rejects theorising (Rawls, 2008). The next sections discusses the research approach of the thesis, which denotes the overall principles that guided this research (Bryman, 2012). Following this, the thesis' research strategy and methods selection will be argued for, based in part on the philosophical position outlined above.

4.1.2 Research Approach

The research approach can be divided into two broad categories; that of deductive research, and that of inductive research (Alasuutari et al., 2008). Deductive research is often utilised with well-established theory, where empirical entailments of the theory are utilised to test the theory (Locke, 2007). Inductive research is generally used in theory building research, where a non-theorised empirical setting is utilised to generate categories that lead to theory generation (Eisenhardt, 1989). A third approach has also been suggested, labelled abduction (Rosenhead and Mingers, 2001). This is where observations are supplemented with a theory of best explanation to produce an inference (Bird, 2006). As such, abduction is related to induction yet explicitly relates inferences to theory (Blaikie, 2009). Given the research questions and propositions, and the determining of a 'micro mechanism', the thesis can be classed as an abductive approach. The thesis fits an abductive model due to two factors: Firstly, chapter three generated research propositions from theory derived from the literature, hence is theoretically informed. Secondly, in the form of the three research propositions, this theory drives the framework of the research. According to the abductive approach, inferences are made from the data as to how they 'best' relate to these theories during the analysis and discussion. In this study, data will be discussed in the light of Dewey's (1925) learning theory, understood from a practice-based perspective. That is, by looking at how people are behaving in response to lean NPD within routines, it will be determined whether they match the behaviours Dewey (1925) describes as reflective learning.

This abductive approach creates a tension with the practice-based study, and particular this ethnomethodological reading of it. The tension emanates from the fact that ethnomethodology's motivation is to provide an alternative to traditional social science (Rawls, 2008). Ethnomethodology argues that traditional theories force theoretical categories onto social situations without understanding the local rationalities of those social situation (Garfinkel, 1967). In essence, ethnomethodology's critiqued traditional social science for ignoring the social realities of the very subjects they were studying. This study *prima-facia* appears to fit a traditional social science method by trying to identify pre-defined categories (reflective learning) in social situations (development routines), contradicting the ethnomethodological basis of the study. This research mitigates these problems by using ethnomethodology's methods and analysis to generate analytic descriptions (chapter five). That is, first, an understanding of how organisational members locally organise their practices around lean NPD actors and artefacts will be determined, according to an ethnomethodological logic (see chapter five **Figures 5.2, 5.7, 5.9**). This understanding will then be compared with Dewey's (1925) concept of reflective learning, to identify if practices can be characterised as such; and if so, how do they actually 'do learning' in the presence of lean NPD. This approach avoids any ethnomethodological concerns about 'theoretical imperialism' of the data (Schegloff, 1997), whilst ensuring that the results will be theoretically interesting by relating them to wider theory (Nicolini, 2012).

4.1.3 Research Strategy

Research strategy has been broadly stratified into qualitative and quantitative categories by scholars such as Bryman (2012). This, Bryman (2012) argues, is determined by the ontological and epistemological basis of the research. However, this typification can be questioned due to the fact that no real definitions of qualitative versus quantitative research exist (Symon and Cassell, 2012). Further, the use of mixed methods suggests that this simple dichotomy may be wanting (Creswell, 2002). A more nuanced approach is to look at the overall strategies appropriate for the research (Saunders et al., 2011). Given the nature of practice, and the ethnomethodological stance this thesis adopts, a primary concern is that practices should be viewed in their naturalistic settings. This automatically means the rejection of strategies such as surveys, archival research, experiments, and action research. Pure ethnography fits the criteria of providing a naturalistic strategy. Ethnography consists of a method whereby the researcher spends an extended period of time researching a culture or a defined group of people (Hammersley and Atkinson, 2007). However, as a research

strategy ethnography looks at very general phenomena; groups and cultures. Also, ethnography does not try and understand practices 'from the inside', but interprets practices through theory, contravening the practice-based position of this study (Atkinson and Drew, 1979). Hence, this strategy was excluded due to the fact that the thesis has very specific concerns, to look at a single phenomenon; learning, within lean routines, and is used to theoretically determine data. Grounded theory could also be considered a naturalistic strategy (Glaser and Strauss, 1968). This consists of a researcher entering a research setting 'theory free', and through immersion in the research setting, deriving novel theory on the subject of study. However, grounded theory was rejected due to the prior theoretical interests of this thesis; it is interested in contexts. Also, this practice-based study needs to understand practices from a participant's perspective, and as such the aim of observations is not to be theory free as grounded theory advocates, but utilising 'members' methods' (Garfinkel, 2002). As Lynch (1984) states, in ethnomethodology, the researcher does not go into a research setting without consideration for the results of previous research, but with the 'analytic noticing's' of prior ethnomethodological research regarding how people achieved their work.

Returning to mores specific concerns from the OM field, this research appears to fit a criterion which Ketokivi and Choi (2014) refer to as 'duality' to require a case method. This criterion states that a case study is needed when the questions require the research to be 'situationally grounded', but also seeking a 'sense of generality'. For this research, situational understanding had to be garnered of how participants behaved within routines, in response to lean NPD. The answer to the questions also have a sense of generality, in that they contribute to theories of how endogenous routine change occurs in response to OM techniques. Specifically, a mechanism will be revealed about how OM techniques function at a micro-level. This also agrees with the wider business and management discipline as to when a case method is appropriate. For instance, by Yin (2008: 18) states, "*A case study is an empirical inquiry that,*

i) Investigates a contemporary phenomenon within its real life context especially when

ii) *The boundaries between the phenomenon and the context are not clearly evident*."

A case study method is the appropriate method for three reasons. Firstly, a case study mirrors the criteria of this thesis' approach, being a naturalistic strategy, used to focus on a specific phenomenon contemporaneously (learning in lean NPD routines). Secondly, a case can be selected that will be theoretically interesting. Thirdly, within practice-based studies there is a historical precedent of using case studies as a method of research, as evidenced by the

research of amongst others, Balogun et al. (2015); Boden (1994); Heath and Luff (2000); Hindmarsh and Pilnick (2007); Nicolini (2010, 2011).

4.1.4 Method

Case studies can be single or multiple. Voss et al. (2002) states that single case studies are utilised in cases of falsification, and provide high levels of depth in data collection and analysis. Furthermore, Yin (2008) suggests a single case to be appropriate when it is a 'critical case'. Critical cases reflect the circumstances that clearly express the conditions stated within a particular theory; as such, they can be used to verify, falsify, or extend the theory in question. Issues with the singular case is that it may have limited generalisability and may provide a bias in studying a phenomenon (Yin, 2008). Multiple cases on the other hand are deemed to provide more convincing evidence, greater generalisability, and robustness (Herriott and Firestone, 1983). Given the thesis' research question, philosophical position, and approach, a single case was chosen. This was because a single case provides the level of depth and granularity that a practice-base analytic entails.

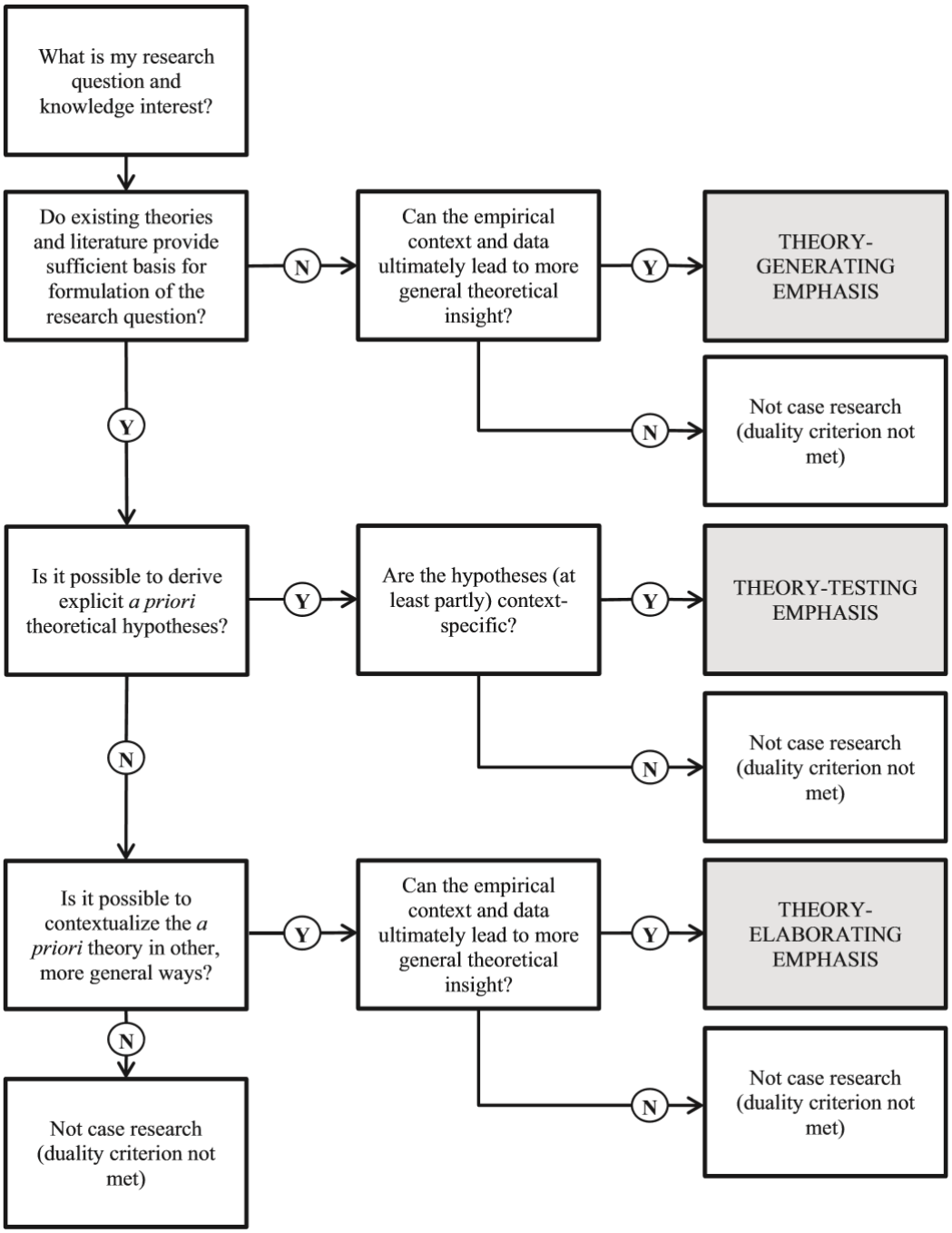
Yin (2008) criticises the single case for its lack of generalisability and its potential for bias. However, this thesis does not seek generalisability in terms of empirical generalisability where the case is representative of a wider population (Mason, 2002). Instead, this thesis seeks theoretical generalisability. This is achieved by firstly choosing an 'illustrative case' whereby the data may show that lean processes can result in reflective learning. Secondly, within the case, 'embedded' strategic sampling will occur (Yin, 2008). Here, strategic comparisons can be made within the analysis to highlight how different learning processes occur under different circumstances. This will then be used to produce 'cross-contextual' generalities (Mason, 2002).

Case studies have been divided into various types such as, intrinsic and instrumental (Stake, 1995). Yin (2008) uses the terminology of 'descriptive', 'exploratory', or 'explanatory' as a typology of cases. Broadly, intrinsic and descriptive cases correspond in reference to providing a detailed understanding of a case. Here descriptions of the case provide evidence that is of interest, but are limited in their contribution to theory (Eisenhardt, 1989; Yin, 2008). Instrumental cases refer to the use of a case to explain or understand a more general phenomenon. Yin's (2008) exploratory and explanatory cases fit within the instrumental category. Yin (2008) differentiates the instrumental use of case studies, where exploratory

designates a theory building case, and explanatory is used to test theory. Under these criteria this research utilises an instrumental case since it is utilising the case to provide evidence of a specific phenomenon, how lean affects the ability of people to learn in routine NPD situations. However, this thesis does not correspond neatly to Yin's (2008) dichotomy of exploratory and explanatory cases. For instance, although it's aims are to explains how lean processes affect learning, there is expected to be exploratory aspects that occur in novel research such as this. For example, it may produce data that will illuminate how learning is actually occurring in the performative aspects of routines. As such, it would seem Yin's (2008) typology of the explanatory and exploratory case in this thesis is inclusive, rather than exclusive.

More recent concerns from within the OM field provide a more useful taxonomy. Ketokivi and Choi (2014) provide the logic displayed in **Figure 4.1** as to the focus of the case. This is primarily determined by the interplay between theory, data, and the context through which the data is generated. There are three ideal types of uses of case research. These are: theory testing, theory generating, and theory elaboration cases. Within these ideal types this research appears to match the theory testing case. This is because following **Figure 4.1**, the first box can be answered in the affirmative; theory informs the research question, that of routines, and reflective theory. This leads to the second box, which again can be answered positively: theorises are used to generate specific propositions within the research as to how lean NPD creates reflective behaviours. Lastly, the subsequent box can be answered in the positive since the research propositions are context specific: the research questions need to be considered in a context of a case where lean NPD is occurring within routines. Hence, following **Figure 4.1**, this case is a theory testing case in which the. As Ketokivi and Choi (2014) point out this is an ideal classification, and, again, it is expected that there will be some aspects of theory generation, and elaboration.

Figure 4.1: A decision tree of case study justification and classification, source: Ketokivi and Choi (2014:238)



Within a single theory testing case setting this practice-based study followed a multi-method approach (Saunders et al., 2011). Firstly, informed by the sequential analysis of conversation analysis this study looked at how the structure and content of interactions were enacted in the presence of lean artefacts and actors (Sacks and Jefferson, 1995). Secondly, shadowing techniques (Czarniawska, 2014) were used to disclose local rationalities around lean processes. This involved participant and non-participant observations, document collection, and employee interviews. These methods are discussed below.

4.1.5 The study of practice

To understand practices from the 'inside' ethnomethodology was utilised as a basis. Ethnomethodology has been uses to study organisations (Bittner, 1965; Boden, 1994; Llewellyn, 2008; Llewellyn and Hindmarsh, 2010; Samra-Fredericks, 2005), and is recently seen a resurgence within routine theory (LeBaron et al., 2016). Lynch (2007) states that the only overarching method of ethnomethodology may be the unique adequacy requirement, which is where the researcher becomes competent in the indigenousness methods of the research setting , and which has been coined a 'hybrid study' (Garfinkel and Rawls, 2002). Hybrid studies are defined by how the, *"... questions they raise orient toward the problems and taken-for-granted competences workers manage in doing their work"* (Rawls, 2008: 724). The notion of being a competent member is problematic, and is aggravated by the fact that competency is not distributed uniformly (Lynch, 2007). Competency within this research is defined as the ability to understand what is occurring within the research setting (Lynch, 2007). Thus, one can understand how action is made mutually intelligible from a member's perspective, and how practice is organised. However, at the same time the researcher needs to foster an attitude of things being 'anthropologically strange', so that practices become visible, and the researcher is aware of just how participants organise practices in their common-day interactions (Garfinkel, 1964).

The unique adequacy requirement was met given the researchers seven years' experience in engineering NPD settings, which provided a basis to ensure the researcher was appropriately qualified. This industry experience included contributing to implementing lean within both supply chains and manufacturing operations. To supplement this experience in-depth pilot interviews were conducted (all ranged from one to three hours) with professional including: a consultant who specialises in Lean NPD in the automotive sector, a specialist Lean NPD consultant, an owner / manager of formula one design studio, a former head of a department that created commercial goods from defence innovations, and an ex-head of a leading automotive manufacturer that implemented lean NPD.

4.1.6 The Analysis of Interaction

The ethnomethodological approach was complemented by the principles of conversation analysis. Conversation analysis states that in-situ understandings of participants can be revealed through the sequential order of their interactions (Goffman, 1983; Sacks and

Jefferson, 1995). That is, participant understanding can be inferred through the context the prior and subsequent interactions (Pilnick and Coleman, 2003). Specifically, these local rationalities are demonstrated by how people manage the evolving sequences of interaction to construct shared meanings about the world. In this way, events, activities, and institutions are "talked into being" (Atkinson and Heritage, 1984).

Ten Have (1999) states that there are four main analytic dimensions that can be used to understand how interactions are organised in general conversation. The first is, how members within a conversation respond to the proceeding talk to reveal what they believe is its normative content (sequence organisation). The second is, how members organise their conversation through the ordering of individuals' ability to engage in talk (turn taking organisation). The third is, how members fix conversation when they are unsure about how to proceed, or what is meant (repair organisation). The fourth is, how members doing the talking use words to denote what route they require the conversation to follow (the organisation of turn design). These analytic dimensions' exhibit participants' shared understandings via their verbal and non-verbal behaviour. Notably, consistent with normative practice-based understandings, there is no theorising of cognitive states or discourse which lies *behind* or *outside* interaction. Hence, to see how artefacts and actors affect people's understandings does not require psychological inspection of an inner world but an investigation into how the interactional order, hence local rationality, occurs in the presence of the artefact.

Given this research is occurring within an organisations NPD project, previous analytic descriptions of institutional interactions were used to determine patterns surrounding artefacts. Conversation analysis scholars have argued that institutional interactions have the features of natural talk, as well as three factors that combine in unique ways to create an organisational fingerprint (Heritage and Greatbatch, 1989). Firstly, institutional interactions always have orientations to goals, which are in turn linked to institutional identities. Secondly, interactions are limited by constraints to what is deemed acceptable to the current task within the organisation. Thirdly, institutional talk is connected to specific lines of inference connected to organisational understandings.

To determine analytically how institutions are constructed in interaction, Drew and Heritage (2006) suggest six ways to analyse the data. Firstly, to look at turn taking organisation. This is whether organisations limit who is allowed to contribute to the conversation, such as a

Chair of meeting would do. Secondly, to determine the overall structural organisation; this is to determine if there are phases of talk related to specific tasks. Thirdly, to examine the sequence of organisation interaction, which looks at what methods participants open or close their business with. Fourthly, to examine turn design, which focuses on how participants choose a certain phrase to create actions from the hearer. Fifthly, to look at lexical choice, which analyses how particular words are used relative to organisational contexts and roles. Lastly, to examine how interactional asymmetry exhibits 'institutionalism' by looking at how rights to knowledge, participation, and organisational know-how, are distributed asymmetrically across the organisation, and are present within talk. A further source of analytic devices come from the scholarship conducted in work place studies (Heath and Luff, 2000; Heath et al., 2009; Luff et al., 1992). These studies have taken ethnomethodological principles and used conversation analysis techniques to determine how technologies affect organisational interaction. Dominant topics of research include how documents are used in institutional interaction (Button and Sharrock, 1994; Harper, 1998), and the use of technology in collaborative projects (Engeström and Middleton, 1998; Luff et al., 2010). These studies also draw on the sequence of bodily movement, such as gestures and gaze, to interpret what is at issue for the participants of their studies (Goodwin, 2000, 2007).

Using the analytic resources from institutional interaction, combined with those of work place studies, provides the basis for conversation analytic focused descriptions of patterns in the data, of how members interact with lean artefacts and lean actors. To avoid any possibility of bias in selectively choosing which section of transcript to analyse, this research chose a comprehensive data treatment (Mehan, 1979). In which all transcripts are analysed to determine recurrent patterns of organisational interaction.

Conversation analysis occurs via audio or video recordings of interactions on naturally occurring talk, which is transcribed in a high level of detail. The transcription method of recordings has been standardized based on the system developed by Gail Jefferson (Atkinson and Heritage, 1984). Once transcriptions are made available, the analyst builds on previous theoretical noticing's within the conversation analysis literature about how people make talk intelligible. Here, the ideal is to have an attitude of unmotivated looking (Schegloff, 1996: 172), similar to attitudes prescribed by grounded theory (Glaser and Strauss, 1967). With the aid of these analytic descriptions the analyst looks for patterns within the data, combined with a local understanding, to assess the importance of those patterns (Ten Have, 1999).

For confidentiality reasons at the organisation under study, recording of conversation was prohibited; therefore, hand written notes of interactions were taken in real time. The main limitation of this being that transcripts do not accord to the Jefferson system, detailed in Atkinson and Heritage (1984). Hence, this study can be said to be informed by conversation analysis. The transcripts, while basic, provided a structure with which to ground an analysis of local understandings, as evidenced by previous research (c.f. Atkinson and Drew (1979); Pilnick and Coleman (2003) and tacitly present in Jordan (2010); Yanow and Tsoukas (2009) Dittrich et al. (2016); LeBaron et al. (2016)). This provides a differing perspective from standard observation by the fact that it is less interpretative and more granular through which to advance theory (Atkinson and Drew, 1979; Schegloff, 1996).

4.1.7 Shadowing

Shadowing involves following artefacts and people through their daily activities to understand what rationalities are in place surrounding the subject of the shadowing (Czarniawska-Joerges, 2007). Shadowing is individuated by the need for an attitude of an 'outsider' and creating an understanding based on differences. Essentially, the shadow tries to understand what is at issue for the subject. Shadowing is different from ethnography since it is not interested in a 'view of life' but how the subject being studied is constituted within its daily activities (Czarniawska, 2014). Shadowing involved the collection of four data sources: employee interviews, non-participant observation, participant observation, and document collection. Richtnér et al. (2014) study into learning in NPD demonstrated that interviewees were more forthcoming in open-ended questions; this study follows their recommendations. Moreover, interview questions were designed to problematize the 'transparent' activities of local participants, such that they reflected on their own activities and revealed the rationalities that they assumed during those activities, as suggested by (Rawls, 2008). This involved asking questions such as "How does this work?", "Why did you do that?", and "What does that mean?".

4.1.8 Secondary product and project data

Secondary data on product and project performance was collected since prior research had found that lean NPD produced multiple operational objectives simultaneously, such as low product and project cost, with high product quality (Clark and Fujimoto, 1991; Womack et al., 1990). Rather than assuming that lean NPD produces these multiple and simultaneous

project and product outcomes, as recorded in the literature, they will be measured in the case. This is to ensure inferences can be made between behaviours occurring within routines and project and product outcomes, and ultimately organisational competitive advantage. This evidence will add to the literature on the project and product level outcomes which lean NPD produces, which is relatively underdeveloped. By connecting these outcomes with learning processes increases generalisability of the findings. That is, if findings display a correlation between outcomes and learning processes, then it would be both theoretically and empirically suggestive that learning processes were the basis of lean NPD's ability to produce these multiple and simultaneous outcomes, in both past and future cases (Guide and Ketokivi, 2015).

4.1.9 Data integration and method of analysis

Data was analysed via two methods depending on its type. Firstly, shadowing data was coded and integrated via an adaptable method pioneered and described by Gioia et al. (2013). This method has been utilised by process studies to create dynamic models of how events occur within organisations (Corley and Gioia, 2004; Gioia et al., 2013). It has been argued that such a method balances the requirement between showing too much and too little data (Pratt, 2009). Furthermore, this method conforms to revised criteria placed on the OM field regarding data analysis. This is, data analysis needs to be transparent, rather than just stating that a formalised procedure was carried out (Holton, 2007). As such, the 'Gioia method' has been proposed as a suitable means to achieve clarity (Ketokivi and Choi, 2014).

Although the method is 'adaptable', it follows a prescribed ideal set of activities: Firstly, themes are coded in the terms voiced by the interviewees / observations (Strauss and Corbin, 1990). These themes are termed first order concepts. Secondly, the researcher then reflects theoretically on the first order concepts to ascertain if they appear in the literature which forms the basis of the study. Thirdly, these first order concepts are then accumulated to create more summative codes, called second order themes. Fourthly, second order themes are then brought together under more general, aggregate dimensions. The relationships should then be revealed pictorially to demonstrate the different levels of abstraction from the data; which is called the data structure. The data structure is a key step in the analysis since it displays how the raw data is connected to the theme which the research is developing. This helps to display transparency within the analysis (Pratt, 2008; Tracey, 2010). The data structure is then converted into a diagram called a dynamic model. The dynamic model's purpose is to

reveal how the concepts attained in the data structure are related so revealing the processes occurring, the purpose of the study. These connections are made between the second order concepts and aggregate dimensions via the researcher's knowledge of the data, and inductive leaps.

This method was utilised within this research, yet adapted for this particular study as described below: For the first order concepts of the 'Gioia' analysis, open coding was performed. This is where the data is broken down into discreet concepts by an iterative process of determining similarities and differences across the data set (Strauss and Corbin, 1990). Following the prescriptions of Gioia et al. (2013) and Charmaz (2014), this was done by giving as much 'voice' to the way the interviewees, and field notes, expressed themselves. For instance, if a code was developed which referred to 'organisational blind spots', this is because interviewees referenced this phrase predominately in their conversation, and conceptually similar references were grouped under this description (see **Appendix B** for an example of first order coding methods). Since the researcher visited the case twice, codes could be developed from the first visit, and then question could be asked surrounding these issues on the second to, "*questioning and constant comparisons (*which*) enables investigators to break through subjectivity and bias"* (Corbin and Strauss, 1990:12). First order codes were also augmented with the findings from interaction analysis (see details below of analytic method). The analysis of interaction detailed key events occurring during the use of lean practices. Occasionally, data could only be captured from the analysis of interaction, and this data formed a first order code by themselves. This was generally due to the nature of the data they captured. For instance, the code 'fact that lean artefacts were designed around information representation considerations', only revealed itself in what people did, not what they said, and represented a first order code by itself.

Second order concepts were then created via the formation of categories which are based on considering whether the first order structure signifies some deeper structure. Essentially by asking what is occurring in the first order concepts, and summarizing, and relating the first order codes into more abstract patterns of activity. Again, concepts formed via this process could be followed up in the subsequent visit, and in telephone interviews to ensure concepts and relationships are adequately defined by the data. These second order themes are categorized into aggregate dimensions by the researcher identifying macro-areas of processes occurring within the data. Within both the first order and second order concept construction, as with the ethnomethodological basis of this study, the researcher maintained

an attitude to the data of being 'anthropologically strange' (Rawls, 2008). That is, by asking, 'what are the participants doing in the data', 'how are they revealing concerns through the practices which they describe and do'? This results in a static model called the data structure. From this static model a dynamic model is then created detailing how these concepts are dynamically related to each other, giving an overall analytic description of the process. Unlike the 'Gioia' analysis which prescribes importing theoretical constructs to do this, this research with its ethnomethodological base, uses the unique adequacy requirement to understand how the activities which participants do, fit together to form a coherent description of their actions (Garfinkel, 2002).

All data was inputted and manipulated via the use of NVivio 10 qualitative analysis software package. Chapter five performs the 'Gioia' analysis for each routine type encountered, which shows how the data was coded. It shows the first order concepts with associated key data, the analysis of interaction, and discusses how the analysis was brought together from a data structure into a dynamic model to reveal processes occurring around lean NPD practices.

Data from the analysis of interaction was analysed according to the prescriptions of section **4.1.6** above. That is, all the data was analysed to try and determine interactional informative episodes within the data (Mehan, 1979). Following the presentation norms of interaction analysis examples of the data are given within the analysis of chapter five (Balogun et al., 2015). These are used as exemplars to illustrate analytically informative episodes. Key parts of the analysis are also described to show the reader how the analysis was done.

In summary, what the 'Gioia' analysis show is the evidence through which the descriptions of the behaviours within the routine were based. Moreover, the dynamic model produces an understanding of how these practices combine as the routine occurs. Consequently, a dynamic model was produced for each type of routine analysed. Hence, in total, in chapter five there are three 'Gioia' analysis's which correspond to the three routines encountered within the case. In chapter five and six, these dynamic models are then compared with behaviours that form reflective learning (as detailed in chapter three), in order to begin to answer the research questions. This allows the reader of this research to determine if the behaviours reported through the 'Gioia' method do in fact correspond to reflective learning, ultimately increasing transparency of the data, and so quality of the discussion, which is the subject of the following discussion.

As identified by Nicolini (2012), there is a tension in the integration of data between the analysis of interaction and shadowing. This debate about what other data interaction analysis 'allows' is present within its methodology literature too (Ten Have, 1999). The argument is that data created by means other than naturalistic situations, such as interviews, utilises a different set of rationalities from the participants, and so reports on a different 'social reality'. Furthermore, observation, such as ethnography, may be rejected since this involves an overly interpretative treatment of the data, rather than a detailed documentation of what is said and done through the analysis of interaction (Atkinson and Drew, 1979). Nocolini's (2012) solution to this tension is to accept it, and equate these diverse viewpoints with definitions of a good (postmodern) social science. While this study somewhat accepts Nicolini's (2012) conclusion, utilising a strong ethnomethodological perspective can cogently accept other forms of data to report on institutional interaction (Lynch, 2007). For instance, as described, interviews were used to problematize participants' normal mode of organising, echoing Garfinkel's breaching experiment (Garfinkel, 1967).

4.1.10 Case Selection

The primary selection criteria for the case was that it was a company involved in lean NPD. However, definitions of lean NPD differ among, and within, both industry and academic practitioners (Holweg, 2007; Leon and Farris, 2011). To remove any reservations concerning whether lean NPD was 'truly' lean NPD in the case, it was determined that a company should be chosen that was irrefutably doing lean NPD based on it being a paradigmatic lean company. A definition of a paradigmatic lean company is one mentioned in the original lean literature and is Japanese in origin. The requirement of a paradigmatic lean company presented issues. Given resource and time constraints, travelling to Japan to do shadowing, record conversations, and have the data translated was not possible. Overseas operations of these companies did not do lean NPD within the researcher's native country (UK). A different strategy was therefore chosen of selecting a company that had 'direct links' with a paradigmatic lean company. For the purpose of this thesis 'direct links' is defined as individuals (consultants or researchers) that have had first-hand experience based within paradigmatic lean organisations.

The second criteria were that an organisation should be chosen which is engaged in radical NPD. This was because as the research is concerned with looking for reflective learning, and such an activity is required in highly novel and unique situations (McCarthy et al., 2006), a

context which exhibits greater novelty is more likely to exhibit the phenomena of interest of this research. However, as chapter one states, definitions of novel NPD are unclear and contested (Adler et al., 2009; Lamming, 1993). Within the research on NPD, novelty is often broken down into radical and incremental NPD. Radical innovation has been defined as using technologies that are not closely related to current firm technologies (Dosi, 1982; Green et al., 1995) or customers (Abernathy and Clark, 1985; Christensen and Bower, 1996), and involve architectural innovations rather than components or module innovation (Henderson and Clark, 1990; Iansiti and Clark, 1994). Incremental innovations are targeted at existing customer bases, modular subsystems, and within their existing technological paradigm (Abernathy and Clark, 1985; Christensen and Bower, 1996; Dosi, 1982; Iansiti and Clark, 1994; Lavie et al., 2010). It was deemed that organisations that exhibited more radical NPD as defined above, would be more suitable for selection.

The third criteria were that the organisation should give a high level of access to the researcher. Given the strong ethnomethodological perspective, the researcher would need to be present within NPD meetings and within the general NPD environment, such as during product tests, and in training sessions. The researcher would also need to take detailed notes of what was said and done. These notes would potentially contain sensitive information, hence, a high level of understanding and trust between the organisation and researcher was required.

4.2 Data collection

4.2.1 The Case

Within the stringent criteria above, a case was selected called 'ROBOT'[2]. ROBOT is a European engineering organisations which makes robots. These robots collect data in areas where it is difficult, or dangerous for human beings to do so. The organisation consists of nominally 35 personnel and was acquired by a larger organisation in 2008. ROBOT is one of three companies working under the same umbrella of a division of a Parent organisation. The three companies are all involved in separate, but complimentary niches, focusing on the

[2] ROBOT is a pseudonym since the researcher was placed under a confidentiality agreement not to disclose who ROBOT actually is as a condition of access. To protect the anonymity of ROBOT some names have been altered during the display of data which are not significant to this research but may inadvertently reveal who ROBOT is.

sensing of data through robots. The Parent company is over 50 years old. ROBOT works relatively independently of the acquiring Parent organisation; however, the Parent organisation has transformed ROBOT's development routines to lean NPD. Consequently, Robot have been doing lean NPD for 7 years. The Parent organisation had been engaged in lean NPD for over 15 years, and ensures very experienced personnel in lean NPD frequently visit ROBOT to advise on development projects. As defined, ROBOT has a 'direct link' to a paradigmatic lean organisations via a set of researchers who first taught ROBOT lean NPD, these were Kennedy and Ward (2003).

Originally ROBOT was a commercial spin-off from the local University. As such, personnel remaining from the original organisations are highly trained, and knowledgeable about the product. The acquiring company too was started from a University spin-off, which added very highly educated personnel from some of the top Universities in the world. Throughout ROBOT, from the General Manager, to the engineering group, personnel were educated to the highest level, and specifically in Engineering. Consequently, most employees have some technical understanding as evidenced by statements such as, "*it helps that everyone is a technologist, even the CEO and everyone was excited by the technology*" (General Manager). See the **addendum part A** for more details on how the case as selected, as well as greater details on the case, and how its situations affected their organisational routines.

ROBOT's market

ROBOT operates in a highly niche concentrated market, both from a customer and competitor perspective. There are two other companies in the world who directly compete with ROBOT, all of which ROBOT knows well due to the occasional transference of employees. One of ROBOT's competitors is significantly larger than ROBOT. The management of ROBOT are expressly hostile to this competitor. The other competitor is more comparable in size to ROBOT, and managements' attitude are more benign to this competitor. Given the cost, relatively scarcity of competitors' products, and logistical issue of actually getting these products; ROBOT did not acquire any of their competitors' products for 'teardown' tests. Instead, they collected competitor information through word of mouth from customers, and via the internet, which appeared a rich source of information. Indeed, the researcher witnessed multiple occasions during the construction of A3 reports where the Engineers would scan the internet for information on competitor products. As one employee stated "*We spend all this time trying to hide what we are doing from one another (each competitor), and we just put it on the web, crazy*!" (Chief Engineer).

Competitor information did drive some development work; rumour of a competitor creating a robot that had significantly more capabilities, caused high level discussions as to whether ROBOT could keep apace. Furthermore, ROBOT's customers were demanding this increased capability. As it turned out, from going through the lean NPD processes, ROBOT abandoned this potential product. ROBOT's management decided that these capabilities were not currently within their technological envelope. Interestingly, ROBOT's competitor who engaged with the development of the new product, subsequently could not deliver. Hence, although ROBOT's strategy of deciding not to compete caused some concern at the time, ultimately it payed off. Since, they avoided a costly development cycle that would have probably resulted in failure, and they enhanced their reputation for technical excellence; they stated it was beyond current technology, and they were proved correct.

ROBOT's customers are extremely large companies, and occasionally governments, with big R&D spends. Although ROBOT's product is a seemingly expensive piece of equipment, comparatively to the projects they are involved in, the cost is minimal. Moreover, ROBOT's customers, in an attempt to advance their own competitive position, are always demanding of ROBOT to push the capabilities of their product. This caused tension within the organisation, since, Engineering could not keep up with the demands from the market. Furthermore, if Engineering developed products too quickly and then they failed, given the environments they were working in, this would most likely cause irretrievable damage to the product. While comparatively to the project the robots are inexpensive, for ROBOT this would be a significant warranty cost. Furthermore, a failure could delay their customer's project, which would be significant cost for all parties, as well as damage ROBOT's reputation.

ROBOT's strategy

Interviewees stated that ROBOT's product differentiates itself through the usability of its robots. Unlike competitor products, which involve significant set-up time, ROBOT's devices are 'plug in and play'. This reduces the technical resources required from the customers. Furthermore, ROBOTs product is deemed to be more tailored to end-user requirements. There was evidence of this during development routines. For instance, employees talked about getting a sample of the gloves through which the end-users would pick-up the product. This would enable them to enhance their understanding of what type of

hand-grip the robot would require. A general concern for usability, and how the customer was actually going to use the product, pervaded most discussion which were witnessed.

A key element through which ROBOT differentiate itself was by its product being modular. This enabled customers to have flexibility through altering the product by adding, deleting, and substituting modules as they wished. In theory, this allowed ROBOT to up-date the product in a continuous fashion around the same product architecture. From a customer's perspective there was no evidence to contradict this idea of flexibility. However, internally at ROBOT, the constraints of the architecture were a source of constant issue for the engineering team. As technology progressed, and modules were updated, the limitations of the architecture became more apparent. Furthermore, some technical solution just were not possible given the architectural constraints. This led to multiple conceptions within the organisation as to what the next generation product should be. For instance, the Electrical Engineer stated that the next generation product should be very similar to the current iteration; with the only changes being to the internal architecture so that the product was much easier to up-date and change. The Operations Manager expressed contradictory views on different occasions. Firstly, he stated that ROBOT needed a radically new product to surpass the competition; and then, on a later date he stated that ROBOT just needs to do whatever the customer wants to take advantage of their customer's large R&D budgets. The General Manager took the position that the next generation product will have to be totally new, a "step change". The reason being that he had expressed to the customers the flexibility of the current system, if the new system looked similar, then this would undermine their current value proposition.

Having an array of contrasting opinions at different levels within the organisation could itself count as evidence for ambidexterity; that of balancing the competing demands of exploration and exploitation (O'Reilly and Tushman, 2008). The General Manager recognised this tension, he wanted ROBOT to listen to its customers and respond to their needs, yet at the same time push technological frontiers and engage in novel experimentation. The General Manger was equivocal about explanations of past performance, and included multiple accounts. Furthermore, the General Manager realised he couldn't manage ROBOT on purely financial metrics; he talked of "Fuzzy returns on investment", and the need to maintain the R&D spend of ROBOT at 10%, even during times such as the recession in 2008. The justification for this is that to do otherwise would jeopardise the competitive advantage of ROBOT within an 18-month time-frame. Targets were set beyond the normal quarterly

period for a publicly traded company, and he ensured that the Engineering team of ROBOT were not micro-managed. He added, “There is always room for experimentation”.

ROBOT’s product

The modular product worked within a set of design constraints. For instance, a change in product design by adding or subtracting a module affected the functioning of the product such as battery life. As well as these innate design constraints, new constraints were placed on the product due to technological advancements. In these cases, new sensors with increased sensitivity that the robot was designed to carry were so sensitive that they were picking up noise from the robot, instead of the surrounding environment. This meant there were constant design modifications to ensure the product was compatible to the evolving technology. To put these advancements into context, the range of the sensors had increased by over three times in the last ten years.

The product can be classified as low volume, high variety with annual sales on average of 10 units. Sales price per unit is from £100,000 to £1million. The product is highly tailored to the customer’s specifications, however, the use of the modules has meant that ROBOT standardises where possible. The average lifecycle of a unit is 15 years, and during those 15 years there is constant product support. For instance, products are often returned for upgrades and refurbishment.

ROBOT and its innovation classification

ROBOT’s NPD ‘could’ be described as incremental NPD. This is because ROBOT’s customer base is relatively stable and concentrated, and that all issues studied in the NPD routines revolved around modular aspects of the product (although often innovations affected the architecture of the product, frustrating design, which was a recurrent theme). That said, products that ROBOT makes can be classified as low volume high variety (Hayes and Wheelwright, 1979), often involving technologies that have never been utilised before in the application ROBOT uses them. Furthermore, customers often demanded of ROBOT to push the technological frontiers into ever more difficult applications and environments. Hence, the level of novelty within the NPD routines studied was extremely high, and can be considered at the forefront of technological possibility. As such, the products at ROBOT can be classified at radical innovations (Hayes and Wheelwright, 1979).

Lean NPD for ROBOT

Lean NPD for ROBOT consisted of a set of formalised routines based around the NPD process described in **Figure 4.4.** Within this broad process flow, there were sub-routines, such as how to use A3 reports, or do, lean 'sprints'. All documentation that was created from lean processes was maintained in a central database. It was explained to the researcher that originally much of the documentation was paper, but since it was becoming overly disordered, the company switched to electronic versions. Within the database documentation was linked by projects, and project numbers. There was also search functions to assists in information retrieval. All employees had access to the database, which they were expected to use. On the whole lean NPD was utilised un-problematically, however, there was some tensions present from legacy issues related to the acquisition. Most notably this came in the form of old systems, where often information had not been captured to the standards that lean NPD, or ROBOT, currently expected. Furthermore, from the acquisition some knowledge on legacy systems seemed difficult to ascertain. Within this system there were five major processes that the researcher witnessed, each will now be described in turn.

Sprints

For software development ROBOT engaged in 'sprint' cycles (Fowler and Highsmith, 2001). These were 2 – 4 week short development cycles which high detail how development activity is linked to product functionality. To make a sprint cycles 'visual', ROBOT utilised a 'burn down chart'. This is where time was portrayed on an 'x axis', and functional requirements on the 'y'. Developers could see how their progress matched remaining time for the development cycle. Burn down charts was used to ensure that development cycles were not left to the last moment. The idea is that functionality could be added to the software in a linear fashion, such that the line on the burn down chart would, in an ideal world be a horizontal sloping line. This differed from traditional software development where typically development only occurred at end of the development cycle.

A3 reports

The most prevalent artefact utilised within the case was an A3 report. There was not one, but multiple versions of A3s, which corroborates previous research on the topic (Sobek II and Smalley, 2008). Each version was designed to solve a specific organisational issues. For instance, at ROBOT there were six types of A3s: 'General proposal', 'customer interest', 'informational', 'project integration', 'decision', and 'test results'. Employees used the report to guide them in the representation of information; in that they had to fill in the information under each sub-heading within the report. Before meetings everyone was

expected to look at the A3 report that was relevant to the topic under discussion. Furthermore, if new topics were surfaced during discussion, A3 reports could be created, or current ones added to; to capture the contents of these new discussions. All members of ROBOT were specifically trained in the use of A3 reports.

SCRUM meetings

SCRUM meetings have not been prevalent within the Lean NPD literature previously. SCRUM meetings were conducted each morning at ROBOT to give updates on where members are on projects, what they are doing each day, and any issues they anticipate. This is done in a circle facing other team members. A ball is passed along the circle, a person can only speak when they have the ball in their hands. Each update lasts from 1 – 5 minutes.

Oobeya Room

While ROBOT did not have a room, they did have a wall within the engineering office which included key metrics. The diagram below taken from ROBOT depicts the type of information they captured. Tasks were broken down into what stage they were at, signified by the columns, and what sort of task they were, indicated by the rows. Each job was stuck onto the correct place on the board by a 'post it note'. No task on the board represented more than 40 hours, a working week for one man. It was explained that information from the Manufacturing department was added later, since it was important for Engineering to be able to schedule its task around capacity constraints.

Figure 4.2: A representation of the Oobeya wall at ROBOT

	Back Log	In process	For review	Done
GROUP 1 (live projects)				
GROUP 2 (maintenance, problems that need to be solved immediately)				
GROUP 3 (Non-emergency technical sales)				With Manufacturing Date and ETA

Road Map

At ROBOT a road map meeting happened once every six months to allocate resources across the organisation, and involved a cross functional team. In these routines every project was evaluated for its urgency and the resources it required. Then this was combined with a strategic assessment of each project to prioritise work. Within the roadmap, generally each product was broken down into a systematic representation of parts such as, 'software', 'electronics' and 'motors'. From this systematic analysis of the projects each one is assessed. While this road map feature has not been described within the lean NPD literature it does represent an artefact that is used to connect projects across innovation cycles, a key trait of Lean NPD projects (Clark and Fujimoto, 1991; Cusumano and Neboeka, 1998).

Check sheets

Check sheets are heavily described within the Lean NPD literature, and it has been argued are a key artefact in producing Lean NPD project performance (Sobek et al., 1999; Sobek et al., 1998; Ward et al., 1995). A check sheet is simple a document which contains all key variables and lessoned learnt within the current design capabilities of the organisations. ROBOT used checks sheets extensively within their development routines. These were connected by numerical reference to A3 reports and could be found within the lean NPD database.

ROBOT's lean NPD embodied within routine theory

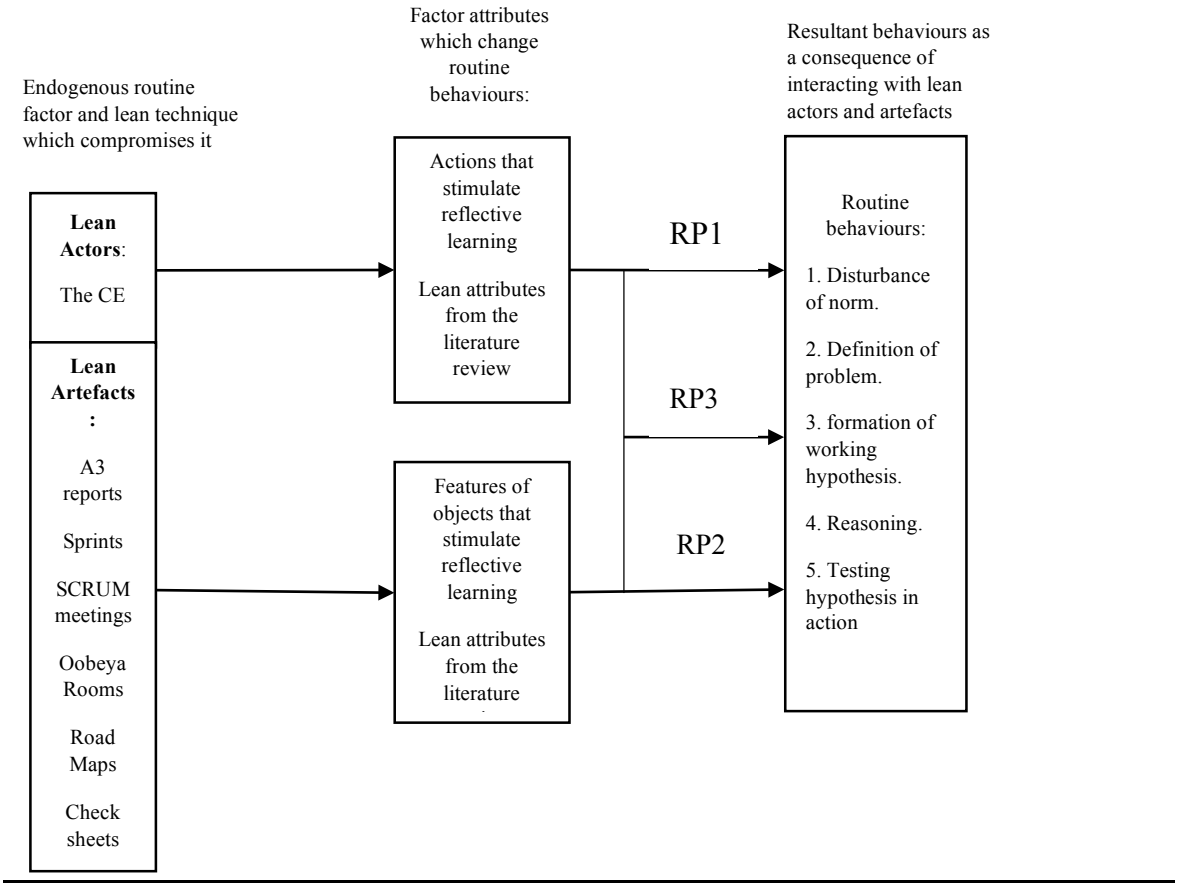
Note that ROBOT's lean NPD technique differ from those found within the metasynthesis literature review. For instance, while they include some techniques such as A3 reports, they have new techniques such as 'SCRUM' meetings. Also, they lack some practices previously identified such as 'guest engineer'. This alters the table of chapter three (**Table 3.2**) which detailed which lean NPD practices could be identified with which aspect of routine theory. The additional techniques found within ROBOT all conform to the identification of these techniques with artefacts. This is because they are all fundamentally tied to physical representation of information, or have objects as their central use (such as the SCRUM meeting). This results in **Table 4.1:**

Table 4.1: Identifying how the major practice from ROBOT, correspond to routine factors which they embody

Major practice found within lean NPD	Factor of the routine they embody
Chief engineer	Actor
A3 report	Artefact
SCRUM meeting	Artefact
Road map	Artefact
Sprints	Artefact
Check-sheets	Artefact
Oobeya room	Artefact

These new practices also revise **Figure 3.2** describing the testable framework. Since new practices are subsumed under the factors of artefacts and actors. This does not affect the proposed attributes which may result in reflective leaning since, as stated, this research is looking at the generic effects of lean actors and artefacts. As such it results in **Figure 4.3** below, which now becomes the testable framework:

Figure 4.3: Overall framework as to how lean NPD practices are embodied in routines at ROBOT, and a proposal as to how their attributes could result in interactions that are defined as reflective behaviours.



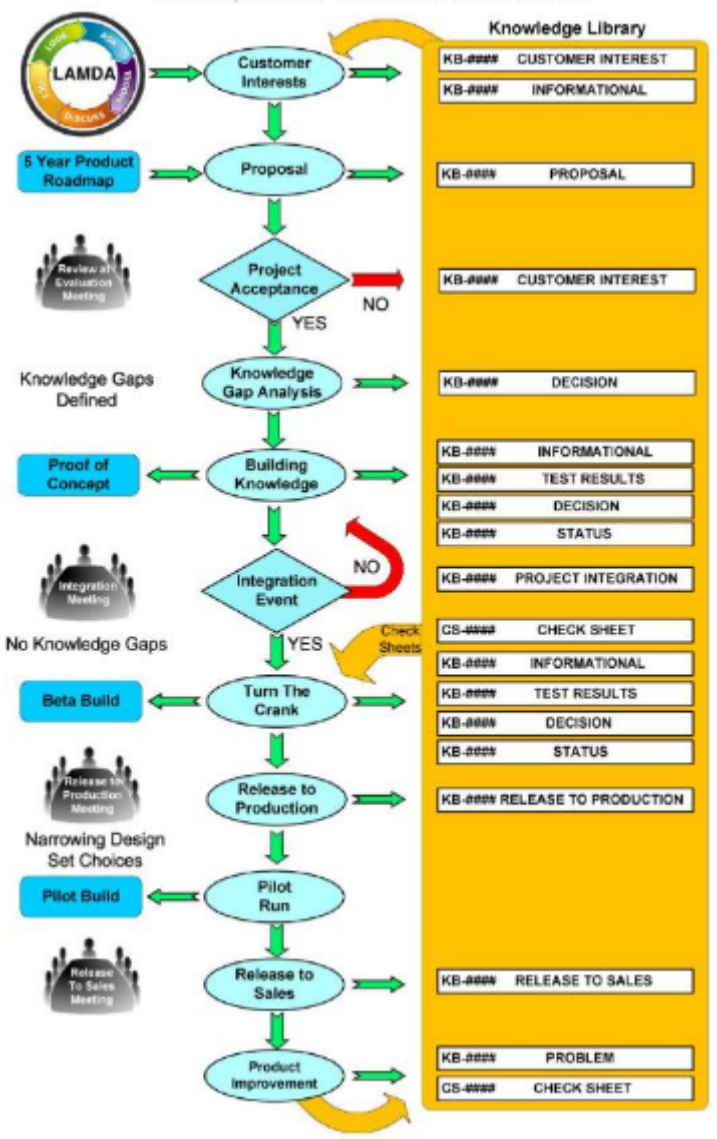
4.2.2 Sampling

The sampling strategy was influenced by *a priori* theoretical concerns, which is how lean artefacts and actors affect interaction within NPD routines. Hence the sampling strategy can be broadly labelled theoretical sampling (Mason, 2002; Strauss and Corbin, 1990). From analysis of the case it became clear that ROBOT consisted of three major development routines. Routines that generated lean artefacts for use within lean development routines, these involved the formation lean artefacts and the filling out of content which would then be used in the development process. Routines that utilised lean processes during the development of products, the task of these routines was specifically organised around solving a development problem. Routines that occurred without lean processes, but were organised around solving development problems. These three types of routine provided differing contexts through which the effects of lean actors and artefacts could be studied and therefore answer the research propositions and question. In fact, the study of routines without

lean processes provided a form of control or deviant case analysis in order to determine how practices occurred in the absence of lean processes. While this sample of deviant routines was not required in order to achieve the purpose of the thesis, that is to determine if reflective learning can take place within routines that is attributable OM techniques, it was utilised in order to contribute to the theory of how lean actors and artefacts do affect internal routine dynamics. Furthermore, since the number of people within ROBOT was relatively small (35), on the whole the same people took part in each routine type. This meant that the way that individual competency affected the results was somewhat controlled for.

Pentland and Feldman (2005) state that routines can be identified by standard operating procedures, and other organisational mapping processes whereby procedures are encoded. A feature of lean NPD is that routines are mapped which constitute the NPD process, providing an overview of the major routines involved in the study. ROBOT's routines were based on a process map provided by the organisation (see **Figure 4.4**). All the routines were sampled as identified in the below diagram up to the 'Turn the crank' phase. The reason for this was that routines preceding this phase were the most experimental and knowledge intensive and so most likely to require reflective learning. Furthermore, consistent with prior theory, the artefacts of lean NPD are most notable in these earlier phases (Thomke and Fujimoto, 2000). Given the theoretical aims of this research, the routines were studied independent of their contents. This allowed the researcher to study the routines within a suitable time frame and so capture all identified routines or 'direct element sampling', irrespective of the project. Pentland and Feldman (2005) describe how some routines may evade being captured by process mapping. Therefore, to ensure that the full spectrum of routines was researched, techniques of shadowing were utilised (Czarniawska, 2014). Nicolini (2012) states that in conducting a practice-based study, a shadowing technique (following people and artefacts around) is most appropriate. Hence, A3 reports (the main lean artefact found) were shadowed throughout the process, as well as key informants such as the major lean actor called the 'Chief Engineer'.

Figure 4.4: taken from Melvin (2013:38) which ROBOT used to formulate it's development routines



4.2.3 Data Collection

Data were collected over a six-month period, via two visits – four days in April 2014, and five days in October 2014. Data was collected with in-situ presence. Day time presence was between six and ten hours a day.

Recorded interaction

Conversations, gesture, gaze, and use of artefacts were recorded in meetings via hand written notes. **Table 4.2** below shows details of where transcripts of interaction were taken, giving the meeting number, a description of the topic of the meeting, whether an artefact was used (and if so what type), and the description of the routine.

Table 4.2: Details of routines where transcripts of interaction were taken

Routine No.	Description	Lean technique used	Routine type
Routine No. 1	Problem of electrical interferences	A3 report	Development routine with lean processes
Routine No. 2	Problem of new sensors	None	Development routine without lean processes
Routine No. 3	New customer requirements	None	Development routine without lean processes
Routine No. 4	Training of use with A3 report	A3 report / Check sheets	Routine for lean artefact creation
Routine No. 5	Problem of new motors	A3 report / Check sheets	Development routine with lean processes
Routine No. 6	Problem of new recovery systems	A3 report / Check sheets	Development routine with lean processes
Routine No. 7	New wiring system	Check sheets	Development routine with lean processes
Routine No. 8	Creation of visual management board	Visual Management board	Routine for lean artefact creation
Routine No. 9	Strategic overview	Road maps	Development routine with lean processes
Routine No. 10	Customer information	A3 reports	Routine for lean artefact creation
Routine No. 11	Transit systems	A3 reports	Development routine with lean processes
Routine No. 12	SCRUM	SCRUM 'ball'	Development routine with lean processes

Shadowing

All data were captured in hand written notes which were then transcribed within seventy-two hours after the visit. All observation was direct observation that occurred during the two visits. Non-participant observation occurred throughout the visit, and notes were made of key events. Observations often occurred when recordings of conversations were not possible, either because events happened in a dynamic situation or because the taking of notes would have been socially awkward. Observations not only contributed to the research questions, but also allowed for an increase in contextual information regarding organisational events. Participant observation occurred during the visit when the researcher was involved in some tasks. This included questions concerning technical matters that the researcher had previous

experience of, as well as being involved as a member of training routines in the creation of lean artefacts. Whenever the researcher was asked to become involved in the organisational routine they did so, however, the researcher never volunteered. Thirty-four individual interviews totalling twenty-eight hours of time, were conducted with nine participants (see **Table 4.3** for a list of interviewee organisational roles and number of times interviewed, and duration of interview). These lasted between twenty minutes and over three hours. Participants for interview were selected on the basis of interaction with lean processes. Furthermore, key informants such as The Chief Engineer (an identified lean actor) were shadowed. Interviews were often conducted after meetings to try and understand the concerns of the participants. Interviews were also conducted to explore how participants interact with lean artefacts during solitary work. Of these, three interviews were conducted over the phone (three of which were follow-up calls after visiting ROBOT), all others were face to face. Documents were collected during shadowing with permission whenever they were available. These included, A3 reports, marketing literature, and some experimental results. Hard copies of most lean practices were not available due to the fact that they were either plastered on a wall, or embedded in software. As such, drawings were taken of both modes of presentation (see **Appendix B table 8.2** for more information on data collected).

Table 4.3: Organisational role of interviewees, number of times interviewed, and lengths of interview

Organisational Title	**Number of interviews**	**Estimated interview time (mins)**
General Manager	2	20, 200,
Chief Engineer	14	60, 200, 200, 45, 30, 30, 30, 30, 30, 30, 20, 30, 30, 20
Head Engineer	5	45, 45, 30, 20, 30
Operations Manager	3	30, 30, 20
Mechanical Engineer	2	60, 20
Electrical Engineer 1	3	45, 60, 20
Electrical Engineer 2	1	30
Sales representative 1	3	45, 20, 30
Sales representative 2	1	30
Total number and time	**34**	1660 (circa 28 hours)

Secondary data

Secondary data was also collected on product and project performance outcomes, this was to ensure that ROBOT conformed to a typical lean organisation of achieving multiple

organisation objectives simultaneously relative to their competition, as explained in chapter 1.1.1. Objective product performance data was collected on ROBOT and its two main competitors. This was collected for all products within the same class, thus normalising the data for comparison. The data was derived from a publicly available database which personnel within ROBOT used, and advised the researcher to use too. Findings from product comparisons were then shown to personnel of ROBOT for comments, and validation of findings. Aspects of product performance included operating range, weight, battery life, the number of products each company has in the same class, and average number of product features. This data is presented in **Table 4.4** below (the source of the database has not been disclosed to maintain the anonymity of ROBOT, also some of the nomenclature in the table has been altered for the same reason):

4.2.4 Product performance

To ascertain the nature of the product performance outputs that were derived from lean NPD at ROBOT, products were compared against competitor products within the same class for performance features and number of products. This somewhat mirrors the strategy deployed by Clark and Fujimoto (1991), who looked at product quality from JD powers surveys as well as number of products released within a year, giving measures of product quality and relative development cycle trine respectively. However, no such data exists for ROBOT's products. Instead, the tables below show the number of products on the market at the time of writing in respect to ROBOT and its two main competitors; Small Comp, and Large Comp. As the data indicates (**Table 4.4**), ROBOT has seven products in the market, more than the total of their competitors combined; Small Comp have three (**Table 4.5**) and Large Comp have two **(Table 4.6**). It could be argued that this increase in products in the market is due to slow replacement by new products. However, such an argument does not stand up when you consider the nature of ROBOT's product features relative to its competitors, as explained in the next section.

Table 4.4: Table showing performance measurements of all of ROBOT's products

Product Name	A	B	C	D	E	F	G
Size (feet) (lxwxh)	1.8x0.2x0.3	1.8x0.2x0.3	1.8x0.2x0.3	1.8x0.2x0.3	No info	No info	2.7x0.2x0.3
Weight (lbs)	49	49	49	49	80	80	80
Remote range (feet)	1000	1000	1000	1000	1000	1000	1000
Speed (feet/s)	1	1	1	1	1	1	1
Max speed (feet/s)	2.82	2.82	2.82	2.82	2.82	2.82	2.82
Endurance (hrs)	7	5	6	6	4	5	5
Typical No. of sensors	8	8	8	8	8	8	8
Warranty years	1 to 2	1 to 2	1 to 2	1 to 2	1 to 2	1 to 2	1 to 2

Table 4.5: Table showing performance measurements of all of Small Comp products

Product Name	A	B	C
Size (feet) (lxwxh)	1.65x0.24x0.24	3.77x0.32x0.7	0.25x0.02x0.2
Weight (lbs)	50	213	70
Remote range (feet)	200	200	300
Speed (feet/s)	1.52	2	1.52
Max speed (feet/s)	2.82	2.82	2.82
Endurance (hrs)	12	26	8
Typical No. of sensors	3	3	3
Warranty years	1	1	1

Table 4.6: Table showing performance measurements of all of Large Comp products

Product Name	A	B
Size (feet) (lxwxh)	1.84x0.19x0.19	1.60x0.19x0.19
Weight (lbs)	45	45
Remote range (feet)	100	100
Speed (feet/s)	1.54	1.54
Max speed (feet/s)	2.6	2.6
Endurance (hrs)	10	10
Typical No. of sensors	7	7
Warranty years	1	1

Within the industry there is a trade-off in product features; for instance, a significant trade-off is represented by the fact that an increase in weight and size would allow a bigger battery and increase remote range, product speed, product endurance, and the number of sensors it can run at one time. However, having a larger product would indicate higher cost, higher transportation cost, and greater difficulty in end-user product handling. Hence, a product which is smaller and lighter, with higher performance features would indicate greater technological prowess, which in turn would be indicative of product quality. Which Clark and Fujimoto (1991) defined as how well the product meets the requirements of the market. Given this trade-off ROBOT's product compares relatively well with its competitors. For instance, **Table 4.7,** comparing averages between the companies, shows that ROBOT's product is only 0.16 feet longer than 'Small Comp' and 0.26 feet longer than 'Large Comp',

moreover, these averages are skewed by one product found within ROBOT (G), otherwise it would have a product length of 1.8 feet, smaller than 'Small Comp' and only 0.8 feet larger than 'Large Comp'.

Table 4.7: Average product performance metrics of ROBOT comparatively to its competitors (Small Comp, and Large Comp).

Company	Small Comp	Large Comp	ROBOT
Size (feet) (lxwxh)	1.82x0.19x0.38	1.72x0.19x0.19	1.98x0.2x0.3
Weight (lbs)	111.00	45.00	62.29
Remote range (feet)	233.33	100.00	1000.00
Speed (feet/s)	1.68	1.54	1.00
Max speed (feet/s)	2.82	2.60	2.82
Endurance (hrs)	15.33	10.00	5.43
Typical No. of sensors	3.00	7.00	8.00
Warranty years	1.00	1.00	1.50

Other dimensions are relatively similar between competitors. ROBOT's product is significantly lighter than 'Small Comp', and only 17.29lbs heavier than 'Large Comp', again these results are skewed by product G, otherwise it would be only 4 lbs heavier than 'Large Comp'. ROBOT's product far exceeds its competitors in terms of remote range, it has joint highest top speed, and the most number of average sensors. The only metric where it performs less is the operating speed, and endurance. ROBOT's product only exhibits a third of the endurance of 'Small Comp', and half of 'Large Comp'. Lastly, ROBOT's product offers the longest warranty period which may indicate confidence in product quality. Overall, it is relatively difficult to attribute product performance in a precise, comparative manner due to the fact that ROBOTs product is modular, and thus fully adaptable, altering the nature of the trade-off to customer requirements. Moreover, how one configures the product for any company alters performance outcomes; for instance, one could run the product at top speed which would affect endurance.

Nevertheless, on the whole it does provide a rough indication that ROBOT's products are equal if not better in terms of product performance. Another way of representing this data is to rank performance, as in **Table 4.8**, with 1 signifying the best, and 3 the worst. The table shows, ROBOT's product comes out with the lowest and, hence, best overall score, again indicating a high product performance. Thus, these figures indicate that the use of lean NPD results in high product quality with variety and high project speed. Project speed is deduced from the numerous models ROBOT is able to produce relative to its competitors. However, there are three factors these figures do not include. The first is, cost, the second, is the long term quality of the product which lean NPD produces, and the third is the human resources

lean NPD consumes in its projects relative to non-lean projects. These performance objectives are highlighted in the following set of metrics on ROBOT's project performance.

Table 4.8: Weighing of product performance objectives (1 = highest performance measurement, 3 = least high performance measurement) of ROBOT's product compared to Small Comp and Large Comp

Company	Small Comp	Large Comp	ROBOT
Size (feet) (lxwxh)	2	1	3
Weight (lbs)	3	1	2
Remote range (feet)	2	3	1
Speed (feet/s)	1	2	3
Max speed (feet/s)	1	3	1
Endurance (hrs)	1	2	3
Typical No. of sensors	3	2	1
Warranty	3	3	1
Total	16	17	15

4.2.5 Project performance

Another key source of secondary data was the key performance metrics collected for each project within ROBOT. This was collected for all projects at ROBOT, and, as an aid for comparison, in similar projects occurring within other companies at ROBOT's parent organisation during 2015. In total this was twenty-nine projects. Due to issues in the data, two projects could not be used, leaving twenty-seven projects. Of these, nine used lean NPD, the rest, no OM techniques. The data was abstracted from a propriety database, then transferred to the **table 4.9**. Data within **table 4.9** has been checked with personnel from ROBOT for accuracy.

Table 4.9 shows project metrics for companies in ROBOT's division within its parent organisations in 2015. There is a total of four companies, including ROBOT. These companies create products for similar markets in which ROBOT operates. Of the twenty-eight projects occurring within the division, ten have been classified as lean occurring at ROBOT, the other projects occur at the three other organisations. For each project the complexity has been measured. This is determined by the time scale of the project and the overall costs involved, whether it was late or early, whether there was a reason for it being late, whether it was a success, the number of functional departments involved, if any changes were required after product release, the actual cost of the project, and the number of days people worked over the estimate.

Table 4.9: Measures of project performance of lean projects within ROBOT and non-lean projects within their parent organisation

Project: Lean or Non-lean	Complexity	Projects	Late	Early	Understanding for delay	Successful	Average functional departments involved	Average costs 1000s EUR	Average change since release	Average work days over due	% Late	% Early	% Understanding	% Success
Lean project	High	3	3	0	2	3	3.00	EUR 500.00	0	36.33	100.00%	0.00%	66.67%	100.00%
Lean project	Medium	3	2	1	2	3	3.00	EUR 85.00	0	15.33	66.67%	33.33%	100.00%	100.00%
Lean project	Low	4	4	0	4	4	2.00	EUR 150.00	0	64.25	100.00%	0.00%	100.00%	100.00%
Lean project	Total	10	9	1	8	10	2.67	EUR 117.50	0	38.64	88.89%	11.11%	88.89%	100.00%
Non-lean project	High	1	1	0	0	1	3.00	unknown	0	206.00	100.00%	0.00%	0.00%	100.00%
Non-lean project	Medium	6	4	2	2	6	2.33	EUR 160.67	0	90.50	66.67%	33.33%	50.00%	100.00%
Non-lean project	Low	11	5	6	3	11	1.73	EUR 153.33	1	38.55	45.45%	54.55%	60.00%	100.00%
Non-lean project	Total	18	10	8	5	18	2.35	EUR 157.00	0.33	111.68	70.71%	29.29%	36.67%	100.00%

Tables 4.9 indicates that on the whole both lean and non-lean produced high quality products which was accepted in the market without too many issues. However, in projects of high to medium complexity lean projects had significantly less over-run, and so consumed less human resources. Furthermore, in projects of medium to low complexity lean projects used significantly less financial resources than non-lean projects (NB there is no data to make this inference for highly complex projects). Interestingly, for all types of complexity lean projects showed a greater understanding of why the project was late compared to non-lean, which it would be assumed is a necessary condition for continuous improvement. Moreover, lean projects utilised more functional departments; whether this is a sign of greater integration via the lean processes, or just a chance effect due to the type of projects which used lean, is not clear from the data.

The only aspect where non-lean projects appear to provide better project performance than lean, is in projects of low complexity where non-lean projects appear to show a significant increase in early delivery, and reduced human but not financial resources. However, it should be noted that low complexity, non-lean projects were the only type that were subject to engineering change orders to correct issues in released products. Hence, it appears that improvement in project speed within low complexity projects, comes at the cost of product quality, and does not improve project cost.

All of ROBOT's parent organisation projects appear to be providing a high quality product, which is no surprise considering the company's expertise in engineering. Of these, lean projects appear to reach their end state, quicker, cheaper, with fewer mistakes, with more integration, and greater understanding of project performance drivers. There may be a case that this is not totally applicable for projects of low complexity, as these less complex projects show a loss of product quality for project speed. Hence, bringing these two sources of metrics together, on products and projects, provides a telling picture of ROBOT's, and more specifically lean NPD's, ability to achieve multiple performance objectives simultaneously. Lean NPD produces products that are a higher product quality (in the sense of few defects) and is highly indicative of producing superior product quality in the sense of market acceptance, than non-lean projects. Furthermore, it produces these products faster and more cheaply than non-lean projects, with more understanding and fewer mistakes. These outputs corroborate findings from previous studies, such as decrease in project cost and mistakes (Ward et al., 1995), increased product quality (Sobek II et al., 1998), and greater variety of product models (Clark and Fujimoto, 1991). Crucially, these metrics

indicate that within ROBOT there is no trade-off in prioritising one performance objective over another, and that ROBOT produces features that express these objectives simultaneously. As such, it conforms to the characterisation of how lean organisation achieve superior performance as detailed in chapter 1.1.1.

4.3 Quality in research design

To ascertain quality in qualitative research requires the use of a criteria by which to evaluate it (Johnson et al., 2006). Johnson et al. (2006) identify two types of criteria: universal, and contingent. Universal quality criteria state that irrespective of the type of the research there is one correct basis. This view has been criticised by scholars such as Salmon (2003), as a misapplication of criteria, and he questions the relevance of universal applications in qualitative research. Symon and Cassell (1998) state there has been a tendency to apply universalistic measures of quality that mirror those of quantitative research, based on a positivist epistemology, within the Management discipline. This has resulted in criteria based on the concepts of internal validity, construct validity, external validity, and reliability. Consequently, the Management discipline appears to use a universal criterion, suggesting that there is a preconceived notion of what good research looks like. Again, this has been questioned given the diverse nature of qualitative research within this discipline (Symon and Cassell, 2012).

A contingent criterion, is one which is applied dependent upon considerations of some key factors. Within the topic of contingent criteria there is some debate about what key factors should determine the application of the criteria. For instance, Johnson et al. (2006) state that criteria should be based on the research's philosophical position, while Hammersley and Atkinson (2007) argue it is determined by method, and Iivari et al. (1999), by subject. Within OM Ketokivi and Choi (2014) state a criteria based on the case method. They state that there are three essential concepts when it comes to moving from the data to theory during the analysis in a case method. The first is transparency, which is where an analytic method needs to be utilised which describes how the data analysis was actually done, not just an appeal to formal system. The second is generalisability, which denotes what range of theories the researcher has considered when moving from data to theory. The third is cognition, this concept is concerned with how theory is fitted to the data. That is, does the researcher simply

see what they want to see when filling theory to facts (Barratt et.al. 2011). While these concerns are valid, they will be built upon and discussed

This thesis will form a contingent approach to criteria, based on the epistemology and method, given that it has been argued that these two factors are intimately interlinked within a practice-based perspective. The application of criteria dependent on subject will be ignored given that one contribution of this study is to bring a unique practice-based perspective to OM issues, with a new method. Based on these key factors, Johnson et al. (2006) provide a summative table (illustrated in **Table 4.10**) concerning what criteria dependent on epistemology could entail.

Table 4.10: showing how quality criteria relate to epistemological position, and practical questions associated with each position (Taken from Cassell, (2013)).

Epistemology	Assessment criteria	Example questions to ask
Positivism	• Internal validity • External validity • Construct validity • Reliability	Is the process described in sufficient detail to be replicable? Is the sampling sufficiently random/extensive and the analysis sufficiently rigorous for results to also pertain to other samples?
Neo-empiricism (Interpretivist)	Internally reflexive audit trail demonstrating • Credibility • Dependability • Confirmability • Ecological validity • Transferability/ logical inference	Is evidence provided that this is an authentic representation of what happened? Have alternative explanations been considered & negative cases analysed?
Critical Theory	• Accommodation • Catalytic validity • Epistemically reflexive dialogue • Discursive democracy	Has the researcher engaged in reflexive consideration of their own position? Have hegemonic regimes of truth been identified, unsettled & challenged? Does the research lead to possibilities for change?
Postmodernism	• Giving voice to previously silenced textual domains • Unsettling of the hegemonic • Articulation of incommensurable plurality of discourses etc. • De-centring the author through multi-vocality	Have assumptions & commitments been deconstructed? Is analysis & argument subjectively credible? Has the author reflexively considered own narrative & elements of its production?

For this thesis the above typology is problematic since being 'post epistemological' it does not adhere neatly to any of the main categories. For instance, 'critical theory' and 'postmodernism' have a strong critical stance which is not present in the practice-based perspective. While the foundationalist and essentialist tenants of positivism (that everything must be scientifically verified (Comte, 1868) are clearly abhorrent to a practice-based view. As such, of the epistemological positions stated above, the criteria associated with neo-empiricism most mirrors the practice based perspective. It could be argued that neo-empiricism, with its assumption that it can objectively and unbiasedly represent data would be abhorrent to the practice-based perspective (Alvesson and Deetz, 2000). However, a reply to this is that through the use of ethnomethodology, we can veridically represent practice from a 'members' point of view, akin to an objective unbiased understanding.

Methodologically, ethnomethodology generally, and the analysis of interaction and shadowing specifically state that it is possible to veridically represent the member's methods, once the researcher has met the condition of unique adequacy (Garfinkel, 1967). That is, once one becomes adept in the indigenous methods under study, one can 'objectively' portray them. This provides further support to use the quality criteria of neo-empiricism. Therefore, utilising the criteria from Lincoln and Guba (1985) there are four main criteria that can be applied to this study which broadly correspond to the 'old criteria' used in more positivistic studies: credibility (previously internal validity), dependability (previously reliability), confirmability (previously objectivity), and transferability (previously generalisability) (Lincoln and Guba, 1985). Each separate criterion, and how it was met, will now be discussed:

4.3.1 Credibility**:** credibility is concerned with the authenticity of representations in the research (Johnson et al., 2006). The main mechanism through which credibility was achieved was the collection of data which under Miles and Huberman's (1994) classification is generally deemed 'strong'. For example, shadowing and interaction analysis are methods which collect data via the 'strong' classification. A possible outlier is that some data was collected in a group setting during the routine, which under their classification is deemed weaker.

Figure 4.5: A classification of strong and weak data taken from Miles and Huberman (1994)

Stronger Data	*Weaker Data*
Collected later, or after repeated contact	Collected early, during entry
Seen or reported firsthand	Heard secondhand
Observed behavior, activities	Reports or statements
Field-worker is trusted	Field-worker is not trusted
Collected in informal setting	Collected in official or formal setting
Respondent is alone with field-worker	Respondent is in presence of others, in group setting

Additionally, the authenticity of the representations was ensured through transparency, and fallibility. Transparency is showing a clear audit trail regarding how data led to conclusions. While fallibility is defined as producing data and conclusions with which another researcher could disagree (Seale, 1999). These qualities were determined via two methods. Firstly, the validity of the data and its interpretations were confirmed by the use of interactive analysis. This method reveals the data and the logic behind the analysis (Ten Have, 1999), allowing for other researchers to determine the basis for the analysis, and so either agree or disagree. Secondly, the method based on Gioia et al. (2013) increases transparency by allowing other researchers to see the initial data structure (see **Figures 5.1, 5.6, 5.8,** chapter five**)** that derived from the initial analysis, the narrative with primary evidence on which the overall dynamic models were built (see **Figures 5.2, 5.7, 5.9,** chapter five), and then how this original data structure was transformed into a dynamic model (Corley and Gioia, 2004), thus showing how data led to results. These techniques were also augmented with an in-depth discussion of the case, allowing the reader to understand the contextual features of the case.

4.3.2 Dependability**:** this is defined as the minimization of researcher idiosyncrasies. Douglas (1976) states a series of activities the researcher can perform to reduce bias. Each one is considered below, with actions taken:

Check against 'hard facts': Given that the research was looking at learning behaviours it was difficult to correlate this process with 'hard facts'. However, through the study of naturalistic settings, the vignettes produced 'hard facts' of behaviour. That is, irrespective of what people said was the case, when engaged in the actual routine activity they demonstrated their beliefs about certain events 'in-action'. In such cases it can be argued that any pretentions that the

research subjects had towards the researcher were dropped. Furthermore, secondary data was collected such as documents, and database that detailed objective evidence.

Check against alternative accounts: The search for alternative accounts was checked throughout; by asking differing subjects about the same routine, multiple perspectives were gained. Questions were asked that tried to bring forth the subjects' views. This led to respondents expressing negative, positive, and contradictory accounts.

Look for 'trapdoor' accounts (what is going on beyond the obvious): Given the thesis' focus, these back-ground accounts were not so apposite, and, as such, not actively sought. However, given the high level of trust the researcher seemed to garner, people did open up when there were some back-ground issues at work. They stated that some organisational issues occurred due to personality types, and social relations that were occurring behind the 'official' organisational schema. While these are inevitable in any organisation, their interest was more due to the fact that they signified trust in the researcher, as well as highlighting the fragile nature of the social processes that contribute to lean NPD.

Share own personal material to open up the respondent: During data collection no material was shared with any respondent since it may have biased the respondent behaviour. However, after the data collection the results were shared with the Chief Engineer to elicit their feedback.

Assert your knowledge of what is going on, and see whether the respondent 'buys it': After each routine part of the interview normally consisted of stating what the researcher thought the routine was about, this occurred with multiple respondents to ensure that the interpretation was correct.

Summarize a state of affairs and ask the respondent to deny it: As stated above, these actions were explicitly taken after the routines had finished. They were normally posed in a question which the respondent could either confirm or deny.

Name possible ulterior motives and see respondent response: This also occurred after the routines, questions were asked to try and problematize events and ensure the respondents opened up.

As well as ensuring the steps above were taken other methods reduced bias. For instance, by performing a comprehensive data treatment ensured that data was not just chosen that confirmed a certain line of reasoning. The use of NVivo 10 software also ensured the minimisation of researcher bias in the treatment and structuring of the data.

4.3.3 Confirmability**:** this is defined as the researcher engaging in self-criticism. This was achieved through the use of negative evidence (Mason, 1996). That is, routines were also studied that lacked any lean NPD techniques. This provided a form of negative instance to compare results with routines that used lean NPD techniques. Moreover, during the analysis stage the results were compared and contrasted with behaviours that constitute reflective learning. Opening up these results to possible other interpretations evoked self-criticism, and hence, the criteria of confirmability.

4.3.4 Transferability/logical inference**:** This is concerned with to what extent findings can be extended to another context. As stated previously, this research seeks generalisability through theoretical transferability. This is where conclusions can be transferred to other contexts which are theoretically similar. For instance, if the conclusion was found that reflective learning did occur around lean NPD artefacts, then in routines where these occur, even in different organisations, one could assume that reflective learning could be present. Theoretical transferability was also ensured by looking at possible negative instances. That is, routines were sampled that did not use lean processes. This sampling processes may add weight to the idea that lean processes are causally relevant in the production of reflective learning.

In conclusion, quality was considered throughout the design and completion of the research, in light of the philosophical principles, and the methods chosen. Engaging actively in questions of quality throughout the research processes ensured that the data, method, and analytics most robustly answered the research questions.

4.3.5 Conclusion

This chapter argued that the basis for reality is the everyday practice that constitute it, which Gherardi (2012b) labels a ‘flat ontology’. Furthermore, it stated that the way to understand practice is from an ethnomethodological viewpoint, whereby one becomes competent in the practices from an insiders’ perspective. A case was chosen where routines could be studied

in a naturalistic setting, which was theoretically illuminating given the research questions. A general overview of the issues of the case was given, highlighting its suitability. That is, the case involved lean NPD. The case involved three types of routines which allowed data to be collected that was relevant to each research question. Data was also collected on routines that did not use lean processes. This provided the basis to test other theoretical explanations, and increase the theoretical transferability of the research. Methods were chosen that were consistent with the philosophical approach and view of human nature, as well as established in the practice-based perspective. That is, practice was understood from an ethnomethodological perspective based on the analysis of interaction and shadowing. These techniques provided the detail as to how behaviours of the participants changed when in the presence of lean actors and artefacts. Showing how these lean actors and artefacts altered behaviour, and, if such behaviour can be classified as reflective learning, will result in the answer of the research questions. The use of the practice-based perspective and corresponding methods are an original contribution to OM research in their own right, and has answered recent calls for radical innovations within the discipline which focus on how things are actually acted out (Marshall et al., 2016; Singhal and Singhal, 2012b).

Interestingly the features of the method found within this research mirrors those of the theories and practices which it seeks to determine. For instance, a practice-based perspective could be aligned with the lean practice of 'gemba gembutsu' where participants are asked to go and look at the actual problem occurring, rather than take an assumed view of the issue. Furthermore, the process of questioning of participants during interviews was done to engage them in reflective behaviours on what was actually occurring and disrupt their normally accepted mode of conducting themselves.

The next chapter follows the method prescribed by Gioia et al. (2013) stated above, for the analysis of each routine independently. This can be classified as a within type analysis (Ten Have, 1999). The purpose of the next chapter is to show a general analytic description of what was actually occurring in each routine type. This is followed by a cross type analysis in chapter six, which will lead to the answering of the research questions and a more general discussion on the theoretical ramifications on this research's findings.

Chapter Five: The within-type analysis of development routines

Chapter overview

This chapter provides an analysis of how reflective learning within routines is affected by lean actors and artefacts. This is done through a within-type data analysis (Ten Have, 1999). A within-type data analysis provides an overall pattern of the processes occurring within a selected corpus of data. As described in chapter four, three types of routines were found, and so are the subject of analysis. There are: routines for the creation of lean artefacts (section 5.1), lean development routines (section 5.2), and development routines without lean processes (section 5.3). The three routines will be analysed individually for how lean actors and lean artefacts affect the ability of individuals within the routines to engage in reflective learning. Across-type analysis will then be the subject of Chapter Six, this is where the roles of the phenomena of interest are compared and contrasted in the different routine contexts to create generalisations and answer the research questions.

As stated in chapter four, analysis follows the method prescribed by Gioia et al. (2013). Hence for each routine type the chapter follows the following sequence. First, a figure of a data structure is given, which reveals the central data the concepts of the analysis are built on (a pictorial representation of the coding). Second, this is followed by a dynamic model, which shows the relationship between the concepts, depicting the underlying processes occurring in the routines. Third, this dynamic model is followed by a narrative of the analysis which determined the concepts (codes) in the dynamic model. These concepts are represented under each subheading below the 'Gioia' figure. This is followed by a findings section where the overall logic of each model is described, and the logic of each model is compared with the concept of reflective learning in relation to lean actors and artefacts. Salient, and interesting features of the model are also discussed within the findings section as prescribed by Gioia et al. (2013). These three analyses are followed by some concluding remarks. Annotations used within the vignettes of interaction analysis are present in **Table 5.1** below.

Table 5.1: Annotation used in interaction Analysis

Annotation meaning	Annotation
Chief Engineer	CE
Head Engineer	HE
Mechanical Engineer 1	ME
Electrical Engineer 1	EE
Mechanical Engineer 2	Y
Firmware Engineer	P
Sales representative 1	Q
Electrical Engineer 2	X
Operations Manager	L
Mechanical Engineer 3	S
Logistics Manager	C
Customer	CU
Trainee engineer	D
Sales representative 2	SR
Software Engineer	SE
Gaze directed at the A3 report	[>>>A3]
Gaze directed at the road map	[>>>RM]
Gaze directed at the check sheet	[>>>CS]

5.1 The analysis of routines for the creation of lean artefacts

The analysis of routines for lean artefacts largely occurred from data collected in routines 4, 8, and 10 (**Table 4.3**). **Figure 5.2** shows how in the creation of lean artefacts there were three aggregate dimensions that were derived from the data that occurred during these routines. The first was that lean artefacts were intended to be created as solution to current organisational problems. The second, that there were specific actions which led to their creation. The third, that there were some behaviours within the routine by some personnel indicating they wished to avoid creating the artefact. What follows is an

analysis and discussion of each of the second order themes which constitute **Figure 5.2**, and contribute to the aggregate dimensions.

Figure 5.1: Data structure of practices in lean artefact creation following Gioia et al. (2013)

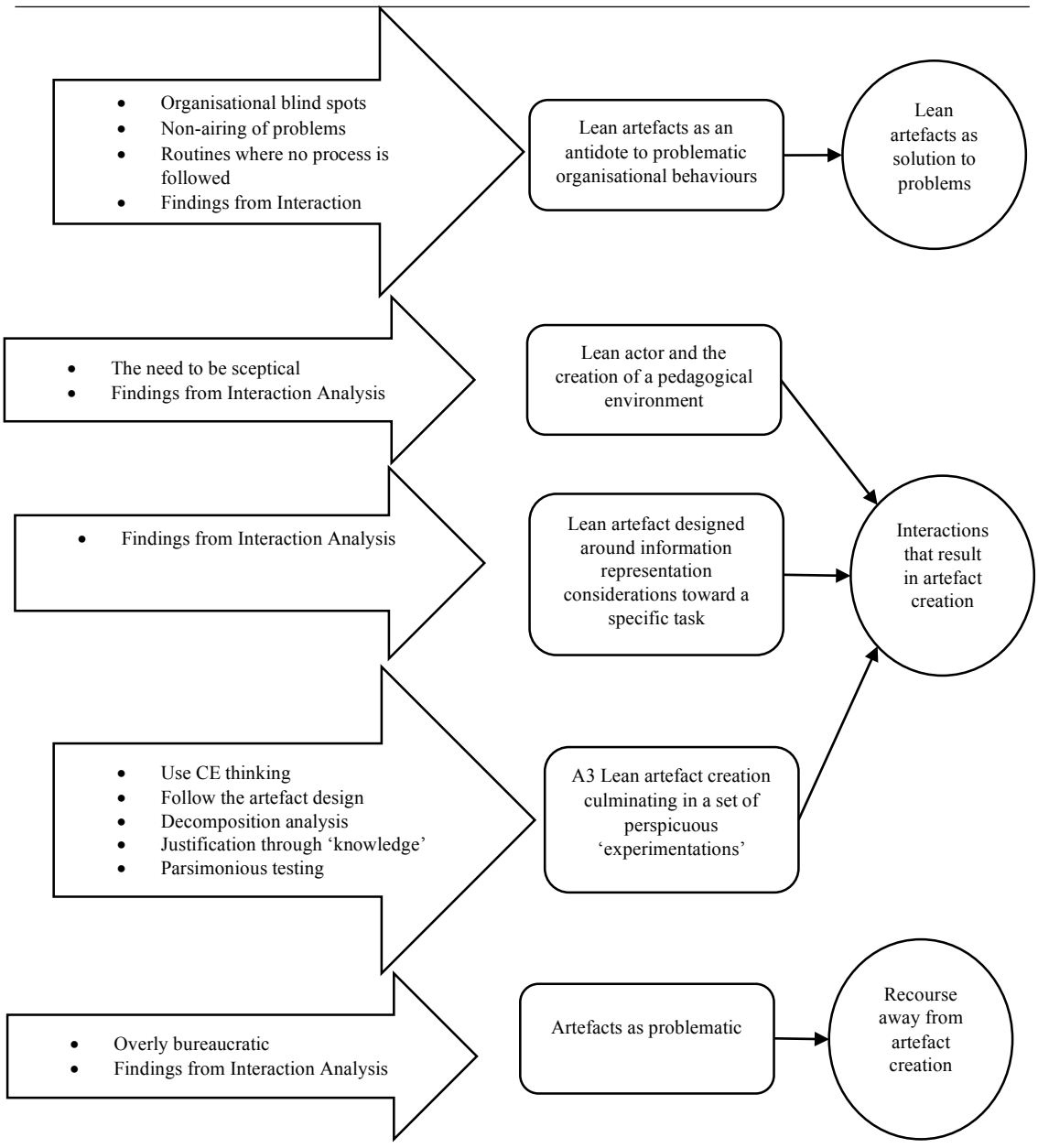
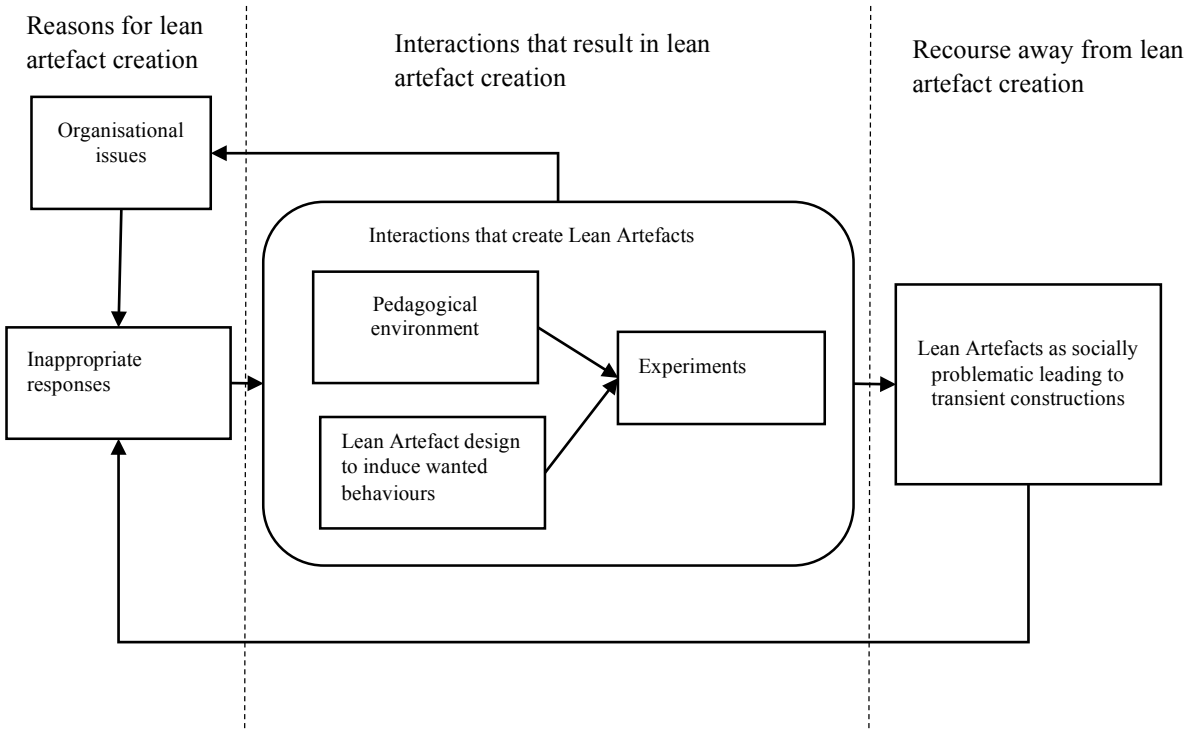


Figure 5.2: Dynamic model as to how practices occur with lean artefacts following Gioia et al. (2013)



5.1.1 The analysis of reasons for lean artefact creation

Lean artefacts as an antidote to problematic organisational behaviours

Consistent features in the data were the origins of lean artefacts as a remedial action to counter problematic organisational behaviours. Lean artefacts and reference to lean thinking were set against the standard or natural behaviours that negatively affected the organisation. This awareness of problematic behaviours was clearly instantiated within interactions. References were made to previous actions that resulted in 'difficult' projects, and used as an exemplar of processes incorrectly followed. This was instantiated by statements such as "We don't want to go down that route and end up like the Polish job" (Head Engineer). While negative examples such as 'the Polish job' appeared unproblematic to air, interviewees became more guarded when they individuated other engineers. For instance, interviewees highlighted personal negative behaviours such as the reluctance of some engineers to state facts in public, "other engineers know but sometimes they just don't dare say" (Electrical Engineer 1). Other interviewees emphasised the inability of some people to learn from their mistakes, "these questions have been asked numerous occasions but no-one seems to take them in" (Chief Engineer (CE)), and "I'll tell you the story of the wrong cables, which everyone knew was wrong, and how it caused reputational damage when it broke in the field

due to being outsourced to a supplier who couldn't do the work-around. Their excuse was 'I need to feel the pain to understand why we use the standards", obviously this is a non-sustainable position' (CE). Moreover, talking about lean artefacts the CE stated "we put them (lean artefacts) there for a reason and somehow they always miss them, it is like a blind spot".

The CE tried to craft lean responses to problems as indicated by statements such as, "how can I create methods so my people learn, but not through the experience of these bad events which are always costly"; with a lean process being the method of learning. This response was also expressed through interaction as demonstrated by **Vignette 1**. During this vignette CE starts with the question of why there have been recurring issues (line 1), X indicates it is because the test is 'too strict' (line 4). The rest of the vignette consists of them trying to negotiate the question of which test is applicable, as indicated by line 6, where HE is unsure of the tests relevance. However, at line 19 CE pauses and states the need is to create a check-sheet. A lean artefact is needed to ensure that it is clear that the right test applies to the right part, to prevent this confusion in the future.

Vignette 1 routine 5

1	CE:	and I want to ask that question again…
2	Y:	we've done this test before
3	HE:	this is what I have got to ask today
4	X:	when the test is set up the test is too strict
5	X&Y:	we need to set up restrictions, but this new piece….
6	HE:	but that is a different meaning
7	CE:	could we simulate the same thing, will a temp test work?
8	HE:	we could
9	X:	50 degrees C?
10	HE:	we need cold
11	CE:	that would be a lot easier
12	HE:	yah
13	X:	pressure test shouldn't be too difficult
14	HE:	we need to do anything?
15		we should try and rap this up
16	X:	how does this behave in oil?
17	HE:	you have….
18	Y:	I have a thing sitting in oil
19	CE:	but what you should do……
20		I think there is a check sheet needed on this actually

5.1.2 Analysis of interactions that result in artefact creation

Lean actor and the creation of a pedagogical environment

A consistent pattern from the data was that the CE as a lean actor plays a central role in creating an environment that can be termed 'learning' or 'pedagogical'. These environments are characterised by the purpose of the task being orientated to how the organisational members relate to the institutional environment, rather being orientated to a specific institutional function. In particular, the CE wanted members to relate to the environment form what can be termed a 'CE ethos'. A CE ethos could be defined much like a Socratic ethos, where questioning, open dialogue, and reasoning are methods whereby the situation is made clear. For instance, the CE was often taking people aside and extolling the virtues of the CE ethos to organisational members with comments such as, "I want to turn you into chief engineers, have you thought about x y z, you need to be a sceptic, challenge yourself and others", and stating "you've got to get people to be the cynic".

In private conversation with the researcher this question of how to instil a CE perspective within organisational members preoccupied the CE. In interviews he constantly struggled with the idea of how he could teach people to take on the CE ethos, as evidenced in statements like "how do I create the chief engineer, bring out knowledge, question what is really going on and be critical or sceptical?". Consistently the CE utilised the creation of lean artefacts as a resource through which a CE ethos could be developed. This is illustrated in the vignette below (**Vignette 2**) where line 1 HE states the goal as being involved within the artefact. However, **lines 2-4** CE performs what Goffman (1976) calls a 'response'. This is a frame breaking reply in which CE requests HE to orientate to issues outside the scope of HE's initial question. CE states the real goal is to 'locate patterns' not to accept the data at face value. In **line 12** CE refers back to this response to demonstrate that we need to be sceptical about representations of reality and not just accept what is present. Through interaction, the CE is always orientating members to new ways of looking at a situation that indicates, 'what is really going on'.

Vignette 2 from routine 8

1	HE	so what is the goal, green closed… [>>>A3]
2	CE	the goal is to watch the patterns
3		it was… why are so many ECOs (engineering change orders) not being closed [>>>A3]
4		number of ECOs per group… [>>>A3]
5	HE	ya didn't need that [>>>A3]
6		i've tried to keep only 20 at one time
7		ECO is not for new products,
8		don't spend any time for them…
9		it took 'X' 3 months to get this, lets see what they come up with [>>>A3]
10		I'll just send here… [>>>A3]
11	CE	yep, do it right now [>>>A3]
12		can never get a formula that is quite right but you can see a trend,
13		good news is that things are going really well

Lean artefact designed around information representation considerations toward a specific task

During the creation of lean artefacts a dominant pattern appeared within the data: lean actors orchestrated their efforts toward three aspects that the artefact would represent: the nature of the information content, how frequently that information was updated, and the mode of the presentation of the information. These three concerns appeared to revolve around the particular issue at hand for the organisation. An analysis of the interaction of **Vignette 3** high-lights this pattern. In lines 1 – 14 participants orientated around issues of content, the level of detail, the nature of the phenomenon included i.e. information content. Lines 15- 31 are focused on the frequency with which the information has to be updated, whether this information is updated daily or for the requirement for another routine, such as the 'Friday meeting' (line 18). The mode of presentation then becomes a topic for lines 32-50. Here the concern is how the information is perceived by the participants, that is whether the information is too confusing, or results in 'overload'. These concerns directed toward the representation of information exhibited in **Vignette 3** are focused around the concern from CE that he and the team are losing sight of important projects. These solutions to problems were by no means static, for instance, previous artefacts were created to measure engineering change order (ECO), but the CE comments, "we no longer measure ECO because it is no longer an issue". This indicates an evolutionary aspect to lean artefact use within routines, once the issue disappears so does the requirement for lean processes.

Although the creation of the artefact cycled through the three topics (information content, frequency, and mode of presentation), around a specific organisational concern, the construction process did not adhere to any independent standards. Instead it rested on the understandings and judgements of the lean actors. Thus, the creative process was not based on any formula for what lean looked like but on the expertise of the members, and what seemed practically relevant to them at the time, as the overall content of **vignette 3** indicates.

Vignette 3 from routine 8

1	CE	we need to determine the visual management board and what it looks like
2	HE	uhh hi
3	CE	I'm thinking..
4		Whats active
5		What's on hold
6		And what's coming up in the future
7	HE	how detailed do you want to go
8	CE	not detailed
9	HE	do you want distractions?

10	CE	no just big projects
11		So distraction don't come up here just big projects
12		Just speaking to 'H' he wants special projects
13	HE	what kind of special projects
14	CE	you know like x [>>>A3]
15	HE	yep when he is working on future stuff [>>>A3]
16	CE	yep that's important to log [>>>A3]
17	HE	he is updating this everyday [>>>A3]
18		You are thinking of this for the Friday meeting [>>>A3]
19	CE	for instance the reel, is.. [>>>A3]
20	HE	is that still in production [>>>A3]
21	CE	I made them start the test [>>>A3]
22		Yeah have you seen this project [>>>A3]
23	HE	yeah looks good [>>>A3]
24	CE	this is how he is doing it
25	HE	this? [>>>A3]
26	CE	im not saying this is what we are doing, it is how he is doing it [>>>A3]
27		On all projects
28		'Active' – (writes in computer) [>>>A3]
29		'Pending' – (writes in computer) [>>>A3]
30		'Hold' – (writes in computer) [>>>A3]
31		'Future' – (writes in computer) [>>>A3]
32	CE	so this is another possibility [>>>A3]
33		Due date, program deliverables, owner, phase, risks, notes, updates
34	CE	for me…. [>>>A3]
35	HE	yep he has been working with software [>>>A3]
36	CE	right [>>>A3]
37	HE	you often have to … [>>>A3]
38	CE	what I don't like about it is… [>>>A3]
39	HE	too much… [>>>A3]
40	CE	yeah it just doesn't tell me what is going on…. [>>>A3]
41	HE	yep info overload [>>>A3]
42	CE	and…too much [>>>A3]
43	HE	yep [>>>A3]
44	CE	confusing for me I don't know if it is on hold [>>>A3]
45	CE	I would like to do something similar to these [>>>A3]
46	HE	yep we have something like that so it is easy for me to send [>>>A3]
47	CE	right [>>>A3]
48	HE	so you know takes a minute [>>>A3]

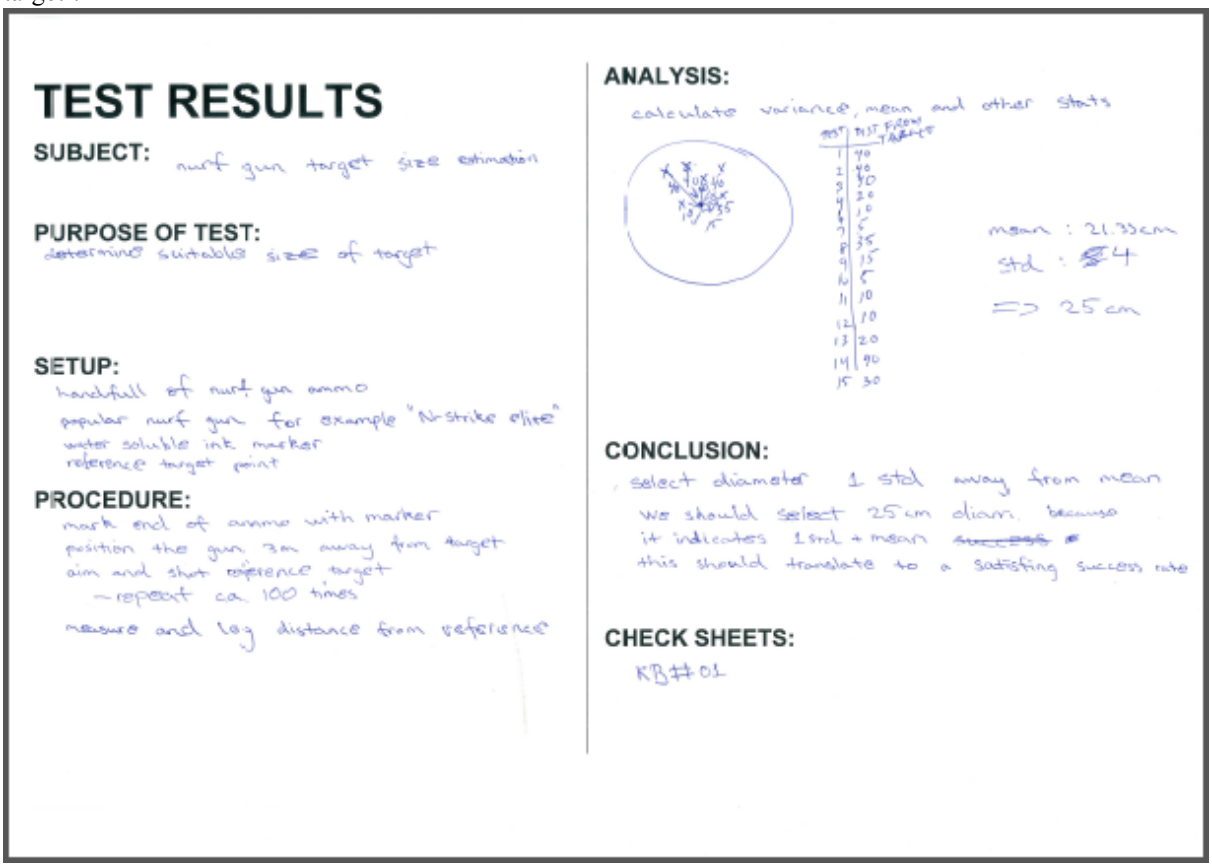
Lean artefact creation culminating in a set of perspicuous 'experimentations'

The creation of a lean artefact brought together the logic of the artefact with an attitude of the CE ethos. This complex interaction between the social / psychological, and the material, to create a lean artefact, was manifested in a training exercise on A3 report creation in **routine 4**. Training in use of the A3 consisted of a mock development project. In the case observed this was the development of a target system for a 'Nerf gun' (**Figure 5.3**). These are guns designed for children that fire foam darts, and which come in various configurations such as pistols, rifles, and multi-shooters. The CE guided the trainees around the A3 reports and stated at which stage and purpose each A3 was designed for, as well as to how to fill out the information. The CE then required the trainees to conduct their own projects in order to develop a target where there was role play between the trainees (as engineers), and the CE (as customer). The CE would interject with questions which the trainees should be asking, and how this translates into the filling out of the A3.

Figure 5.3: Nerfs gun examples

The CE instructed that the A3 were used not to solve problems in themselves, as there were other tools for this, but to represent information in an organised way. Demonstrated by the CE's assertion that, "A3s are not about solving problems by itself, it is keeping it visible to solve, we need other techniques to solve problems such as 5 whys, design of experiment etc., lean NPD just keeps the problems visible…that was lost on me…". This organisation of the A3 was based around the logic of a specified content, a presentation style, and a given frequency, directed toward a particular goal, as described in the previous section. There was not one A3 but several standard templates designed for specific organisational issues. For instance, the researcher was trained in the use of six types of A3s: 'General proposal', 'customer interest', 'informational', 'project integration', 'decision', and 'test results'. Each was set up to deal with the particular problem that the name indicates. **Figure 5.4** shows an actual A3 completed during a training exercise.

Figure 5.4: Example of an A3 for test purposes taken from ROBOT whilst training on designing a 'Nerf target'.



As the figure shows, the A3 has a clear set of areas under headings such as 'analysis', 'purpose of test', that members have to complete. These headings provided sub-goals which the content, the mode of presentation, and to a degree the frequency of information input requirement was controlled. For instance, for a 'Customer Interest' A3 on Nerf targets the participants had to answer the questions in the A3 controlling the content. This involved asking questions such as, who the targets were for and what the customer demographics were. Secondly, a sales and market analysis was performed, which included investigating current products on the market and market size. This was followed by a competitive positioning of the organisation, and an engineering analysis. Theses question also controlled the mode of presentation, since they followed the layout of the A3 which put the information in a particular order specified by the logic for which the report was created. The frequency of information input, although less well-defined in the A3 than other artefacts, such as a visual management board, manifested itself in the A3s relationship to other artefacts. This is denoted by a unique reference number on each A3 and relates to a wider topic or project. If new information was discovered that was relevant it could be included into a wider knowledge structure of lean artefacts indexed through an overarching database (indeed, this is what the 'Informational A3' was largely used for). **Table 5.2** gives subheadings present

in all A3s present within ROBOT, that dictated the information content, structure, and frequency within the artefact:

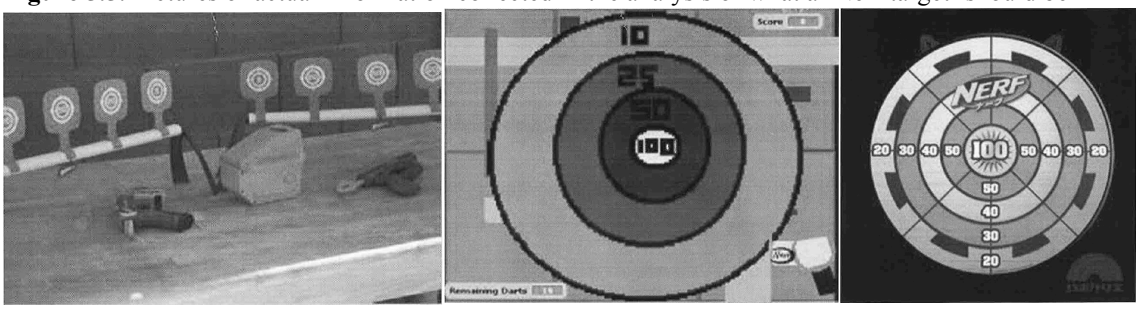
Table 5.2: Each type of A3 is shown in bold in the top row, the column below each type of A3 lists the questions and commands with the A3 contains

Test Result A3	**Project Integration A3**	**Informational A3**	**Decision A3**	**General Proposal A3**	**Problem A3**	**Customer interest A3**	**Release to production A3**	**Release to sales A3**
Subject	Subject	Subject	Subject	Subject	Description	Description	Knowledge base	Knowledge base
Purpose of test	Do you have the knowledge necessary to proceed with design of this product	Check sheets	Decision statement	Background	Root cause	Customers	Engineering design review and verification	Sales and Marketing
Set-up	List of customer interests (are all interests met?)		Significance	Objectives	Alternatives	Sales and marketing	Manufacturing	Manufacturing
Procedure	List any remaining knowledge gaps		Key influences	Plan (resources, schedule, and budget)	Recommendation	Competitive position	Product compliance	Compliance and export
Analysis	List design sets to be narrowed during design and their effects on final product performance specifications		Analysis	Analysis	Action plan	Engineering analysis	Manufacturing plan	Customer documentation
Conclusion	Cost analysis		Check sheets	Knowledge gaps	Result		Financial/ Business	
Check sheets	Does it fit into our 5 year roadmap				Check sheets			
	Compliance issues							
	Plan (Major dates)							

Each A3 topic heading was encountered via the attitude of a 'CE ethos' which challenged the trainees to consider the problem under different assumptions and explore what these assumptions would entail for the domain presented by the heading. This was largely done by an analytic method of decomposition. Concepts once taken for granted were, through questioning, and the use of domain specific and general knowledge, broken down into simpler more basic components (Alexander, 1964).This method of decomposition was expressed by CE's statements such as, "Need to look at the system, and then the system sub-group, we can make a block diagram and start breaking it down…". Decomposition led to a reformulation of the basic problems under each sub-heading and an identification of different lines of inquiry. For instance, in considering the target, the CE questioned what was the shape of an actual target (e.g. round, square, a point) and basic components, (e.g. materials, parts to hold it up right, required colour). These were then considered under different assumptions about the environment where the target would be used; such as indoors, outside, or a combination. These analyses would have implications for material choice. For example, cardboard whilst cheap, could potentially disintegrate in the wet, whereas steel would be more robust, but may not meet the price point.

The CE consistently challenged the trainees to push the notion of decomposition to imagine (and note down) as many options as possible, and what these would mean for the product. For each possible option which resulted from the decomposition analysis, the CE implored the trainees to base the content of the report on actual data wherever possible and include the content in the report. Specifically, he advised his staff to be 'practical', to, "…translate their thoughts and concerns and turn it into something an engineer can use for design". These various options resulted in potential design solution.

Figure 5.5. Pictures of actual information collected in the analysis of what a 'Nerf target' should be



Potential design solution would only be enacted in the light of having 'knowledge' since anything else was considered 'wishful thinking' (CE). Here knowledge was conceived as

engineering data that would make the realisation of the design possible. Thus, either a design solution would entail knowledge that was currently stored within the organisation (via the resource of A3 records) or via experiments. If experiments were required these too were subjected to the same intense analysis of the 'CE ethos'. This manifested itself in the question: 'Given resource constraints, what are the most parsimonious and expedient sets of data required to determine the feasibility of a design solution?'

There was anxiety that more data could always be collected to increase the likelihood of a successful design. The CE countered this anxiety with an understanding that testing had to end somewhere, and that data was only required so that engineering could occur; "sometimes you just have to think what is the simplest and easiest way to do this without putting loads of resources into it", and "if you try and solve something you cannot get everything right, need to prioritise the critical first". Indeed, through questioning, the CE encouraged trainees to see 'the root cause', conceived as the most parsimonious set of variables in the light of the analysis, which would allow engineering work to continue.

This process prevented some potential designs from being attempted. Where a design option required too many resources in order for an experiment to occur such designs lacked 'knowledge' and so would be excluded from consideration. However, these unrealised design options were still included on the A3, along with the reason why no action had been taken. All results would then be captured by an A3 (such as **Figure 5.4**). This resulted in artefacts that exhibited sets of perspicuous experiments and hypothesise around various design options, laid out to a prescribed logic and representational format.

5.1.3 Analysis of recourse away from lean artefact creation

Lean artefacts as socially problematic resulting in transient construction of lean artefacts

There was evidence throughout that participants found it bothersome to construct the artefacts. For instance, in some meetings participants had not constructed an A3 to deal with the problem where the routine requirement is that they should do one, with clear ramifications for routine performance. In the interviews participants directly expressed their dislikes "A3s are ok but I don't like filling them in" (Electrical Engineer 1). Some participants stated deviance from the requirement such as "The A3 is overly bureaucratic, just have a meeting for brainstorming in start-up phase, then do the drawings, and export it

to production" (Mechanical Engineer). Within A3 training some employees indirectly displayed their dislike of the process, for instance, their gaze and attention was constantly elsewhere in the meeting, such as toward a mobile phone and laptop. Approximately an hour and a half into the training they excused themselves stating they had urgent work to do. This dislike or scepticism of the process was exhibited within interaction as participants went through the A3 training. For instance, in the vignette below, 'C' questions the organisational resistance to the use of A3s (exhibited in lines 1, 6, 10, 13, and 19), rather than how the A3s should be constructed in the first place. This had a somewhat disruptive effect on the routine.

Vignette 4 from routine 4

1	C	do you find sales is an ally or a nemesis
2	CE	some sales hate but some of them are getting better, here I mean amenable
3		to the process…
4		no they don't want to do it – we have hired ex 'N' employees, and it is so hard –
5		but eventually they do come around
6	C	seems there is a big struggle
7	CE	T loves it, they do love it, they are getting better, but I wont sign it until I see an A3
8	C	you sign off
9	CE	yeah
10	C	what if there is a sign-off issue with the A3
11	CE	problem with id but should be changing
12	D	what does it mean to have.A3…i..seen it
13	C	you could punish
14	CE	lets get to it, we did hoops, has to be why
15		And latterly
16	CE:	Start using knowledge K briefs,
17		go to more testing,
18		Lean response is to find the root cause
19	C:	How well does this work if other departments don't do it
20	CE:	They should do it but I agree they do enough corrective action

The researcher whilst being trained in the A3, also felt the difficulty in completing it. Basic questions, dictated by the sub-headings appeared somewhat trivial, but proved difficult to answer. For instance, a simple question such as 'who are the customers?' appeared platitudinous, however this question problematized the issue. Who was the customer the product was designed for; the person using the product (e.g. the children using the nerf gun), the person paying for the product (e.g. the parents buying the nerf gun), or a group (e.g. the parents and the children co-jointly using the nerf gun)?

5.1.4 Findings

The creation of lean artefacts involved the occurrence of two mutually reinforcing practices. Normative obligations were placed on A3 creators through the A3's headings combined with instructional commands from the CE and his creation of the pedagogical environment. This

led to practices that can be characterised by participants as reflective learning throughout the artefact creation routine. According to Dewey, for learning to occur normal experience has to be disturbed via an experience of 'breakdown' this arouses the notion of inquiry (Koschmann et al., 1998). The A3's use of headings and subheadings pose questions that problematized domains, which disrupted participants' pre-conceived ways of understanding. These headings were supplanted and sanctioned by the organisation in the form of an authoritative figure (the CE) who further added to the problematization of previously accepted concepts through the 'CE ethos' and the creation of the pedagogical context. This pedagogical context prevented participants from relying on commonly held assumptions. Instead they had to provide evidential justifications, as evidenced by the CE's command for "no wishful thinking, we will make decisions within the knowledge".

This questioning ethos, combined with the questions of the A3 and the domain specific expertise of the participants', were utilised to discursively formulate a hypothesis of what was occurring under each task represented by a heading within the A3. The A3 heading determined the problem and also guided the formulation of the solution; this mirrors Dewey's process of intellectualization of the problem. Drawing on the EM concept of design typification where common understandings of the application of design are present within the design community (Schon, 1988; Sharrock and Anderson, 1994), designers utilised their understanding of what the object of design typically consisted of, such as who was the 'typical customer?', or 'what is a nerf target?'. Interestingly, typifications not only provided the basis of the problematization, but also formed the subject of analysis. Moreover, this analysis was necessarily supplanted with physical instances through the instantiation of artefacts, such as the pictures of real life targets in the training routine (**Figure 5.5**) to justify any analysis, and have "the knowledge, don't guess" (CE). The use of materials in such a process was intrinsic as the basis of the analysis, since common understandings were derived from the actual representations of typifications rather than a taken for granted understanding, which formulated new understandings of 'the problem'. Stated in Dewey's terms, these materials increased the transactional frequency between the individual and the environment, and so by his definition increased the ability of individuals to think (Fineman, 2003; Vince, 2002). In total these processes appear to blend what Dewey termed the 'working hypothesis', and, 'reasoning discursively of possible options' to reformulate the problem situation.

Throughout this activity participants' utilised the lean artefact as a resource in looking at possible options of design. Options were written into the artefact exhibiting rational lines of

argument, reifying the in –situ discursive analysis, which in-turn reified the context and so the local rationalities. Similar studies into the interaction of learning identify displaying knowledge as central to learning (Koschmann et al., 2005). This corresponds to the CE's instructional mantra, "it is not knowledge unless it is written down". The final stage of A3 culminates in whether further action is needed to solve the problem, if so action is taken to conduct a test. These material outcomes are then inscribed into the lean artefact. However, during this routine the last of Dewey's learning processes is only partially complete. In line with Dewey, actions are taken to test the hypothesis and results are inscribed on the A3. However, the critical evaluation of the hypothesis which the experiment was designed to confirm or deny is not done within these routines. This evaluation is not completed in the creation of the lean artefact. At this stage in the artefacts life hypotheses' and results are only recorded. The evaluation of these results in relations to the initial problem, and any further actions, are suspended for other routines.

Utilising Garfinkel's (1964) concept of the moral order (consistent with this research's ethnomethodological perspective) also proves illuminatory on how artefacts affect action. The moral order refers to what a person or group would expect to be the normal course of action in a given situation. Here the artefact determines the context through it's instructional content, and combines with the CE's questioning, creates a normative set of actions which create the conditions for learning. In a sense creating a particular kind of moral order with its own footprint within the institution (Heritage and Clayman, 2011). However, such a normative context is not unproblematic as evidenced by some participants' dislike for the process. Here, the routine of the artefact creation put what they felt was needless demands on how they went about their work, and the disruption caused by the questioning of their typifications was irrelevant to their local concerns. It seems the abnormal normative structure and its requirement for new forms of justification and action in the ascriptions of the A3 were overly bureaucratic to some members; the up-front effort of questioning typifications was occasionally experienced as irksome.

5.2 The Analysis of lean development routines

The analysis of lean development routines largely occurred from data collected in routines 1, 5,6,7,9,11, and 12 (**Table 4.3**), see **Appendix B table 8.3** for a full list of quotes. **Figure 5.7** shows how in lean development routines there were three aggregate dimensions that were derived from the data that occurred during these routines. The first, was that were consistent

behaviours in the routine prior to using a lean artefact. The second, that there were specific actions that were derived from interacting with the lean artefact. The third, that there were behaviours within the routine by some personnel indicating they wished to stop using the lean artefact. What follows is an analysis and discussion of each of the second order themes which constitute **Figure 5.7**, and contribute to the aggregate dimensions.

Figure 5.6: Data structure of practices within routines that use lean processes following Gioia et al. (2013)

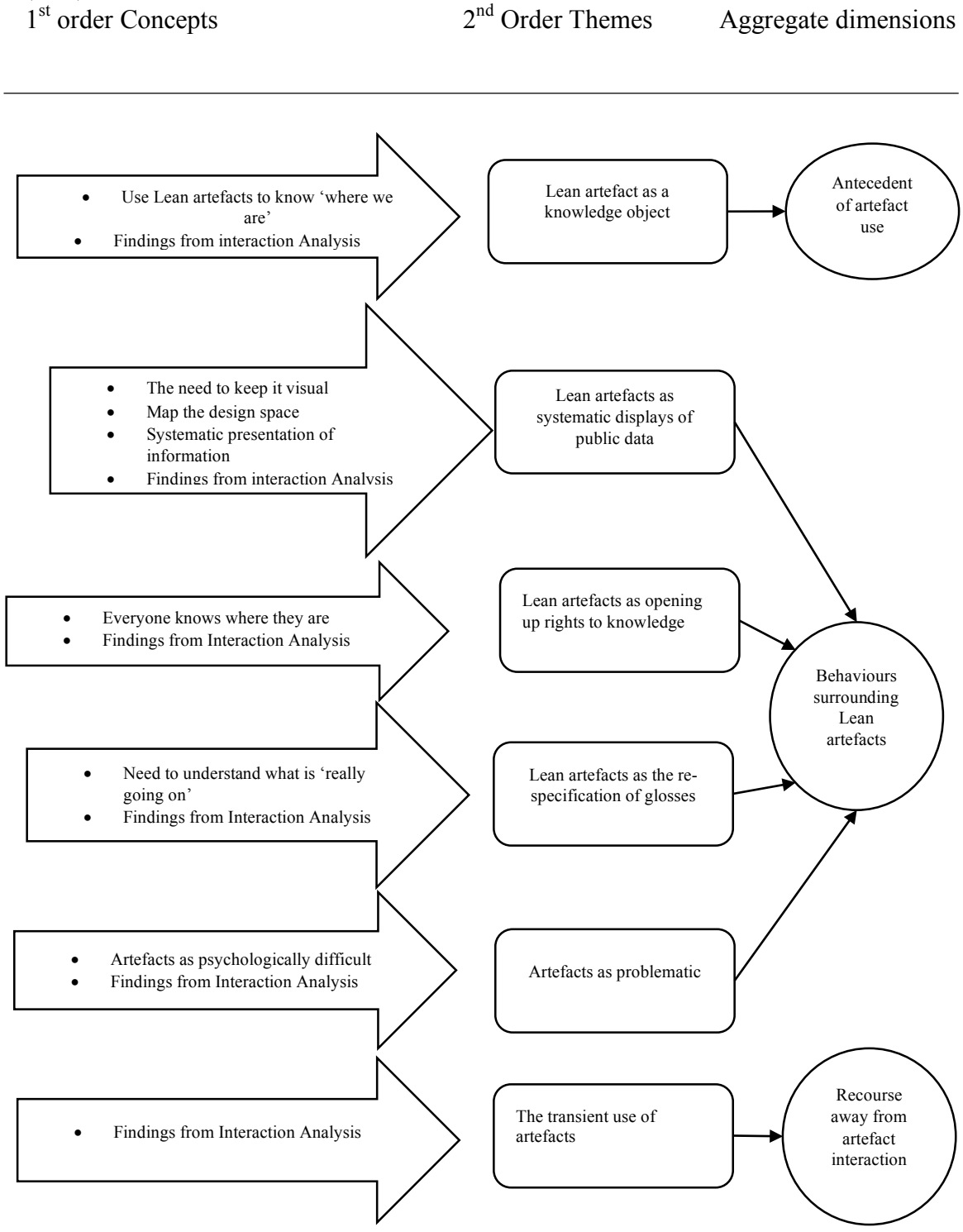
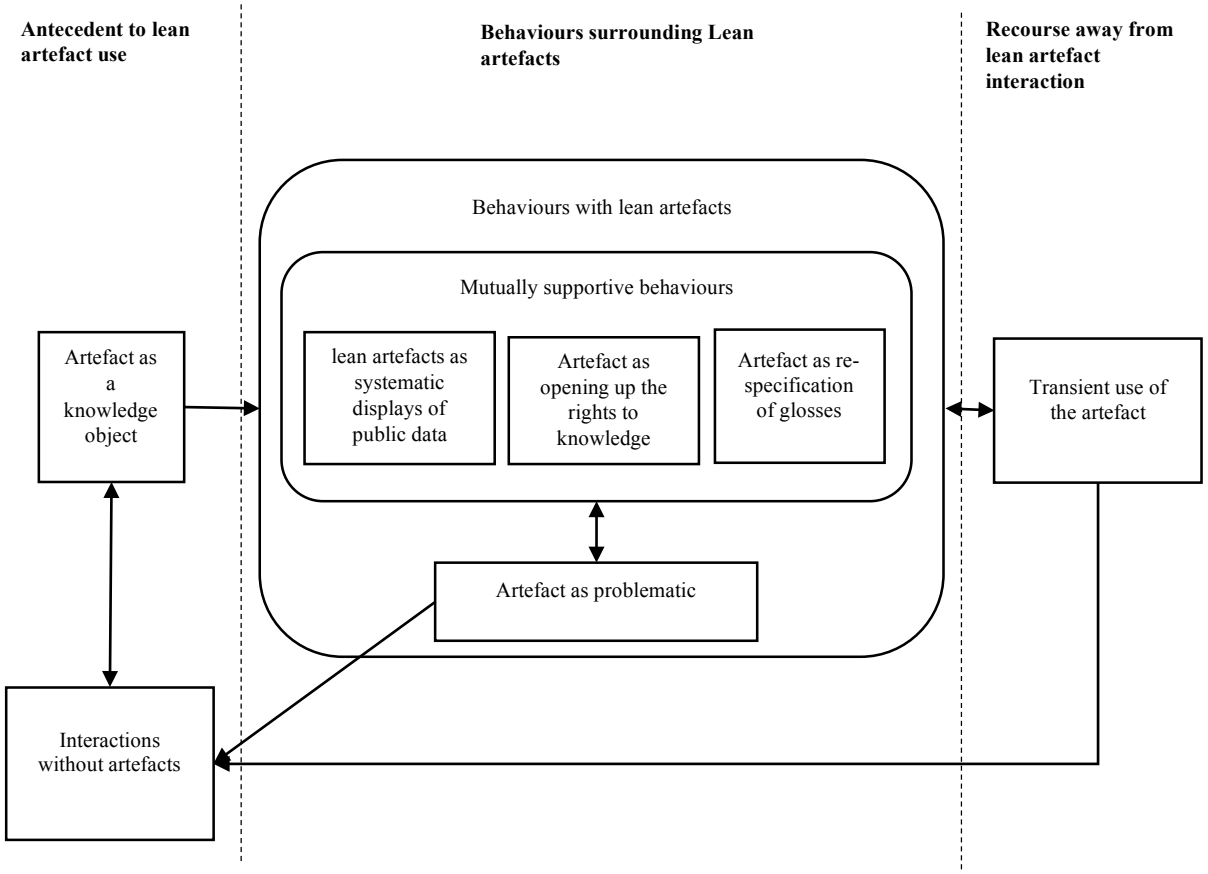


Figure 5.7: Dynamic model as to how practices occur within development routines using lean processes following Gioia et al. (2013)



5.2.1 Antecedents to lean artefact use

Artefact as a knowledge object

The notion of Lean artefacts as bearer of knowledge and as a basis for legitimate action was consistently alluded to by interviewees and observed in their behaviour. Indeed, some interviewees became quite assertive in their tone, "we put this information within the report, people are expected to go and look in, if they don't, well… that's their problem" (Sales 1). Observational data provided clues for this legitimacy. Individuals that had expressed reservations in the use of lean artefacts in private, within meetings scrambled to find an A3 report in a bid to justify their claims. During meetings reference to an A3 report elicited two responses. The first response was to accept that the A3 report stood for a legitimate investigation. It represented an enquiry which had taken place on a topic, and so there was no need to continue the line of examination. The written outcome was utilised to continue the current concerns of the meeting without any investigation into its constitutive arguments.

For instance, **Vignette 5** is illustrative of this use of an A3. At line 2, CE asks a question, the response by HE is to refer to an A3 report that 'D' completed as a form of justification. CE appears to accept this justification (line 4) since the microprocessor is no longer an issue for him; he orientates to a new issue, 'space'.

Vignette 5 from routine 6.

1	HE	its going out, going out
2	CE	we are not using that micro-processor?
3	HE	no 'D' is changing it based on the A3 report
4	CE	space is no problem, extra 10cm not a problem?
5	HE	so let's get going . . . thoughts, weak points, 'D'?

The second response to a reference of an A3 report was to open the report up fully and engage in a group activity. This activity could be described as 'doing A3 reports'. A3 were opened to signify a topic for discussion. Most often the A3 would be projected onto a white board which would set the topic for the meeting. With informants stating "if we put it in A3 reports then we know what we are going to look at" (Head Engineer). More often than not an A3 would be opened in response to dissatisfaction with the current course of the meeting, when members were perplexed or uncertain as to the way forward. As one participant stated "A3s really helps us see what we have done previously and bring that to bear on the current situation" (Mechanical Engineer). For instance, **vignette 6** gives an example of an appeal to an A3 (line 6) here it is not sufficient to reference the A3, they need to 'gain confidence' (line 7). Their activities have so far been deficient, instead they need to 'learn' (lines 1-4). To do this an A3 is opened. As soon as the A3 is available (line 9) attention automatically orientates to the issues presented within it (lines 10 – 13). The group are now engaged in 'doing A3'.

Vignette 6 from routine 6

1	CE:	we need to go back to knowledge gaps, this the third time
2	EE:	we need to learn, close the circle
3	CE:	we need to learn
4	EE:	yes there will be something
5	HE:	ok a couple more days if it is still changing
6	CE:	let's look at the old A 3 report and see what we have at least
7		We need to gain confidence
8	HE:	yeah let's give 'roger' a chance, but yeah
9		(CE is opening up the report and puts it on the screen)
10	ME:	and, and, there are ways to avoid this grommet? [>>>A3]
11	HE:	Grommet? [>>>A3]
12	ME:	yeah there are ways [>>>A3]
13	HE:	I'm worried about this piece here [>>>A3]

5.2.2 Behaviour surrounding lean artefacts

Lean artefacts as systematic displays of public data

Interviewees constantly referred to the efficacy of making information visual, “unless the problem is written down we cannot properly see it, I need to him to write it down” (Chief Engineer), and “it is keeping it visual to solve” (Electrical Engineer 1). While this efficacy of visualisation was alluded to, it was unclear through which mechanisms being visual resulted in problem solving. Seeing a problem does not result in being able to solve it. More clues to what visualisations gave the participants were represented in another theme, that of ‘design space’. This theme refers to an area concerning what is possible to engineer given the current situation, which is, what are the constraints and freedoms to solve the issue. This is instantiated by the Head Engineer when he stated, “The A3 rearranges the situation, what we did know, what we didn't know, this is true for the group as well as for people”. The CE reiterates this theme when he says, “It allows you to look at the mistakes you have made before design, I am going to ask what about x, is it a mistake we have made previously, how can we avoid it?”.

Observationally, and also present within the transcripts, before using the A3 participants would try and state what they thought the problem was in an unsystematic fashion. This resulted in problems being raised and dropped-in sporadically, without much debate. In contrast with the A3, each topic was discussed in turn and evaluated with data present. Participants were aware of this, “The A3 re-specifies the issue and reconnects the ideas in a logical sequence” (Sales 1), and, “The A3 organises you to do your tasks, it gives you discipline” (Mechanical Engineer). These themes manifest themselves by the way participants sequenced their interaction. **Vignette 7** shows how, with the artefact open for everyone within the meetings to view, participants ordered their interactions around each other’s utterances *and,* at the same time, the lean Artefact. Everyone’s gaze and action was ‘intertwined’ (Orlikowski, 2007) with the A3 report. Here the interactional character is of short half sentences, with constant references to the information within the A3. These utterances only make sense with the A3 data inter-woven with them. For the participants their concern is focused on the data within the A3 and what this may mean in respect to their knowledge domain, Engineering.

Vignette 7 from routine 5

1 HE you are just increasing the whole [>>>A3]

2	ME	yah (pointing to A3) [>>>A3]
3	HE	so it's increasing whole size [>>>A3]
4	CE	and we are guaranteed?
5	HE	what [>>>A3]
6	ME	it is calculated at 16% [>>>A3]
7	ME	is it… [>>>A3]
8	HE	is ok... [>>>A3]
9	CE	No it has [>>>A3]
10	ME	it is the same [>>>A3]
11	CE	it is the mil standard [>>>A3]
12	HE	I have the same [>>>A3]
13	ME	equal margin, 10% etc. [>>>A3]
14	HE	Any, CE?

Lean artefacts as opening up rights to knowledge

Participants were aware of the democratising effect of lean artefacts, stating that by using the artefact it ensured that everyone had the same access to information and expressed by statements such as, "so everyone is on the same page; even top level" (Sales 1). The CE acknowledged that this happens despite other factors as exhibited in statements like, "some territorial behaviour, there always is in these meetings, but we go through the process, and by the end everyone is on side". Daily SCRUM meetings contribute to this democratising process. This is a lean technique in which a ball is passed around the development team. The person with the ball has the 'right' to speak for a few minutes, the rest have to listen. Occasionally people do interject, which is met with sensor; this includes more senior people who check themselves for interrupting. Previous analysis of organisational talk (Drew and Heritage, 2006) indicates that it is not enough for organisational members to know something, they need to feel they have the right to air that knowledge in the public domain.

Analysis of interaction revealed that members referenced the artefact in their opening assertions as a form of justification to speak, in a sense the A3 provided context which sanctioned interaction. For instance, below EE uses the interaction with the A3 report as an opener to orientate members to the fact that there are major problems occurring that they have not recognised, this occurs throughout the meeting (lines 2, 3, 21-25, 44, 46-50). While he does interact on other occasions (lines 9, 12, 14, 16, 38, 53, 56-57), in these other instances EE is responding to the concerns of the group. It is only when addressing new topics of concern, of the kind that Boden (1994) refers to as 'queries', that something deeper occurs, that is, he utilises the A3 report to justify his concern.

Vignette 8 from routine 1

1	CE:	Nice to see, I think we are all agree (pointing to the test data on the A3 sheet) [>>>A3]
2	EE:	Strange electricity can't know where it is going, [>>>A3]
3		where the fuck…on differing points [>>>A3]

HE: Experimental conclusion but they are using the super sensor
which is not reliable for testing [>>>A3]
but this is what the customer sees.
Need a repeatable measurement.
CE: so we can do a retrofit?
EE: I think the best thing is to put a modulator
HE: problem is it doesn't fit in battery module
Why can't we put a BD on 45v?
EE: Too much electricity at the beginning.
HE: what about using an inductor?
EE: problem is the main motor
CE: but switched f controller?
EE: not just main sheet
HE: Keep it in mind
CE: Just don't use . . .
(All – Laughs, interlude about classic history of computer components)
(All then look at the A3 report on the screen in the diagnosis section)
EE: thought it was no problem but actually it is a massive problem. [>>>A3]
Look at connection that are connected and not, [>>>A3]
there are a lot of issues. [>>>A3]
(EE runs over all the options figuratively with the cursor and points
to how a change causes another change in the components) [>>>A3]
EE: probably some issues we didn't catch.
HE: I think if we do, do it new gen.
CE: Yes I agree
EE: We can do it but have to recall some parts
CE: So that would be sales and marketing
(All continue to gaze at diagrams of potential issues and solutions on the A3)
CE: It's going to complicate things!
(What follows is a long monologue on the reason why the company is
winning in the market place due to its customised product).
HE: I can agree as long as we do it on the next one.
CE: Move toward but doing it for years.
HE: summing up above.
EE: we don't have all the resources in the world
CE: Need to understand modulator – it can only help.
HE: EE has already done most of the work
(EE's layout is a background for conversation at this stage it is not really used
– CE points to the board and says issues to keep in mind – he then goes through and brings out assumptions)
CE: it can only help
EE: What about knowledge from other work done on the 'Tethers' concept? [>>>A3]
CE: I agree shield power
EE: there are other sources of noise [>>>A3]
There is so much more going on . . . [>>>A3]
(the A3 is alluded to bring out aspects of the reasoning EE has gone through such as his decision tree
– he often think that he has not scratched the surface when considering all the inter dependencies.
This part is not overtly discussed but it is seen as evidence for all his work)
All: Focus on A3 [>>>A3]
CE: (typing in the decision part of the A3) I'm going to do this now [>>>A3]
EE: Testing condition 900 RPM correct? [>>>A3]
CE: We don't want to over engineer
CE: [Talks about what customers want]
EE: tethers, cables, shielding (reading off the A3 sheet discusses other solutions that has not been in the discussion so far it opens the discussion up to more solutions) [>>>A3]
HE: how does it affect road map?
CE: Cables is manufacturing, outsource we haven't transported that to production [>>>A3]
HE: (looking at requirements on A3) Level of detail on customer requirements…do an ECO
CE: CAD it and mark it up

Lean artefacts as the re-specification of glosses

Related to the analytic discoveries above is the use of lean artefacts to re-specify glosses. Glosses are words which are used as resources in conversation to denote taken for granted references (Sacks and Jefferson, 1995). The use of artefacts through the use of publicly available data allows these glosses to be re-specified. That is, the actual referent of the word is made explicit rather taken for granted. For example, in **Vignette 8** above all the participants jump to a solution at each stage of the A3 report, firstly as modulator (line 9), then the need to do it 'next generation' (line 27). Here the members keep engaging in glosses to what they all assume is the issue. Yet as they go through the report these positions appear to become untenable. Through interaction with the A3, EE (the author of the report) then suggests the Tethers concept (line 44), offering a solution to what he first thought was unsolvable. What follows is a period of intense silent scrutiny of the A3 report (line 51). The next action (line 52) is to add the offered solution to the A3 report as an action. Previous 'solutions' to an apparent 'problem' no longer appear to be an issue, the issue has been re-specified through an intense period of interaction with the A3. This eventually results in a gestalt like episode and a completely new understanding of both the problem and its solution. This need to drill down into the most basic descriptions possible regarding an event was a recurring theme in participants' explanations of their work. The following comment by CE illustrate this: "talk of standards is ok for Aluminium but for other aspects we use a trade name, we need to get away from the trade name and use a chemical formula, we need specification". Other participants stated that "Sometimes its ok to solve the problem on your own, sometimes you go to see them (like manufacturing), where the problem is occurring, actually it is always better to go and see the problem directly" (Electrical Engineer 1). Participants stressed the need for first hand data and where possible included primary data in their reports.

Lean artefacts as problematic

Sometimes when discussing the differing logics of the A3 participants those who created them made excuses as to why they had put the information in the report, stating them as 'crazy', or 'just thoughts', wishing to distance themselves from the ideas. After a meeting I asked a participant why they were so resistant in expressing these ideas, the response was "its hard stating problems and ideas in public" (Electrical Engineer 1). Afterwards the same interviewee said "I thought engineering was about doing it on your own but the A3 helped bring it out, it's sometimes hard to talk about problems; team work and testing that is what lean is about". The CE related stories about how engineers signified dissatisfaction with

having to put information into the report with disparaging comments such as; “I have A3 of the week, next thing I see is someone puts up there A3 of the ‘weak’, its ok they will come around, not everyone will but…”. Participants experiencing difficulties were seen in interactions with lean artefacts. For instance, **Vignette 9** shows how the head engineer failed to understand the group’s problematic gasps (line 3) about the A3 report, and is then corrected by reference to some of the information in the report. Lastly **Vignette 10** shows how a member using the check sheets and answers them proficiently, but then starts to have some difficulty in answering, denoted by the pauses. The pauses are followed by stating that he feels unqualified to answer the questions before he promptly removes himself from the conversation (lines 19-21).

Vignette 9 taken from routine 2

1	HE	so we have this A3 report, so what is so exciting [>>>A3]
2	All	(gasps) [>>>A3]
3	All	‘2’ [>>>A3]
4	CE	what is so exciting [>>>A3]
5	Y	it’s the lower scales [>>>A3]

Vignette 10 taken from routine 7

1	CE	We have these check sheets so I was going to ask you for a few quick questions [>>>A3]
2		The first is do you need this capacitor? [>>>A3]
3	P	I don’t know
4	CE	the only reason I ask, do we have to do something pretty interesting
5		Are the cables locking connections? [>>>A3]
6	P	let me think, this will be mortex connections,,,
7		And some as4
8		So…
9	CE	so
10	P	the power into this area is typically not locked
11	CE	10 pin
12	P	I forgot
13	CE	10 pin
14	P	no its epoxy
15	CE	we just want to know its something in
16	P	yeah its epoxy
17	CE	how is the padding is it o ring or… [>>>A3]
18	P	yeah i…
19		I’m not sure…
20		your talking to the software and firmware engineer

5.2.3 Recourse away from lean artefact interaction

Transient use of the lean artefact

The analytic descriptions above all refer to interactions with the artefact, however, these interactions were not constant. Interactions ranged in a spectrum from full commitment, to

partial, to none, and these varied across time and within the group. Interactions often moved away from those characterised above into less data driven, less open, involving more glosses, and appear to revolve around specialised knowledge of the utterer. The extended **Vignette 8** is illustrative of this with participants jumping to solutions before interacting with the A3. Once the A3 is used a solution is forthcoming. Organisational members with clear epistemic authority in some areas disrupted the interactive order and moved the conversation away from the artefact into a more emotive gloss on the situation. For example, in **Vignette 11** the Sales representative uses the category of 'customers' (line 7) to signal to the previous participants that there are issues that they do not have legitimacy to talk about, effectively closing down productive discourse. These lapses of artefact use are soon corrected by the routine adhering to the lean artefact's format. For instance, **Vignette 11** at line 14 CE closes down the conversation with "let's move on", directly referencing the artefact in his gesture.

Vignette 11 from routine 9

1	X	I don't want to stop thinking about loss mitigation [>>>A3]
2	L	yes but it is not a project [>>>A3]
3		We need to keep it in mind
4	HE	yeah like recovery system
5	S	yes, that is what we have here
6		It shouldn't be too broad
7	Q	yeah tell our customers loss mitigation is not a concern
8	X	I'm just thinking of recent stuff
9	L	this is for projects that we need to finish
10	Q	you could probably categorise
11	L	yes some of these things should be in the user manual
12	S	we're due a lot of good stuff but we need feedback from repair not ops
13		But I think it is a service project
14	CE	let's move on [>>>A3]

5.2.4. Findings

Previous research has found support for the multi-role artefacts play within organisations (Nicolini et al., 2012). This research corroborates these findings concerning the use of Lean artefacts. Evidence suggests at one level of abstraction that artefacts have a dual role; it is either used for justificatory purposes where it is simply referred to in a rhetorical use, or it is used as a basis for an investigation as an integral part of the routine. Where participants used the artefact in the former instance it could be argued that this limited their reflection processes, for example they could have considered an under-researched topic closed and pursued other lines of enquiry without investigation. This study is focused on the second use of the artefact, how it affects the performance of a routine when in use, its internal dynamics. That is, if routines are "*repetitive and recognizable patterns of interdependent actions,*

carried out by multiple actors" (Feldman and Pentland, 2003: 95), then how does the use of lean NPD artefacts affect these actions which constitute routines?

The use of artefact within routine problems led to interactions that can be understood through Dewey's concept of learning. These include the concept of backtalk with materials expressed by the interweaving between talk and the artefact present within **Vignette 7.** The discursive activities of the participants based on, and informed by, the systematic presentation of information through the alternative logics within the A3 correspond to Dewey's notion of problem determination and the formation of a working hypothesis. During this process participants engaged in interactions that can be characterised with Dewey's notion of 'reasoning' through the artefact. Finally, the last stage in Dewey's reflective cycle is present in the routines that use the A3 artefact unlike routine within the A3s creation. That is, the results of the experiments found within the A3 are evaluated to determine future courses of action, within the group activity, this reformulated the assumptions and hypothesis behind the problem. Here, each course of action is tested by within the routine, 'imaginatively' (Dewey, 1910), to clear the way for the next course of action. For instance, in **Vignette 8 routine 1** the impression of how to deal with the issue of electrical currents is transformed by the end of the interaction with the A3, from an unsolvable problem to one which existed within their current capabilities. This ended with firm action to put forward an 'Engineering change order' (ECO) and 'CAD it up' (line 60-61).

Vignette 8 showed how routine participants came to solve a problem which they first thought unsolvable, through the use of reflection via lean practices. This solution happened to reuse current knowledge which was inscribed within the artefact. However, other lean development routines highlight even more radical consequences stemming from reflection behaviours, which may show how reflective behaviours result in more readily accepted 'new' knowledge.

For instance, **vignette 12, routine 9,** which uses the roadmap to form a strategic overview, demonstrates reflective behaviours. As described these consist of: surprise (line 1), problem definition (line 2-5), working hypothesis (line 6), reasoning (lines 7-14), and testing (end of line 14). Although such a sequence looks innocuous, the ramifications from the learning episode is dramatic. The engineer is in fact saying (X), that instead of buying or developing new hardware and software module to fit onto the product, they can just change the software of the current camera to perform the same scan. This significantly increases the products

function at minimal cost and is a revolutionary concept to produce more impact from their current hardware systems. Notice how this mirrors historical descriptions of lean development from chapter two: assets are reconceptualised to produce more functionality, reducing cost and engineering time.

Vignette 12 taken from routine 9

1	X	what is that [>>>RM]
2	L	it's mostly mechanical [>>>RM]
3	HE	is there customer interest
4	CE	our competitor has it? [>>>RM]
5	Q	Yes we need one, we need it now, they would love one [>>>RM]
6	X	yeah but we can calibrate it from a camera [>>>RM]
7	Q	Really, great
8	CE	it's a huge animal
9	HE	can't we just try I and see how it compares
10	S	yeah good to see
11	HE	but should it be camera rather than a new sensor
12	Q	there is customer interest for that
13	HE	so how much will this cost?
14	CE	it's like a scanner, I'll put it up there (writes in road map) [>>>RM]

Findings indicate that the artefact played a central role in managing the local interactions of participants to produce these characteristic learning practices. Three mutually reinforcing activities occurred. Firstly, interactions had clear referents through the artefact, words were expressed in 'extensional' terms (Extensional terms refer to actual instances of the things being used rather than a property or an idea of thing (Frege, 1997)). As in previous literature this situated meanings within the artefact (Carlile, 2002), resulting in verifiable meanings, rather than in assumed meanings or glosses. This allowed participants to build understanding through the artefact via sequential interaction with it (Boden, 1994). Having verifiable meanings on public display opened up the interaction for all participants to engage in; since information was public they had the possibility or a 'right' to comment on it (Drew and Heritage, 2006).

Justifications were not linked to epistemic authority of an organisational member but linked to the accessible information within the artefact which gave the ability to be checked and validated publicly by all present. The process of going through the artefact further broke up the sequential order and provided openers through which participants could comment. The artefact also represented alternative logics as to how to solve issues, this orchestrated the participants to systematically analyse a problem according to the logics which had been constructed within the A3. The data showed that the information content and it's structure

enabled these interactions and was a resource through which they were made possible (Suchman, 2005). Echoing findings from Koschmann et al. (2005: 3), collective understandings were negotiated and expressed via individual understandings, the lean artefact being key to this process. This allowed participants to represent the problem at hand in great detail and manipulate it according to their domain of expertise; Engineering.

Lean artefacts played a key role in managing aspects of the interaction that can be seen as a condition of learning. That is, the artefact formed the focus of group attention which was ephemeral. There was a spectrum of use with the artefact from full and constant use to relatively little. Shifts in use happened suddenly as participants orientated to the nearest concern. This supports previous ethnomethodological research into organisations which argues that attention is fleeting, and participants often orientate to the closest episode (Boden, 1994). In this case participants were reoriented back toward interaction with the artefact without exception due to the structure of the meeting and future actions were determined by inscriptions in the artefacts. This is seen in **Vignette 8** and **Vignette 11** (line 14), and would suggest that the artefact provides an enduring reference point for organisational attention to fix on, attention which, by itself, is transitory. Such a fixed point ensures that the processes of learning are not lost, in case the group's attention becomes distracted by other concerns (Ocasio, 1997).

The CE as a lean actor also played a subtle part in orientating organisational attention. The CE as main proponent of the lean artefacts continually referenced their use. For instance, **Vignette 11** illustrates how he pulls the conversation back toward the artefact when attention strays to other topics. The CE, as the authority figure, on the whole grounds their conversation and debate in the artefact. The CE legitimates the artefacts when he could, by rights, refuse to engage with them. Counter examples do exist of the CE being distracted and ignoring the artefact (as you would expect if limited attention is a human feature), such as in **Vignette 8**. Within interactions the CE does not seek epistemic authority through his senior position, but via legitimization within the artefact. In a sense, the CE is subverting his own authority and placing it within the lean artefact.

Like lean artefact creation, when in use artefacts caused psychological discomfort for some users. Participants variously felt embarrassed, expressed frustration, and sometime refused to engage in interactions with the artefacts (as illustrated by **vignette 10**). Again this suggests that the use of the artefact conflicted with a normative belief held by the subject. Participants

found artefacts irksome, as a form of embarrassment, and as a potential source of being 'found out'. This appears to be linked to concerns over their institutional role, as participants expressed providing public information an affront to their expertise, or an undermining of it. Interestingly this psychological discomfort rarely entailed a-disconnect with the artefact; subjects often carried on with its use within the routine despite these issues, apparently un-phased by the temporary discomfort.

5.3 The analysis of development routines without lean processes

The analysis of routines without lean processes largely occurred from data collected in routines 2 and 3 (**Table 4.3**). **Figure 5.9** shows how in non-lean development routines there were three aggregate dimensions that were derived from the data that occurred during these routines. The first was that there were consistent behaviours in the routine where personnel were unclear on what others were referring to. The second, that interactions within these routines were characterised as having no public information available to those in the routine. The third, that there were no artefacts of any kind utilised within the routine. What follows is an analysis and discussion of each of the second order themes which constitute **Figure 5.9**, and contribute to the aggregate dimensions.

Figure 5.8: Data structure of practices within development routines without Lean processes following Gioia et al. (2013)

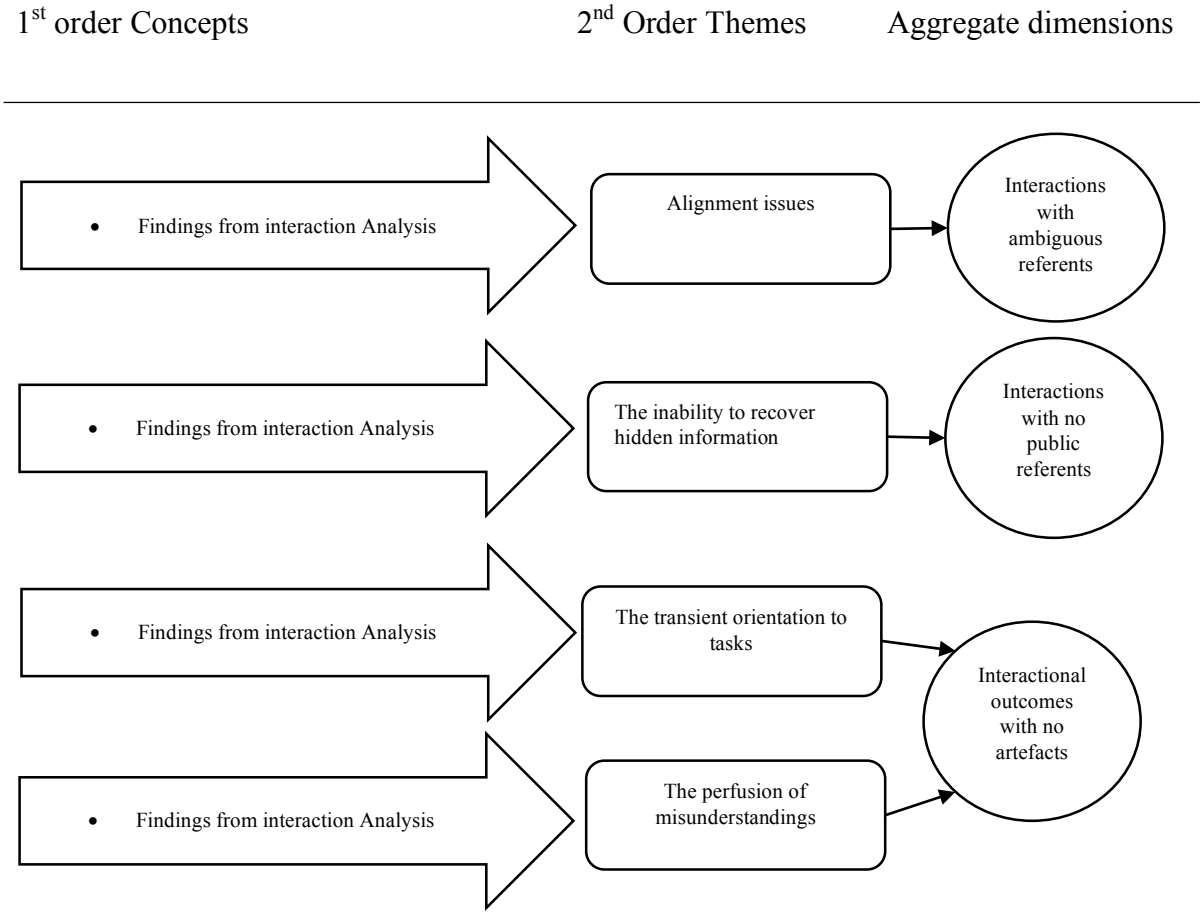
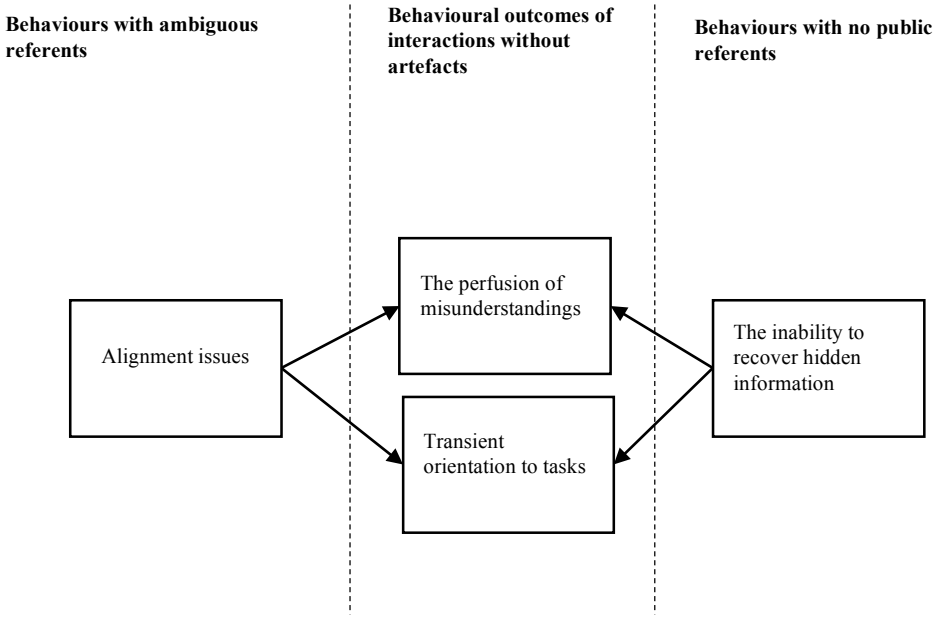


Figure 5.9: Dynamic model of practices within development routines without Lean processes following Gioia et al. (2013)



5.3.1 The analysis of practices where there are ambiguous referents

Alignment issues

During interactions of organisational members without lean artefacts, there is a profusion of what can be termed 'alignment issues' (Ten Have, 1999). Alignment issue denote different or ambiguous references people use during interaction, and as a consequence talk past each other. These then result in people questioning what is actually occurring, preventing progress on a topic. Further, they did sometimes develop into misunderstandings, defined as when people actually encountered trouble in talk, which then resulted in the need to repair understandings (discussed in section 5.3.3.). For instance, **Vignette 13** below shows how CU keeps using ambiguous referent to what he wants; something for, 'training' but not, 'too expensive' (lines 3, 7, 10, 18, 20-21, and 23). CU is not determinate in what he wants despite the best efforts of SE and HE. This leads to a totally non-productive conversation in which all parties are no clearer as to actually what they are trying to do. This is evidenced by HE's question immediately after the interaction (line 28) which highlights that these misalignment issues are in need of repair. These alignment issues appear to prevent common understandings from being generated and, hence, productive talk; it is only taking up organisational member's time.

Vignette 13 taken from routine 3

1	SR:	(calls 'CU' on the phone and questions them on what they require).
2	CE:	(talks through requirements to CU)
3	CU:	yes that is the purpose but . . . (talks through a story logic about training etc.)…
4	CE:	so created file is ok what sensors do they need?
5	CU:	what we have e.g. SS and of course version x.
6	CE:	(talks through some more assumptions)
7	CU:	(checks and affirms decisions); just as it is in the H
8	CE:	and 'x' is included in scope of supply?
9	SE:	for 'Y' fit up vehicle do you need x, am I missing anything?
10	CU:	the purpose is . . . training
11	(Everyone in the room looks quizzical)	
12	SR:	I understand what he says (this is directed to the meeting room not CU)
13	HE:	So can you explain x
14	CE:	yeah can you explain?
15	CU:	oh yeah it is just . . .
16	CE:	oh yeah
17	CE&HE:	(make rapid questions about specifications)
18	CU:	what is possible but within a price, but if it is not a big issue that would be great
19	CE:	so do you need x?
20	CU:	what is possible, in my understanding . . .
21		but as long as it is not too expensive, that would be a big problem
22	CE:	[nods]
23	CU:	there is no president, you can give them different data, other possibilities, it is up to you.
24	CE:	nods
25	CE:	(summaries the requirements then confirms)
26	CU:	Yes exactly…
27	CE, HE, SR, SE:	Thanks, Bye
28	HE:	we put the sim in the dummy vehicle then?

5.3.2 The analysis of practices with no public referents

The inability to recover 'hidden' information

This analytic description differs to the alignment issue stated above since the referents are clearly established between participants so that alignment is not an issue. Rather this interaction is characterised by the fact that the members of the meeting have not made the information public. Since information is not publicly available participants have to expend effort to determine which issues may have a bearing on the situation. This allows members, intentionally or unintentionally, to conceal relevant information from one another and have difficulty with recall. This type of interaction was particular manifest in **routine 2,** when the participants were trying to determine a new sensor. Both engineers in the meeting were highly experienced and knowledgeable to the issues at hand. However, in trying to construct a solution to the issues of the meeting the CE could not sufficiently establish whether or not the other Engineer had covered all the pertinent issues. There were no physically accessible indicators that the engineer had actually done a comprehensive study on the topic. The engineer who had done the work which was the focus of the meeting, constantly responded to questions with the opener of "I think…" emphasising the provisional nature of the response. This limited further development of the topic since it was unclear what elements of talk were speculation and which were fact. The assumptions through which the Engineer constructed inference was also unclear for instance "should be ok since small passed in test" (ME) and the "…FMEA says it is close" (ME). The CE responds to these glosses with the phrase "Lots of questions, no answers". This meeting ended with the requirement for the ME to put their understanding of the issue into an A3, that is, follow a lean process.

5.3.3 The analysis of behavioural outcomes in routines without lean processes

The transient orientation to tasks

Routines that lacked lean processes exhibited the pattern of members sporadically focusing on issues which they felt to be salient in a specific instance. This meant that the direction of the meeting never achieved its intended goal, and that not all of the issues on the agenda were discussed. For instance, this is evidenced where after **routine 2** the meeting became stuck in conversation about margins of safety in product design which were not the focus of the meeting and derailed the discussion from important topics as evidenced by the CE, "I didn't even ask about the colour of the plastic, this is the sort of thing that we are trying to sort out. . .I will go for the acrylic, it is a $50 part and I have not got the resources, but I will

let him chase the problem for a while". On other occasions this transient orientation became clear within interactions during meetings before the artefact was utilised, as detailed in section 5.2. V**ignette 8 routine 1** is a typical case; before CE and HE engaged with the A3 they moved through topics in an erratic fashion, orientating to what they 'believed' was salient, before the use of the lean artefact.

The perfusion of misunderstandings

Without lean processes interactions typically resulted in what conversation analysts' term, 'repair sequences' (Schegloff, 1979; Schegloff, 1992). In 'repair sequences 'an utterance is seen as a source of trouble, through which the next sequence tries to rectify that difficulty. The sequence can also ask people to self-repair, such as 'Could you rephrase that please?'. Without lean artefacts misalignment often occurs during interaction (see section 5.3.1.). While initially this misalignment is dealt with without problematizing communication per se (they are just misalignment issues), this soon develops into the requirement for repair, as in **Vignette 13** line 28. This is typified in **Vignette 14** where interactions during lines 1 – 5 are characterised by alignment issues. This culminates in the statement in line 6, this is responded to in line 8 where CE asks SR to repair. However, CE initiates his own repair sequence through sense-making activities, lines 8-9. This confuses SR who at line 13 asks again for another repair, "So I don't need to ask the customer?", to which CE replies that the customer still needs contacting (line 14). These interactions are thus characterised as prevalent with instances of misunderstandings intrinsic to the interaction, which requires time and energy to rectify from the participants. During these episodes the tasks at hand are not progressed with because all organisational attention is used in trying to construct understandings of the situation, but significantly none is achieved.

Vignette 14 taken from routine 3

1	HE:	we want it on a Linux / windows, a virtual way
2	CE:	what about legal requirements of license?
3	HE:	it is cheap
4	CE:	used to be expensive
5	CE:	price and specs are needed
6	CE:	all these customer requirements are too generic
7	SR:	they have another simulator
8	CE:	I'm confused –
9		what do they want (CE breaks down as to what he thinks they want, x y z)
10	HE:	Do we need to revert to customer's most logical explanation?
11	CE:	(brings up e-mail from client to make more sense)
12	SR:	(puts requirements on board)
13	CE:	so I don't need to ask the customer?
14		No, I still want you to make contact

5.3.4 Findings

Routines without lean artefacts expressed in two types of interactions which resulted in the same outcomes. The first is where the individuals within the routine are unclear about the meaning of the terms used within the conversation. Participants endeavoured to engage in meaningful talk but ultimately this results in an eventual break-down or misunderstanding, and an ability to deal with a topic systematically. This cycle repeated itself which ultimately resulted in the task of the meeting never being accomplished. The second pattern occurred when all people in the meeting understood what was being talked about, however, they couldn't publicly access the information, and so determine all lines of reasoning. This meant that much effort was spent trying to surface all relative information and ultimately an inability to maintain focus on a line of argument. This resulted a constant change in the topic of information and an inability to co-confirm inferential lines, and so misunderstandings occurred.

Both these types of interaction lack correspondence to reflective learning. In each case the participants were aware that something was at issue, as is indicated by the fact that they were present in the routine to solve a particular problem. Hence, one can infer they experienced the initial stages of reflective behaviour through the notion of back-talk. However, this is as far as the process goes. The stage of Dewey's intellectualisation never occurs; data appears to present participants engaging in a form of intellectual 'grasping' followed by instances of what can be called working hypotheses and reasoning occurring. These stall, however, because they are not accepted as issues by everyone in the routine (Koschmann, 2011). This is evidenced by the frequent incidence of repair situations where issues appear to be troubling for the participants, and issues get in the way of solving the organisational problems the routine was designed to do.

Both interactions lack data that the group can co-verify, however, in each case there are different reasons for this situation. Where there are ambiguous referents data needs to be sought to determine what actually is the case, whereas where the data is not publicly available there is a clear practical issue of the need for representation. Throughout both interactions there was no ways to objectively legitimate assertions so that they could be jointly seen by participants as ways to formulate the problem within the routine. Thus, there is no formulation of a group working hypothesis, which inhibits the reflective learning cycle.

All routines irrespective of the presence of the lean actors resulted in a lack of progress on the topic without the use of a lean artefact. Each time this occurred the CE indicated that the task would have to be performed again, but this time 'following the process', that is, using lean artefacts such as an A3 report.

5.3.5 Conclusion

The within-type analysis has demonstrated some surprising results. Within routines for lean artefact creation (section 5.1), lean actors play a key role in expertly designing the artefact to representational considerations around a specific organisational issue they wish to remedy. Within these routines lean actors teach other organisational members to react to the artefacts' questions in a specific way, through utilising a sceptical attitude and only relying on empirical data. Through a combination of these trained responses and commands from the artefact, participants that construct artefacts such as the A3 report engage in interactions that can *almost* be characterised as Dewey's reflective learning. No actual decisions are made in the A3 construction routines that would complete the reflective learning cycle. Interestingly the creation of the artefact was problematic for some routine participants, it clashed with their sense of how work should be done, that is a their 'moral order' (Garfinkel, 1964).

Within lean development routines (section 5.2) members engaged in a full cycle of Dewey's conception of reflective learning. In these routines the lean actor appeared to have a vital yet subtle role in forming interactions that could be characterised as reflective learning. They devolved power to situate legitimisations of assertions within the artefact. This resulted in the lean artefact as the focus of reflective learning interactions. The artefact altered the character of the interaction, opening up rights to knowledge, systematically presenting information, and removing organisational glosses such that reflective learning occurred. Critically the lean artefact anchored organisational attention, which was generally sporadic, so that orientation to the routine task was maintained, and participants generated concrete development tasks from the routine. Again the use of the lean processes provided problematic to some members, they felt silly or over-exposed by putting their thoughts in the A3 and exhibiting them to the group within the routine.

Development routines in the absence of lean processes (section 5.3) were identified as having no reflective learning behaviours. Rather these routines became mired in attempts to

legitimate understandings which was shown to be difficult under the conditions within the routines. This resulted in a decision to re-run the routines under lean processes.

Prima-facia these findings appear to contribute to the research questions and to the wider literature. However, these issues are dealt with in the next chapter where a cross-type analysis is utilised comparing and contrasting the three routines, so that theoretical generalisations can be formed related to reflective learning and lean actors and artefacts (Ten Have, 1999). Results from the cross-type analysis will then be utilised to answer the research question and propositions. This will then be followed by a broader discussion as to how these results connect to the wider literature and the contribution they have to theory and practice.

Chapter Six: Cross-type analysis and discussion

Chapter Overview

Chapter five identified that reflective learning is occurring within lean NPD development routines as a consequence of interacting with lean NPD practices; it, is, therefore, highly indicative that the research question can be affirmed. To address this question explicitly, however, a cross-type analysis needs to be performed (Ten Have, 1999). Here the three routines can be contrasted and compared as a collective. A cross type analysis augments the within-type analysis of chapter five in two ways. Firstly, it will build on the prior analysis to understand the meaning of practices as a whole within the organisation, and thereby provides a deeper understanding of what specific practices mean (Nicolini, 2012). Secondly, it will add detail to the exact interactional conditions which result in reflective learning. Once such an analysis is performed, the research propositions and question can be fully answered.

Specifically, the cross-type analysis will provide the basis for comparing the behaviours which lean actors and artefacts engender within routines, and so establish the *mechanisms* by which they interactively affect routines (Peng et al., 2008). This follows the logic of Mill's (1884) eliminative induction, prescribed by Ketokivi and Choi (2014), which provides the basis on which the answers to the research propositions will be discovered. This strategy also follows the prescriptions of Mason (2002), who believes that to ascertain an understanding of organisational mechanisms we need to determine how a construct behaves in differing contexts. Ultimately, this will result in the affirmation, or modification of **Figure 4.3**, which provided the testable framework based on the three research propositions. The research propositions and question to be answered are:

RP1: *Interaction with lean actors increases the 'willingness' of people to engage in reflective behaviours within routines.*

RP2: *Interaction with lean artefacts increase the 'capability' of people to engage in reflective behaviours within routines*.

RP3: *Interaction with lean artefacts combined with lean actors increases the 'willingness' and 'capability' of people to engage in reflective behaviours within routines.*

RQ1: Does the interaction between lean NPD practices and people within organisational routines lead to reflective learning behaviours?

The second major section of this chapter discusses the ramifications of the findings for wider theory. In particular, these findings will be discussed in the light of the theories used in the construction of **Figure 4.3,** such as theories of reflective learning, routine theory, and the lean NPD literature.

6.1 A cross-type analysis of routines

Chapter five demonstrated there are some behaviours produced as a result of interacting with lean actors and artefacts, could, using Dewey's (1925) criteria, be labelled as reflective learning. However, the analysis is not sufficient to answer the research propositions and question because it only considers the routines in isolation. As such, the analysis fails to consider the different contextual features where lean actors and artefacts result in reflection, and of equal importance, when they result in non-reflective behaviours. Furthermore, considering these practices as a whole may shed light on the meanings of the practices.

This cross case analysis follows two routes. The first discusses emergent features from the data to provide a holistic understanding of factors which occur within the data. Specifically, it will be argued that the findings show two other key factors which affect learning: the role of social norms, or 'moral order' expressed in an 'ethnomethodological language' (Balogun et al., 2015; Garfinkel, 1967), and the role of a routine factor previously identified as organisational understanding (Parmigiani and Howard-Grenville, 2011). These emergent findings are derived from the observation that all three routines are related, and form an underlying picture of how routines function within ROBOT. This is displayed in **Figure 6.1**. In the second route, a cross-type analysis is performed in direct response to the research propositions. Here interactional contexts which lead to reflective behaviours are detailed.

6.1.1 Emergent features of the data

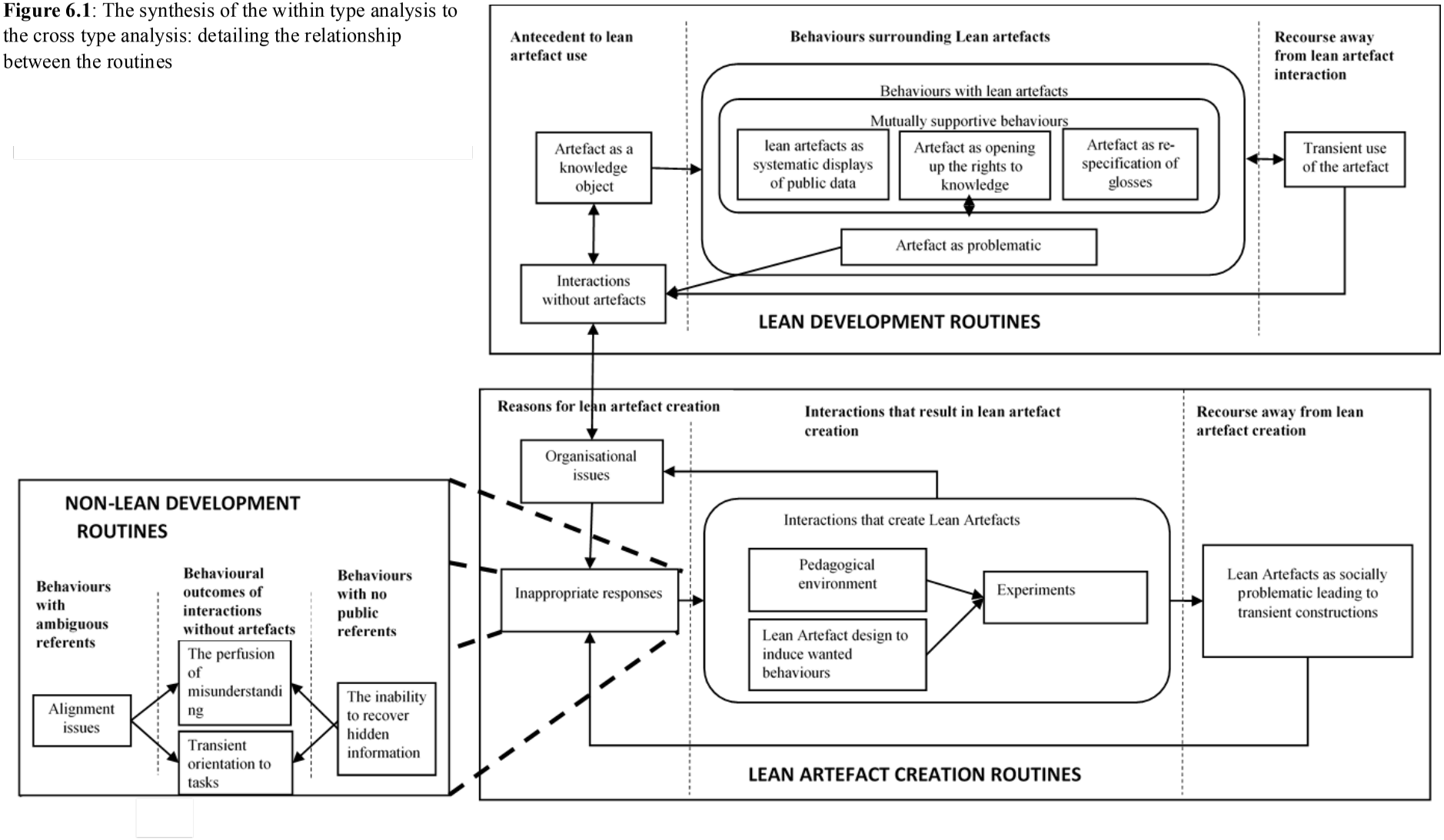
The relationship of the three routines is shown in **Figure 6.1**. This emerges from the 'Gioia analysis' (Gioia et al., 2013) of each of the routines found within chapter five, and preserves each routine's behavioural detail generated by the analysis. The data displayed in chapter

five clearly shows why each routine is being performed and their connection to other routines. Routines for the development of lean artefacts are performed to create artefacts as a corrective of inappropriate behaviours in *previous* development routines. These are denoted by the box of 'inappropriate responses' leading to the box identifying 'lean artefact design to induce wanted behaviours'. Inappropriate behaviours are deemed inappropriate by the chief engineer. Interestingly, these behaviours can also be found in non-lean development routines. These routines are performed to solve engineering issues in order to bring a product to market, yet they lack any lean processes; as a consequence, behaviours occur that prevent such engineering issues being fully solved. The behaviours identified in non-lean development routines display the nature of these inappropriate responses when a routine is actually occurring. Thus, non-lean development routines are related to lean artefact creation routines in their exhibiting of behaviour that lean artefacts are created to correct. Hence, in **Figure 6.1**, the 'inappropriate behaviours' box within lean artefact creation routines exhibits a dotted line to non-lean development routines. The Gioia analysis of the non-development routines expresses in detail the behaviours which constitute these inappropriate responses that lean artefact creation routines refer to.

The logic behind the relationship between routines for lean artefact creation and lean development routines is relatively clear. Once an artefact is created (via the routine for lean artefact creation) it can be placed within a development routine, which thus produces a lean development routine. This, in effect, connects the routines of artefact creation and lean development. The artefact is placed in a development routine to help bring about behaviours that can firstly solve engineering issues during NPD and, secondly, prevent unwanted behaviours that would normally occur without these artefacts (those exhibited in the non-lean development routine). This connection is expressed in **Figure 6.1** by the arrow from the organisational issues box for lean artefact creation routines, to interactions without lean artefacts box in lean development routines. This is the appropriate connecting box since the artefact is now, as a consequence of the artefact creation routine, present within the development routine. However, the participants within the lean development routine can determine how they use the artefact (e.g. they may ignore it, use it as a 'knowledge object' or fully interact with it). Hence, the two-way arrow in **Figure 6.1** between the two routines; artefacts may need updating to new forms if they do not correct behaviours they were initially sought to remedy.

Figure 6.1 illustrates the logic of the relationships between the routines and the arrows indicate the complexity of these relationships. For instance, in lean development routines people may decide not to use the lean artefact, or find it socially difficult to use, or, equally, they may have their attention diverted away from the artefact. These may all result in unwanted behaviours, which may themselves require new routines for lean artefact creation to solve. Furthermore, as displayed in the data in chapter five, some unwanted behaviours may no longer persist, or be an issue for the organisation, which may result in the dissolution of an artefact. For instance, artefacts for the measurement of ECOs were created, and then stopped within ROBOT, once the issue they were created to solve stopped being a problem.

Figure 6.1: The synthesis of the within type analysis to the cross type analysis: detailing the relationship between the routines



Moreover, in routines for lean artefact creation, these were not always performed to their full extent: This resulted in a lack of efficacy of the artefact or in the inability of the routine in which the artefact was supposedly being used to have any effect on the routine. This ultimately maintained the routine as a non-lean routine, as in **routine 2** where the engineer had to do the routine again 'properly' (i.e. with the lean processes). Thus, the chief engineer was constantly trying to coach employees in the benefits on fully engaging in lean artefact creation routines. What the above discussion states, and the diagram depicts, is that there is a constant shifting of behaviours both within, and between the routines themselves. Consequently, although this research aim was to find how lean NPD altered learning behaviours within routines taken in isolation, this emergent finding indicates that the nature of the interaction with lean NPD may be a result of interactions built up across other routines, which mirrors the findings from other scholarship that focuses on the use of artefacts (Cacciatori, 2012; Salvato, 2009). This emergent finding is important because it provides an explanatory context for the function of lean NPD practices within routines.

Given this emergent finding, the data of **Figure 6.1** is analysed in order to determine any new meaning, given this research's theoretical lenses. Firstly, it will be argued that these practices cumulatively express conflicting social norms which occur within the routine, called a conflict of moral order (Garfinkel, 1964; Rawls, 2008). Secondly, it will be posited that organisational understanding within the routine plays an important role in learning behaviours (Turner and Rindova, 2012).

6.1.2 A conflict of moral orders

One overarching theme expressed in the data is the presence of conflict occurring within the organisation between two social norms (or specifically the concept of moral orders found within ethnomethodology (Garfinkel, 1967)); this is between the native, non-lean moral order and the lean NPD moral order, each having their own unique behavioural footprint (Heritage and Clayman, 2011). 'Moral order' is a concept previously introduced in this research stemming from ethnomethodology, which expresses normative, unnoticed, expectations about how routine activity *should* occur (Balogun et al., 2015; Fox, 2008; Goffman, 1981; LeBaron et al., 2016).

> *The Moral Order consists of the rule governed activities of everyday life. A society's members encounter and know the moral order as perceivedly normal courses of action, familiar scenes of everyday affairs, the world of daily life known in common with others and with others taken for granted. (Garfinkel, 1964: 235)*

What the moral order is, is determined by the interaction between the people present and the context which they find themselves in. For instance, when a lecture starts, students take up seating in the correct part of the lecture theatre, quieten down, take out notebooks and pens and expect to be talked to by someone standing out in front; such expectation is not expressed in rules, but forms part of a 'moral order'. Through a set of famous experiments, labelled 'breaching experiments', Garfinkel (1967) asked his students to consciously behave in an overly polite fashion, as though they were strangers, to members of their own family. The result was that some students found the experiment too difficult to do due to the psychological discomfort it caused them. Some were ostracised by their family; some were verbally attacked for their behaviour. Garfinkel (1967) concluded that the students, by acting contrary to the expectations of the context, 'breached' a moral order (i.e. of how they should behave in a given situation). These observations of the breaching experiments mirrored interactional exchanges within ROBOT, so much so that the routines demonstrated a conflict of moral orders between expectations how to behave in non-lean and lean routines. Each moral order will now be discussed with supporting evidence for this observation.

Routines without lean processes exhibit the interactional footprint which characterises the normal organisational, moral order, that is, how people behave, (or feel they should behave) in response to the need to develop products at ROBOT. The key consequences of this moral order produces behaviours represented in the Gioia analysis of non-lean development routines (**Figure 5.9**). These were, alignment issues, an inability to recover hidden information, which led to a transient orientation to tasks, and the perfusion of misunderstandings. This is how people automatically act in accordance with their 'native' organisational understanding. The CE, as lean actor identifies these behaviours of the native moral order with the achievement of poor outcomes. The CE states that these behaviours cannot continue in the organisation since they would result in too many mistakes, hampering NPD performance. For instance, the CE's expressed exasperation from the statement of one project member who said he needed to feel the pain of making an incorrect inference, so not to make the mistake again. The CE stated that this type of behaviour could not be prevalent within the organisation, since it would hamper competitive advantage. Hence, the first move

that the CE makes as lean actor is act as a *monitor* within routines for behaviours which he deems inappropriate. It is as though the CE has his own individual moral order, set against the native organisation's. How this can be done, given that the CE is exposed to the same contextual features as other members in the routine, can be put down to the long experience of the CE, and shall be the topic of subsequent discussions. Evidence for this monitor role is a dominant pattern in the data. For instance, in all routines observed without lean NPD practices, the conclusion was to do the routine again, but follow lean processes. Furthermore, a major concern of the CE is to censor inappropriate behaviour, and promote 'lean thinking', that is he *monitored* for inappropriate behaviour. This brings us to the next explanation of what lean practices do – they set-up a new moral order within the organisation.

Lean practices utilised to set-up a lean moral order include the following three elements: training routines, the use of artefacts with their own explicit rules, and the collection of data to encode the artefacts in contexts outside the native organisation's 'moral order'. The first task which the CE does as lean actor to set-up a new code of behaviour, or moral order, is to take individuals away from the development routines which focus on mainly engineering issues. They are moved to routines which are set-up to examine how they interact with the institutional environment. Essentially, this consists of extolling the participants of the routine to open themselves up to new potential issues occurring within the environment, and question everything which they encounter.

Within this atmosphere, which can be characterised as pedagogical environment (see the Gioia analysis **Figure 5.2**), the CE introduces the artefacts, such as the A3 report. These artefacts have already been set-up by the CE to produce a particular context in which the participants of the routine are to act. Chapter five described how these artefacts contained their own local rationality determined by the questions they possessed. That is, the questions determined the nature of the information sought, the way it is presented across the artefact, and the timeliness of that information. These questions were expertly designed to express a logical argument within the artefact, exhibiting a thought process of what was occurring around the specific task the artefact was designed for. Furthermore, participants were required to complete these artefacts in a way in which they were unaccustomed, that is, to actually go and see the issues at hand which comprised the data of the artefact. All these behaviours were unusual to the participants, hence the need for the training in the use of the artefact, and the routine. Participants could not just access artefacts and then use them as

they were designed by the CE. Rather, they needed to be socialised into their use, with new social norms being established.

These factors of training-utilising artefact questions, the fulfilment of the artefact with empirical data, and the completion of the artefact in specific contexts-*establish* a lean NPD moral order. That is, a unique context is created, and encoded in the artefact, which exhibits a significantly different set of behaviours in comparison to the ones normally persistent within the organisation.

With these practices and artefacts established outside the normal organisational concerns, within lean routines focused on developing products the artefacts could be used in a variety of ways. They could be ignored, neglected, or used sporadically. Indeed, the negative interactions displayed in the non-lean development routines were also present in lean development routines before the lean artefacts were used. However, within these development routines, the CE could refer to an artefact during the routine, thus changing the contextual features of the routine. This essentially changed the context, altering individual's behaviour within the routine to what 'should' occur, now determined by the 'local rationality' of the artefact. Yet, it is only through the CE's authority that these artefacts were utilised, that is, he *instigated* the lean NPD moral order.

Within lean NPD development routines these artefacts, created in 'off-line', non-development contexts, are then instigated and exposed to the participants within the development routine, generally in the presence of the CE. As described in chapter five, these result in behaviours which can be identified by those Dewey (1925) labelled 'reflective learning'. During artefact utilisation, participants automatically responded to the features within the artefact as though it was transparent. Participants were seemingly unaware of how they were using it, and how this coloured their interactions. However, as chapter five explains, participants' behaviours were in fact based upon the very properties which the artefact contained. Lean NPD practices, therefore, *enabled* the lean NPD moral order.

Through the establishment, instigation, and enablement of a lean moral order, there were behaviours that correspond to what Garfinkel (1967) described as 'breaching'. For instance, in lean development routines, while the use of lean artefacts was particularly effective in providing a context for experimentation, it upset the 'moral order' (Garfinkel, 1967) of normal institutional interaction. That is, it produced behaviour and lines of inference which

transgress the norms of normal institutional interaction (Drew and Heritage, 2006); this is notable in the psychological difficulties some of the participants experienced when using the artefact, as depicted in **Figure 6.1**. Moreover, these difficulties were also seen in the routines for lean artefact creation. Some individuals found creating the lean artefacts problematic and tried to remove themselves from the situation. Interestingly, these problems were not observed as being a consistent activity, but momentary experiences as participants used lean practices.

A striking example of this is in **Vignette 8, routine 1**, a lean development routine. At first, the CE, although himself a lean actor, fails to engage with the A3 report, and ignores the data. This leads him and the head engineer to engage in behaviours that constitute the native organisational moral order; they focus on solutions based on mutual assumptions rather than those based on the data. However, the electrical engineer uses the A3 report to interject, bringing forth behaviours which constitute the lean moral order. Yet he finds this distressing, or 'crazy' (indicative of breaching), and appears to retreat back to the native moral. Furthermore, within this routine context, the electrical engineer cannot even think of solutions he discovered in a previous context where he created the A3 (echoing theoretical insights from Dewey (1925); Miettinen (2000) about how contextual features effect what one can recall). For instance, he says there is no solution to the problem when the solution is actually written on the A3 that he created. Finally, however through continued use of the A3, they agree upon a solution present in the A3 and exhibit behaviours of the lean moral order. This solution is then inscribed into the A3 for future actions. It is noteworthy that some people, including the chief engineer, as lean actor, had trouble in engaging with the A3 and the lean moral order. Aspects that were clearly present in the A3 were ignored whilst the native rationality was applied in the routine. It took an interactional context between the artefact and the people present in the routine to 'see' what was actually present during that routine, that is, it took a unique moral order to account for critical features of the context. Hence, it is the ability of lean practices to be enduring, because of their materiality (Latour, 1999), that fixes participants attention and ensures the lean moral order is *maintained*.

In conclusion, the analysis shows that lean NPD practices can monitor, establish, instigate, enable, and maintain, a system of social norms or moral orders which are different from those normally found within the organisation. Moreover, the lean NPD moral order is set-up, at least within ROBOT, as diametrically opposite to the natural moral order. Within the routines, the social discomfort and different inferential systems which each moral order

places on individuals can be seen through people's interactive behaviour, and most notably in episodes which mirror those described in breaching experiments.

The moral order is an appropriate concept to apply to these observations because the lean practices do not change the purpose of any 'native' organisational routines. That is, in development routines, both without and with lean practices, the objective was the same: to bring a product to market. The only difference within these routines was how participants went about their work. The way they did this, within these different routine types, is fundamentally expressed by their responses to one another through interaction, which indicates how they deemed they should respond (i.e. the moral order).

6.1.3 The organisational understanding of the routine

While the concept of moral order plays a role in explaining the reactions of those within the routine and how they were influenced by lean practices, the ability of learning to be actioned, and understood 'organisationally' (i.e. so that it was codified in organisational data systems (Argyris and Schon, 1978)) was dependent on the organisational understanding of the specific routine. Chapter four identified four factors which affected a routine's performance: the actors, artefacts, ostensive and performative aspects, and how the routine's role related to organisational understanding (Parmigiani and Howard-Grenville, 2011). It was argued that lean NPD embodied parts of the actors and artefacts which constitute a routine. However, other aspects of the routine clearly affect the ability of people to learn.

The data shows that reflective learning only occurs within lean development routines. This is true even when the information contained in the artefacts is sufficient for learning to occur from the lean artefact creation routines. However, it was only through a process of discussion with all parties within the lean development routines that this information could be jointly actioned and accepted as learning. Accordingly, reflective learning as defined by Dewey (1925), which must be actioned upon to complete the full cycle, only occurred in routines where the actual organisational role of the routine was to consider organisationally relevant issues. Therefore, the organisational understanding of the routine is a key factor in whether reflective behaviours are 'fully' present. This research has been relatively silent on the distinction between individuals learning, and how this is transmitted to organisational learning (Rerup and Levinthal, 2014). Partly, because learning was defined as a series of practices which are constituted at individual level. However, it appears that what individuals

can learn, as defined by Dewey (1925), can only be actioned upon, when they are in a specific context which can take the content of the artefact and accept it as organisationally relevant information. Organisational learning as defined by Argyris and Schon (1978), becomes organisational when learning is encoded in organisational systems. Within ROBOT, it appeared that for action, and so learning to occur, it could only take place in a context which mattered 'organisationally'. Thus full reflection only occurred when people accepted lean artefacts as encoding organisationally relevant information. This accords to Argyris and Schon (1978) definition of organisational learning.

Bringing these two concepts of moral order, alongside the routine's role within the organisation leads to some interesting insights. Somewhat ironically it appears that the normative pull of the organisation's moral order becomes more intense within the routines where the objective is focused on an overtly organisational objective, such as development. Evidence for this comes from the higher prevalence of breaching, even by the CE (as described above), during interactions in these routines compared to those in artefact creation routines. Ultimately, where lean NPD behaviours are needed most, to enable reflective learning, they are hardest to sustain. Theoretically, this concurs with the insights of Garfinkel (1967) in the following ways. Where the context matters more organisationally, as in a development routine where the purpose is to continue the organisations product stream, the more likely the values of the organisation are to be present in an individual's action. Conversely, within a routine where the objective is not intimately linked with the original organisations purpose, such as an artefact creation routine, new behaviours are easier to establish. However, a reflective learning cycle cannot fully be achieved in such a context. These insights can now be applied to the research propositions of this study. They are intended to highlight the interactional contexts through which lean actors and artefacts affect learning within routines.

6.2 The research propositions

RP1: *Interaction with lean actors increases the 'willingness' of people to engage in reflective behaviours within routines.*

As chapter five shows, routines without lean processes exhibited an array of behaviours which prevented progress on problems encountered within the routine. This occurred despite the lean actor of the CE being present in all routines studied. Throughout these interactions

the CE did try to keep people 'on topic', and to provide common understandings of the issues encountered within the routines. However, these activities appeared to have no real effect on how the routines was performed; they are all characterised as having poor outcomes. What the CE did achieve, in all non-lean development routines, was to relay the importance of lean development routines being followed for there to be progress on the topic. This however, was only proffered at a later stage after there was clear lack of progress during the routine. Although late, the CE's actions did appear to increase people's willingness to engage in reflective behaviours. For instance, within these routines there is constant questioning and answering, and a 'grasping', trying to understand one another's views, as signified by the repair sequences which are prevalent. Ultimately however, these interactions did break down.

Surprisingly, within non-lean development routines, such as **routine 2**, the open questioning and inquiry which would signify a willingness to reflect, actually led to defensive behaviours within the interaction. Recalling the engineer who felt personal discomfort during the process, as described previously, he refused to elaborate on any response, the opposite of 'yes and…', of which characterises reflection (Yanow and Tsoukas, 2009). This was so prevalent that the researcher had to stop making notes during the exchange due to the awkwardness of the situation. Within **routine 3**, interactions that at first appeared positive, and could be characterised as a willingness to reflect, also concluded in less constructive behaviours. Rather than defensive exchanges, these displayed individuals trying to impose their own sense on what was going on, which ultimately led to group misunderstanding. Thus, in non-lean development routines it appears that interactions initiated by the lean actor actually reduce the willingness of participants to reflect. What the lean actor does achieve, however, is to *monitor* the routine for behaviours which can be remedied in future routines through lean NPD practices.

Behaviours expressed by the CE within routines for artefact creation directly correspond to an increase in people's willingness to engage in reflective behaviour. This has interactional consequences within the data; for instance, in **Vignette 2 from routine 8**, when the CE asks the HE to question the data, the HE responds by stating the limitations of what is occurring in the situation, "*ECO is not for new products*?" (HE). Moreover, within the same routine, the CE expresses reservations about how clearly the artefact can represent reality: "*can never get a formula that is quite right but you can see a trend*" (CE). This shows how CE instils HE, through dialogue, the ability to see multiple truths. Within the training routine, the CE

is constantly carolling subjects to be cynical of what they immediately see, and engage in multiple viewpoints about a particular problem. This vividly expresses, that the CE, in *establishing* a lean NPD moral order, increases participant's willingness to reflect. That is, these sets of behaviours in which the CE is trying to, and achieves within the routine's subjects corresponds to definitions of willingness to reflect: to accept multiple truths, be open to new possibilities, and realise the fact that one's current position may be wrong (Jordan, 2010).

It could be argued that by *instigating* the lean NPD moral order, the CE interactively displays a 'willingness' to engage in reflection-in-action. Rather than interacting directly with the participants, he is interacting with the context (bringing forth an artefact), which then leads to altered behaviours within the participants. For, by bringing forth a 'knowledge object' into the routine, the CE signals to the other participants his willingness to engage in reflective behaviours. For example, he requests everyone to use the artefact, importing epistemic authority into the object rather than in his own hierarchical power (Yanow and Tsoukas, 2009). He understands that his viewpoint may be wrong, which is why he opens up to issues that may be found within the artefact. Ultimately, by doing this, the CE signals to personnel within the routine the necessity of being open to new possibilities, to engage in a conversation with the issues at hand, not his authority, and be prepared to be surprised; all of these are key elements which exhibit a willingness to reflect (Schön, 1987). It should be noted that such willingness is not engendered by interacting with the artefact, rather, this is the antecedent operation before the use of the artefact. It demonstrates how the CE has a critical role as the authority in the situation before the use of the artefact. His behaviour alters the context, which then changes the context for other personnel in the routine; this indirectly affects their behaviour, and ultimately increases their willingness to reflect. However, during the lean development routines the CE does not necessarily engage with the lean artefact with the 'willingness attitude'. Surprisingly, his interactions can be characterised as the opposite of these behaviours, and more accordance with a behavioural footprint of the native 'moral order'.

In conclusion, while the lean actor on the whole acts in accordance with a willingness to engage in reflective behaviours, these only have interactional 'traction' during lean artefact creation routines. Within the other routines, the lean actor might have a negative effect on behaviours, as in non-lean development routines, or no effect, as in lean development routines. Hence, the organisational understanding of the routine affects how people react to

the CE's interactions. Critically, however, the CE is able to create the lean NPD moral order. That is, he *monitors*, *establishes*, and *instigates* an expected set of behaviours for use in development routines. He may have an indirect effect of increasing people's willingness to engage in reflective behaviours by his own efforts to displace his own epistemic authority to that of the information found within lean artefacts.

RP2: *Interaction with lean artefacts increase the 'capability' of people to engage in reflective behaviours within routines*.

Lean artefacts exhibited questions which initiate users to engage in a particular conversation *with* the artefact. This was seen both in artefact creation routines, and in lean development routines. In effect, they are used as a basis of a 'dialogical' exchange with the artefact (Bakhtin, 2010; Shotter, 2010), dialogical in the sense that it is only through interaction with the artefact that these meanings are brought forth and surfaced. Furthermore, as in the mode of the Socratic ethos of the CE, they are done in such a way that they base the conversation on valid inferences rather than power (Koschmann, 2001). This transactional mode between the participant and the artefact shows how it is through, and by virtue of the artefact's questions participants start to interact with it. This description mirrors what Jordan (2010) refers to as a capability to engage in reflection in action (Koschmann, 2001, 2011).

However, this is not just a two-way conversation between the participant and the artefact, a third party is included in the transaction, that of the external environment. That is, the questions which the artefact asks, and the standard of justification requires by the CE in instilling his 'ethos', mean that the participants necessarily have to engage in a transactional process with the world, through experimentation and information gathering. Again, this directly corresponds to what Jordan (2010) refers to as a capability to engage in reflection-in-action. Importantly, this collecting of information, and experimentation occurs outside the immediate concerns of the organisation. The artefacts and training demand the individuals to go and see the problem for themselves (echoing the lean principle of Genchi Genbutsu (Liker, 2004)), and use as much primary information in the creation of the artefact as possible. Doing this exposes the creators of the artefact to a new context, and, as such, to the local rationality occurring at that specific time. This would mean the encoding of the artefact in a situation outside the 'native moral order', or outside an immediately 'organisational' context. Furthermore, in accordance with reflective theory, the collection of data within different environments means that new information is derived that would only be

remembered in *that* specific context (Miettinen, 2000), increasing the information content yet further within the artefact. As such, artefacts are inscribed with information which contain specific local rationalities of where the data was collected. This mirrors the findings of D'Adderio (2001), who stated that artefacts could be problematic due to their tacit encoding of assumptions. However, in this study the chief engineer in ROBOT specifically utilises this property of artefacts to alter future contexts, and help *establish* the lean moral order.

It is explicit through the interaction with the artefact, that behaviours are created that lead to a full reflective cycle. That is, as expressed by the Gioia analysis **Figure 5.7**, they enable the behaviours linked to systematically displaying knowledge, opening up 'rights' to knowledge, and re-specifying glosses with empirical data; which determine interactive behaviours which map on to the description of reflective learning. Importantly, these mechanisms echo the findings of Schön (1987) who explicates the efficacy of reflective learning through an increased capability via the use of 'frame experiments', which question current assumptions, through artefacts he labels 'virtual worlds' (Jordan, 2010). Virtual worlds are representations of the states of affairs which can be manipulated to create experiments that question assumptions, ultimately leading to reflective learning. Schön (1983) states that these virtual worlds can be enhanced by their ability to be 'transactional', which is where reality provides resistance to required change and indicates what is not possible within the frame experiments, and the ability of the virtual world to represent the real one. Clearly, the properties of the lean artefact, and the conditions under which they are created, mirror his definition of a virtual world, and the factors which contribute to their efficacy. That is, it is suggestive that lean artefacts, as they contain highly empirical content and alternative logics are a suitable medium which to conduct frame experiments, thus appearing as a 'veridical artefact', or a 'virtual world' (Schön, 1987).

Notice however, that it is the ability of these artefacts to allow, alter, or *establish* the moral order, such that these practices can take place; the artefact produces a context which participants use as a resource through which to represent their development projects (Suchman, 1987). The highly empirical, systematic, and public nature of the artefact allows them to engage in practices which can manipulate the world, and aid the understanding of possibilities within it. Moreover, lean artefacts, containing a specified way of presenting information, produce their own internal set of rules which participants interact with, again allowing a unique moral order. Crucially, within development routines the reason why the

full reflective cycle of Dewey can be carried out is because these routines provide a context in which action can occur; this is a necessary basis for reflective learning to occur (Miettinen, 2000), and accepted by that from the participants (Koschmann, 2011). Unlike the creation of the lean artefact routine, which possessed almost a full learning cycle and which was not completed, the development routine provides a place where the results of the lean artefact, and the subsequent discussion can be accepted by the organisation, which can then be used for future action. This is done by encoding the actions back into the artefact, and hence having a permanent *record* of future actions from the routine, as signified by **Vignette 8 from routine 1:**

> *HE: (looking at requirements on A3) Level of detail on customer requirements…do an engineering change order*
> *CE: CAD it and mark it up"* (writes in the A3)

Critical to this activity is the ability of the lean artefact to fix the attention of the participants within the lean development routine, and so *maintain* the lean NPD moral order. Clearly, to engage in reflective behaviours personnel had to perform a series of inferential actions which, if they could not fully attend to, would not occur. The artefact did not just increase capability through containing features which led to increasing one's capabilities, but also, due to their enduring status, allowed members to fix their attention and thereby increase their capability to reflect. However, not all interactions with artefacts were positive. In all routines the use of artefacts produced behaviours which were socially difficult for routine participants. That is, they felt silly, they experienced them as a burden, and as something not required by their job specification. Ultimately, the use of the artefact appeared contrary to their expectation about their role in the organisation. For these individuals, the artefact contravened their moral order and led them to either remove themselves from the routine or to interact with it sporadically.

In conclusion, on the whole, interactions with lean artefacts increased the capability of participants to engage in reflective behaviours by opening up the rights to knowledge, systematically displaying information, and re-specifying taken for granted beliefs with actual data. The artefact, by its enduring nature also increased the capability of users to reflect and fix organisational attention, which helped *maintain* the lean moral order. Nevertheless, in all situations of its use, it had the potential to lead to non-reflective behaviours if the individual using it believed it contravened their own moral order.

RP3: *Interaction with lean artefacts combined with lean actors increases the 'willingness' and 'capability' of people to engage in reflective behaviours within routines.*

RP1 and **RP2** detailed interactional contexts where lean actors and artefacts individually affected individuals' behaviours. Although lean actors and artefacts were consistently spatially collocated (except non lean development routines which had only a lean actor the CE present), they were often temporally separated, in that they were used within the routine at different times. The one exception to this was artefact creation routines.

Routines for artefact creation combined lean actors and artefacts both spatially and temporally in training the participants of the routine to utilise the artefact in the 'correct' way. This, in effect, socialised members to use the artefact in a particular way, the CE created an expectation around the features of the lean artefact previously detailed, such that he created a 'moral order'. These actions did combine to increase participants' willingness and capability to reflect, as previously stated. At the same time, they determined new ways of behaving which this research has labelled the 'lean moral order'.

Although in other routines lean actors and artefacts were temporally separated they did combine to produce reflective behaviours. Principally, this came about through their combined effort to produce a moral order, which then created a context in which people automatically behaved with an increased willingness and capability to reflect. Both lean actors and artefacts were mutually dependent on each other for consecutively creating this new moral order. Firstly, the lean actor monitored routines for incorrect behaviours. Once these negative behaviours were identified, the CE, using his expertise, constructed an artefact. Then he established a set of expectations as to how behave around the artefact, which increased participants' willingness and capability within the artefact creation routine. Once in a routine for development, the CE initiated the use of the lean artefact, instigating the moral order around it. As detailed, the ability of people to behave was predicated on the unique properties which the artefact contained. Thus, the artefact enabled the lean moral order. Also, as the artefact could endure and fix attention, the moral order was maintained. These interdependencies created a context where individuals were expected to behave with an increased willingness and capability. However, this also caused some issues with behaviour. For instance, the combination of lean actors and artefacts during their creation of the lean moral order caused breaching where some members felt uncomfortable acting

according to these new expected codes of action. For example, they tried to disrupt or avoid the routine, or 'hedge' (Goffman, 1955) their behaviour. That is to give excuses for their new forms of behaviour in case it left them vulnerable to public ridicule.

RQ1: Does the interaction between lean NPD practices and people within organisational routines lead to reflective learning behaviours?

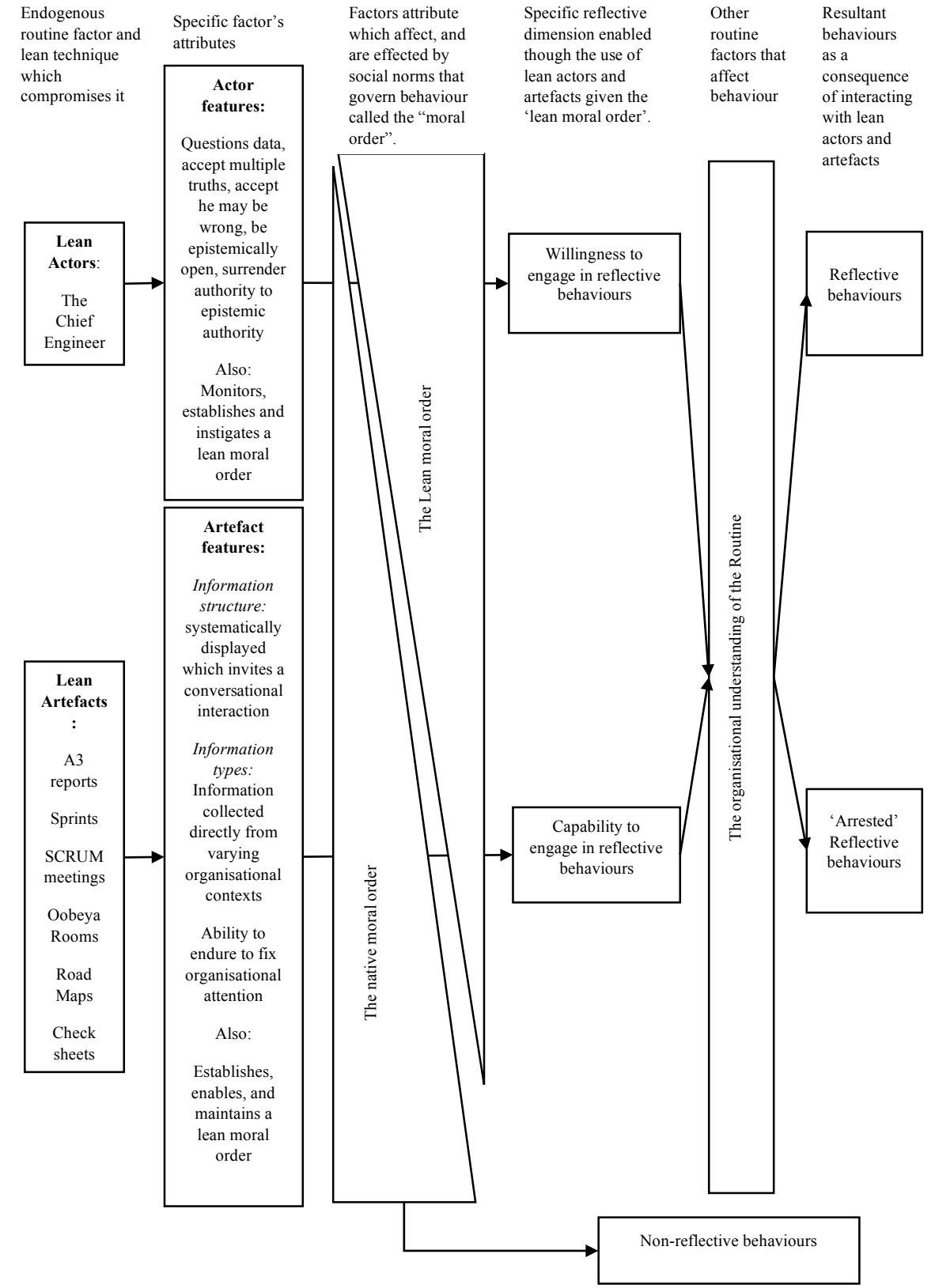
The interaction between lean practices and people within a routine created three responses: Firstly, as chapter five detailed, reflective learning behaviours were performed within lean development routines as a direct response to the interaction between lean practices and people. Furthermore, the research propositions have argued the mechanics of how these reflective behaviours occur. These include particular properties of lean actors (questions asked, and attitudes expressed) which increase the willingness of people to reflect, and lean artefacts (displays of information, types of information, fixing attention, being public in nature) which increases the capability of people to reflect. The ability of these practices to induce these responses is affected by the moral order, which they at the same time create. That is, lean NPD practices monitor, establish, instigate, enable, and maintain a set of expectations about how to behave, which in turn, if accepted, result in an increased willingness and capability to reflect. Furthermore, the results of these behaviours can only be fully reflective if they are actioned upon and organisational viewpoints are altered. It was argued that this only occurred in routines in which the objective was to take part in a task that was considered organisationally important.

The second response to lean practices is where their use was declined by organisational members. This occurred at any time, in situations where members found the 'new' expectations placed on them as contrary to what they considered 'good' behaviour, and thus refused to take part. As such, interactions which take place where the expectation of what is considered correct practice is contrary to those proffered by lean NPD actually resulted in non-reflective behaviours. These non-reflective behaviours, characterised by the native organisational moral order, were observed in non-lean development routines.

The third response to lean practices was to participate in 'arrested' learning behaviours. This did occur in lean artefact creation routines. Here, members engaged in reflective behaviours due to lean practices, however, since they were not in routines where organisation action was being determined, they could not action their learning, and so not fulfil a full reflective

learning cycle (Miettinen, 2000). These observations transform the testable framework of **Figure 4.3** into an actualised framework which depicts the varying impact lean NPD practices have when they are utilised within routines, expressed in **Figure 6.2** (where the framework is explored in the **addendum part B**). **Figure 6.2** also details the mechanisms through which lean NPD practices can affect routine performance, and factors not considered prior to the analysis, such as the concept of moral order and the organisational understanding of the routine.

Figure 6.2: A modified overall framework of the ways in which lean NPD practices are embodied in routines and how their attributes produce interactions that are defined as reflective behaviours.



In conclusion, this section has shown that in certain contexts lean actors and artefacts *can* combine within routines resulting in reflective behaviours. Moreover, as expressed in **Figure 6.2** a mechanism has been derived to explain how lean NPD changes behaviours within routines; this modifies the proposed framework based on theory expressed in **Figure 4.3**. Significantly, this shows a more complicated relationship between how lean actors and artefacts increase reflective behaviours within routines than was initially proposed through theory. Through the cross-type analysis, it was demonstrated that the function of lean NPD is actually to alter participant's behaviours. Fundamental to this explanation was a practice-based view of human nature. Utilising the ethnomethodological concept of 'moral order' it was argued that lean NPD tried to alter the native organisational moral order through the use of lean NPD practices. Furthermore, it was only in certain routine types, those which tasks were aimed at changing the organisation, where reflective learning could be fully actioned. These findings have significant ramifications on several theoretical fronts as now will be discussed.

6.3 Discussion

6.3.1 Theories of reflective learning

The use of reflective theory in this research was not to test it, but to use it as an explanatory tool. That said, interesting results from the analysis highlight features of reflective theory that are new, or have been overlooked within the literature. Firstly, a key aspect that enabled people to reflect was the fixing of attention. Although attention has been linked to organisational performance (Ocasio, 1997), it has never been directly referenced as a key antecedent to reflective theory. As the detailed accounts of routine behaviour have shown (Boden, 1994), corroborating other research, organisational attention is fleeting. To engage fully in a reflective learning cycle requires a serious amount of joint attention, and in this research artefacts provide the key 'anchoring' for such a state. The role of artefacts in the reflective processes has been relatively neglected in previous research, with only a sustained exegesis on the topic provided by Schön (1987). However, Schön (1987) does not mention the key attribute of attention as a key ingredient in being able to reflect. People's ability to follow the reflective cycle is predicated on a lengthy inferential process. To do this, this research shows, attention underpins the process. It was only due to the fact that the artefacts were enduring and formed an integral part of the lean NPD routine that participants reoriented back to the artefact (or they left the situation as in **routine 7**). This is suggestive

that artefacts play a key role, not just in representation of states of affairs to enable reflective activity, but also as an enduring object which anchors participants' attention. Without this stability participants do not have the attention to organise around common meanings, and it would be plausible to suggest that in complex environments such as NPD this is critical (Weick and Sutcliffe, 2006).

The layout, and type of information present within the artefact facilitated reflective behaviours. These observations have not directly linked learning and artefacts before, and may go some way to answering the call of Nicolini et al. (2012) to individuate key mechanisms within artefacts as to how they result in behaviours, rather than being an explanatory 'black box'. It was argued that these attributes of the artefact increased people's capability to reflect, by their ability to exhibit qualities what Schön (1987) refers to as 'virtual worlds'. As stated, since its release, Schon's (1987) work on virtual worlds has had little attention in the literature. Unlike previous research which indicates the effects of the artefact, such as its ability to share 'understandings' (Bechky, 2003; Okhuysen and Bechky, 2009), 'meanings' (Carlile, 2004), this research has identified attributes which are central to the learning process. This has important consequences for the design of artefacts, and understanding.

A key finding in relation to reflective theory is the occasional difficulty it engendered when people engaged in reflective behaviours. While Argyris and Schon (1978) record the difficulty in different behavioural systems, in identifying 'O1 learning systems' as defensive and closed, and 'O2 learning systems', as open and collaborative, they never links personal discomfort to the learning process itself. What this research demonstrates is that personal discomfort may necessarily be experienced when engaging in reflective behaviours. This has been explained somewhat via the concept of breaching (Garfinkel, 1967); that is when people behave contrary to the accustomed or expected way in a context they can experience discomfort, or even be 'ostracised' by their peers for acting differently. If reflective behaviours lead to new ways of acting, and interacting with the environment, as one learns new ways of apprehending the environment, then breaching or social discomfort may be an intrinsic feature of reflecting. Whether this concept is expressed within Yanow and Tsoukas (2009) idea of vulnerability, which states that we need to show we are 'unknowing' during reflective behaviours, is open to question. However, if reflective behaviours necessarily involve acting contrary to social normativity, then it would explain why learning, and especially the questioning of one's assumptions is so difficult. This is corroborated by other

research disciplines who describe how participants try and shield themselves from information which is somehow problematic (c.f. Hodgkinson and Healey, 2011; 2014).

Interestingly, unlike Jordan (2010) who, following Lave and Wenger (1991), states that that the willingness to engage in reflective learning is enhanced by full participation in the activity, the CE emphatically rejects this tactic. His reasoning is that full participation which will ultimately lead to experiential learning on the issue, is too expensive (in terms of both product and project mistakes). Instead, the CE uses the notion of artefacts, and experimentation through the artefacts, so that people might 'experience' the effects of their action, but in a controlled and recorded environment. This mirrors Schön's (1987) idea of a reflective practicum, which is an environment whereby people can conduct experiments which mirror the real world, and thereby learn how to behave. What is key, and what individuates these findings, is that the CE explicitly did not want to socialise people into a native moral order. Instead, by creating a specific context (the artefact creation routine) which extolled new behaviours. These behaviours were then inscribed into artefacts such as the A3 report and introduced into other organisational environments. These artefacts then disrupted the native moral order, and formed new behavioural responses by employees utilising them.

6.3.2 Routine theory

There has been little synthesis between the broader lean literature and routine theory. The work of Adler et al. (1999) is an exception. They utilised a 'capability' definition of routines, while this research has utilised a practice based understanding (Parmigiani and Howard-Grenville, 2011). Peng et al. (2008) argue that there has been little synthesis between OM and the routine literature more generally. As such, this research contributes to the synthesis of OM and the lean literature within routine theory. This is important, since by linking these literatures it is possible to draw on a large body of theory related to how routine actions cumulatively affect organisational performance (Cyert and March, 1963; Dosi et al., 2003; Zollo and Winter, 2002), and, how OM interventions can, by affecting routines, impact organisational outcomes (Anand et al., 2009).

Furthermore, it has answered numerous calls from within the routine literature to extend micro-studies into the mechanics of how routines function (Becker and Lazaric, 2009; Parmigiani and Howard-Grenville, 2011; Vera et al., 2014). Although the literature has

shown that endogenous routine change can occur, meaning that organisations can organically adapt to their environments, the detail of how this occurs has largely been missing, except by the reference to 'learning processes'(Feldman, 2003) (with the notable exception of Dittrich et al. (2016) who show how reflective talk may lead to routine change). This research has revealed a mechanism through which learning can take place within routines as they are enacted, such that they can endogenously change (see **Figure 6.2**). Cacciatori (2012) and D'Adderio (2011) noted that the way artefacts affect behaviour within routines was in its infancy. This research adds to the body of literature which understands how artefacts affect behaviours within routines.

This research shows that artefacts are utilised in a purposeful manner to bring about a desired set of behaviours, and these, in the routines observed, were realised. This finding is different to that of Pentland and Feldman (2008), who argued that artefacts often resulted in different routine behaviours from those initially intended. Furthermore, previous research stated that artefacts use within routines is to limit behaviour, and so create 'dead' routines (Cohen, 2007). Hence, this research indicates they have a contrary use, to generate new behaviours. However, as **Figures 6.2** and **6.1** show**,** the explanation of behavioural responses that occurred during interaction with the artefacts is complex. Factors such 'moral orders', and the type of routine they are utilised in, play a key part in determining responses in routine to their presence. This may go some way to explaining the mixed results of the impact artefacts have had in within organisations in previous research (Parmigiani and Howard-Grenville, 2011).

6.3.3 Lean NPD

Purposely, this research did not *a priori* interpret lean NPD practices occurring within the data via a dominant discourse from the lean literature. For instance, central lean concepts could have been applied, such as waste, value, flow and standards, to an interpretation of the data. The reason for this 'neutral' analysis being the purpose of the research was to take a critical view on how lean NPD affected behaviours within routines. As such, the practice-based perspective was utilised, and in particular, an ethnomethodological stance was taken in an attempt to understand what people were trying to achieve during interaction when using lean NPD. This has produced a view of lean which eschews the language found within the dominant literatures on what lean NPD is 'about'. For instance, none of the interactions were understood in terms of waste reduction (Sobek et al., 1999). Furthermore, language

classically associated with lean was conspicuously absent from the talk of personnel within ROBOT itself. This has created a view of lean NPD that differs from significant parts of the lean literature.

Interestingly, the conclusion from the literature review in chapter two was an identification of the features of lean NPD independent of these dominant concepts too. That is, lean NPD was defined as fundamentally producing practices which centred around presenting information in a certain structure and of a certain type. This conclusion was also present within the actual analysis of lean practices found at ROBOT. For instance, A3 reports utilised a particular structure of information representation (systematically organised around questions within the artefact) and focused on utilising information that was directly apprehended from the situation. However, the findings from the case provide an explanation of the nature of lean NPD which go beyond the conclusion from the literature review. This research demonstrated that information structures and types encoded within artefacts were used to create a particular interactional context that resulted in desired behaviours determined by the chief engineer. Furthermore, the cross type analysis which highlighted that these practices were not created to target behaviours in a general way but specifically targeted around problematic organisational behaviours. As such, lean NPD can be seen as creating a context through artefacts whereby problematic organisational behaviours can be altered.

This view of lean NPD can be considered akin to current work that is being done on cognitively shaping organisations within the domain of behavioural strategy. For instance, Powell et al. (2011) state that cognitive biases are present within routines, and that the 'organisational architecture' needs to be designed to be beneficial rather than detrimental to organisational performance. While such cognitive language is contrary to the theoretical perspective of this research, it agrees with the underlying argument that people's behaviours need to be shaped via contextual features to overcome unwanted or undesirable traits. In lean NPD the 'cognitive architecture' of the organisation is shaped by the artefacts designed by the chief engineer. That is, the chief engineer purposely changes the organisational context to alter organisational behaviours.

This view of lean NPD as cognitively shaping the organisation through the use of artefacts is not entirely new to the wider body of lean literature found within manufacturing. The work of Spear working alone (2010; 2002a, b), and with others (Spear and Bowen, 1999) used

ethnographic techniques to try and uncover the 'principles' of how lean works in a manufacturing context. These authors state that manufacturing uses physical diagnostic signals so that shop floor works can automatically 'see' issues; that is, the context is manipulated so that they do not need to 'think' if there is any problem, the context changes and informs them of a problem occurring. Clearly, this is extremely close to the ideas of visual management which occurs within dominant lean literatures (c.f. Liker (2004)). Yet, Spear and Bowen (1999) emphasise the explanation of lean shaping the environment to induce wanted behaviours, given the constraints of human faculties. One can see this in lean problem solving going back to Deming (1986), where it is not the worker that is the issue, it is the system or the context in which they are operating. However, this feature of how lean NPD cognitively shapes behaviour within knowledge work, such as NPD, has not been proposed before. Returning to ROBOT, in the data we see the consistent patterns of workers wanting to do their work and create the best solution, however, unwittingly to them, the behaviours they think (or tacitly assume) they should employ are sometimes detrimental to the development process. Hence the need for lean NPD to direct their behaviours.

The behaviours which lean NPD induce through the practices it employs have been identified as reflective behaviours. It has been shown that through the use of reflective behaviours organisational members have been able to determine solutions to problems that were not immediately present to them when considering the problem from their 'native moral order perspective'. That is, without lean practices they distorted a view of the situation to what they thought should be the case rather than what is actually the case. It was only via reflective behaviours that they could 'free' themselves of particular world views. As such, these reflective behaviours have been shown to produce outcomes which are radically different to what was originally thought possible within the organisation, such as **Vignette 12**, where through lean practices current technologies are reused for new functionality. This ability to reconceptualise problems is cited in the literature (Lamming, 1993; Whitney, 1993) and is a prominent feature of lean NPD, as identified in the literature review. However, no previous literature has identified the particular *mechanisms* by which lean NPD can consistently achieve this ability. For instance, Liker (2004), provides narratives of people engaging in lean NPD to 'see' problems in the NPD process which would have otherwise been uncovered. While such examples are interesting, they fail to provide an underpinning of the behaviours and context which lead to this enhanced ability to solve an issue. Through the theory of reflective behaviours, and the study of behaviour and context in which they are

achieved, this study reveals the social mechanism that leads to this ability for improved problem solving.

This view of lean as shaping new behaviours which positively affect the organisation is not contrary per se to those who specify lean NPD in terms of specific practices, or tools and techniques. For instance, Khan et al. (2011) define lean NPD by the practice 'Set Based Concurrent Engineering'. For, lean NPD as 'behaviourally shaping' can incorporate specific practices, as is demonstrated in the case of ROBOT. However, it would be contrary to this view of lean NPD that it can be *only* stated as a specific set of practices that are fixed. That is, the explanation of lean NPD is as a corrective to organisational problems. Theoretically, it may be possible to have an organisation where there are no behavioural issues to remedy. Furthermore, if behavioural issues are derived from moral orders idiosyncratic to a specific organisation, the manifestation of lean NPD may have to be specific to that particular moral order. To add further complexity, the native organisational moral order may not be the same across time, and as societal, technological, and organisational contexts change, so may the moral order which lean NPD sets itself against. This has occurred at ROBOT, in interviews with the CE reflecting back on project and product performance in early 2016, he stated that:

> *"I recently realized that personalities can play a big role in lean. We have to educate our customers (even internal ones) that deadlines at the expense of 'polishing the cannonball' is #1."*

According to this understanding, practices of lean NPD will be constantly evolving, and specific to the context. This evolutionary ability of lean has been recorded in the wider literature (Holweg, 2007) and is shown within the literature review of this study. Lean NPD has very different manifestations both within a company (for example, with Toyota engine plant compared to its chassis development (Ward et al., 1995)) and between companies (for example between Toyota and Denso (Whitney, 1993), and over time (the evolution of Toyota's use of front loading the development cycle (Thomke and Fujimoto, 2000). The basis of lean NPD as a corrective to problematic organisational behaviours is able to provide explanations for the observations of these phenomenon.

A response to this characterisation of lean NPD is that this study has demonstrated that artefacts and actors, such as A3 reports and chief engineers, enhance reflective behaviours through increasing the willingness and capability to engage in reflective behaviours. They

do this via the information structure they possess, the type of information, their ability to fix attention, and to publicly display information. Hence, it could be argued that lean NPD must necessarily contain factors that contribute to a willingness and capability to reflect, such as artefacts that contain a certain information structure and type. It would appear that lean NPD must contain *some* practices which enhance the ability of participants to engage in reflective behaviours, and that although it has not been necessarily proven, it is highly likely that these will be based around the key factors highlighted in this research. A response to this could be: Why does lean NPD necessarily need to encourage reflective behaviours? But, as this research has argued, utilising reflective behaviours helps organisational participants remove their 'taken for granted' apprehension of the world, and move closer to a veridical understanding of it. When constructing real life artefacts, that is, developing new products, to understand what is actually occurring out in the real world, seems the basis of how to make a good design (Alexander, 1964).

Thus far the discussion has centred around the use of artefacts. However, as argued, key to lean NPD is the chief engineer. If lean NPD can be characterised as creating cognitive architecture, then the chief engineer, under this metaphor, assumes the role of architect. Indeed, as argued, his main focus is setting up the lean NPD moral order such that it 'makes sense' for organisational members to engage in certain behaviours. While this understanding could be seen as congruent with those found within the literature review of chapter two, previous literature has defined the chief engineer in mainly functional terms: as a good communicator, resolving conflict, having informal authority (Clark and Fujimoto, 1991). This study shows that the chief engineer has a much more significant role within lean NPD. This person formulates practices that determine what lean NPD is, and how it should integrate with organisational routines. Becoming in a sense the architect of lean NPD's moral order. It could be argued that since this research was not conducted at Toyota, and the chief engineer was the main champion of lean NPD at ROBOT, this gives him unusual responsibility. Although this is true, throughout the literature the chief engineer has been given overall responsibility for the NPD project (Itazaki, 1999), and like at ROBOT, given full responsibility to interject and change the development process. As such, it could be argued that they have similar responsibilities within both companies and that the findings of ROBOT can be extended to other lean NPD research.

As architect of the moral order where does the chief engineer find his 'blue prints' to create lean NPD practices? As discussed, this study utilised, and found no real mention of dominant

lean NPD concepts within ROBOT, such as 'waste' or 'flow' (Morgan and Liker, 2006). According to previous literature, the chief engineer should be utilising a method or principles for ascertaining value or waste within the system (Morgan and Liker, 2006). However, as this study shows this simply was not the case. Rather, the chief engineer appeared to tacitly know when a routine was going wrong (for example, in **routine 2** after the routine had occurred he requested them to redo it), and what features a particular artefact required (for example, the information frequency of artefacts). This never appeared to correspond to an overtly rational set of formulations of what lean NPD is, yet as the data shows, the chief engineer acted in a relatively consistent way. Potentially, the chief engineer operated under the concept of expertise which is resistant to codification. Recent literature in organisational theory has argued that expertise is a non-reducible skill (Dreyfus and Dreyfus, 2005; Gherardi, 2012a; Shotter and Tsoukas, 2014). While such an exploration is beyond the aims of this study it provides a potential fruitful avenue for understanding how lean systems are *designed*.

How then do these findings relate to reasons within the literature for lean NPD performance? As the original work on lean and lean NPD, ROBOT exhibits evidence of obtaining multiple performance objectives simultaneously. Ward et al. (1995) described lean NPD as the 'second Toyota paradox', since lean NPD systems used counter intuitive practices which appeared to increase NPD development time and cost (such as delaying decisions, increased bureaucracy such as A3 reports, delaying decisions) but actually resulted in significant performance benefits. ROBOT mirrors some of these features of having counterintuitive practices and superior product and project performance comparatively to non-lean companies. However, this research has revealed the mechanisms which result in these objectives being reached. Previous research's main focus has been on the practices which constitute and uniquely identify lean NPD (for instance, the results of chapter two), which correspond to what Jarzabkowski et al. (2016) label the 'what', which is what actions people do. This study looks at the 'how', which is how the actual carrying out of practices occur within context. Taking the results from this study, performance is not predicated on a particular practice, but on creating an interactional context, which allows participants within routine situations to veridically and constructively apprehend the situation to enable them to manipulate it to their required end goal. Building on this idea, within ROBOT routines which used lean practices were shown to progress on a topic, while those without resulted in no progress. If, as theory suggests, capability performance is premised on routine performance (Felin et al., 2012), then this study explains why lean NPD results in NPD performance.

Recent literature on Lean NPD has implicitly called for a study into this how perspective, for instance:

> *The final design, including the product, manufacturing, and supply chain specifications, is the product of a complex network of interrelated technical decisions. How developers interact in the decision-making process — everything from framing problems, choosing ideas, and negotiating constraints to testing prototypes — is what shapes the product… What's important in lean product development isn't just whether you follow the right steps but how the work is done. Indeed, there are plenty of cases where companies followed "good" processes but had terrible results… Until organizations view people as central (and leaders act accordingly), the risk that development process improvement efforts will not improve anything (Ballé et al., 2016: 64)*

However, it is precisely the 'how' of the 'people centric' view which has been missing from previous research on the topic. This makes the prescriptions of Ballé et al. (2016) to have a 'people centric view', incredibly hard for practitioners to follow, and academics to critique. By looking at the naturalistic settings of interactions which make up lean NPD routines, this 'people centric' view has somewhat been illuminated. As such, without the appropriate moral order, or social ties in place, lean NPD practices are likely to have little or no effect on NPD performance. Furthermore, this view of lean NPD as dependent on social relations of a moral order give a far more complex and nuanced view of how it works. For instance, even at ROBOT, the lean and native moral orders were in constant strife as to which one would surface at any given moment. Thus, if lean NPD is behaviourally (or cognitively) shaping organisational interactions, it is this which needs to be the focus of OM research on lean NPD to determine whether such implementations of lean NPD are having the desired effect or not. Such an understanding could potentially prove profitable in explaining why lean NPD implementations are successful or not, and lend credence to why resistance to some lean implementations is strong within particular organisations (Jayaram et al., 2010a).

6.3.4 Conclusion

Fittingly for a study on NPD, a process which stands at the intersection of many organisations functions, the conclusions of this study stand at the intersection of many disciplines. The study has shown how lean NPD changes behaviour in routines, and that this

can result in reflective learning. By placing lean NPD within the routine literature and showing that through reflective learning it is the loci of endogenous routine change, it provides a mechanism through which new capability formulation can occur, and ultimately organisational advantage and renewal in dynamic environments. Seminal works within the strategic management literature on organisational renewal through new, or 'dynamic' capabilities, had placed great emphasis on the role of top management in their ability to sense, seize, and reconfigure resources (Teece, 2007), which some scholars believed placed too much importance on these particular employees (Eisenhardt and Martin, 2000; Peteraf et al., 2013). This study shows that strategic renewal may actually come from mundane day to day interactions, and that OM processes have a vitally important function in this mechanism. This idea builds on work occurring within organisation studies and the strategy as practice literature which highlights that abstract properties of an organisation can actually determined though the mundane day to day interactions of its participants (Balogun et al., 2015). As such, firm performance is cumulatively based on these micro-interactions which make up organisational activity.

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Chapter Seven: Conclusion

Chapter Overview

This chapter summarises the main arguments brought together within this research, and presents the conclusion. The potential impact of the research will then be discussed by describing its contribution to theory and practice, balanced by recognition of the limitations of the research. Lastly, building on the limitations, potential new lines of research stemming from this study are suggested.

7.1 Research summary and conclusion

The problem which this research sought to answer is whether lean NPD can result in learning within operational routines, and, specifically, how it does this. Evidence from the OM field indicates that organisations such as Toyota can consistently produce organisation outputs which are explained via a learning capability derived from operational practices coined 'lean NPD' (Clark and Fujimoto, 1991; Ward et al., 1995; Womack, 1990). However, although the nature of these practices are well understood, how they affect performance at the routine level is not (Peng et al., 2008). Scholarship has suggested that accessing OM techniques through organisational outcomes is inappropriate, since OM techniques are utilised within routines (Hayes and Pisano, 1996), and that organisational outcomes are aggregate measures (Peng et al., 2008; Adler et al., 2009). To address this problem this research has uniquely utilised a practice-based routine perspective to determine how OM routines are enacted at a micro-level, and to measure learning outcomes within routine dynamics. A routine theory analytic allows these practices to be deconstructed to expose how they affect what people say and do as they are enacted, thus revealing a mechanism as to how they change organisational behaviour and ultimately result in capability formation (Jarzabkowski and Spee, 2009). Interestingly, findings from routine theory suggest that practices observed at a macro-level often display different properties through a micro-level analysis, which in turn point to new explanation as to how these macro-practices are sustained within an organisation (Jarzabkowski and Kaplan, 2015). However, there remains a paucity of literature that uses a micro-level analysis.

Specifically, to address this research gap, learning was reconceptualised as the ability of individuals to question their assumptions through reflection (Cohen, 2007; Dewey, 1925; Schön, 1987). Lean NPD was reconceptualised into practice routine theory (Parmigiani and Howard-Grenville, 2011), where it was argued that its practices affected routines through embodying elements which constituted a routine's micro-dynamics. Utilising the literature review as an anchor of theory from chapter two it was proposed that lean NPD embodied factors which affected a routine such as, 'lean actors' through the chief engineer, or 'lean artefacts' manifested in the use of physical objects such as A3 reports. Given the recorded outputs of lean NPD organisations, this research took the perspective that a mechanism needed to be posited which could account how lean NPD *might* produce learning within routines. This was done utilising the lean NPD literature, reflective theory, and practice-based routine theory, resulting in the following research question and propositions.

RP1: *Interaction with lean actors increases the 'willingness' of people to engage in reflective behaviours within routines.*

RP2: *Interaction with lean artefacts increase the 'capability' of people to engage in reflective behaviours within routines*.

RP3: *Interaction with lean artefacts combined with lean actors increases the 'willingness' and 'capability' of people to engage in reflective behaviours within routines.*

RQ1: Does the interaction between lean NPD practices and people within organisational routines lead to reflective learning behaviours

Throughout the research, in both use of theory, and methodology, a practice-based perspective was taken (Gherardi, 2012b; Nicolini, 2012). The practice-based perspective has been used in other management disciplines to look at what is actually occurring during the activity within organisations (Whittington, 2006). As explained in chapter four, the practice-based perspective provided the most pertinent lens through which to understand the affect of lean NPD. This resulted in a methodology, based on ethnomethodology, which recorded how lean NPD affected the day to day interactions of individuals within routines (Garfinkel, 1967; LeBaron et al., 2016; Rawls, 2008). The routines were examined, (as explained in chapter four) in a single case study pseudo-named ROBOT, where verbal and non-verbal behaviour was recorded utilising the methods of interaction analysis (Ten Have, 1999) and

shadowing (Czarniawska, 2014). Interactions were analysed to determine if they corresponded to definitions of reflective behaviour. This resulted in the following framework (**Figure 6.2**) detailing the mechanism as to how lean NPD affects routine behaviours, which is explained further in the **addendum part B**. Ultimately it was shown that lean NPD can be the site of reflective behaviours, or, explorative learning within the organisations. In achieving the aims of this research, several contributions to the theory and practice with far-reaching applicability are presented; these are detailed below.

7.2 Contributions

The **addendum part B** details the focus of this research's contribution. However, the areas below are also areas of scholarship which this research has contributed to:

1. A practice-based perspective in OM

Uniquely, this study employed a practice-based perspective within the discipline of OM. These studies have had significant impact in other management disciplines such as strategy (Jarzabkowski et al., 2016; Seidl and Whittington, 2014; Whittington, 2006) and organisational behaviour (Corradi et al., 2010; Nicolini, 2012). Such a study could be subsumed under the banner of behavioural operations, being a social theory used to understand how people actually behave around OM techniques (Gino and Pisano, 2008). However, behavioural OM has been exclusively researched in conjunction with cognitive theories (c.f. Croson et al. (2013)). A practice-based study focuses on the detail of how people interact with OM techniques, how the work 'works', which brings in how people use their bodies, gestures, and materials (Jarzabkowski et al., 2015; Streeck et al., 2011). This perspective has been conspicuously absent from the OM field, which tends to focus on what Jarzabkowski et al. (2016) called the 'what'. For instance, the impactful article by Shah and Ward (2007), looks at measuring what lean manufacturing *is*. However, what is problematic about this 'what' view, is that the efficacy of practices detailed are not solely based on what practices people do, but how they are enacted (Jarzabkowski et al., 2016). For instance, this research has demonstrated that positive outcomes can be associated with the use of A3 reports. The 'what' view may assert that as such A3 reports are positive for organisational performance. However, a practice-based perspective specifically, and uniquely, shows that *how* people use artefacts (such as A3 reports), is deeply and intimately woven within the specific sociological context in which they are utilised. As such, assertions that do not engage with, or acknowledge *how* the practices are used may be misleading. A response by

the ‘what’ view may be that such varied performance in practices may be accounted for by extraneous factors, such as those covered within contingency theory (Ginsberg and Venkatraman, 1985). For instance, the research by Chavez et al. (2013) uses this contingency approach which looks at factors which affect lean manufacturing performance, such as industry clock speed. However, for these ‘contingency’ types of research the practices that people do, and how they enact them, is still fundamentally unproblematic for their research. *How* these practices are done by the people doing them is not considered by these dominant, over-arching perspectives.

In opposition to the ‘what’ view’, the practice-based perspective considers how people enact their day to day business as fundamental to understanding organisational activity (Gherardi, 2009b). Mirroring assertions from other practice based studies, this research has shown how OM techniques are acted ‘into’ and ‘out of’ being by people doing them (Feldman and Orlikowski, 2011; Orlikowski, 2008). For instance, during observation of meetings at ROBOT people’s attention and concern were fleeting; at one moment they were utilising lean techniques, and in the next moment they stopped, and such techniques were not unproblematic in their use as expressed by the occasional social discomfort they engendered. As such, in accordance with other practice-based studies in other disciplines (c.f. Whittington (2003) in Strategy, and Cox (2012) in Information Systems), this research has shown what ‘doing’ lean NPD ‘is like’, and is therefore different from the prevailing studies which concentrate on ‘what’ practices it involves. Lean NPD, and the practices it used were specifically designed to correct problematic organisational behaviours. Features of lean artefacts such as their information structure, type, and enduring nature played a central role in bringing about this change. Sociological factors influence how people experience OM techniques and, in particular, the ‘moral order’ in which they are employed. This view shows that their use was changing, fragile, in flux, and in a state of ‘becoming’ (Tsoukas and Chia, 2002; Weick, 2012).

2. Methodological contribution to OM literature

Recent OM literature has called for innovation in methodologies, and to utilise insights from other disciplines (Marshall et al., 2016; Singhal and Singhal, 2012a, b). This research answers this call by utilising insights from the practice-based perspective (and in particularly ethnomethodology), to determine its methodological basis. This led to the use of interaction analysis (Llewellyn, 2008; Ten Have, 1999) and shadowing (Czarniawska-Joerges, 2007).

These techniques have been used in other management disciplines to understand how enacted micro action cumulatively results in organisational performance (Balogun et al., 2015; Dittrich et al., 2016; LeBaron et al., 2016). This study represents the first utilisation of these techniques within the OM field, which captures the actual *content* of doing OM work. This opens an exciting opportunity for OM scholars, since it ties analysis to the actual and intimate detail of what is occurring on a moment to moment basis, showing how OM techniques affect the way people carry out their work as they '*organise'* during their day to day activity. Such intricacy is often lost through studies at a macro level. This potentially provides a way to reduce scepticisms on the causality between OM techniques and outcomes (Lewis, 2000).

3. Lean NPD

In regard to lean NPD, this study contributes to the literature in three major ways: through the metasynthesis literature review, by linking lean NPD to the routines literature, and by showing how attributes of lean NPD practices affect routine performance. Each will now be considered in detail.

Chapter two conducted the first systematic synthesis literature review within the lean NPD field. This gave six different results from previous literature reviews on the subject. Firstly, it showed that according to the exclusion criteria used, only twenty sources could be defined as primary research into lean NPD. Controversially, it was argued that lean NPD could not be defined through a singular practice, unlike previous research, such as Al-Ashaab et al. (2010). Although lean NPD could not be individuated through a single practice, the most consistent feature of lean NPD found within the literature was its ability to produce practices which create a particular information structure, and information content. The review showed that articles which declared 'new' findings, could arguable be found in previous research, such as Sobek II et al. (1998); discovery of 'Set Based Concurrent Engineering', which appears much like Clark and Fujimoto (1991) description of Toyota's communication techniques almost seven years earlier. Furthermore, there is a wide heterogeneity of lean NPD implementations from those found at Toyota (Womack, 1990) to those in very different industries such as at Nippon Denso (Whitney, 1993). Lastly, the use of applying a manufacturing paradigm to NPD, while prominent in practitioner literature (Morgan and Liker, 2006), has little supporting evidence of its application within the academic literature.

By linking lean NPD to the routines literature, answered a call from within OM which had identified the need for greater integration with this theory from strategic management (Peng et al., 2008). This stems from the thought that routines are a key explanatory mechanism for capabilities within strategic management (Easterby-Smith et al., 2009; Helfat and Winter, 2011). Connecting lean NPD to this literature allows links to be made to current research within strategy, and so develop the understanding of how OM techniques contribute to organisational strategy (Peng et al., 2008). This research has shown that lean NPD can be a major factor in fostering explorative learning, which can drive endogenous routine change, and so capability formation (Abell et al., 2008). As such, it shows that lean NPD is 'strategic'. Viewing OM techniques under this perspective may provide a useful lens for bridging work within operations strategy, and the strategic management literature, to show how OM effects the long term competitive positioning of an organisation.

The use of the practice-based perspective resulted in a unique view of lean NPD as cognitively shaping organisations to produce corrective behaviours to those which are naturally occurring within the organisation and considered 'problematic' (Powell et al., 2011). The mechanisms to how this occurred corroborated the literature review; in that a key feature of lean NPD at ROBOT was to produce particular information structures and types within its practices to encourage reflection. Other key factors were also discovered: the 'moral order', organisational attention, and the routine type were shown to be causally efficacious in behavioural change. This view of lean NPD builds on previous understanding of lean within manufacturing which shows how it is used to systematically alter the environment to induce wanted behaviour (Spear and Bowen, 1999). Significantly, this research demonstrated that this also occurs in lean NPD, and revealed *how* these behavioural changes occurred.

4. Reflective learning and routines

An emergent contribution from this research were insights into the mechanisms of reflective behaviour within routines. The study made three contributions to these literature streams: Firstly, it showed that attention was key to ensuring that a full reflection cycle occurred. The role of attention within the reflective learning literatures receives little attention, yet significant research has argued for its importance in organisational competitiveness (Ocasio, 1997). If the ability to alter routines is premised on the ability to reflect, then the ability to

fix members attention on consistent activity within the routine is a major contributor to this process.

Secondly, the research detailed how reflective behaviour resulted in social discomfort. It was argued that this is derived from competing expectations about how to behave within a context. Since reflection necessarily involves a change in the way we understand a context, tensions relating to how to behave from other participants' expectation may arise, hindering learning. Dewey appears to be suggesting that learning does involve a conflict of sorts: "*In advancing fields of research, inquirers proceed by doing all they can to make clear to themselves and to others the points of view and the hypotheses by means of which their work is carried on. When those who disagree with one another in their conclusions join in a common demand for such clarification, their difficulties turn out to increase command of the subject"* (Bentley and Dewey, 1949:3). However, this has not been explored within the business management literature in regards to reflective learning. Nelson and Winter (1982) explained an aspect of routines as a 'truce'. That is, a truce is formed between those performing the routines about how to do the work. This research indicates that routines may also be a source of conflict if reflective learning is occurring.

Thirdly, this research extended the research as to how artefacts may help foster reflective learning. Although Schön (1987) explores this topic in detail via the concept of 'virtual worlds', since his initial research the topic had received little attention. Furthermore, this research built on this initial understanding by detailing features of the artefact which enabled reflective learning. By detailing the features of artefacts, this research also contributed to the routines literature concerning aspects of artefacts which are efficacious (Cacciatori, 2012; Nicolini et al., 2012). The research showed that while these features are necessary for the creation of reflective behaviours, they only hold their meaning for those using them within a web of social constraints. Particularly, the moral order through which the participants act, and the way participants understand the routines role, where the artefact is utilised within the organisation.

5. Wider strategic management

An intention of this research was to investigate how OM techniques such as lean NPD can result in learning within routines. By demonstrating that OM techniques can be the loci of reflective learning within organisational routines, and thus the stimuli for endogenous

routine change (Rerup and Feldman, 2011), a mechanism is provided whereby these techniques can be the basis of new capability building (Felin et al., 2012). Consequently, the research supports the opinion that OM techniques may be essential in maintaining strategic fit for organisations within dynamic environments (Hayes and Pisano, 1996). This may require a re-examination of how strategic management views OM techniques. For instance, Teece's assertion that, "*Absent a broader overarching set of dynamic capabilities, a firm that is merely competent in operations will fail*" (Teece, 2007:1345); suggests that OM techniques have no strategic importance within the organisation. As the loci of new knowledge generation and organisational learning, this research would indicate otherwise, and thus offer a significant contribution to wider strategic management, and certainly triggers a call for further inquiry.

7.3 Managerial contributions

Insights derived from this research can prove useful for managers on three levels: the technical, managerial, and strategic. Firstly, at the technical level, this research has highlighted factors of OM techniques which can increase employees' ability to reflect. For instance, the techniques need to display information publicly, in a systematic fashion, and utilise information collected directly from the context in which it was produced. These techniques may cause social discomfort, and some responses to them may be negative, however, this may be a necessary part of the learning process. Application of the right technique will not solely be dependent on contingent external organisational factors, rather, the way organisational members respond to them as part of the native moral order.

Relatedly, managers need to be sensitive to the context in which they implement these techniques (Pentland and Feldman, 2008). Importantly, they should be aware that learning may engender defensive responses by their employees. To foster organisational learning, care must be taken to manage these negative responses which could potentially undermine efforts within this process. Indeed, some personnel may 'push back' from the social difficulties it derives. This research demonstrates that utilising context and artefacts is critical in enabling organisational members to learn. Managers need to be aware that they cannot foster learning through just expressing encouragement to employees to look at information in new ways. Rather, they need to create the correct context whereby learning activity becomes appropriate for all involved. This research suggests that a talented manager would be mindful of the careful balance in creating a learning environment in a context

which is constantly evolving; bearing in mind that conditions in which learning flourishes can easily turn into conditions that inhibit such a process. Furthermore, it is apparent that employees could be trained to increase their awareness of their habitual, but occasional erroneous responses, based on their respective native moral order; reducing such behaviour may facilitate their learning experience. As such, the research has highlighted the manager's intrinsic role in understanding that 'correct' responses to lean NPD techniques may take time and resources to achieve.

Expertise in lean NPD may not be reducible to a clear set of techniques that can be codified, read, understood, and distributed unproblematically. Hence, managers should be mindful of materials and professionals that appear to have a single solution for increasing NPD performance through lean. This is clearly demonstrable through the role of the chief engineer who adapts the way he responds to the demands of the situation to achieve lean NPD behaviours. Thus, organisations which seek to utilise lean NPD would do well to understand that skills needed to *truly* achieve it are hard to acquire, but may contribute significantly to having an inimitable capability (Barney, 1991). Relatedly, a lean NPD moral order will take time to achieve. Again, organisations trying to mimic the responses to these techniques will find it difficult to do so without committing significant resources. Hence, lean NPD may have clear strategic benefits in building a unique capability. Significantly, this research has shown that lean NPD can be used to improve the ability of the organisation to garner new knowledge, which may allow them to renew current capabilities, and maintain competitive advantage in dynamic environments.

7.4 Limitations

Although there are contributions to the academic literature and management practice from this study, there are four explicit limitations through which these assertions need to be tempered.

Firstly, the data were collected through hand-written notes by the researcher contemporaneously within the routine as the individuals used lean NPD practices. Originally, it was hoped that audio and video recordings (anonymised) could have been used, as this would have yielded copious information and allowed for the most in-depth analysis. However, due to data protection rules of ROBOT, both audio and video recording were vetoed despite early requests. Although hand written data collection methods have been

utilised on numerous occasions within other disciplines to study interaction (Atkinson and Drew, 1979), it does contain potential weaknesses in comparison to video, or audio recording of interactions and interviews. This is because it necessarily lacks the detail of machine recordings, and cannot recover all things said and done in the situation. Moreover, the researcher cannot hear all aspects clearly, and, naturally, was subject to concentration lapses during recording of the data. As such, the data could not conform to the Jefferson system, the formal method of representing conversation interaction (Sacks and Jefferson, 1995). While numerous studies have not utilised this method, including recent articles such as Dittrich et al. (2016); LeBaron et al. (2016); significant research has utilised this as a gold standard (Sacks and Jefferson, 1995). While these are issues with the data, the limitations should be measured against what the data was required to explain. The data was required to determine behaviours occurring around lean NPD practices in a sequential manner, so that their meaning could be understood. To that end, the data proved to be sufficient with the aims of the research. Similarly, it is hoped that the inhibition of audio and visual recording reflects the integrity of ROBOT as an organisation; an organisation working on an international scale, adhering to strict confidentially, thereby adding gravitas to the overall results of this study.

Secondly, a significant limitation of this research is the assumption between the micro-processes occurring within the routine and their relationship to organisational outputs. Although learning has been identified at the routine micro-level, and organisational performance at the firm level (product and project performance), it lacks any evidence from the meso-level, which shows how multiple routines result in these organisational outputs. Although such an assumption is borne out from theory (Teece, 2007), notably the behavioural theory of the firm (Cyert and March, 1963), there is no evidence how these processes ultimately result categorically in performance outputs. Research within routines has spent significant time tracing the results of multiple routines within an organisation to determine how they cumulatively contribute to capabilities and product outputs (Salvato, 2009; Salvato and Rerup, 2011). A reply to this criticism is that such multi-level research was beyond the scope this research.

A third limitation of this research is that it did not use a paradigmatic lean organisation like Toyota. As the literature review of chapter two stated, due to the difficulty of defining lean, the debate over what is and isn't 'lean' can be questioned in companies that aren't considered paradigmatic. Accordingly, the results of this research using a non-paradigmatic company

can be called into question since they could be doing a OM technique which they call lean NPD, when in fact it is not. This research tried to mitigate this criticism through the selection of a company which had 'direct links' with a paradigmatic lean organisation. The logic being that the understanding of lean that these direct links have of a paradigmatic company can be transferred to a non-paradigmatic company such as ROBOT. Again, this is an assumption that has not been tested. The researcher approached various companies in order to attempt data collection from a paradigmatic lean organisation, however, unfortunately all paradigmatic lean organisations declined to participate in the research. Furthermore, the use of the Japanese companies may have provided methodological and practical obstacles. For instance, the unique adequacy requirement of ethnomethodology may have been in doubt given the cultural differences within Japan. Furthermore, the practicality of getting everything translated from Japanese, or indeed another language, would have required significant resource, and arguably may have lost valuable information in translating nuances.

Lastly a possible criticism also comes from the use of a single case. Yin (2008) has criticised a single case for its lack of generalisability of the findings, and the possibility that it is an isolated incident. That said, other contributions could be strengthened through more research, such as the behavioural view of lean NPD, the observations on reflective learning, and the study of more lean NPD practices in detail to understand their unique features. Furthermore, new contexts could provide insight into how different native moral orders, produce different manifestations of lean NPD. A considerable amount of time and resource would have been required to study, and compare more organisations in this intricate level of detail.

7.5 Future research

There is wide opportunity for future research which could not only address the limitations of this study, but also extend the practice-based perspective to other areas of OM. For instance, future research could look at specific features of artefacts which transform behaviours. For example, there may be specific representations of information and structures which are particularly efficacious in bringing about particular behaviours. Techniques stemming from visual theory maybe useful in determining these features (Ware, 2012). Furthermore, while this study was relatively small scale, larger studies could take a multi-level view as to how OM techniques cumulatively effect all levels of organisation routines, and how they evolve over time into organisational performance.

A second potentially interesting line of future research would be to use the practice-based perspective to study more OM techniques, such as TQM, or Six Sigma. While the performance effects of these techniques have been studied (Schroeder et al., 2008), the practice-based perspective provides a potentially fruitful new way to study these practices, and their impact. Moreover, although psychological explanations for OM are gaining more attention in recent research (Croson et al., 2013), there is a relative paucity on social explanations for OM techniques. By adopting a practice-based view, this may provide a philosophical and methodological set of tools through which the consequences of a wide range of OM techniques can be illuminated. The potential impact of utilising research methods such as ethnomethodology proffered by the practice-based perspective should not be underestimated (Nicolini, 2012). If, as ethnomethodologists have shown in other disciplines, that activity based within a specific sphere of practice is qualitatively different from what people *say* occurs within that practice (Lynch, 1985), then this method, and ones similar to it, which look at activity as it occurs in real-time, may provide a window into operational practices which OM has heretofore overlooked.

Addendum

Addendum - Part A

This section makes explicit three aspects of the research: firstly, a more detailed discussion as to why and how the case was chosen. Secondly, more features are described concerning the case setting, and in particular the unique qualities of the case. Lastly, the unique qualities of the case are discussed in reference to their influence on organisational routines, and the bearing these unique features have on the research question. Consequently, the next section discusses how and why the case was chosen.

One of the key factors in case selection was utilising a company which was competent in the use of lean NPD. Lean NPD is not as diffuse in Industry as lean applied to operations (Haque and James-Moore, 2004), as such, it is difficult to find a suitable organisation. Senior employees of various organisations that proffered to be advanced in lean NPD were contacted via telephone and email by the researcher to ascertain if the organisation would be suitable for the case study; similarly, whether the organisation would allow such an intimate case study of their daily practices. Face to face discussions were also arranged with a number

of proposed organisations. However, on further and deeper inquiry with the proposed organisations, it transpired that the majority had recently adopted these practices, and appeared somewhat naïve in its process. For this particular piece of research, it was important to study an organisation that have lean NPD embedded into their daily work practices, and therefore had established a fundamental ethos within the organisation. Interestingly, of the organisations which reciprocated contact, there were no organisations that declined be part of the study, but there were a few which did not reply to the initial contact.

On approaching ROBOT, it rapidly became apparent that personnel were particularly well versed at lean NPD; the chief engineer is a prominent author on the subject, lecturing in lean NPD at various trade conferences, as well as being on the board of two internationally recognised lean knowledge exchange organisations. Initial contact was made, via social media, to explore a research opportunity. After this first discussion, the research visits were set-up.

The numerous advantages of ROBOT as the case study were clear from the outset. The positives of using ROBOT included its direct links to personnel who had conducted original research at a Japanese organisation, signalling it had routine transfer from a paradigmatic lean organisation. This was augmented by the huge knowledge the chief engineer (in particular) exhibited on the subject of lean NPD, and the length of time they had been practising it (over nine years). This facilitated much fruitful discussion on the subject, as well as having an expert in the field who could articulate their thoughts fully. A further advantage is that ROBOT is a relatively small organisation (35 employees), as such, all routines could be seen within a reasonable time frame. Correspondingly, during the research most of the personnel, and all involved in lean NPD practices could be met which allowed the researcher to control for the effects of lean NPD practices on differing personalities and have a clearer understanding of the organisational culture; this rare luxury would not have been possible if the case organisation had been a large (any greater than 40 employees). It also meant that there was no need to ‘select’ a sample of employees thereby introducing selection bias, as all personnel at ROBOT directly involved in lean NPD were included in the research That said, the case did have some peculiarities as will be described below. On balance the case was deemed appropriate as will be argued for in the conclusion of this section. However, next, the case is described in more detail, with its unique features made manifest.

The company was situated in a two-storey unit situated in an industrial park outside the country's capital. The unit was exclusively occupied by ROBOT. Within the industrial unit there were three main research settings, two on the ground floor, and one on the first floor. The first was based within the engineering department, which was a large open-plan office littered with parts and desks. This area contained the Oobeya wall, and was where the SCRUM meetings were held each morning. The second main area was a meeting room adjacent to the engineering department; this was where most of the routines were encountered, and where training took place. On the ground floor there was also was a dining area, as well as a manufacturing area, which looked like a craft production workshop. The firstfloor consisted of three offices, a general office, an office for the operations manager, and a conference room. These were connected by vestibule which was an open office. The third research setting was the conference room on the first floor and this was where the roadmap meeting took place. (see **figure A1)**.

Figure A1: The meeting room (first floor) where the roadmap meeting took part at ROBOT

ROBOT itself was founded in 1997 from a University spin off. It then grew for thirteen years employing around eighteen people with modest product output of around fifteen units per year. In 2008 it was purchased by a much larger organisation where ROBOT had seen to have complimentary product offering to the acquiring Parent organisation. Once ROBOT was bought in 2008 its lean NPD implementation began. Lean NPD had a specific framework within ROBOT (figure 4.3), and given the experience of the parent organisation transferring these practices to other organisations they were clear as to what they wanted ROBOT to do. To help in its implementation staff from the Parent organisation made various visits to ROBOT throughout the year. Also, staff from ROBOT had frequent communication with other companies within the Parent, and travelled to the Parent's HQ from time to time. The timeline below indicates these key events at ROBOT as well as the research visit dates and times.

Figure A2: A timeline of key events at ROBOT with added PhD research case study dates and times

The case was located in a geographically isolated part of Europe, with a unique culture and a native language. All employees of ROBOT, and hence study participants, were fluent in the English language. Where English was not their first language (the majority of employees), there was no concern from a research viewpoint regarding employees command of English; they articulated themselves very clearly when speaking English, and potentially in an effort to avoid confusion, it appeared that issues were spoken about with a high degree of unambiguity that may not have happened with native English speakers.

It was standard practice at ROBOT to conduct meetings in English where at least one member of the group present is English-speaking; this is most meetings. All meetings studied as part of the case study were conducted in English, and would have been regardless of the presence of the researcher, since there were other solely English speakers present throughout. Although naturally, there were on occasion, an odd word or paraphrase in the native language they immediately translated the words back into English. Therefore, overall it is fair to say that the research findings were not compromised by language constraints, indeed it reflects that the selection of organisation was not biased towards 'English' organisations and may lend to the applicability of the results on an international platform.

The unique native culture was apparent to the researcher on arriving at ROBOT. Employees engaged in specific cultural rituals, mainly around meals, and were clearly proud of their cultural identity, as evidenced by their discussions with the researcher about their role in recent geopolitical events. The researcher felt welcomed into the organisation and was fortunate to strike a good rapport with the employees, which, in turn created a conducive climate for data collection; being an inconspicuous presence as far as possible. Interestingly, given the small size of the country, family ties were strong, and most employees were aware of relationship structures outside the organisation; employees often had familial ties with external consultants which occasionally made relationships more complex with some impact on ROBOT. In private conversations with employees, (therefore beyond the remit of this research) about processes which had gone wrong, it was clear that certain projects had been

allowed to persist longer than perhaps they should have because of delicate familial relationships intertwined with the project, as is the nature of a geographical area with a small population.

The relative isolation of the country which ROBOT was situated in was tempered by two factors. Firstly, the country had excellent communication ties, this meant that it was relatively cheap, and easy for inhabitants to travel, as well as for visitors to come to the country. Secondly, it was an international tourist hub, which meant the inhabitants were exposed to frequent tourist traffic. Hence, although in many ways the country had an insular culture, it also had an international outlook, with English spoken widely. The impact these unique case features had on the research question will be discussed in the next section.

The impact of the unique cultural situation did have a bearing on the case given the subject matter of lean NPD, and the analytic of organisational routines. The influence of culture has been explored in the implementation of lean production systems, indeed it has been argued that lean was specific to the Japanese cultural context and did not export to other areas (Wiengarten et al., 2015). This idea has largely been abandoned given the success of Japanese transplant organisations, specifically that of Toyota's Nummi plant (Adler and Cole, 1993). Culture has been shown to impact routine dynamics, since these are constructed via people's agency (Howard-Grenville 2005), hence a concern was that ROBOT with its unusual cultural background may have unique routines, and so implement lean NPD in unique ways (Edmondson et al. 2001). There was also a concern that lean NPD may not fit into ROBOT's unique cultural climate given that lean NPD was transferred from the acquiring organisation (Canato et al. 2013, Lozeau et al. 2002). Previous research had indicated that high trust between the parent and target organisation enables effective practice transfer, as does being sensitive to transplanting new practices within a different culture (Kostova and Roth 2002, Ansari et al. 2014, Maritan and Brush 2003). Other aspects which are argued as important in routine transfer include legitimization (Westphal et al. 1997) the internal characteristics of the adopting organization (Canato et al. 2013). Furthermore, targets must also adapt their culture to the new practices (Ansari et al. 2010, Gondo and Amis 2013, Winter and Szulanski 2002). Research suggests that if practices are poorly defined, then there is a need for greater nuance in their transference (e.g., David and Strang 2006, Wang and Bansal 2012). These concerns at ROBOT were addressed early by the researcher and alleviated through initial discussions with the CE concerning management at ROBOT, and their use of lean NPD. The CE and the parent company had great experience

at transferring the routines and were deeply aware of the role 'cultural fit' played in adopting new practices. "*Some companies have been much more agreeable than others, some are very territorial, Europeans are not, Americans are, which is interesting in itself*" (Chief Engineer). Hence, the parent company of ROBOT had successfully transplanted lean NPD routines across other parts of the globe which mirrored those found at ROBOT. Thus, the impact of cultural concerns on the routines at ROBOT were alleviated.

Aside from the national culture, ROBOT had a particular 'firm' culture, or ethos, too. This could be described as a bedrock of being technologists, with a high focus on engineering and problem solving, with a highly-educated work force. Most of the employees has studied (usually to post graduate level) at top Universities at the Parent's native (English-speaking) country, which again lessened the impact of cultural influence. This was evidenced by the fact that most senior engineers had published papers, and were considered experts in their field. All employees were aware of the strong creative streak within ROBOT, *"We have innovative customers, innovative opposition, and innovative people (here at ROBOT"* (Operations Manager), and *"All of our projects are highly experimental, we try and use standards, but we are never in the same environment"* (Head Engineer). The focus on technology and the engineering discipline was also portrayed in ROBOT's employee's motivation; they were not necessarily innately customer focused but, *"The mentality is that you get paid for coming into work so you get paid to work on whatever I want*" (chief engineer). The engineers also appeared to take pride in being creative. The majority of the projects observed were aimed at pushing the product further than it had ever been designed to thus far.

This creativity did result in tension within ROBOT between engineers and management as the chief engineer explained "*There is Ying and Yang; Ying is that they have brilliant ideas, Yang by the way we have loads of projects and have a constant battle for resources. It's a very interesting dynamic, engineers just what to go out and play all the time, we all know the dynamic, managers have to make sure we are serving the customer requirements, neither is frustrated over the other. It's not confrontational, we need to all get along"*. The conflict over resources and potential engineering work also influenced their use of lean NPD; they adapted lean NPD so that the removed the most resource intense aspects of it. For instance, the creation of trade-off curves which shows performance trade-off as environmental variables change involves a lot of testing, some of which may be redundant (Sobek II et al., 1999). ROBOT chose to drop these aspects of lean NPD "*we are only a small group of 50*

*engineers (*including the Parent) *with 50 projects so we cannot create a complex set of spread sheets, we just need to focus on what is important*" (chief engineer). Indeed, part of the rational of using lean NPD was to remove waste which was deemed not necessary, so the engineers could get on with development rather than follow an overly long process, or, *"removing waste so we can focus on the important stuff"* (chief engineer). This also caused some tension with the shareholder philosophy of upper management, particularly from the Parent. At ROBOT there was a growing push to have more insight on projects which senior engineers felt was overly bureaucratic and "*anti-lean*". Instead of using A3 reports, there was an oversight committee of separate personnel that utilised traditional project management techniques. Although these two organisational systems existed for controlling projects, only lean NPD was prevalent at ROBOT. Furthermore, although there was some quarterly pressure derived from the shareholder model, the general manager understood the need to keep investment in R&D no matter what otherwise, "*we need to keep R&D investment of at least 10%, otherwise our competitive position will erode in 18 months*".

The products of ROBOT was relatively unusual for lean NPD techniques to be applied to. While some studies have research lean NPD in unusual product settings such as helicopter engines (Khan et al., 2011), and Harley Davidson motorbikes (Oosterwal, 2010). Most research has focused on the automotive setting (c.f. Morgan and Liker, 2008). Theories of isomorphism argue that an organisation structure should mirror a products features (Sosa et al., 2004, 2004). For instance, within an automotive company parts of the organisation are functionally separated by functions of the product; there is a department for body stampings, engines, and so forth.. Therefore, ROBOT's unique products may influence the routines that occur within it. Needless to say, this was true to a point with a functional area for logistics, testing, engineering, and manufacturing. However, given ROBOTs small size these functional specialisations had not evolved so much that engineering was broken down into departments. There were experts in electrical, mechanical, and software engineering, but these experts were all collocated. Hence, although employees utilising lean NPD had a specialisation there was no issue of personnel becoming isolated in their own knowledge area, which have been described as 'thought worlds' (Dougherty, 1992) or 'boundary spanning issues' (Carlile, 2002), or silos, created by functional specialisms. This allowed the internal routine dynamics to be studied without the problematic nature of pronounced intersections of knowledge domains, ensuring the effects of lean NPD techniques can be studied in isolation from these factors. Furthermore, these highly innovative products increased the likelihood of company personnel needing to reflect during routines to solve

problems, which provided a greater chance of determining how lean NPD practices affected this process. It could be argued that the use of lean NPD techniques in such an environment begs the question since they will ultimately result in reflective behaviour no matter what. However, the research methods used showed how lean NPD techniques interactively resulted in behavioural outcomes. Hence, utilising a research setting that had the potential for rich learning was vital such as NPD, such that it could be determined how the techniques affected behaviour in this environment. Studying lean NPD techniques would clearly show if they were negatively affecting learning behaviours in such a context.

Although the situation of ROBOT was somewhat unique given the cultural specificities and the highly innovative product, this presented itself with some strengths and weaknesses for the research's central questions. The research's main focus is to look at micro-behaviours of how lean NPD influence routine enactment, specifically in relation to learning. These techniques will always be utilised against a background of a specific culture, whether this be as a result of a country, an organisation, or a combination of both (Crampton and Hinds 2014). ROBOT's situation, like all companies, presents with some idiosyncrasies. With Toyota the paradigmatic lean organisation itself has a rich and diverse history (Spear, 2010). However, for this research, focusing on the micro-level, it was looking at the mechanics of how lean NPD techniques changed behaviours in routines. If, as the OM literature argues with some evidence such as Nummi, OM techniques can be used across cultures to increase operational performance, then a case such as ROBOT with it's unique cultural history should not be an objection for its use. Much like the routines of Toyota replicated at Nummi, the routines encountered at ROBOT were replicated globally and successfully through new acquisitions by the parent, irrespective of culture.

Addendum - Part B

This part of the addendum comprises of two sections. Firstly, it articulates the contribution this research makes to OM theory. Secondly, it details parts of the research which substantiate this contribution. These sections will now be discussed respectively:

On the whole, OM techniques have been assessed by their impact related to organisational objectives (Peng et al., 2008). These include multiple objectives at the business level such as speed, flexibility, cost, quality, and dependability (Boyer and Lewis, 2002; Ferdows and De Meyer, 1990; Flynn and Flynn, 2004; Noble, 1995). Furthermore, using this method,

unique practices are generally identified as causally relevant in determining weak or strong performance outcomes (Ward et al., 1998). These unique OM practices are generally treated like a 'black box', where it is unclear how they are utilised at the operational routine (micro) level (c.f. Chavez et al, 2013). Significant scholarship has questioned this aggregated measure of operational performance, which eschews what is occurring during the actual operational activity level of an organisation (Peng et al., 2008; Lewis, 2002; Lamming, 1993). They argue that operational capabilities which lead to organisational objectives are formulated from operational routines (Clark, 1996; Hayes and Pisano, 1994), which are an under-utilised analytic resource within the OM literature, given this is where OM work is actually performed (Peng et al., 2008). To understand how operational capabilities are formulated, one needs to understand how OM practices shape routines performance in which they are utilised (Peng et al., 2008). Furthermore, measures related to OM practices' performance need to be determined at this level of analysis (Adler et al., 2009).

However, given these concerns about how OM practices effect operational routines, and the need to measure their impact within routines, few studies have investigated this problem from a routine theory perspective. Consequently, this research utilises practice-based routine theory (Feldman and Rafaeli, 2002; Pentland and Feldman, 2005) to determine the effect an operational technique has on a key driver of business performance, namely learning, within routines. Specifically, the research looks at how an OM technique 'lean NPD' shapes routines' micro dynamics such that it effects the abilities of individuals to engage in reflective learning. Scholarship has argued that learning is a key capability through which lean and lean NPD result in superior organisational objectives (speed, quality, cost, flexibility, dependability) (Morgan and Liker, 2006; Spear, 2004). These studies often appeal to macro-organisational phenomenon, such as unique OM practices, combined with positive organisational outputs as evidence of how a learning capability is generated (Spear, 2010; Peng et al., 2008). It has been argued that lean practices accelerate learning (Spear, 2010), balance different type of learning activities (Adler et al., 2009), and enable participants to engage in unique learning experiences such as reflective or "deutero-learning" – which is the ability to "learn how to learn" (Bateson, 1972). Indeed, work by Ohno (1988) relates how he altered the production system, based on his ability to think differently about how production systems work as described in **section 1.1.1**. Furthermore, continuous improvement, a central theme of lean has been explained through theories of learning; *"the process of improving action through better knowledge and understanding*" (Fiol and Lyles, 1985, p. 803), and so, "*more than anything, it is this 'dynamic learning capability' that is at*

the heart of the success of TPS" (Holweg, 2007). However, although learning is cited as a key capability which drives performance, derived from the use of lean practices, no scholarship has conducted a micro study as to how these practices actually do in fact change behaviours. This research aimed to answer the call for further study, and thereby addressed this exact deficiency within current literature. Seminal research had referred to reflective learning as the critical learning process at the micro-level which results in endogenous routine change (Feldman and Pentland, 2003). Feldman (2000:625) utilises the work of Argyris and Schon (1997) to explain what learning is:

> *From my observations, organizational routines involve people doing things, reflecting on what they are doing, and doing different things (or doing the same things differently) as a result of the reflection. Thus, organizational routines can include the ''double loop learning'' that Argyris (1976) and Argyris and Schon (1978) have identified.* Feldman (2000:625)

For radically new knowledge to occur, personnel have to engage in double loop learning. This is described as "… when error is detected and corrected in ways that involve the modification of an organization's underlying norms, policies and objectives" (Argyris and Schon, 1978: 3). That is, double loop learning can be identified by a change in schema, or base assumptions. Scholarship has characterised double loop learning under the broad category of 'reflective learning', such that assumptions are reflected upon and altered (Argyris and Schön, 1997; Feldman, 2000; Jordan, 2010; Tsoukas and Chia, 2002). Reflective learning is also described as playing a key part in lean systems. For instance, the work of Spear (2010, 2004), Browning (2009), and Morgan and Liker (2006), all refer to reflective learning as critical to how lean achieves performance. As such, given the prominence reflective learning plays within the OM lean literature, and the practice-based routine literature, it was utilised as a measure of learning at the micro-level.

However, no study has been conducted from a practice-based routine perspective which demonstrates the micro-mechanisms as to how lean NPD practices results in learning within a routine, which ultimately results in capability formation. The practice-based routine perspective provides the appropriate analytic resources to address this problem since it reduces organisational phenomenon into what people say and do, and the material means they draw upon to perform activity within routines at the micro-level (Gherardi, 2009a). As such, using this perspective it opens up the 'black box' of OM practices (Jarzabkowski and Kaplan, 2015), and details how these practices 'work' in routines (Jarzabkowski et al., 2007). Such an analytic also provides the conceptual and methodological resources to measure

behavioural outcomes as a consequence of these OM practices (Gherardi, 2009b). Since all concepts can be operationalised via action, it can be determined if behaviours classified as learning are enabled by the use of lean NPD (Orlikowski, 2005).

Hence, this research focused on operational routines, and determines how the use of OM techniques affects the routine dynamic in reference to the behavioural outcome of reflective learning. Consequently, a significant contribution of this research to current literature was to give new details and insights about how people used OM techniques at a micro-level of analysis. This research revealed a micro-mechanism about how OM techniques can affect people's work in respect to stimulating learning behaviours. In doing so it revealed a mechanism contrary to the dominant view of OM techniques. Instead of being stable, enduring, unproblematic practices, which previous research had considered at the macro-level (Morgan and Liker, 2006), at the micro level they were in fact used in a sporadic, dynamic way, which changed with time and their locations of use. Furthermore, social factors were significant in the efficacy of their use, as well as the context of the routine they were utilised in. This has revealed hereto hidden factors about how OM techniques work in routines, and their relationship to reflective learning. The next section articulates the contribution and demonstrates how this research substantiates the claims of the contribution.

A conceptual contribution made by this thesis, is the articulation of reflective learning in terms of specific behaviours. Previous research has been unclear about what constitutes reflective behaviour (c.f. Dittrich et al., 2016). Influential research had referred to reflective learning as critical to the process of endogenous routine change (Feldman, 2000), but lacked detail as to what this actual behaviour was, except for its ability to alter basic assumptions, and an appeal to the work of Argyris and Schon (1997). More recent work specifically concerned with understanding how reflective talk changes routine enactment treated the nature of reflective talk as unproblematic, and so apparent to the reader (c.f. Dittirch et al., 2016). However, this research, by analysing seminal contributions about the nature of reflection, namely Dewey (1949, 1925), Schon (1987), and Heidegger (1927), and, argued that reflective talk is a relatively consistent set of behaviours, and utilised the work Dewey as the exemplar (see **figure 3.3** for the details of these behaviours). This allows future research to have a clear referent, and so readily assess when, and if, reflective learning is taking place.

This research has also conceptually extended the theory on antecedents to reflective behaviour. By analysing contributions in reflective theory, it was argued that antecedents to reflection utilised two dimensions: specific attitudes increased people's willingness to reflect, whereas, specific material contexts increased the capability to reflect (**figure 3.4**). These were then mapped to descriptions found within the literature of lean NPD practices which appeared to correspond to the features which were antecedent to learning. For example, it was argued by using Schon (1987) that an antecedent to reflective learning was the ability of people to use materials to create 'virtual experiments'. The use of A3 reports in lean NPD seemed to correspond to Schon's (1987) description, they provided a material context for people to engage in thought experiments based on empirical data. Overall, if lean NPD techniques mirrored the features that were antecedent to reflective learning, then it would be highly probably that these features would stimulate reflective learning within routines.

Evidence ultimately supported the previous statement, which detailed specific attributes of lean actors and artefacts which led to an increase of a willingness and capability to reflect, leading to reflective behaviours as shown in **vignette 8** and **12**. This 'mapping' is shown in the first column (endogenous routine factors and lean technique which compromise it) and second column (specific factor attributes) of **figure 6.2** whereby features of lean NPD artefacts and actors identified as central to lean NPD through the literature review mapped onto antecedents of reflection as presented in the fourth column (specific reflective dimensions enabled through the use of lean actors and artefacts given the lean 'moral order'). For instance, lean NPD artefacts exhibited characteristics of increasing a capability to reflect, where shown to be empirically relevant at ROBOT to participants within the routine, and enabled them to reflect. Specifically, lean artefacts allowed information to be displayed publicly , in a systematic fashion, which allowed all present to contribute to the problem, and use the data in the artefact rather than assumed truths. The findings of **section 5.2** argue through the observations (detailed in **table 8.3** and **Vignettes 5, 6, 7, 8, 9, 10**) which constructed **figure 5.7** that these specific attributes of lean NPD artefacts led to reflective learning. Furthermore, through analysing the literature it was argued that the Chief Engineer was described as having characteristics that exhibited a willingness to reflect. These characteristics of lean NPD actors were encountered at ROBOT described in **section 5.1**. For instance, evidence of a 'willingness to reflect' from **Vignette 2 and 3** which constructed **figure 5.2** occurred predominately in 'routines for lean artefact creation'. Here, evidence showed how the chief engineer created a Socratic questioning environment which

corresponded to definitions of a willingness to reflect (Jordan, 2010). Evidence of the lean actor's willingness to reflect was also in other routines, for instance **Vignette 8** (lines 30-32**)**, where the CE voluntarily removes his own assumed views from the situation to ground debate in the A3 report. What the research showed is that attributes of lean actors and artefacts were utilised as resources by participants and shown to be interactionally relevant (via the vignettes) to those that enacted the routine to bringing about reflective learning. For instance, the reflective learning in **Vignette 12** only occurred via as a direct consequence of interacting with features of the artefact (the roadmap). However, as **figure 6.2** depicts lean NPD actors and artefacts did not uniformly produce these antecedents to reflective behaviour, and so reflective learning. Other factors effected the internal routine dynamics, which will now be discussed.

As detailed in the first column of **figure 6.2**, by revealing the mechanisms which led to reflection, other, wider social dynamics were also shown to be of importance which had heretofore have been excluded from OM research. These include the ability to fix attention, the ability of the artefact to create a context which promoted reflection, and social discomfort around the use of lean NPD artefacts. The role of attention has had had little impact in the routines or OM literature, yet a key feature of lean NPD artefacts was their ability to fix attention, as described in **section 5.2** and the analysis of **Vignette 8,** and **11**. Participants were shown to move across topics and not be able to concentrate within the observations. Scholars from other disciplines had recognised the fragmentary nature of attention within organisations (Boden, 1994), the use of lean NPD techniques anchored participants focus to the task at hand, and allowed group interaction to centre on communal discussion points as evidenced by the discussion grounded in the A3 report in **Vignette 7**. The increase in attention was not a feature of the artefact per se but a consequence of its materiality, it endured with the information it expressed in it as conversation wondered. As such, it shows how social dynamics are mixed up with materiality in the use of OM techniques. The interaction of social and material process has been researched under the concept of 'sociomateriality' (Orlikowski, 2007) and utilises an understanding of human experience as 'embodied' (Merlau-Ponty, 1962), and a 'knowing in action' that is suffused with materiality (Suchman, 1987, Suchman, 2005, Ingold, 2000). Such an understanding blurs the line between material and non-material objects… "to signal this ontological fusion. Any distinction of humans and technologies is analytical only, and done with the recognition that these entities necessarily entail each other in practice" (Orlikowski and Scott, 2008: 456). Barad (2014) uses the metaphor of 'entanglement' to describe this relationship between

human and artificial action. Interactions with artefacts showed how this entwining occurs in the constructions of meanings within routines. For instance, **vignette 7** showed how, for the participants, the artefact became transparent. They depended on the artefact to construct their sentences and meanings, and without the A3 report what they achieved interactionally would not have been possible. However, uniquely, this research identified that sociomateriality was not a uniform or lasting phenomenon, participants became fully entwined and 'de-twined' in an instance due to variance in their attention. As participant's attention, and so interaction with the routine shifted, so did their behaviour. **Vignette 8** shows how the CE moved from grounding his observations within the artefact (line 1) so that the data he was justifying claims with were present to all, to making assumptions about what was going on based on his own private privileged information (lines 8, 15, and 28), and back again to using data (line 31). Critically, it was only due to the fact that the artefacts were enduring and formed an integral part of the lean NPD routine that participants reoriented back to the artefact. This is suggestive that artefacts play a key role not just in representation of states of affairs to enable reflective activity but also as an enduring object which anchors participant's attention, and so go through the inferential cycle which is reflective learning. It appears that without this stability participants do not have the attention to organise around common meanings, and it would be plausible to suggest that in complex environments such as NPD this would be critical (Weick and Sutcliffe, 2006).

Encoding information into the artefact also had other consequences. Within the thesis it was argued using Dewey's reflective theory (1929), that only in specific contexts did certain facts become discussable, and that reflection was not simply a product of a human will, but dependent on the interaction of humans and the environment to create the ideas which enabled reflection. This research found empirical evidence that lean NPD worked in the way that Dewey described and provided a context which led to reflection. For instance, **Vignette 8** and described in routine 5 showed that participants without having the information in front of them, or engaging with an artefact, became drawn to certain explanations. They seemed unaware, or unable to discuss solutions that were seemingly not preeminent on their mind. This altered once they used the A3 report, they discussed items based in the artefact, and new paths of action, that had moments before never been considered, suddenly became topics of thought experiments (**Vignette 9** line 5). Striking examples of this existed such as the instance in **Vignette 8** when 'EE' who created the A3 report stated a variety of solutions to the task at hand before engaging in the A3 report and the problem was inherently problematic (line 49). When before and after he engaged in the A3 report and found a

solution which he himself had written (line 44 and 56); he seemed to have forgotten, or not be able to discuss this solution without the support of data encoded within the A3 in front of him to adapt the context.

While analysis showed cases of lean actors and artefacts combining to result in reflective learning these were not unproblematic processes. The third column in **Figure 6.2** indicates that social norms governed participants use of the features of lean actors and artefacts, showing the complexities surrounding internal routine dynamics. Complimenting previous findings on the use of artefacts within organisations **figure 6.2** shows while all lean artefacts had standardised features, which could produce learning outcomes, the behaviour which they produced varied according to context and time (Blackler et al., 2000; Eden & Ackerman, 1998; Sapsed & Salter, 2004). Unlike more macro, functionalist research in OM (c.f. Chavez et al., 2013), evidence showed lean actors and artefacts were not seen as an objective set of standards, which, if participants were acting 'rationally' or implemented lean 'correctly', would produce a standard set of behaviours (Jarzabkowski and Kaplan, 2015)**.** Rather, two dominant patterns of behaviour were seen in response to lean artefacts and actors, indicating people felt conflicted as how they should behave around their respective features. These will now be discussed.

The first pattern of behaviour is that participants could engage with the lean actor and artefacts. They could sincerely accept what the lean actor says as in **Vignette 2** and **3**, and use the lean artefacts as in **Vignettes 7** and **12** as a resource to form a line of reasoning. These behaviours have been described above as in cases where features of lean actors and artefacts combined to produce reflective behavioural outcomes. They are behaviours which used lean NPD as resources to act, with a particular interactive footprint, and behavioural outcomes (exhibited by **figure 5.7**). The second pattern of behaviour indicated what participants naturally adhere to without lean NPD artefacts and actors, and also, in some cases, a response to them. Some of these behaviours have been described above when participants disengaged with lean NPD actors and artefacts whilst doing the routine, such as **Vignette 8** and described in routine 5. These behavioural outcomes include utilising a taken for granted solution to the problem the routine is designed to address, the use of personal knowledge, with epistemic justification based on authority rather than publicly assessable data. These behavioural traits without lean NPD actors and artefacts were most conspicuous in non-lean NPD routines.

Section 5.3 of chapter five analyses operational routines without lean NPD processes. The analysis showed that without the use of lean NPD artefacts, negative behavioural consequences ensued as displayed in **Figure 5.9,** which is determined from the evidence of **Vignettes 13** and **14,** interviews and observations. These were identified as the inability of participants to build up joint understandings, participants talking past each other when trying to engage on a topic, not being able to access information, or having to engage great energy to find information on a particular topic, and ultimately an interaction that can be characterised as mired by misunderstanding. Routines without the use of lean NPD techniques had to be carried out again, and did not progress on a topic with a clear achievable outcome. However, participants justified not using lean NPD techniques due to issues such as their overly bureaucratic and rigid nature; they found the systematic steps they had to go through burdensome. Interestingly they were ambivalent on the fact that the behavioural outcomes of these routines were largely negative, as evidenced by comments such as, "*I can see the point, but I don't always 'enjoy', 'doing them' – obviously we get pulled in different directions*" (Mechanical engineer 2*)*.

Most striking of the conflict between these two different ways of acting within ROBOT was when they actually resulted in conflicted behaviour within the routines. For instance, **sections 5.1, 5.2,** and **5.3** describe how participants did not like using these techniques: They removed themselves from the routine (**Vignette 10** line 20), made excuses for their actions as though they were embarrassed for using the lean artefacts "*its hard stating problems and ideas in public*" (Electrical Engineer 1), and tried to disrupt the routine such that they did not have to interact with it (**Vignette** 4 where 'C' constantly interrupts). Questions by the lean actor or embedded in the artefact could irk the participants *"A3s are ok but I don't like filling them in"* (Electrical Engineer 1) and "*The A3 is overly bureaucratic, just have a meeting for brainstorming in start-up phase, then do the drawings, and export it to production"* (Mechanical Engineer 1). Significantly, this was not consistent to a specific person, location, or time. Participants displayed these behaviours intermittently, moving from using lean NPD techniques to finding them problematic and back again to using lean NPD techniques (CE and EE in **Vignette 8** and **Vignette 10** for instance). After the routine, some of the participants who had taken part explicitly stated that they were embarrassed by raising questions in public concerning the content of lean NPD artefacts *"I thought engineering was about doing it on your own but the A3 helped bring it out, it's sometimes hard to talk about problems; team work and testing that is what lean is about"* (Electrical Engineer 1). Furthermore, the chief engineer found it problematic that on occasion

knowledge needed within the routine was not surfaced because people felt unable to air information publicly *"I'll tell you the story of the wrong cables, which everyone knew was wrong, and how it caused reputational damage when it broke in the field due to being outsourced to a supplier who couldn't do the work-around. Their excuse was 'I need to feel the pain to understand why we use the standards"*. These observations indicate social dynamics impact participant's interpretation of operational techniques. Hence, the use of OM techniques were not stable, and that wider social dynamics impacted the efficacy of their use. This social instability between different attitudes of lean NPD is signified by the broken box in the third column in **figure 6.2**. It was only when lean NPD processes were engaged with and not seen as burdensome that participants used the features within them as antecedents to reflection. Within the main body of the research the concept of 'moral order' was utilised to explain how this social instability could occur. This research argued for an ethnomethodological understanding of the practice-based perspective of routines. Consequently, as Samra-Fredericks (2010 :2148) states, "*Ethnomethodology's distinctive focal analytical interest is in explicating the methods and reasoning procedures or inferential practices for accomplishing a social–moral order*". Thus, it was argued that the conflict of how lean NPD techniques were treated, was to a degree, dependent on how participants using the techniques reasoned. Given the different patterns of behaviours surrounding lean NPD techniques described, and using ethnomethodological resources, it was inferred that this was due to two different 'moral orders', as labelled in **figure 6.2**. However, as **figure 6.2** displays there are other factors other than just the conflict between interpretative stances to the lean NPD practices. As the fifth column in **figure 6.2** indicates, which routines these techniques were used in contributed to their behavioural outcomes.

Previous work has identified how actions within routines are construed and related to other routines within the organisation (Feldman et al., 2016). This research extends the understandings of how routines are embedded within their organizational contexts, specifically in relation to operational routines. The concept of routines' embeddedness (Howard-Grenville 2005) derives from the observation that routines are performed in the presence of other routines (Narduzzo et al. 2000, Feldman 2003, Gersick and Hackman 1990). Routines micro-dynamics, such as actors and artefacts, result in behavioural outcomes which may concurrently influence other aspects of participants understanding of the organisation, and so other routines.

A key insight of this research is that for full reflective learning to occur, (learning that is actioned), particular types of organisational routines have to be utilised. These routines can be classified as having a task that is seen central to the progression of an organisational problem by those within the routine, as is present within lean NPD development routines where all instances of full reflective learning occurred. Participants are aware that action needs to be taken and the status quo cannot be accepted, thus new ways of acting to overcome issues are acceptable. For action and so learning to be achieved members within the routine need to jointly agree an action, as is the statement to 'CAD it up' in **Vignette 8**. In routines for lean NPD artefact creation all aspects of information where there within the artefact for full reflection to take place, however, these are not actioned until a development meeting. Hence they result in 'arrested reflective behaviours' as in the sixth column in **figure 6.2**. Non-lean NPD routines also faced organisational problems yet these never came to a conclusion that could be accepted jointly by the participants (see **vignette 13 and 14**), thus no examples of reflective learning were seen in these instances (as indicated by the bottom arrow in **figure 6.2**). Hence, behavioural outcomes of a routine are not just a consequence of the micro-dynamics combined with social dynamics, but also the understanding of the routine's place within the organisation. The OM literature, as well as the routine literature, does not address how features of practices are shaped by the purpose of the routine within the organisation in which they employed. This may account for the varied role artefacts play within organisations (c.f. Hales and Tidd, 2009).

The mechanisms described above represented in **figure 6.2** indicate a complex set of interactions between actors and artefacts, social dynamics, and interpretations of routines within ROBOT. It provides the actual details of how OM techniques were used, rather than appealing to more macro organisational phenomenon such as 'learning'. In doing so it provides insight into how OM techniques affect routine behaviour, and provides new perspectives on what may affect the ability of those actually 'doing' OM work to perform it.

The identification of specific factors in lean techniques which lead to learning is important for OM since it augments previous research where learning is a central research focus. For instance, the work of Spear (2004, 2010) argues the efficacy of Lean systems (operations and product development) are predicated on the ability of these techniques to increase the speed of learning. The mechanism he describes as to how lean works is via a problem solving discipline which involved seven steps: Firstly, to provide a background to the situation, secondly to show the current condition, then do a root cause analysis, provide

countermeasure treatments, and then provide a target condition to be reached, determine what actual outcome was achieved, and lastly to do a gap analysis with the predicted target. Within this process he argues lays the fundamentals of the 'scientific method' of testing outcomes against clear hypothesis, which ultimately is a discovery process (Spear, 2010:252). Other OM scholars have articulated similar theories of how lean techniques lead to increased learning (Adler and Cole, 1993). For instance, lean techniques allow organisations to balance contradictory forces (Adler et al., 2009), or to continually engage in deliberate perturbation of their operational routines (Adler et al., 2009). This research augments these studies by revealing the micro-processes needed to achieve this. By looking at the interactional practices where lean techniques are used reveals how these more macro practices are achieved.

For instance, to achieve Spears (2010) problem solving steps this research indicates that artefacts and actors need to combine to create a situation where these steps can be completed and true discovery take place. Specifically, participants need information displayed in a systematic fashion so that they can follow a detailed root cause analysis, when data is displayed publicly it allows those present to interject rather than rely on a dominant person within the group, and that true scientific inquiry cannot take place on issues without the data written down so that people can manipulate it 'in-situ' rather than rely on memory which is often fallible and leads people to rely on prejudice rather than data. Furthermore, organisation members do not just do these activities when asked, but they need to be trained via lean actors fostering specific attitudes and demonstrating that these are organisationally acceptable ways of acting. Without these features this research has shown that achieving sustained thought on topics is difficult, and often leads to misunderstanding with people talking on different topics and recursive conversations (see the analysis of **section 5.3**). Furthermore, following steps like Spear's (2010) problem solving discipline may not necessarily result in any discovery, one can imagine situations where these are just followed without reflection. By linking specific features of actors and artefacts with the mechanisms of reflective learning demonstrated how these techniques do lead to learning, showing a more precise pathway rather than a black box process. This in turn informs both theory by showing how OM techniques shape behaviour to result in specific outcomes, and practice, by informing managers on specific observable actions and materials needed which lead to learning, as well indicating the specific behaviours which signify learning is taking place. Revealing these micro-mechanisms of how OM techniques such as lean NPD lead to micro-learning may also reveal a general theory about how OM techniques lead to learning, not

just specific to lean NPD. Thus, micro-studies of OM techniques may provide the perspective which systematically links disparate OM techniques, such as lean and six sigma.

Crucially, this research has not just been able to understand the mechanics about how OM techniques change routine behaviour, but also it has been able to access the impact of the OM techniques at the routine level of analysis via the operationalisation of reflective learning through specific actions detailed in **figure 3.3**. This removes concerns within scholarship about determining the influence of OM techniques at the organisational level (Adler et al., 2009; Peng et al., 2008). Furthermore, this research has shown a novel method in OM about how to link OM techniques and performance outcomes at the micro-level through studying them contemporaneously using a practice-based perspective. As such, it provides further evidence as to the positive use of lean NPD within organisations (Morgan and Liker, 2006). As Peng et al., (2008) argues, linking OM techniques to routine theory is important since by indicating how OM techniques affect routines provides an explanatory mechanism as to how they can affect wider organisational performance, since routines are the 'building blocks' of capabilities (Zollo, M., Winter, 2002). In essence, it provides a mechanism as to how OM techniques can be strategic, OM techniques can alter routines which alter capabilities, which are key determinants in organisational performance (Katkalo et al., 2010). How OM techniques affect internal routine dynamics has been a significant gap within the OM literature. This research has addressed this gap by providing evidence for a mechanism about how OM techniques can do this in respect to achieving reflective learning outcomes; a key explanatory mechanism in the wider OM literature (Spear, 2010).

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Appendices

Appendix A

Table 8.1: The key sources, research methods used and data collection sample with interpretative lens ordered in chronology of publish date (earliest to latest)

Author, Title, Source / Media	**Research methods / data collection sample**	**Interpretative lens**
Imai, M. (1986). "The key to Japan's competitive success." McGraw-Hill/Irwin. Book	Unknown but references lean companies and has interview exerts from them.	Interested in the Japanese concept of Kaizen
Graves, A. (1987). Comparative trends in automotive research and development, International Motor Vehicle Program. Article	Interviews and analysis of company reports and information – part of the MIT IMVP	
Womack, J., Jones, D., Roos, D (1990). The Machine That Changed the World. New York, Rawlinson Associates. Book	Interviews and analysis of company reports and information – part of the MIT IMVP	Lean as the best of craft and mass production, high variety at low cost
Clark, K. B. and T. Fujimoto (1991). Product development performance: Strategy, organization, and management in the world auto industry, Harvard Business Press. Book	Structured and unstructured interviews and questionnaires. Based on automotive industry from 1985 - 1988, looked at, 3 US, 9 European, 8 Japanese manufacturers which consisted of 6 projects in the US, 11 in Europe, 12 in Japan	Lean as the best of craft and mass production, high variety at low cost

Lamming, R. (1993). Beyond partnership: strategies for innovation and lean supply. New York, Prentice Hall. Book	Interviews and survey Over an 8-year period, 181 interviews (56 with assemblers, 109 with suppliers, 16 with industry associates) and 4-year involvement in IMVP	Lean as the best of craft and mass production, high variety at low cost
Whitney, D. E. (1993). "Nippondenso Co. Ltd: A case study of strategic product design." Research in Engineering Design 5(1): 1-20. Article – Case	extensive interviews with engineers and managers, plant tours and talking to authors of work published by Nippon Denso 7 visits between 1974-1991	Lean as the best of craft and mass production, high variety at low cost
Cusumano, M. A. (1994). "The Limits of Lean"." Sloan Management Review 35: 27-27 Article	Unknown	Polemic concerning the negative effects of lean
Kamath, R. R. and J. K. Liker (1994). "A second look at Japanese product development." Harvard Business Review 72: 154-154. Article	Interviews and surveys In 1992-1993, visited three large Japanese automakers - Toyota, Nissan, and Mazda - and more than a dozen of their suppliers in Japan. Surveyed 143 Japanese suppliers of parts, components, and subassemblies to Toyota and other Japanese automakers, and 189 U.S. suppliers to General Motors,	Interested in Supplier relationships with commodity type

	Ford, and Chrysler.	
Ward, A., et al. (1995). "The second Toyota paradox: How delaying decisions can make better cars faster." Sloan Management Review 36: 43-43. Article	Unclear in the article but the work of Sobek (1997) states that it was interviews In 1993 5 interviews with Toyota, 8 interviews at 6 of Toyota's suppliers	Lean NPD as a method to explore the design space and reduce rework Deductive method looking for Set based concurrent engineering influenced by the theoretical NPD simulations of (Ward and Seering, 1993)
Sobek, D. K. (1997). "Principles that shape product development systems: A Toyota-Chrysler comparison." PhD thesis	Interviews and Site visits In 1995 26 interviews of 23 people totalling 43 hours at Toyota, there were also unspecified supplier visits	Lean NPD as a method to explore the design space and reduce rework A grounded theory approach but deductive method for SBCE as Ward, et al. (1995)
Cusumano, M. A. and K. Neboeka (1998). Thinking Beyond Lean: How Multi Project Management is Transforming Product Development at Toyota and O, Free Press. Book	Interviews 227 interviews at Japanese automotive manufacturers from 1992 – 1997	Multi-project managing
Muffatto, M. (1998). "Reorganizing for product development: Evidence from Japanese automobile firms." International Journal	Case study	Historical perspective

of Production Economics 56: 483-493. Article	Unclear	
Sobek, D. K., et al. (1999). "Toyota's principles of set-based concurrent engineering." Sloan Management Review 40(2): 67-84. Article	Interviews Based on the interviews of Sobek (1997) described above and interviews (number, people, hours unspecified) of Japanese and American Engineers at Toyota Technical Centre Ann Abor Michigan in 1997	Lean NPD as a method to explore the design space and reduce rework Deductive method looking for Set based concurrent engineering influenced by the theoretical NPD simulations of (Ward and Seering, 1993)
Itazaki, H. (1999). The Prius that shook the world, Nikkan Kogyo Shimbun Limited. Book	Interviews 'many' over 6 months unspecified year	A journalistic story of the Toyota Prius development
Thomke, S. and T. Fujimoto (2000). "The Effect of "Front-Loading" Problem-Solving on Product Development Performance." Journal of Product Innovation Management 17(2): 128-142. Article	Interviews and public presentations of data Toyota personal interviews but unspecified number, people, or hours.	A problem solving perspective on NPD
Morgan, J. M. (2002). High performance product	Interviews and site visits	Uses manufacturing paradigm of lean to

development: a systems approach to a lean product development process, University of Michigan. PhD Dissertation	Interviews of 17 Toyota personnel at 3 sites totalling 526 hours. Plus interviews 7 people at 3 Toyota suppliers totalling 100 hours	understand lean NPD. Also uses action research to introduce lean manufacturing tools into NPD
Liker, J. K. (2004). The Toyota Way. New York, McGraw-Hill. Chapter 5 Book	Interviews Unspecified, but quotes an interview with the chief engineer of the Lexus	Experts from the interview
Mehri, D. (2006). "The darker side of lean: an insider's perspective on the realities of the Toyota production system." The Academy of Management Perspectives 20(2): 21-42. Article	Ethnography and interviews Worked for 3 years at Nizummi a Toyota keiretsu supplier. Also did 75 interviews of workers and labour relations staff ranging from 10 minutes to 2 hours	Polemic of Toyota production and development system
Horikiri, T., et al. (2009). Oobeya – Next Generation of Fast in Product Development QV Systems MIT Sloane. Report	Practitioner description	Description of a method developed by the author for Toyota
Tanaka, T. (2011). Learning from Toyota's Management System. L. S. 2011. Video Presentation	Practitioner description	Description of a method developed by the author for Toyota

Appendix B

Table 8.2: Supporting data collected

44 e-mails
2 x presentations (product and project internal information, Chief Engineer attributes)
1 x dataset of projects
13 x internal documents (A3 reports (10), marketing informational content (3))
5 x examples of A3 visual data (pictures of problems)
1 x field notebook (118 pages of field notes)

Table 8.3: Example of interview data compromising Figure 5.6 and 5.7 the Gioia analysis of lean development routines

Aggregate Dimension - Antecedent to lean artefact use	
Second order themes - Lean Artefact as knowledge object	
First order Concept: Use Lean artefacts to know 'where we are'	we put this information within the report, people are expected to go and look in, if they don't, well… that's their problem" *(Sales 1)* If we put it in A3 reports then we know what we are going to look at *(Head engineer)* A3s really helps us see what we have done previously and bring that to bear on the current situation *(Mechanical engineer 1)* Sometimes we forget and there can be loads of work done to get to the same place, but this (A3 reports) helps us bring back the information, we just need to find it sometimes but usually its ok *(Electrical engineer 1)* We need to put it in this table, so that we can see how far in front or behind we are, we realised we needed more information than was originally on it (Visual management board) so we included manufacturing *(Head engineer)* Its 200 days now since we have been using this visual management board, and we can see by people looking each day how the back log has come right down *(Chief engineer)* Really helps us to see what we have done previously and bring down to bare on our current situation *(Head engineer)* We will have a knowledge gap meeting before any action we can see whether we

	looked at the problem years ago *(Chief engineer)* We need to look at it from the customer's perspective, to see what they see, and to really understand their point of view, I can look at how their voice is captured and see if we are designing to what they really want *(Head engineer)* Before we start designing like mad, we can go into the database and see previous work, we can recycle the knowledge, look at check sheets, it gives us a head start *(Chief engineer)*
Aggregate dimension - Behaviours surrounding Lean artefacts	
Second order themes - Lean artefacts as systematic displays of public data	
First order concept: The need to keep it visual	Unless the problem is written down we cannot properly see it, I need to him to write it down *(Chief engineer)* It is keeping it visual to solve *(Electrical engineer 1)* Like to keep it visual, you can quickly pick it up and understand it, I don't want to be reading loads and loads of documents *(Head engineer)* It just lets us illuminate knowledge gaps, that is what we need to understand before we start going into the later development phases *(Chief engineer)* What if we approach an issue from this perspective, how do can we see it, what if we approach it a different way? We would capture that on A3 reports, it would capture why we want to capture a certain design, and that is critical to me why we get one design *(Chief engineer)* Any mistake that I make, I can put it in the A3 for next time, and it makes it easy to see, since otherwise you just kinda forget *(Electrical engineer 1)*
First order concept: Map the design space	The A3 rearranges the situation, what we did know, what we didn't know, this is true for the group as well as for people. *(Head engineer)*

	It allows you to look at the mistakes you have made before design, I am going to ask what about x, is it a mistake we have made previously, how can we avoid it? *(Chief engineer)* If there is a problem, then we always do testing to get the answers *(Mechanical engineer 1)* We always have a second option because that is what kills us not having a second choice, we always need an alternative, or a backup, cost isn't generally too much of an issue *(Chief engineer)* They always want to go with one component, but for me I want to develop a few, and they roll their eyes, but if we don't get it working we miss our shipment *(Chief engineer)* The manager is always thinking about how to have something as backup to keep the deadlines, it is very hard to keep options *(Electrical engineer 1)* We have over 4000 documents, they give a really good history, they are great at capturing the knowledge *(Chief engineer)* Also, sometimes I can find a solution to a problem that I already had. often we have something in the company already designed to do it, just need to flick through some A3 reports *(Electrical engineer 2)* What we did pick up on was how we used A3s, so there were a lot of things that did work. And the whole lean thinking, the whole waiting to learn until the bitter end to make your design decision, so the hole lean thinking did work. So that is where we focused on *(Chief engineer)* I break the problem down and I can see how different parts of the product work and see how this relates to manufacturing, spares etc, and where my design fits in *(Electrical engineer 1)* Sometimes you just need to be aware of what is out there, we can paste competitor

	information in an A3, and then it allows you to see possibilities and what worked for others *(Chief engineer)*
First order concept: Systematic presentation of information	The A3 re-specifies the issue and reconnects the ideas in a logical sequence *(Sales 1)* The A3 organises you to do your tasks, it gives you discipline *(Mechanical engineer 1)* It is always a huge mess and you get people in working out things, but in the end, when they see the logic they are all ok. *(Chief engineer)* We need to be solving the right problems, and to do that we need to find the root cause and focus on what is important, so that we just have a few key relations *(Chief engineer)* Engineers just want to go out and play all the time, neither of us are frustrated by each other, we always get along with everyone. I am constantly standardised on processing even the way we name our drawings, components, and this happens all the time because we buy companies I like, I want the same file name structure, just to avoid mistakes and it makes us more efficient, really not asking a lot of these guys, they have got to do it anyway *(Chief engineer)* If you try and solve something straight away, you can never get anything right. You need to sit back and break the problem down so you know how everything is related, then you can see critical paths and solve the issue *(Chief engineer)*
Second order theme - Lean artefacts as opening up rights to knowledge	
First order concept: Everyone knows where they are	So everyone is on the same page; even top level, its great *(Sales 1)* Some territorial behaviour, there always is in these meetings, but we go through the process, and by the end everyone is on side *(Chief engineer)*

	We need to do it in teams because one person on their own in the initial phase you get too focused, it is really dangerous, the A3s stop this a bit *(Head engineer)* Explanation as to why this method was chosen, such that nothing is forgotten, we have an internal overview once a week. We realised we needed manufacturing added later due to aspects we needed to remain in view, and at certain points it was killing us. *(Head Engineer)* SCRUM is good for understanding and awareness, we can get an idea of what everyone is up to, sometimes I go and speak to people after, yeah it makes work easier *(Mechanical Engineer)* They help me, sometimes I am a little removed from some of the issues going on down there, but for sure, I can see what is occurring through the reports and change orders getting closed, it definitely helps *(Operations Manager)* Yeah, they do help, you can get lost in the day to day, and you can give the A3 a quick read, and suddenly you can see how things fit together, and where my works fits into it all, definitely *(Electrical engineer 1)*
Second order theme - Lean artefacts as the re-specification of glosses	
First order concept: Need to understand what is 'really going on'	Talk of standards is ok for Aluminium but for other aspects we use a trade name, we need to get away from the trade name and use a chemical formula, we need specification *(Chief engineer)* Sometimes its ok to solve the problem on your own, sometimes you go to see them (like manufacturing), where the problem is occurring, actually it is always better to go and see the problem directly *(Electrical engineer 1)* I need my hands on things, at that point you actually learn something new through feedback, I need to follow the product through *(Electrical engineer 1)*

	Any problems, and I prefer to have a conversation with the actual person where the problem occurs *(Electrical engineer 1)* Testing transforms knowledge *(Electrical engineer 1)* This is why we do it, we call a meeting and everyone reviews it, when we do a design it is difficult, these people may be too similar. Maybe if we had different people it would be more unique *(Head engineer)* We need the simplest system to determine what is really going on *(Chief engineer)* The A3 give everyone a voice to what is really going on, you need that so people have no problem saying how things are *(Sales 1)* No way you can predict financial information, processes ok but what you really need is to grasp the logic, for instance tools paper *(Chief engineer)* FMEA, equals the sceptic, which equals the chief engineer. You are expected to be a critical thinker, and get to the root of the matter *(Chief engineer)* They do lots of physical prototypes, always looking for better operationalisations so that they do not test, but it is difficult to predict, and we really need to understand how these materials are behaving *(Mechanical engineer)* Really helps going out to see the product in action, so difficult to understand what people were talking about until you actually went and saw the product, now I could take part in the conversation with confidence *(Sales 1)*
Second order concept - Artefacts as problematic	
First order concept: Artefacts as psychologically difficult	Its hard stating problems and ideas in public *(Electrical Engineer 1)* I thought engineering was about doing it on your own but the A3 helped bring it out, it's sometimes hard to talk about problems;

	team work and testing that is what lean is about *(Electrical Engineer 1)* I have A3 of the week, next thing I see is someone puts up there A3 of the 'weak', its ok they will come around, not everyone will but… *(Chief engineer)* Sometimes standardisation is ok, but I don't just like doing it without understanding why, sometimes we miss out on the point, and it doesn't translate from project to project *(Mechanical engineer1)* I can see the point, but I don't always 'enjoy', 'doing them' – obviously we get pulled in different directions *(Mechanical engineer 2)* I can sometimes see people in a bit of panic, but they should know these things, and use the check lists, they are here to help everyone *(Chief engineer)* We need a safe environment to get information out of people's heads and onto paper, it is hard, but we need to learn that is ok (Chief engineer) It can be difficult keeping everything up to date, but we need to do it because it ultimately helps, they are there to help ultimately *(Head engineer)* Before I wasn't sure why we did it, and to some extent I found it difficult, but now I understand, it does make sense… *(Mechanical engineer 2)*