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Driving Health Innovation: The Dynamics of Strategic Learning and Quality Management in Product Development

A Case Study of Canada-Based Startup: OTO

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ABSTRACT

The intent of this study is to underscore the critical features of what drives innovation capabilities within business in the startup phase. Within the contents of this thesis, findings are derived from the case study of OTO, a startup company based out of Toronto, Canada and seeking to rapidly develop innovative technologies within the health technology industry. After the acquisition of Omegawave, a health technology company based out of Espoo, Finland, OTO began a change management process based around underlying strategic direction towards a new market and the effort to improve product quality, of which this paper will investigate in detail.

Two core areas of research will be discussed. Firstly, the role of strategic learning in innovation contexts. Secondly, product-level quality management in innovative contexts. A qualitative single-case methodology was employed within this study, allowing in depth investigation into the strategic perspective and company aims. Different perspectives on these topics are explored through semi-structured interviews, enabling a nuanced examination of how OTO's strategic learning and quality management choices shape its innovation capabilities.

Findings result from the perspective of OTO related to the interplay of the two main areas of research, and its results on creating an innovative product within OTO. The intent of translating OTO's innovation capabilities to an innovative product, as well as maintaining a high standard of quality for the consumer are critical components of technology firms and remain an area that is greatly influenced by many variables, both internal and external to the company in question. This paper's intent is to conduct a study that contributes to theoretical understanding of what important attributes derived from the areas of strategic learning and quality management have the largest impact on innovation capabilities.

KEYWORDS: Strategic learning; Quality management; Innovation capabilities; Health Technology; Product development; Knowledge management.

Table of Contents

Figures

Tables

1 Introduction

1.1 Background

In the ever-changing business environment that entrepreneurs and startups face there remains a constant dilemma: how to innovate in the safest and most effective way possible? The development of innovative products has been and always will remain as a central driver of competitive advantage of contemporary businesses based around technology. Continuously striving to adapt to a dynamic business environment while pursuing rapid and significant technological advancement can, in many cases, undermine the consistency of product delivery by compromising quality. This ultimately gives rise to a productivity dilemma, where efforts to innovate may conflict with the need for stable and reliable operational performance (Benner & Tushman, 2015, p. 498).

It is generally agreed that the concept of strategic learning capability falls under the rubric of organizational learning defined by Levitt & March (1988). As we understand, organizational learning simply describes the underlying mechanisms and processes pertaining to how an organization and its members learn (Huber, 1991). However, there is an acknowledgement that must be given to the specific concept of strategic learning within an organization or business, as it relates to innovation. Strategic learning aims to generate learning in support of future strategic initiatives that will then foster knowledge asymmetries that can lead to differences in organizational performance (Thomas, Sussman, & Henderson, 2001).

Further to that, if we undertake the task to assess the overall capability for strategic learning from a company, then we intend to measure a firm's proficiency at deriving knowledge from past strategic actions and subsequently leveraging that knowledge to adjust firm strategy (Anderson, Covin, & Slevin, 2009), which in turn has implications for how firms can adapt innovative technologies in a more effective manner (Zollo & Winter, 2002, pp. 340–341).

The purpose of this research is to maintain specificity related to the strategic learning capabilities of the Canada-based firm: OTO, with no wider reaching implications within the area of organizational learning as a concept due to its broad applicability within the areas of psychology, sociology and systems theory. This choice is also motivated by the ability to outline relevant actors within the company's management team and development team, thereby generating a causal link between the actions that directly lead from knowledge management into innovative developmental outcomes.

To achieve innovation within the product space, emphasizing exploration, adaptation, and reconfiguration of knowledge to pursue emerging opportunities remains paramount to an organization under a learning orientation. Therefore, throughout the course of this research paper, emphasis will be placed within the area of strategic learning, focusing specifically on the underpinning of absorption, adaptation and alignment of knowledge sources. Organizations who have established strategic learning practices are able to adjust to market signals, experiment, and effectively redirect resources to avoid loss of market share. All of which have implications of innovation capabilities of an organization (Teece, 2007, p. 1341).

Leading on from the area of strategic learning, the main competence that firms within the startup space must invest in is to create consistency and continuous improvement related to their quality management system, and to enable it to be as people-focused as possible (Hamid et al., 2019, p. 164). Contemporary software and hardware quality management processes and principles enable more effective downstream competencies in the areas of quality assurance and quality control. Which has resulted in an overall evolution in principles originating from manufacturing efficiency and compliance (Hamid et al, 2019, p. 165). Furthermore, quality management is sought to be the additional field of research that has a contributory factor related to successful innovation of products (Perdomo-Ortiz, González-Benito & Galende, 2006 p. 1171). Throughout the inception of management sciences, quality management processes have taken shape through a variety of disciplines to maintain consistency within the product development process, as

well as embedding reliability within the products themselves, contributing to value creation for the consumer.

Development and launch of successful innovative new products are one of the most critical, yet most challenging tasks managers face, and this study seeks to argue that innovation capabilities within technology firms in the startup space emerge not from competencies within strategic learning or quality management alone, but from the precise mechanisms of their interaction.

1.2 Research Gap

The interplay of these two critical features of business practice remains an underdeveloped area within the research space. Specifically, the thesis conducted in 2009 by Hannele Lampela at the Lappeenranta University of Technology, Finland, exploring the relationship of interorganizational learning and innovation networks was of particular importance when identifying a research area. She poses towards the end of her paper the following:

> *"One possible topic for future research is also the applicability of different methods and the ease of their adaptation to innovation process… continuing with forming a survey based on these more thematic and descriptive results to obtain more insights and detailed information"*

Additionally, Caccamo, Pittino & Tell (2023) indicated within their paper related to contributing factors behind innovation management that a future area of research should specifically address the innovation management practices behind the staged product development process, indicating the following related to the temporal boundaries within innovation settings:

> *"Look at specific features and types of objects that support information processing in relation to the stages of innovation projects and how they are "acted" by stakeholders involved in the process."*

1.3 Purpose of Study

The purpose of this study is to investigate in detail the dynamic interplay between strategic learning and quality management and the manner in which they both contribute to innovation capabilities within an organization. While there is existing literature related to the importance of strategic learning and quality management for startups independently, there is a lacking area regarding the way these two domains interact specifically within their relationship to innovation capabilities. In the past, large scale studies in manufacturing and large-scale contexts have demonstrated the relationship between the domains. However, this research aims to introduce a new link between the two areas within the startup environment.

While strategic learning and quality management may reinforce one another in shaping innovation capabilities, tensions may also arise as organizations balance the need for rapid learning with the structure imposed by quality management systems. Furthermore, the dominant capability within the organization, either strategic learning or quality management, may shape how innovation capabilities develop, with learning processes driving innovation in some contexts and quality decision structures guiding and channeling innovation in others. Therefore, the contribution of this study will be focused on the specific choices management teams within the startup area can make through the underlying competencies of both strategic learning and quality management. Specifically acknowledging the mechanisms that support these two major competencies will lead to a direct improvement of innovation capabilities.

The study will include five different chapters. Following this introduction, the study will present a literature review in the second chapter that will seek to understand the underlying influences of innovation capabilities as it relates to strategic learning and quality management. Following the literature review, the methodology section in the third chapter will explain in detail the motivation behind the decision for a qualitative

approach to the research inquiry, as well as outlining the questions and patterns in the responses from the semi-structured interviews. This is followed by the fourth chapter that introduces the findings of the study. The concluding chapter as well as the discussion of the results of the research will highlight the main lessons garnered from the study as well as limitations. Finally, areas of future research are acknowledged within the final section of the paper regarding the influences and further unexplored areas that impact innovation capabilities.

2 Literature Review

The literature review of this study will comprise of two main topics. The first outlines and discusses the most consequential strategic learning variables within the innovation context. Linking the underlying principles of strategic learning then understanding what contributes to innovation capabilities at a more mechanistic level is then explored within the literature. Then the literature review focuses on the concept of quality management within the innovation context. Within this section, again mechanistic links are made between the fundamental importance of quality management as they relate to enabling innovation within the quality management protocols of a firm. Finally, a theoretical framework on how to understand the interplay between these two areas for the study which will remain fundamental to the data collection section.

2.1 The Role of Strategic Learning in Innovation Contexts

The following section is the first part of the literature review of this thesis, comprising of three subchapters. The first will be a background on the concept of strategic learning and how organizations have benefited from having robust strategic learning practices and identifying key characteristics of strategic learning. Secondly, this thesis will explore the general concept of innovation capabilities, how the research area contributing to the area of innovation capabilities has evolved considerably, as well as attempting to apply the concept of innovation capabilities within the context of technology firms. Finally, important mechanistic links of how innovation is enabled by strategic learning within an organization are made in the final section, approaching the concept of how both external and internal knowledge sources are then managed by firms in order to drive innovation.

2.1.1 The Concept of Strategic Learning

In order to achieve long-term strategic goals, organizations need to be able to learn to acquire, disseminate and apply knowledge to realize those strategic aims (Calantone, Cavusgil, & Zhao, 2002). In the context of organizational theory, organizational learning framework provided a central concept to label an organization's capacity to adjust their strategy in a thoughtful manner from learning from both external factors and internal experiences (Huber, 1991, pp. 91-97). The pioneering publication within the area of organizational learning was delivered by of Argyris & Schön tiled, *Organizational Learning: A Theory of Action Perspective* in 1978 established the framework for understanding how collective behavior is governed and improved by single-loop learning and double-loop learning, which focused on correcting errors in actions and assumptions values and norms of an organization are modified to enhance learning capacity. While these early models of organizational learning were beneficial for organizations, they were critiqued mainly for their lack of contextual complexity, which necessitated the emergence of strategic learning as an area of study (Rhodes, C. 1998, p. 108).

It is generally understood that the abilities of an organization to apply concepts of strategic learning are only as strong as its abilities to gain feedback about their products or services. Nancy Dixon indicated the following in her influential book, *The Organizational Learning Cycle: How We Can Learn Collectively*:

> *"Learning is not only or even primarily about obtaining correct information or answers from knowledgeable others; it is fundamentally about making meaning out of the experience we and others have in the world…. Organizational learning results from intentional and planned efforts to learn. Although it can and does occur accidentally, organizations cannot afford to rely on learning through chance." (Dixon, 1994, as cited in Godfrey, 2005, p. 173).*

Evolving out of the need to continuously dynamically adjust firms' ability to learn, strategic learning is fundamentally a dynamic capability and thus enabling organizations to reconfigure their knowledge systems and innovation processes in response to long-term strategic goals. David J. Teece (2007, p. 1341) fundamentally identifies "learning" and "reconfiguring" as two of the three core organizational and managerial processes that serve as asset "orchestration" processes. Therefore, strategic learning can be better understood by first acknowledging that its fundamental qualities are focused on adaptability and iterative nature. In order to enable firms to effectively apply strategic learning principles, they must first re-examine the foundations of organizational learning and understand how strategic learning introduces specific and distinct organizational considerations.

2.1.2 The Concept of Innovation Capabilities

A firm key driver for achieving a competitive advantage capability is to promote innovation and creativity while controlling the quality of its products or services (Cho & Pucik, 2005, p. 555). It is nearly impossible to find an industry that is not engaged in continuous or periodic innovation and reorientation due to the dynamic nature of most markets (Hurley & Hult, 1998, p. 42). Innovation is a topic that has generated tremendous attention from the academic world and has continued to evolve in terms of how we conceptualize it. In a review of Schumpeter's seminal work: *The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle*, Joseph Schumpeter argues that economic growth cannot be explained merely as an adjustment to external conditions; rather, it emerges from within the economic system through the introduction of "new combinations" (Schumpeter, as cited in Fritsch, 2017). These could come in the form of new products, processes, markets or forms of organizations that are seen to be disruptive.

Within the contemporary business environment, disruptive technology such as the proliferation of large language models (LLMs), have enabled rapid change at both the organizational and individual levels. On an organizational scale, the deployment of LLMs has been shown to increase overall productivity by an average of 14%, in terms of measuring the percentage of issues resolved per hour across the firm, while also observing that access to LLMs can improve how customers engage with support agents across all levels of skill and experience (Brynjolfsson et al., 2023, pp. 14-15).

Scholars have attempted to define innovation from the perspective of how knowledge is obtained and disseminated within an organization. For example, open innovation, as Chesbrough (2004, p. 23) describes, is the importance of leveraging as many varieties of knowledge as possible within an organization, both internal and external. This was seen as then allowing the rapid integration and sharing of ideas and technologies, thereby re-applying known technologies and ideas in different ways, leading to innovation. This provides us with a more systematic way to understand innovation at the firm level.

The study of innovation is multi-faceted and inherently complex due to the abstract nature of innovation itself. The complexity of this construct is reflected in the different ways it is categorized, ranging from cognitive and organizational dimensions to its treatment as a dynamic capability (Perdomo-Ortiz, González-Benito, and Galende, 2006 pp. 1172-1173). Categorizing innovation as a dynamic capability is well captured by its goal of increased effectiveness within the definition provided by Zollo & Winter (2002), who describe dynamic capabilities as:

> *"learned and stable pattern of collective activity through which the organization systematically generates and modifies its operating routines in pursuit of improved effectiveness"* (p. 340).

This conceptualization of innovation as a capability aligns with the dynamic capabilities' framework, focusing on an organization's capacity to sense, seize, and reconfigure its knowledge assets to enable a competitive advantage. This approach directly

acknowledges that not all stages of the innovation process are open and adjusting approaches to the management of knowledge and innovation accordingly are required to maintain the competitive advantage (Gloet & Samson, 2016, pp. 4282-4283).

In relation to the outcome of increased effectiveness and competitiveness, innovation capabilities are also defined as an organization's capacity for the acceptance, and implementation of new ideas, processes, products, or services as it relies on the acquisition and use of new knowledge to successfully transform creative ideas into tangible outcomes (Calantone, Cavusgil, & Zhao, 2002 p. 516). Building on the preceding discussion of open innovation and the notion of "leveraging diverse sources of knowledge," this research defines innovation capabilities as an organizational capability that deploys resources and effectively leverages knowledge to create value. This definition aligns closely with that proposed by Minna Saunila (2014, p. 167), who identifies seven critical dimensions within her research framework that collectively constitute an organization's innovation capabilities (Figure 1). Many of these dimensions revolve around the concepts of knowledge acquisition and management.

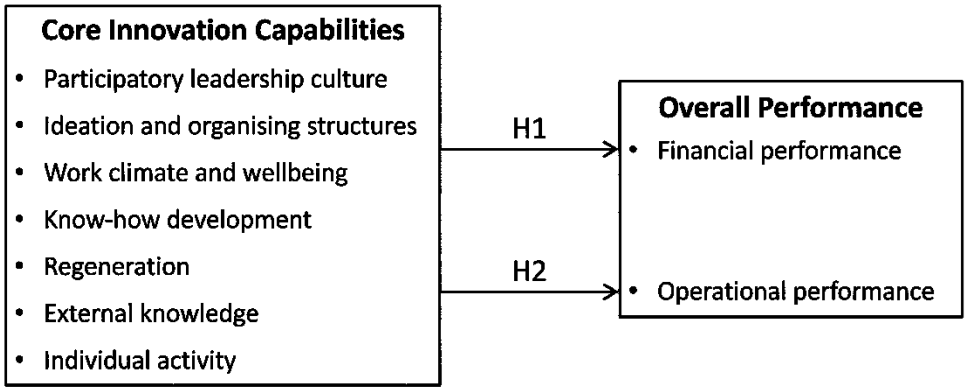

Figure 1. Innovation capabilities association with overall firm performance. From Saunila (2014, p. 167).

Innovation capabilities build off both the concept of open innovation and dynamic capabilities to give the most comprehensive definition which is conceptually aligned in the most applicable manner as a knowledge-intensive organizational capability. This paper defines innovation capabilities not just as the ability to generate new ideas and deploy resources, but as an organization's ability to systematically use knowledge, processes and resources to develop and implement valuable and sustainable innovations.

2.1.3 Mechanisms Linking Strategic Learning and Innovation Capabilities

It would be challenging to argue that a single manner of approach would be the sole determinant of a company's success within the area of improving their innovation capabilities. However, attempting to explore the causal relationship between strategic learning and innovation capabilities remains a research area that both acknowledges the complexity of the topic of innovation, yet underscores its importance in businesses attempting to gain a competitive advantage. Proceeding to the concept of innovation capabilities, this is the area in which strategic learning plays a strong role, particularly in dynamic and high-tech industries (Tamayo-Torres et al, 2016, pp. 1445-1451). Strategic learning capabilities provide a distinct advantage for firms looking to channel innovation to gain a market advantage by providing customers with an innovative solution to address a consumer need (Ferreira et al., 2021, p. 632). To bridge the gap between strategic learning and innovation capabilities, this paper draws on the fundamental mechanisms that link strategic learning and innovation capabilities. The connection between these two areas in literature primarily centers on the role of knowledge.

Knowledge comes in many forms, market knowledge, product knowledge, customer knowledge and each plays a pivotal role in the success of the company. However, not just how much knowledge each organization has allows it to become successfully innovative through strategic learning. Rather, the key feature is the organization's strategic learning capabilities, particularly its ability to obtain and apply knowledge effectively. For the

purposes of exploring the concept further within this section of the literature review, the paper will divide this concept into three key strategic learning capabilities as it relates to the handling of knowledge. These key areas are the ability to absorb, adapt, and align knowledge effectively. These three mechanisms clearly connect the relationship of strategic learning and innovation and have been identified as three main themes within knowledge management and strategic learning literature.

In terms of **knowledge absorption**, an excellent frame of understanding can be obtained from Cohen & Levinthal's paper *Absorptive Capacity: A New Perspective on Learning and Innovation,* (1990) They assess the implications of innovative activity as it relates to learning result from basic research, the adoption and diffusion of innovations, and decisions to participate in cooperative R&D ventures (p. 148). What follows from the preceding analysis is that as firms provide themselves with more knowledge, it then allows them to collectively exploit rapidly useful scientific and technological knowledge and respond very quickly to rapidly changing business environments (p. 128).

Thus, clearly focusing on the nature of the knowledge inputs themselves, as opposed to the highly new and novel idea of knowledge outputs after the innovation process within the firm, we begin to understand that the role of basic knowledge acquisition is utterly fundamental to innovation, and remains a core component of the connection between strategic learning and innovation.

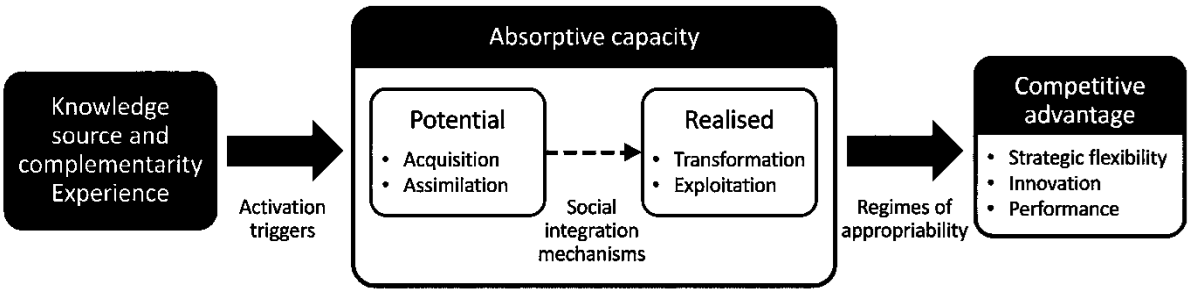

Figure 2. Reconceptualized absorptive capacity. From Zahra & George (2002).

Zahra & George (2002, pp. 189-190) later reconceptualized the original ideas of absorptive capacity within the main idea of knowledge acquisition as implied by Cohen & Levinthal (Figure 2). This reconceptualization entailed reframing the concept of absorptive capacity onto a dynamic capability framework. Additionally, the more important components underneath the absorptive capacity within the acquisition capabilities are speed, intensity and direction of the acquisition of knowledge. The intensity and speed of a firm's efforts to identify and gather knowledge can determine the quality of a firm's acquisition capabilities, while the direction influences the specific paths or types of knowledge the firm follows.

The positive implications of these capabilities are that the greater the efforts firms undertake to develop them; the quicker firms will be able to build further positive impact on the development of a firm's learning capabilities. Thereby quickly fostering the technological capabilities necessary to successfully transition from mere imitation to sustained innovation within dynamic global markets (Kim, 1997). With this new precedence on the idea of knowledge acquisition, we now can underscore areas of measurable future impact when undertaking the task of assessing an organization's absorptive capacity as it relates to innovation. It can be argued that innovation capabilities are supported by the components of speed, intensity and direction as

previously stated, considering high levels of speed of knowledge acquisition enables a firm to capitalize on early opportunities (Markman et al., 2005, p. 1061).

Moreover, the higher the priority a firm place on knowledge intensity, defined as a greater ratio of R&D resources costs relative to manufacturing costs, the greater the increase in the firm's overall level of firm-specific knowledge. This has been identified as one of the primary drivers of a firm's competitive advantage and internationalization strategy (Almor, Hashai, & Hirsch, 2006). While the direction of this knowledge dictates a firm's business direction and scope, the alignment with strategic goals is maintained through inter-functional coordination. This integration of departmental objectives allows firms to effectively channel knowledge into radical innovation, securing the product and brand advantages necessary to maintain competitiveness (Shih, 2018, pp. 14–16).

Knowledge adaptation relies upon the idea of continual reflection and feedback loops by utilizing mechanisms such as environmental and self-adaptation verifiers (Hall, Paradice, and Courtney, 2000, p. 176). Firms can learn which aspects of their business are strategically beneficial and which information has become irrelevant, ensuring the organization remains on course toward its ultimate success (Hall, Paradice & Courtney, 2001, p. 4). Additionally, these feedback components play a central role in the overall fostering of innovation. This is considering that knowledge adaptation fosters innovation by acting as an interpretation system that allows a firm to readjust itself to environmental changes and sub-processes such as interpretation, and memory. By providing the infrastructure to embed individual innovative behavior into organizational-level performance, these processes transform human capital into a foundational competitive advantage (Wang & Ellinger, 2008).

As demonstrated by Akbar et al. (2018), feedback loops address the issue of improving organizational knowledge at early stage of the innovation process, thus underscoring the important link of adaptation of knowledge, improving the strategic learning capabilities a firm has, leading to positive innovation outcomes (pp. 445–446). These cycles facilitate adaptation of knowledge and enhance strategic learning capabilities, ultimately refining

ideas into deliverable concepts that drive sustained innovation and competitiveness (p. 460).

Further to the concept of organizational memory within the adaptation of knowledge, valuable insights on categorizing lessons to enhance organizational memory can be derived from the work of Pedraja-Rejas, Rodríguez-Ponce & Rojas-Miranda (2025). Their study proposed that innovation practices could be improved through an analytical framework that emphasized explicitly tracking the number of formally incorporated "lessons learned." By systematically documenting these lessons, their research proved that organizations strengthened their organizational memory which in turn enhanced strategic learning processes and had a positive impact on innovation (p. 11), thereby enabling institutional innovation tracking systems as a key metric supporting these dynamic capabilities. This systematic approach to improve organizational memory and thereby enable knowledge adaptability as a foundational driver for organizational innovative performance, particularly in turbulent environments where rapid knowledge integration is essential for survival (Kamasak, Yavuz & Altuntas, 2016, p. 230).

Knowledge alignment remains the final and equally critical component of understanding the link between strategic learning and innovation capabilities. Maintaining the assumption within the organizational alignment perspective is that a firm's capabilities must be aligned with its strategy to enable superior performance, this "alignment skill" is a complex, tacit, and scarce resource that allows organizations to effectively integrate their structural differentiation and integration to foster higher performance (Powell, 1992, p. 120). This research builds upon the concepts of exploration of new possibilities and the exploitation of old certainties. Unlike strategies that favor one direction, March (1991) argues that organizational prosperity depends on maintaining an appropriate balance between the two areas of exploitation and exploration and focusing on one to the exclusion of the other leads either to undeveloped ideas or to becoming trapped in suboptimal equilibria. Whichever direction an organization chooses enables their relative organizational ambidexterity to be improved (March, 1991, p. 71).

However, there is a risk of losing out on innovative outcomes if knowledge is misaligned within the firm. This risk is best represented by Banerjee, Lampel & Bhalla (2020) in their paper: *A question of (mis)alignment: Innovation mandates and absorptive capacity routines*. The paper posits that the closer an organization is aligned with its R&D mandates, the more positive improvement on their innovation outcomes. This relationship between absorptive capacity (AC) routines and the firms chosen type of mandate for gathering knowledge (exploitative/explorative) is identified in their Innovative Output Matrix (Figure 3).

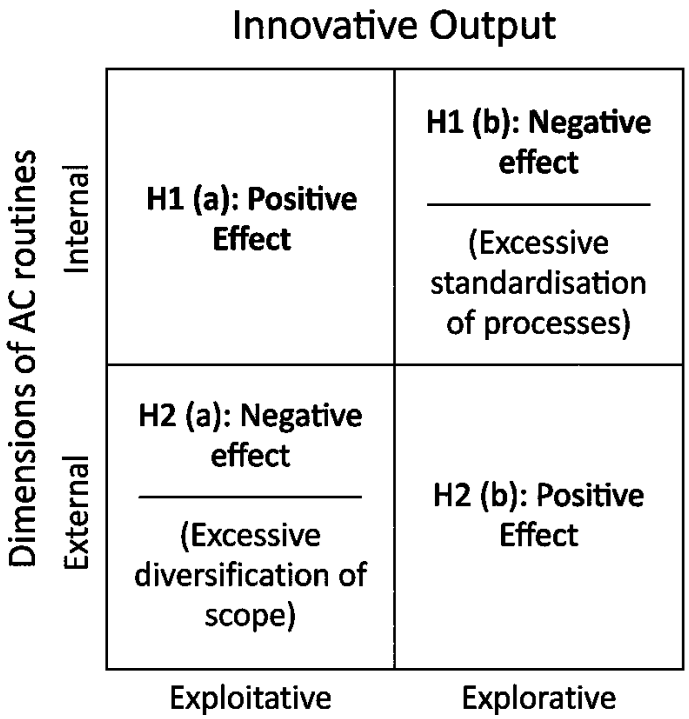

Figure 3. Innovative output matrix. From Banerjee, Lampel, & Bhalla (2020).

The Figure illustrates that firms with an exploitative mandate may become too focused on old certainties (top-right) when they place a high priority on internal dimensions of AC routines, then ineffective standardization can result. This excessive standardization of process, reducing autonomy needed for experimental search, and has a negative impact on the firm's innovation outcomes. Conversely, when a firm engages in external

dimensions of AC routines, and an exploitative mandate, this also leads to an excessive diversification of scope, also negatively impacting innovation outcomes. Only when the firms' mandates are naturally paired with exploitative mandate with an internal AC routine, and an explorative mandate into external AC routines, do positive innovation outcomes occur for the firm. Crucially, the central takeaway from the diagram is that coherence among a unit's activities is the primary predictor of competitive advantage within the innovation context. While organizations may sometimes impose misaligned routines, the main goal is to ensure knowledge can be shared globally across the "internal network", and as the matrix suggests, this lack of knowledge alignment can risk resulting in suboptimal innovation outcomes.

2.2 Product-Level Quality Management in Innovation Contexts

The following section constitutes the second part of the literature review of this thesis, comprising three subchapters on the relationship between quality management and innovation. The first section explains quality managements recent evolution from a control oriented operational philosophy and its interplay within the innovation context, with a strong emphasis on total quality management (TQM) literature. The next section provides a conceptual background on the concept of innovative life cycles and the downstream implications on quality management protocols. In particular, through the the Plan-Do-Study-Act (PDSA) cycle. Finally, in order to give a more fulsome understanding of quality managements modern applications within the business environment, the remaining section gives emphasis on quality managements perspective within the contemporary business environment and instead underscores it as a more strategic and capability driven approach within the dynamic capability literature.

2.2.1 TQM, Strategic Choices & Innovation Outcomes

The development of process layer of quality management theory and practice represents one of the largest, and most consequential shifts within the contemporary business environment. During the 1950's-1970's, this major shift began focusing on an improved manner in which business operations were conducted around the world. The academic literature surrounding this change was centralized behind Japan's motor company: Toyota. The development of the Toyota Production System (TPS), more formally known as "Lean Manufacturing", which was founded on principles of uniformity, repeatability and operational excellence, foundationally changed how business in Japan approached the production process layer of quality management. (Marksberry, 2013, pp. 18-19).

The TPS focused on the repeatability of process control, as well as system level thinking. This new refocusing on operational excellence also required business operations thought leaders to engage in a more long-term perspective when studying complex problems. During this period of time, American statistician Edwards Deming's teachings within Japan on statistical quality control to engineers, managers, and executives catalyzed the nation's industrial processes completely which paved the way for the modern conception of TQM (Deming, 2000). The business literature within Japan was flooded with books on the "Japanese Miracle" many of which contained stories about the American statistician who had made a significant contribution to that transformation (Smith, 2021. p. 59).

The idea behind the new systems approach to the TPS and TQM was inherently related to decreasing the level of variation within production. This view was predicated as understanding operational systems as being stable over time and designed with the sole purpose of efficiency and reducing defects, thereby reducing operational waste. This perspective presupposed that those innovations be then characterized as system anomalies rather than a normal function (Marksberry, 2013, pp. 26-27; Benner & Tushman, 2003, p. 242, 246). As a result, negative associations within the intersection of TQM and innovation were identified within the literature in various capacities.

Traditionally, during the time when TQM began gaining more academic attention in the early 1990's, arguments arose centered around the fact that there are central principles of TQM which are customer focus, continuous improvement and a systems perspective (Sitkin, Sutcliffe & Schroeder, 1994 p. 541). Therefore, the implementations of a TQM practice within any organization being dominated by high levels of standardization, and a traditional dominance over complete control of process implementation (Spencer, 1994, p. 452), began to perpetuated the belief that TQM could provide a "foundational environment" for innovation and sustainable competitive advantage (Prajogo & Sohal, 2001; Cameron, 1994, pp. 540–541).

Within the context of innovation, TQM represents an area worthy of deeper exploration. Examining the relationship between TQM and innovation is challenging due to the competing definitions and interpretations of TQM itself. Seminal contributions to this research stream were provided by Prajogo and Sohal (2001, 2006), who examine the relationship between quality performance and innovation performance. In their work, broader contextual factors such as organizational environment and culture are also considered as influencing elements within innovation performance. To address the conceptual complexity surrounding both TQM and innovation within organizations, Prajogo and Sohal (2001) argue that TQM should be viewed as a multidimensional construct rather than a single, fixed management practice. This perspective allows TQM implementation to be adapted according to an organization's strategic direction and the external business environment. Within the scope of these studies, particular attention is given to organizational strategy as a key dimension linking quality performance and innovation performance. The role of an organization's strategy is of utmost importance when viewing the impact of TQM on innovation. Because market positioning is a critical feature of business success (Porter, 1991, pp. 99).

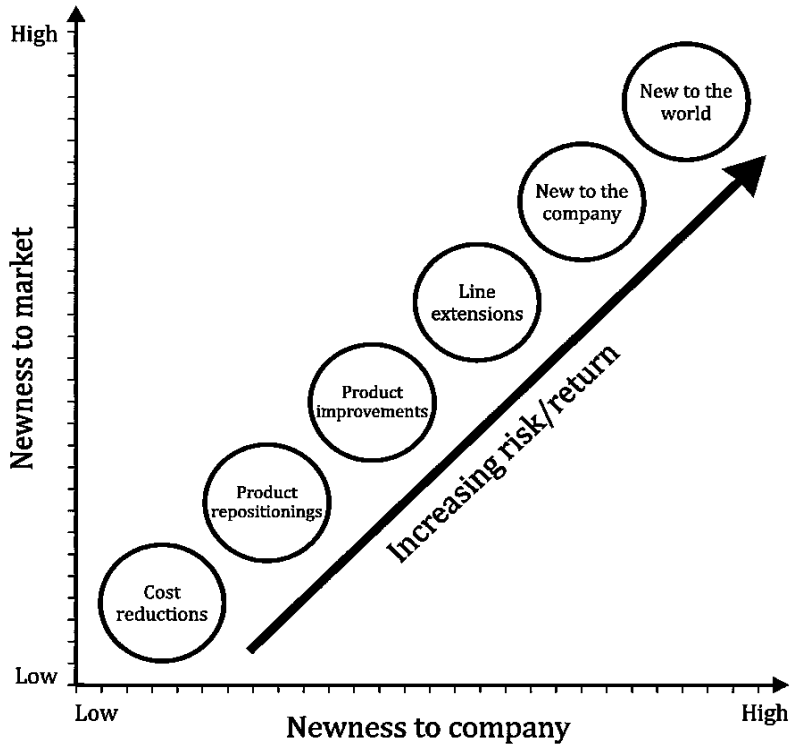

Figure 4. Risk/return relationship between company and market perceptions of product innovation. From Davis & Moe (1997, p. 340).

In a related fashion to the concept of organizational choice of strategy, an aspect that is integral to the relationship between quality management and innovation is the risk of new concepts and how they are interpreted by the market, as well as to the company itself. Figure 4 represents the risk/return relationship between company and market perceptions based on the early work of Davis & Moe (1997), who argued that the development of an innovative mindset is the only way for an organization to continuously achieve success and maximize its risk/return posture (Davis & Moe, 1997, p. 338). According to their research, they concluded that successful companies must leverage a balanced portfolio of new products ranging from low-risk cost reductions and product improvements to high-risk new to the world innovations to effectively diversify risk while maximizing potential returns (Davis & Moe, 1997, p. 340).

Additionally, related to the importance of the concept of a firm's strategic orientation related to innovation, see Figure 5 from Prajogo and Sohal (2006). This figure outlines how the two factors of the novelty of markets, as well as the novelty of technology, interact with one another to determine which general strategic orientation a firm is designed to have.

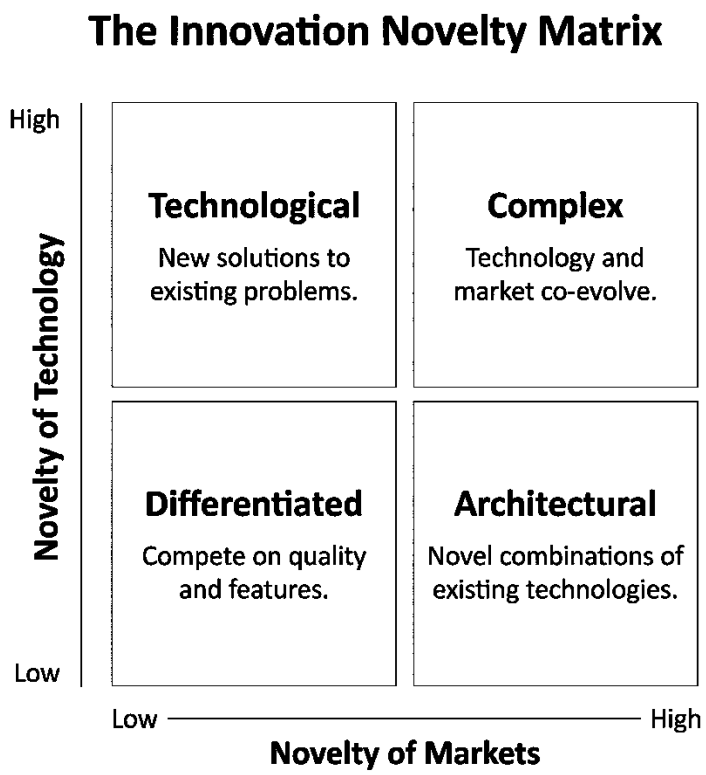

Figure 5. Technological and market maturity determining market strategy. From Tidd et al. (1997), as cited in Prajogo and Sohal (2006, p. 299).

As illustrated within Figure 5, as the novelty of technology and novelty of markets increase, organizations must move beyond the "Differentiated" quadrant where TQM typically operates by focusing on incremental improvements. However, it is important to consider that firms avoid the strategic danger falling into the pitfalls of maintaining only a differentiated strategy, as the predictability and low technological change can be strategically dangerous as competition intensifies (p. 298). Prajogo and Sohal conclude

that due to the increasing rate of competitive business environment, this requires organizations to pursue more complex dimensions of performance, most notably within the areas of quality and innovation (p. 297). Hence, attempting to move to the "Complex" quadrant should be the main aim of companies attempting to have the areas of quality and innovation perform together (p. 308).

Innovation is a critical dimension of entrepreneurial orientation and is essential for a differentiation strategy to achieve higher performance (Zehir, Can, & Karaboga, 2015, p. 359). It is understood that the firms which pursue a differentiation strategy through new product development do so as a key mechanism for sustaining their competitive position, as well as striving to lead in quality, efficiency, design innovations or style (Miller, 1988, p. 283). However, within Miller's early work, *Relating Porter's Business Strategies to Environment and Structure: Analysis and Performance Implications* in 1988, he also explicitly links the strategy of innovative differentiation and its many implications for organizational structure, indicating that there are inherent requirements for an organization to adequately execute upon a differentiation strategy. This innovative differentiation of a new product relies on highly skilled technical personnel who are tasked with devising complex designs that customers see as unique, thereby erecting competitive barriers to entry (p. 286). Furthermore, the idea of maintaining competitive advantage based on innovative differentiation requires continuously changing complex product designs, which thereby necessitate technical expertise and organizational investment in highly trained technical professionals, and an intensive investment within research and development (Lee & Lee, 2019, pp.4-5).

Bridging these previous research outcomes of business strategy on the innovation outcomes of a firm to a more contemporary analysis can be found from the empirical research of Nimfa et al. (2021) in *The Impact of Innovation Competitive Advantage on Product Quality for Sustainable Growth among SMEs: An Empirical Analysis.* This research highlights the importance of a firm's strategic business model (SBM), as a critical driver of innovation competitive advantage. While SBM was found to have a significant direct

positive effect on product quality, customer preference did not directly influence quality performance. This was attributed to the high cost of quality and general consumer price sensitivity, which forces firms to prioritize broad market applicability over individual preferences in order to remain viable. To bridge this gap and better respond to specific consumer needs, technology adoption was identified as a mediating mechanism, enabling SMEs to upgrade their business models and more effectively interpret customer demands, thereby supporting sustainable innovation competitive advantage (pp. 49-51).

2.2.2 Innovation Life Cycles & the PDSA Cycle

Innovation cycles are an important component to understand the foundation of innovations relationship to quality management, as these cycles relate directly to the quality management protocols of an organization. Viewing innovation cycles through the lens of quality management, it can be argued that there are two main opportunities in which companies can attempt to harness the strategic benefits of innovation. The first opportunity is through an initial strong priority in product innovation, the second is through an eventual and gradual priority in process innovation. For the purposes of this thesis, the focus will remain on product innovation and the supporting mechanisms that enable its success.

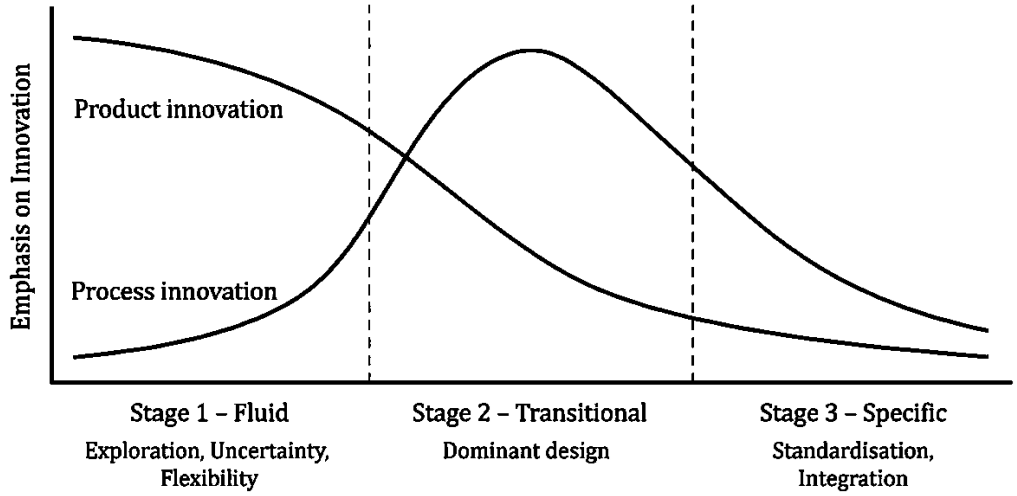

Figure 6. Abernathy–Utterback innovation cycle. From Tidd and Bessant (2025, p. 59).

The stages of the following iterative process supporting a high amount of product innovation are characterized by Stage 1 within Figure 6. Abernathy and Utterback (1978) first introduced this model in *Patterns of Industrial Innovation*, which utilized the model to describe the evolution of innovation patterns over time, which later became widely known as the Abernathy–Utterback innovation life cycle. It was later re-conceptualized as seen in *Managing innovation: integrating technological, market and organizational change* by Joe Tidd.

Related to the stages within the Abernathy–Utterback innovation life cycle, after the initial Stage 1 (Fluid) has been undertaken by a firm in which exploration and flexibility are prioritized, then within Stage 2 (Transitional) commences. Importantly, within this stage the most popular design as dictated by the industry, not necessarily the most technologically sophisticated or elegant design based on the first phase, begins to transition from product innovation towards process innovation (Tidd & Bessant, 2025, pp. 59–60). This precise transition from between Phase 1 and Phase 2 represents a critical moment for quality management systems, as organizations must balance continued experimentation with the standardization and reliability required to scale the emerging product design.

The transition from the experimentation of Stage 1 in the innovation cycle to the transitional phase of Stage 2 is effectively operationalized through the PDSA cycle, outlined in Figure 7. This cycle effectively functions as a "quality wheel" to coordinate cross-functional activities from design and product development, improved production within a firm's knowledge uptake (Dahlgaard-Park, 2011). The PDSA was originally popularized by W. Edwards Deming as a systematic method for continuous improvement with a strong emphasis on iterative feedback integration, as well as process standardization (Moen & Norman, 2010, p. 24).

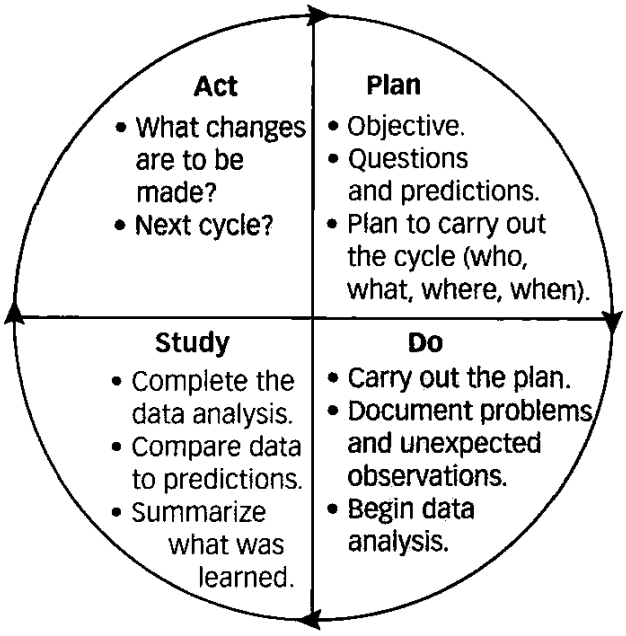

Figure 7. PDSA cycle. From Moen and Norman (2010).

Within the Japanese business context as previously outlined in section 2.2.1, the PDSA cycle was adopted and treated as a long-term quality management orientation through holistic management philosophy. The main connection between the idea of continuous improvement and innovation outcomes appears when firms move beyond a short-term quick-fix mentality and use the PDSA cycle as a vision driven tool for continuous learning

and improvement, thereby avoiding stagnation and loss of competitiveness associated with a purely mechanistic view of quality management (Dahlgaard-Park, 2011, p. 506).

This systematic approach is essential for scaling an emerging design, but it's also vital for applying the PDSA cycle within the innovation context (Moen & Norman, 2010, p. 26). An important idea to understand as it relates to the comparison between continuous improvement and the concept of innovation is the notion of how firms intend to sustain the benefits of innovations. This is an important consideration for firms, whether the innovations sustained are either product oriented or process oriented (Benner & Tushman, 2003). The early work of renowned Japanese consultant and author Masaaki Imai argued that within the context the more western notion of innovation (being identified as radical and discontinuous 'break throughs'), that the more Japanese ideas of continuous improvement philosophy (or *kaizen*) was not intended to be a substitute for this interpretation of innovation. Instead, Imai argued that kaizen was utterly necessary to sustain these innovations. By centering firms' quality management protocols around this cycle, organizations are enabled to adequately transition eventually from more exploratory product experimentation, and instead in favor of process innovation (Prajogo, & Sohal, 2001, p. 542).

2.2.3 Quality Management as a Dynamic Capability

Quality in products and services has long been recognized as a critical determinant of firm performance and a key source of sustained competitive advantage (Garvin, 1987; Russell & Taylor, 1995). Specifically referring to the product-level quality management processes within technology-based SMEs, the idea of quality should not be merely thought of as an outcome of production processes. Instead, it should rather be considered a foundational enabler of innovation within product development. The fundamental reframing of quality management as a dynamic capability relates to the innovation context and also requires a further reframing of the conceptual idea of product quality itself. While there is no

universal or global definition of quality, key insights into the interpretations of quality can be gleaned from the 4 different definitions below in Table 1. These definitions were put forward by Carol A. Reeves and David A. Bednar in their 1994 paper: *Defining Quality: Alternatives and Implications* summarized by the following table p. 437:

Table 1. Quality definitions. From Carol A. Reeves and David A. Bendar, 1994

Definition	Strengths	Weaknesses
Excellence	Strong marketing and human resource benefits. Universally recognizable mark of uncompromising standards and high achievement	Provides little practical guidance to practitioners. Measurement difficulties. Attributes of excellence may change dramatically and rapidly. Sufficient number of customers must be willing to pay for excellence.
Value	Concept of value incorporates multiple attributes. Focuses attention on a firm's internal efficiency and external effectiveness. Allows for comparisons across disparate objects and experiences	Difficulty extracting individual components of value judgment. Questionable inclusiveness. Quality and value are different constructs.
Conformance to Specifications	Facilitates precise measurement. Leads to increased efficiency.	Consumers do not know or care about internal specifications. Inappropriate for services.

	Necessary for global strategy. Should force disaggregation of consumer needs. Most parsimonious and appropriate definition for some customers.	Potentially reduces organizational adaptability. Specifications may quickly become obsolete in rapidly changing markets. Internally focused.
Meeting and/or Exceeding Expectations	Evaluations from customer's perspective. Applicable across industries. Responsive to market changes. All-encompassing definition.	Most complex definition. Difficult to measure. Customers may not know expectations. Idiosyncratic reactions. Pre-purchase attitudes affect subsequent judgments. Short-term and long-term evaluations may differ. Confusion between customer service and customer satisfaction.

In reference to Table 1, as it relates to innovation, the definition of quality as value most closely aligns with the concept of innovation capabilities. This is considering that progressive research within the area of dynamic capabilities have explicitly defined a firm's abilities to focus attention on a firm's internal efficiency (exploitation) and external effectiveness (exploration) as being highly related to innovation outcomes (Prajogo & Sohal, 2006, p. 298). Building on this comparison, it becomes relevant to reconsider how product quality is positioned within an organization. Through the early academic literature of TQM, ensuring high levels of product quality was more defined through the concepts of standardization and operational excellence. (Hamid et al., 2019, p. 159). Transitioning into a contemporary business environment, product quality is not merely the result of well-executed processes, but an organizational ability to continuously

iterate, reconfigure, and apply knowledge in response to evolving customer expectations as well as technological change (Nimfa et al., 2021, p. 41; Tamayo-Torres et al., 2016, p. 1447).

As consumer preferences constantly change in the contemporary business environment, firms need to become more proactive in relation to obtaining the skill of sensing and learning necessary to identify market opportunities (Nimfa et al., 2021, p. 43). Within this requirement, quality management as a capability provides foundational operational routines to enable appropriate design choice improvements as well as process improvement (Kumar, Ramanan & Keelath, 2020, p. 80). When considering this new, more modern approach to dynamically adjust to external demands of the market and adopt and integrate sensible internal processes quickly, firms ensure that innovation is not merely a reactive "market-pull" response, but instead a proactive, "technology-push" driven strategy.

In a broader sense related to the advancement of technology, the evolution of the ability to establish a "technology-push" strategy has been only enabled by the recent evolution of technological paradigms where the most significant shift originates from advances in scientific and technological knowledge, rather than external market factors alone (van den Ende & Dolfsma, 2005, p. 93). Thus, the ability for firms to centralize around a 'technology-push' strategy allows eventual change into new technological paradigms. By adopting this proactive stance, firms align their internal capabilities with the intrinsic dynamics of technological advancement, enabling them to shape the trajectory of the market and move beyond the constraints of current consumer price sensitivity to establish entirely new competitive frontiers (van den Ende & Dolfsma, 2005, p. 94).

2.3 Theoretical Framework: Integrating Strategic Learning, Quality Management, and Innovation Capabilities

Previous chapters have reviewed the literature on strategic learning, quality management, and their relationships to innovation capabilities and innovation outcomes. Building on this review, the theoretical framework (Figure 8) illustrates the interconnections among these elements and guides the empirical analysis of the underlying drivers of OTO's innovation capabilities.

Strategic learning enables firms to acquire, interpret, and integrate knowledge from both internal experience and external sources, thereby supporting the development of innovation capabilities over time. In the context of OTO, particular emphasis is placed on the underlying mechanisms that support strategic learning, namely knowledge absorption, adaptation, and alignment. To explicitly capture both external and internal knowledge inputs, the construct "knowledge sources and complementary experience" is incorporated into the framework, drawing from the reconceptualization of absorptive capacity by Zahra & George (2002) (see Figure 2).

Product-level quality management is incorporated into the theoretical framework through the PDSA cycle, originally developed by W. Edwards Deming. This complements strategic learning by embedding iterative learning within operational routines through structured processes, performance measurement systems, and continuous improvement mechanisms. Collectively, the interaction between strategic learning and quality management within OTO plays a central role in shaping its innovation capabilities, enabling the effective translation of knowledge into consistent and innovative product outcomes.

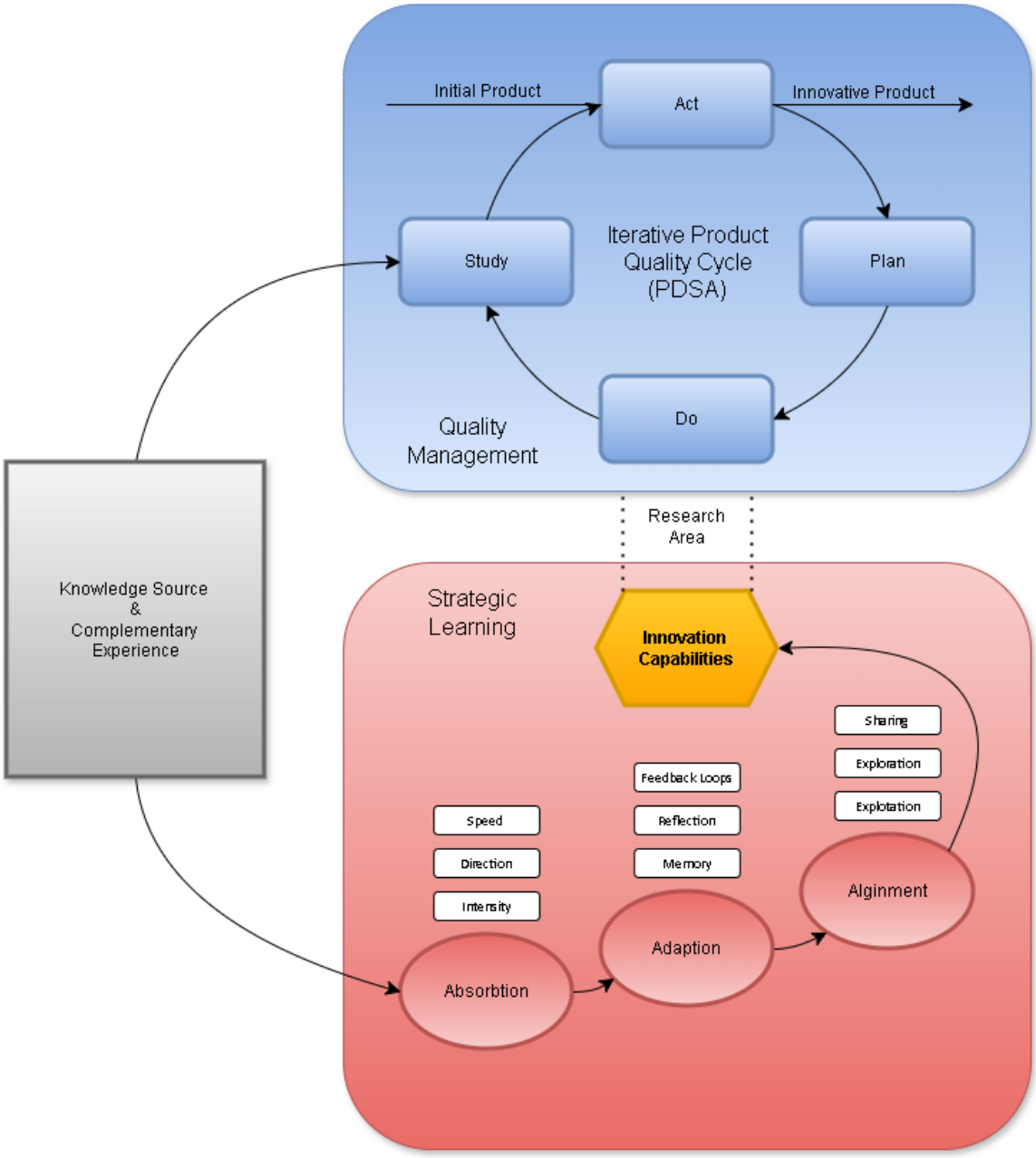

Figure 8. Theoretical framework.

3 Methodology

Following the theoretical background, this chapter outlines the methodological approach to the research study, its applicability as well as limitations. While the initial subchapters introduce the general characteristics of academic research and justify the selection of a qualitative case study methodology. This chapter further presents the case company, providing relevant background to contextualize the empirical findings. The methodology section concludes with a detailed description of the data collection and analysis procedures, focusing primarily on semi-structured interviews with key organizational decision makers. An assessment of data quality, credibility, and limitations is also included to ensure methodological rigor.

3.1 Research Approach

Research can be understood as a systematic process through which information is collected and analyzed in order to explain and understand phenomena related to organizational practices and decision making. The selection of an appropriate research approach is guided by the study's research question and the theoretical objectives of the research itself. In the context of this thesis, the research approach follows a structured research design framework consisting of several interconnected methodological decisions, including research philosophy, research approach, research design, data collection methods, and data analysis techniques. This framework provides a structured basis for linking the study's theoretical foundations with its empirical investigation.

Additionally, interview questions related to the more important components of both the quality management framework chosen (PDSA), as well as the identified supporting mechanisms within the strategic learning literature for innovation capabilities

(absorption, adaptation & alignment), which were chosen to underscore the conceptual framework illustrating these relationships as presented in Figure 8.

The study builds upon existing literature on strategic learning, quality management, and innovation in order to develop an area of study subsequently examined through empirical analysis. The research design therefore focuses on systematically analyzing relationships between these constructs in order to better understand how organizations develop innovation capabilities. By structuring the research methodology through this layered framework, the study ensures methodological consistency between the theoretical framework, the empirical analysis, and the research objectives guiding the investigation.

3.2 Case Company

In the case of OTO, a health tech startup headquartered in Toronto, Canada, the need to maintain sustainable innovation within their product is one of the main focuses of the company. However, understanding the requirements of both integrating legacy technology into newer, more contemporary systems, as well as realigning the strategic direction of new technology altogether has proven to be an immense challenge. These challenges have provided OTO extensive, concentrated experience within the area of cultivating its innovation capabilities.

When purchasing the sport technology company, Omegawave, based out of Espoo, Finland, OTO's management tasked the company to not only redefine the direction of the company, but also to reconfigure the acquired technology to serve a new client base. This type of combination of strategic learning requirements and the necessary quality management protocols to properly re-develop the new product offering has enabled OTO to be an excellent case study of the benefits and challenges of cultivating the innovation capabilities it relies upon for a competitive advantage.

Previously, Omegawave was a company operating in Espoo Finland for over 40 years within the health tech and sports performance industry. The Omegawave technology is a synthesis of extensive research in the fields of neurophysiology, cardiovascular physiology, and sport performance physiology. Using wearable biosensors to measure heart rate variability (HRV), alongside electroencephalography (EEG) electrodes to capture indicators of central nervous system activity, the technology enables the assessment of an individual's physiological readiness and recovery state. Based on these measurements, it provides insights into the user's capacity to respond to specific physical or psychological stressors. These scientific breakthroughs and technological capabilities allowed Omegawave to contribute to the areas of injury prevention, stress management, effective athlete periodization, and enhanced athletic performance.

The strategic direction which OTO is currently attempting to take the original Omegawave technology is now into the area of the fertility industry. OTO determined that the current infertility crisis, which in many countries around the world are experiencing as measured by the progressive decreasing of birth rates, can be properly aided using this innovative technology. Research by Dr. Alice Domar & Kristin Rooney confirms that infertility is a major life crisis causing distress comparable to a cancer diagnosis. Crucially, their work documents that psychological interventions that lower stress are associated with significant increases in pregnancy rates (Domar & Rooney, 2018, pp. 41-42). The biomarkers that the Omegawave technology specialized in, related to brain activity, heart rate variability and energy supply systems are key in determining the stress resilience of the user's entire physiological system.

Within the length of this thesis, I will uncover the strategic learning methods that were utilized when repurposing the technology, how the development team within OTO employs quality management protocols in order to further develop the product and continually improve the innovation capabilities of the organization. This thesis explores how health technology firms can leverage strategic learning and quality management to

drive innovation, with OTO's transformation of Omegawave's performance technology into a fertility solution serving as a practical case study.

3.2 Data Collection

Qualitative interviews were selected as the primary data collection method due to their suitability for examining complex organizational processes and managerial interpretations. Interviews allow researchers to gain in-depth insight into how individuals perceive, interpret, and enact practices related to learning and quality within organizational settings (Kvale & Brinkmann, 2015). The interviews ranged in duration from approximately 25 minutes to 90 minutes. A semi-structured interview design was employed to collect primary data and ensure comparability across interviews while allowing flexibility for respondents to elaborate on issues they considered particularly relevant (Saunders et al., 2023). This approach was considered appropriate given that strategic learning and quality management practices are often embedded in informal routines and evolving processes rather than fully standardized procedures, particularly in technology-intensive firms.

The sampling strategy followed a purposive logic, aiming to include participants from different functional areas and organizational levels to capture diverse perspectives on the research topic. As there have been many strategic influences and rational behind the acquisition of the Omegawave company, as well as large changes into the strategic learning and quality management protocols, this study aims to develop a much more robust picture of how the OTO team managed to arrive at these various decisions regarding what strategic direction to take, as well as how to support those decisions from a quality management perspective.

Primary empirical data for this study was collected through semi-structured interviews with employees of OTO who are directly involved in product development, quality management, and strategic decision-making. The three main groups were interviewed for this study: Management (3), Quality Assurance (2), Product Development (2). This diversity was intended to reduce the risk of single-perspective bias and to provide a more comprehensive view of how strategic learning and quality management support innovative product development within the company.

Management is responsible for leading strategic direction of the company, allocating investments, shareholder management, and strategic partnerships of the company. Quality Assurance professionals are responsible for hardware and firmware management, hardware improvements, testing methods, quality management protocols and identifying errors in technology and general technical expertise. Product Development professionals are responsible for software development, technology integration, and testing protocols related to software hardware integration.

The interview questions consisted of three main sections. The first section on the dynamics of strategic learning and product-level quality management within the organization. The second section explored the idea of strategic learning processes being the dominant capability within OTO, with questions including knowledge integration following acquisitions and learning across organizational functions. The third section explored product-level quality management practices as the dominant capability within OTO, with questions related to the application of quality management protocols within the company. While the same thematic structure was used in all interviews, the phrasing and emphasis of questions varied depending on the interviewee's role and expertise. All interviews were conducted remotely via Zoom and were recorded with the informed consent of the participants. 6 interviews were recorded and transcribed electronically, and 1 interview was transcribed by the author and all interview questions are outlined in Appendix A.

3.3 Data Analysis

The purpose of qualitative data analysis is to move beyond description toward the development of conceptual understanding grounded in empirical material. The empirical data for this study consisted of recorded semi-structured interviews and all interviews were transcribed verbatim. The transcriptions were reviewed alongside the audio recordings to ensure accuracy and to clarify potential ambiguities between spoken and written language. This process was carried out along with data collection to allow for early familiarization and no follow-up interviews were deemed necessary.

The analysis proceeded through a systematic categorization process. Categorizing the individual answers into sections which relate to identifying recurring patterns, similarities, and differences across the interviews. These decisions for categorization of answers were derived inductively from the data while remaining informed by the study's theoretical framework. Data segments that were not directly relevant to the research questions were excluded from further analysis. This refinement resulted in a focused dataset that formed the basis for deeper thematic interpretation, and the empirical findings are presented using direct quotations from interviewees. These direct quotations were chosen and represented within the upcoming section in order to illustrate key themes and enhance the credibility of the analysis.

4 Findings

This chapter presents the empirical findings derived from interviews conducted with team members across management, quality assurance and product development roles at OTO. The objective of the analysis was to examine the relationship between strategic learning and quality management, and to assess how these constructs contribute to innovation capabilities within an early-stage health technology company.

First, the relationship between strategic learning and quality management is examined Second, strategic learning is analyzed as a driver of innovation capabilities. Third, quality management is explored as a driver of innovation capabilities. The chapter concludes with a summary synthesizing the key empirical insights.

4.1 Strategic Learning and Quality Management at OTO

The first area of inquiry examined whether strategic learning and quality management operate in synergy or whether they exist in tension and require balancing. Across interviews, respondents consistently described both dynamics as present. Rather than a simple binary relationship, strategic learning and product-level quality management were portrayed as simultaneously interdependent, particularly within the context of an early-stage company operating in a regulated health tech industry.

4.1.1 Synergy Between Strategic Learning and Quality Management

A strong theme emerging from the interviews was that strategic learning and quality management are not separate processes, but instead the description was consistently thought of as intertwined mechanisms within the company. Respondents also frequently described learning as embedded within quality work, rather than occurring independently of it. Interviewee 2 emphasized that strategic learning and quality management are interdependent but operate differently depending on the context of the product and industry:

> *"Quality management is an aspect of strategic learning because it's one of those levers that you have to be aware of when you think about the strategic management from a product perspective…if your quality management is poor, then you have to fix that, but it is determining what part of quality is bad that's important." (Interviewee 2, Management)*

They further described the importance of feedback loops, noting that actionable learning cannot occur without structured quality data:

> *"If you have no feedback loops, you're sunk… how do you control both your input and output feedback loops in terms of that data set so that you can really make good decisions on problem identification and solution management?...without having that data, you're flying blind." (Interviewee 2, Management)*

These comments suggest that strategic learning and quality management reinforce one another when feedback mechanisms and data collection are embedded in the product development cycle. Quality stabilizes the information gathered from the market. Moreover, strategic learning ensures that quality practices are targeted and effective. Respondents who were in management positions consistently described the relationship between strategic learning and quality management as mutually reinforcing, though not without complexity that requires consistent analysis and consideration. Interviewee 7 articulated this clearly as well as extending this logic to the current development of new hardware. In this framing, quality management processes were not identified as merely

control mechanisms, they actively shape the firm's innovation capabilities together with strategic learning.

> *"I would say it's a mix of both. So of course, they do inform each other. We do quality checks to test. So, when something is not working, we learn: 'oh, this doesn't work.' Then we need to change something. I mean, in a software, it could be a bug that's easy to fix, but in other cases, it could be informing the overall product… for example, with the new wrist device, capturing the ECG from the wrist might be very different from the chest band. So just doing that quality and test will inform how we move forward. Do we change the overall product and how we want to approach it?" (Interviewee 7, Management)*

However, synergy between strategic learning and quality management was thought to be conditional by those in quality assurance. Specifically, Interviewee 6 suggested sequencing the two areas, which in turn suggests that strategic learning drives direction, while quality stabilizes execution afterwards. From the quality assurance perspective, strategic learning was described as deeply embedded within quality management processes.

> *"It's more that strategic learning comes first and then the quality management will support that… because for us to maintain the gold standard of data analysis and presentation, we have to really consider the implications and how it's going to affect the customer first." (Interviewee 6, Quality Assurance)*

Strategic learning from user interactions, testing results, and internal reflection was said to directly inform improvements in execution. Based on this, innovation capabilities did not emerge from strategic learning alone, but from synergistic effect of strategic learning being operationalized through quality processes.

> *"…there's also this aspect of quality management cycle within the product development process which is driven by strategic learning… if strategic learning gives you the data points to ensure that your quality management within the product cycle is efficient, then that is really how the synergy between them operate." (Interviewee 2, Management)*

Interviewee 1, part of quality assurance, took a different approach to identifying the relationship between the two areas and articulated this by clearly distinguishing between macro-level strategic learning and micro-level quality management. When asked about whether strategic learning and quality management had a synergistic relationship with OTO's innovation capabilities, the following response was given:

> *"One operates at a strategic or macro-level guiding direction, priorities, and long-term positioning (strategic learning). The other operates at an operational or micro level shaping day-to-day execution, troubleshooting, and validation (quality management)… strategic learning feeds both layers. It helps determine what should change at the macro level, while also improving execution at the micro level… so overall, the strategic learning layer is extremely important. It enables innovation, but it does so within and through the quality management structure rather than in opposition to it. (Interviewee 1, Quality Assurance)*

At the macro-level, it is evident that strategic learning shapes strategic direction and priorities. At the micro level, strategic learning informed day-to-day validation and troubleshooting activities. In both cases, strategic learning did not bypass quality management; it strengthened it.

Interviewees in product development reinforced this interpretation. In the case of the company's data algorithm refinement, strategic learning was described as a prerequisite to maintaining product credibility. When algorithmic failures occurred, the team was required to study the data, understand the root cause, and evaluate whether changes could be implemented without destabilizing the broader system. In this context, strategic learning functioned as a diagnostic mechanism, while quality management acted as a safeguarding mechanism.

The synergy was evident in the iterative refinement of the algorithm by way of data collection, internal discussion, user testing, and controlled troubleshooting as identified as occurring in a continuous loop. Innovation capabilities emerged from this structured process, rather than from ad hoc experimentation. Interviewee 4, part of product development highlighted that strategic learning and quality management are deeply

interdependent in practice and there was emphasis placed on learning from users' interactions with the product directly inform quality improvements, while maintaining high quality ensures that the knowledge gained is reliable and actionable. As they explained:

> *"I think the strategic learning, while these algorithms exist and we're trying to make improvements to them, we have to really study them in the product quality side, because if we don't, we risk failing our users, letting them down ultimately when it comes to the science-based knowledge that we're providing them." (Interviewee 4, Product Development)*

This comment illustrates that iterative strategic learning cannot happen in isolation, as it relies on stable and well-defined quality processes to ensure that improvements are meaningful. Interviewee 4 also discussed how strategic learnings from focus groups feed into both innovation capabilities and quality management, allowing these capabilities to work together synergistically. Importantly, interviewee 4 also framed product quality not as a fixed attribute but as something shaped by end-user experience. Thus, indicating that synergy is achieved when strategic learning and quality management are integrated with a customer focused mentality, resulting in a feedback loop that continuously strengthens innovation capabilities.

> *"We're learning, we're building, and we're discussing, and then we're providing those results to the different people in our focus group... but if we don't continue down that path and we don't really finalize it, we're never going to be able to provide real insights… I think the final decision on product quality is based on what the customer feels and experiences." (Interviewee 4, Product Development)*

Further confirmation that a synergistic relationship exists between strategic learning and quality management was emphasized by Interviewee 5, also part of product development, who indicated that strategic learning and quality management are very closely intertwined. This link was largely strengthened through accumulated experience, as he described strategic learning as the process of improving customer experience and improving efficiency over time, stating the following:

> *"The strategic learning, it's basically how you build your (customer) experience. You get information, you get better at what you do, you do it faster, you do it better. When you do it better, you know how to get to a better quality." (Interviewee 5, Product Development)*

However, he noted a potential caveat: familiarity of process can sometimes lead to complacency, where self-checking and peer review are neglected. This indicates that while synergy exists, it must be actively maintained through structured practices like code reviews or team checks. Additionally, the developer described the tension between planning, execution, and quality verification:

> *"Sometimes you spend two hours planning, half an hour developing, then two hours checking what you did…If you have a time constraint, then something needs to give." (Interviewee 5, Product Development)*

This reinforces the idea that quality and strategic learning are connected but constrained by operational realities and further implies that while a synergistic relationship exists between these two areas, the most effective synergy requires careful sequencing of priorities and review time of current strategic learnings.

Management interviews similarly emphasized that without feedback loops, both strategic learning and quality management would collapse. Strategic learning was described as dependent on actionable data customer use patterns, engagement metrics, purchasing behavior, and retention indicators. Quality management, in turn, was framed as one of several 'levers' that must be informed by that data. In this view, synergy between these two areas was identified to only occur when strategic learning provides highly accurate signals that are proven to be indicative of macro-level themes occurring within the user experience, and only when quality processes are positioned to translate those signals into improvements.

This also directly aligns with the descriptions of strategic learning being more macro-related and quality management being more micro-related as previously communicated

by Interviewee 1. Further support for this type of specific conditions to enable the synergy between this relationship was provided by Interviewee 3, part of management. They highlighted that strategic learning and quality management operate in tandem at OTO, with iterative feedback loops enabling both rapid development and informed quality adjustments. Emphasis was placed specifically that early-stage product testing which relies heavily on user interactions, thereby informing product decisions while balancing quality concerns. They further indicated how agile methodologies support the simultaneous pursuit improved innovation capabilities:

> *"Your data users, focus groups end up being your testers… as long as you can then iterate quickly when you get feedback from your users… the agile method of working… still encourages adapting to priorities, users, feedback as it comes in… I think that drives more innovation because you're not set on one feature for X amount of time." (Interviewee 3, Management)*

This illustrates that synergy between strategic learning and quality management arises when iterative strategic learning and flexible quality mechanisms coexist, allowing innovation to thrive without being constrained by rigid procedures. Importantly, synergy was most visible within the product life cycle, rather than at the regulatory compliance level. Respondents noted that in regulated medical contexts, high level quality standards are externally defined and non-negotiable. In those instances, learning does not redefine quality thresholds but instead informs product-market fit and feature prioritization. Within the product iteration cycle, however, synergy was described as essential.

Overall, findings support that strategic learning and quality management were consistently described as mutually reinforcing when functioning effectively. Innovation capabilities appear stronger when strategic learning is able to obtain highly accurate information and only when structured quality improvements and quality processes are set to quickly action those lessons. Strong priority was given to speed of knowledge absorption and speed of product iteration as having a positive impact on the innovation capabilities of OTO. Importantly, within this context, speed was explicitly indicated as being a conditional to the improved innovation outcomes of OTO.

4.1.2 Balancing Strategic Learning and Quality Management

While synergy was widely acknowledged, respondents also described persistent tension between speed-driven learning and quality control. This tension was particularly acute in the context of early-stage growth. The most consistent theme across interviews was speed of knowledge absorption. The Innovation capabilities of OTO were frequently equated with rapid iteration, hence the priority on obtaining as much relevant and usable knowledge as fast as possible. Respondents described operating under pressure to "move quickly," "get things out," and avoid "feature lock". In this context, quality validation was interpreted as sometimes deprioritized. Similarly, management described a deliberate weighting toward strategic learning speed, which was attributed partly to structural limitations. However importantly, no respondent described sacrificing quality as a strategic goal. Instead, tensions were characterized as contextual. As indicated by both Interviewee 1 and Interviewee 3.

> *"We are operating under significant pressure to move quickly in order to support innovation, which at times means solutions are pushed out before they are fully validated… it's not about choosing innovation over quality. It's about ensuring we are innovating in the right areas." (Interviewee 1, Quality Assurance)*
>
> *"I would say we prioritize getting things in quick…" (Interviewee 3, Management)*

Some respondents explicitly stated that innovation capabilities are weighted slightly more heavily than formal quality control at the current stage of the company. Quality lapses were not described as intentional neglect, but as structural consequences of resource constraints and startup velocity. This increases pressure and introduces risk, as internal testing cannot replicate real-world user behavior. Interviewee 7 described the structural pressures of the startup environment at OTO:

> *"Especially in startups. With limited resources, I think quality management is always a challenge because startups with limited resources and limited funding and you want to get to the market very quickly. And so, what ends up happening is you skip some important things that need to happen. And one of them can be the quality management piece." (Interviewee 7, Management)*

They further explained how this manifests operationally when referring to product testing:

> *"Obviously as a startup, it's the developer sometimes, it's the managers, it's us who's doing it as opposed to a team dedicated for that usually that does the quality, have the test procedure, all the things that they need to test for, and that's how it should be done." (Interviewee 7, Management)*

Balancing decisions were often framed as business trade-offs rather than purely technical judgments. In discussing wellness versus medical positioning, Interviewee 7 stated:

> *"The trade-off is, if we do wellness, get to market faster, but then we'll have to spend time going back, documenting everything, maybe finding out there are some things that need to change within the product, so redesigning. So, there will be more time spent down the road… as opposed to (if) we spend more time ahead of time doing everything right from the beginning, but that will mean we get to market later." (Interviewee 7, Management)*

They summarized these decisions as dependent on business decisions, the trade-offs were mainly framed through the classical trade-off triangle descriptions, with similar sentiments of trade-off's also echoed by Interviewee 2:

> *"And to make those trade-offs is usually it's a mix of business decisions, resource availability… and by resources it could be money, funding, and it could be people." (Interviewee 7, Management)*
>
> *"You're always trying to balance speed, quality, and cost. You can pretty much win on two of them at all times. You can't win on three." (Interviewee 2, Management)*

Management emphasized that companies can rarely optimize all three: speed, quality, and cost simultaneously, and during consequential moments for the business, such as

preparing for launch of a new product or responding to market opportunities, decisions may temporarily prioritize time to market over exhaustive validation. In such cases, quality risks are mitigated through rapid post-release iteration. A particularly illustrative tension arises in regulated environments, especially within the health tech industry. Once a product passes regulatory approval, modifying core features may require restarting the approval process. This creates “feature lock,” represented as an outstanding risk of an inflexible quality management process, thereby negatively impacting quality decisions long term, as indicated by Interviewee 2:

> *“Because you had to take everything through that process… and if you wanted to change something, you can't… or you have to go through the whole process again to go through the regulatory approvals because now you've changed something feature-wise, that is really challenging.” (Interviewee 2, Management)*

Respondents described this as a structural constraint on innovation, where strategic learning may identify necessary improvements, but quality frameworks restrict immediate implementation. The trade-off dynamic was also influenced by organizational maturity. In early-stage conditions, iterative feedback from focus groups in some cases can be relied upon substitutes for product testing. However, as the user base expands, the risk associated with releasing unvalidated features increases significantly.

It was identified that innovation capabilities depend not merely on strategic learning or quality management alone, but on managing the trade-off between them when faced with constraining variables mainly identified by Interviewee 2 of speed (of product change), quality (of product overall), and cost (of product development). Despite strong evidence of synergy, a trade-off perspective between speed driven strategic learning and resource constraints is consistently acknowledged.

Thus, findings conditionally support that strategic learning and quality management are engaged in trade-off dynamic, however this trade-off was only identified through commentary on resource priority, and further explanation on the decision marking to

absolve that resource constraints was not further explored within the context of this study. These responses thereby acknowledge the innovation capabilities within OTO are improved through the dynamic interaction of strategic learning and quality management capabilities but are only enabled through managerial decision points on managing this trade-off without allowing speed, quality of cost to dominate excessively. Again, strong priority was given to speed of knowledge absorption and speed of product iteration.

4.2 Strategic Learning Driving Innovation Capabilities

The second major area of inquiry examined strategic learning as the main driving capability that enables OTO to improve its innovation capabilities. Strategic Learning questions were operationalized through three sub-dimensions: knowledge identification and absorption, reflection and integration, and alignment across teams. Strategic learning was identified to drive innovation capabilities through feedback loops, rapid absorption, and adaptive iteration. Formalized documentation that allows for increased organizational memory and reflection opportunities remains limited. However, the effectiveness of innovation capabilities within OTO depends on alignment mechanisms that translate insight into coordinated action. A very strong priority was found to be placed on the specific capability of knowledge absorption, with the three identified qualities being speed, direction and intensity of knowledge, with further emphasis on the speed of knowledge being identified once again.

The ability to detect whether users adopt, engage, or abandon features was described as a critical indicator guiding strategic learning. Additionally, the perspective that strategic learning was the main priority over quality management was reflected in management, indicating that there needs to be a priority on strategic learning and analysis of product market-fit continuously and strategic learning seems to be the first priority to establish as a capability before the synergistic effect is thought to occur when paired with OTO's quality management capability. Thus, while reflection and integration occur, they remain

partially dependent on project momentum and team communication. Therefore, the area of research in which strategic learning primarily drives the innovation capabilities at OTO is supported through the respondents descriptions. However, the durability of that strategic learning may be vulnerable without stronger institutional memory and focus on knowledge alignment efforts, as these were seen as an even higher priority than formalized documentation.

4.2.1 Knowledge Identification and Absorption

The company's knowledge absorption capability was described as relatively high. New insights are reportedly understood quickly and translated into action. Interviewee 6 and Interviewee 1 emphasized the speed of knowledge acquisition under the absorptive capacity category as one of OTO's strongest capabilities. Thus, absorptive capacity appears high, even if systems are rather informal during the current business stage:

> *"If we have something that we need now because it's really going to be a big win and something that's really achievable, they (product development) get it done within 24 to 48 hours pretty regularly….Our turnaround on making improvements in the past before OTO was very slow… but this team right now… they (product development) absolutely learn something, figure out where it would be valuable, and then apply that knowledge very quickly." (Interviewee 6, Quality Assurance)*
>
> *"When new knowledge or insights emerge… they are quickly understood and applied." (Interviewee 1, Quality Assurance)*

Overall, identification of important and useful knowledge appears robust, and the speed of absorption was consistently reiterated as the most important quality which supports OTO's innovation capabilities, but long-term retention mechanisms remain underdeveloped:

"If they don't buy it, if they don't keep using it, if they don't like it, then you have to understand why that is... the feedback loops are really the biggest aspect of this, because they only inform the data that, your feedback both community learning and quality management." (Interviewee 2, Management)

Interviewee 7 described knowledge absorption as filtered through the simple test of how large the opportunity intends to be, indicating an example of prescribing OTO through Health Canada:

"What determines how fast that learning turns into action? I would say one is the opportunity, depending on this learning what's the opportunity coming up from that learning, like the business opportunity." (Interviewee 7, Management)

"If this (new product) was Health Canada approved, it would be prescribed as opposed to recommended, which is a big opportunity. So that's when we switched gears and started exploring, okay, if we want this to be Health Canada, what does that mean?" (Interviewee 7, Management)

4.2.2 Feedback Loops, Reflection & Organizational Memory

Across all roles, feedback loops, reflection and organizational memory were acknowledged as important characteristics to support strategic learning. Feedback loops emerged as the primary mechanism of knowledge adaptation. Customer usage patterns, support tickets, and overall market signals were described as central and vital data sources. Management emphasized that without feedback loops, decision-making becomes speculative. Additionally, a priority was placed on product-market fit which was framed as a learning outcome rather than an initial assumption:

"Product-market fit has to be on, you're trying to navigate regulatory frameworks and something that's never been done before, which means that you have to solve policy depending on how governments think about the deployment of health resources" (Interviewee 2, Management)

Interviewee 4 described owning features, which encourages accountability and internal reflection. Yet this model relies heavily on individual memory and discipline rather than institutional systems. Product management referenced potential tools (e.g. road mapping platforms integrating user insights) that could enhance organizational memory. The absence of such systems suggests that retention of strategic learnings currently depends on interpersonal alignment rather than formal knowledge repositories. The idea of reflection on learned lessons was also emphasized as critical and currently reliance is placed on individuals rather than systems:

> *"Reflection is not just useful; it is necessary to institutionalize learning." (Interviewee 1, Quality Assurance)*
>
> *"We are supposed to (individually) own it from the start to the finish line and test (new features)." (Interviewee 4, Product Development)*

Reflection was described as critical but not always structured. Respondents noted that while absorption is rapid, formal documentation and institutionalization of learning are less consistent. Quality assurance emphasized the necessity of self-assessment to determine "what sticks" over time. Without deliberate reflection, learning risks remaining episodic. In practice, integration often occurs through iterative product cycles. Agile sprints, incremental feature releases, and bug fixes function as mechanisms for incorporating lessons.

> *"We forget about some of the lessons necessarily that we had learned from customers." (Interviewee 6, Quality Assurance)*
>
> *"I always say you didn't write it; you didn't say it; you didn't hear it... if you're expecting for people to remember, then people become indispensable to the company… and that's not in the best interest of the company… if that person is sick, structure or whatever, then you have a big hole there… you need to have some type of documentation." (Interviewee 5, Product Development)*

While this encourages individual accountability, it also increases dependence on individual memory rather than formal repositories. Reflection and institutional memory

are more fragile based on certain responses. There appear aspirational perspectives of knowledge adaptation rather than a formalized system of maintaining learnings. Interviewee 5 and Interviewee 6 also noted that in the absence of formalized documentation, the erosion of institutional memory begins to take place. However this leads to the reliance on human resources, which was identified as leading to individual employees becoming indispensable. Having specialized knowledge that leads to a company reliance on human memory and informal knowledge sharing methods, also necessitates a further priority to communicate lessons effectively across teams at OTO, as noted further in the knowledge alignment section.

4.2.3 Knowledge Alignment and Strategic Application

Alignment across teams emerged as a moderating factor. Strategic learning informs innovation only when knowledge is shared effectively across the departments of OTO efficiently and effectively. Communication was repeatedly cited as essential. Product developers emphasized managing expectations and maintaining transparency when deploying changes. QAs highlighted the need to centralize feedback to avoid misalignment, but also emphasized the continual need to be flexible so as to not fall into decision making patterns that are not useful when continually done the same way, indicating the following:

> *"That reminds me of this Peter Drucker quote: "There is nothing so useless as doing efficiently that which should not be done at all." So, the real challenge is making sure innovative efforts are aligned with what actually creates value… accidental imbalance can occur if decisions are not approached holistically." (Interviewee 1, Quality Assurance)*

Management framed alignment in broader strategic terms: ensuring that innovation efforts target meaningful value rather than efficient execution of misdirected initiatives. The stage of company maturity also affects alignment efforts, as early-stage flexibility

enables rapid adaptation but increases risk of fragmented understanding. As scale increases, more formal coordination mechanisms will likely be required. Knowledge alignment was described as essential for meaningful innovation, and also that knowledge alignment depends heavily on focus of that obtained knowledge to be meaningfully disseminated within the team, driving strategic decision making. Interviewee 1 and Interviewee 7 emphasized:

> *"There is a difference between moving quickly and moving meaningfully." (Interviewee 1, Quality Assurance)*
>
> *"Focus is key… yes, it's great to have a product that can be used in different markets, but you need to focus on a market to succeed in and then expand to other markets afterwards… we will always get distracted with things here and there and opportunities that come up. But we always have to gear back to focus." (Interviewee 7, Management)*

Interviewee 7 also emphasized a high priority on communication between teams as an even higher priority that formalized documentation, indicating the following:

> *"Very important is communication between teams to make sure there is no mismanagement, there is no isolations, there is no misleading information here and there… second is documentation, so things are not forgotten or lost. And once it's within a process, and then like once you communicate, you figure that out, then you document it. Hopefully that will turn into some kind of a process that is used moving forward so that the lesson is not lost." (Interviewee 7, Management)*

Management emphasizes broader strategic orientation, and alignment also determines whether innovation creates value. Speaking clearly on the underlying exploration characteristic of the knowledge alignment capability at OTO:

> *"Strategic learnings almost become: Do we have product market fit? Are we building something anybody cares about?" (Interviewee 2, Management)*

4.3 Quality Management Driving Innovation Capabilities

The final empirical domain examined identifying if quality management was the driving capability that supports OTO's innovation capabilities. Rather than being a constraint, quality management was often described as a necessary stabilizing force. However, it was not identified as an equally strong driving force to improve innovation capabilities, as compared to strategic learning. Quality management is understood as playing a critical enabling role by reducing variability and ensuring that foundational processes operate effectively, thereby creating the conditions under which innovation can occur. However, despite its importance in supporting operational stability, quality management was not perceived as the primary driver of innovation capabilities when compared to strategic learning. Instead, its role was more indirect, functioning as an underlying infrastructure that supports and sustains innovative efforts rather than actively initiating them.

4.3.1 Defining Product Quality

Quality assurance emphasized reliability and meaningfulness of insights delivered to users. Product quality was framed not simply as technical correctness, but as the ability to deliver trustworthy, science-based outcomes which OTO relies upon. There remained an acknowledgment that innovation capabilities can help improve the actual perceived quality of the product, and that there exists a theoretical point at which the product is stable enough to being exploring more, but only once there is ensured reliability from a quality management perspective:

> *"There are some cases where innovation can absolutely help on the quality side… I think there's a lot of cases as well that the innovation can help improve the experience for the customer and even the usability from a product standpoint… getting it (the product) into a place that is very reliable, from a reliability and validity standpoint, you get to that kind of robustness and then it allows you to potentially explore other avenues that you can improve the product on." (Interviewee 6, Quality Assurance)*

Quality was further defined along two axes: Interviewee 6 indicated scientific defensibility and usability, while Interviewee 7 added the simplicity dimension indicating that the idea of quality includes adoption feasibility:

> *"The one thing that our company and products was always striving for was scientific validity and being able to be defendable from that standpoint." (Interviewee 6)*

> *"Sometimes simplicity is key… to address a problem, it's not necessarily the more complicated or innovative the solution is, the better. Sometimes simplicity determines success at the end of the day… especially in healthcare… the simpler the product to use, the more it will be adopted. If it's complicated and time-consuming, the chances of it being adopted within the clinical workflow decreases.* (*Interviewee 7)*

Developers associate quality with system integrity and algorithm stability. Even minor miscalculations risk eroding user trust. Interviewee 5 indicated the manner in which quality is generated, stating that it is generated through practical experience. Knowledgeable teams that internalize best practices and anticipate errors before they happen were seen as the primary source of quality. Interviewee 5 stressed that positive company perspectives about learning are more influential than rigid department rules:

> *"I really think that it comes on the quality of the team, on the experience, on how much you make sure that the team learns…not depending on the strictness of a quality department." (Interviewee 5, Product Development)*

Across roles, quality was tied to credibility. Particularly in health contexts, inaccurate outputs threaten not only customer satisfaction but reputational integrity. Quality was defined differently across roles. Management indicated that quality establishes the minimum threshold for market participation and innovation outcomes within the product, which cannot thereby occur outside these parameters. Instead, it must operate within them. Management also emphasized trust and scientific integrity, while also specifically describing the structural trade-offs between time, cost, and quality as being relevant to acknowledge:

> *"You're making trade-off decisions all the time…companies do sacrifice quality at points to try and decrease time to market or costs... In a medical device company, quality is defined externally… you don't have a subjective choice." (Interviewee 2, Management)*

While acknowledging that quality may be deprioritized in early-stage development, quality was still framed as foundational for reliability and user trust. Therefore, quality is not equated with perfection, but with functional stability. Interviewee 4 further clarified the limits of quality as a direct innovation driver:

> *"If we ever do something that goes too far or screw up, we lead to the potential of damaging our reputation… having perfect quality is not necessarily going to innovate…It could be a trigger in some cases, but I don't think that's what quality should be there for." (Interviewee 4, Product Development)*

This highlights the importance that quality is primarily stabilizing rather than driving innovation capabilities. It creates the conditions for safe innovation but does not inherently produce novelty. Collectively, these responses indicate that product quality at OTO is defined as compliance, reliability, and credibility and are seen collectively as establishing the boundaries within which innovation can occur.

4.3.2 Structure and Flexibility of the PDSA Cycle

The PDSA cycle was found to operate informally at OTO. While iterative improvement is constant, structured testing and formalized product testing functions are limited. Agile methodology dominates development processes and iterative released are shown to allow learning to occur in real time. Thus, quality structure at OTO is adaptive and evolving rather than rigidly institutionalized. The findings show that flexibility within the PDSA cycle supports innovation, but excessive informality risks undermining stability. This importance of flexibility was reiterated within the responses from Interviewee 3's recognition of agile methodologies as quotes in section 4.1.1.

However, respondents acknowledged that a higher-level organizational maturity would necessitate more structured quality processes. Informal PDSA cycles are effective in early-stage contexts but may require formalization as complexity of the product development increases. This subsection captures how quality processes operate structurally, particularly through the PDSA cycle, and how formalization affects innovation capabilities at OTO. Description from Interviewee 4 indicated that the company's current approach is intentionally less rigid based on both resource limitations, however also enabling quick adaptation.

> *"Right now, I think we operate on a less rigid structure, but it is not as formal as most corporate companies might go. I see a benefit...but also an issue with it is basically...with it not being as rigid, it allows us to adapt quickly, move quickly, and to output code. However, it does lead to issues such as...possible regressions along the way" (Interviewee 4, Product Development)*

Here, flexibility supports the speed of product adaptation. This reflects a calibrated PDSA cycle rather than a fully formalized one. Structure is applied selectively, depending on risk exposure and system criticality. The dynamic nature of quality cycles was further emphasized. However, insufficient rigidity can result in technical debt or overlooked defects. To address this, OTO is aiming to move toward a hybrid model:

> *"We're kind of trying to become almost a hybrid of this, where we're not as rigid in certain areas, but become more rigid in others. I think having too much, being too rigid slows the company down and they can never iterate. But at the same time… just letting it all loose...causes damaging issues within the company… sometimes we keep doing things so fast that we don't really complete the cycle… development speed is way faster, but quality checks are sometimes lighter." (Interviewee 4, Product Development)*

This indicates that the PDSA process is operating informally and unevenly across projects. While iteration is continuous, the 'Study' and 'Act' phases may be compressed under time pressure. Interviewee 4 also acknowledged ongoing process refinement:

> *"Every team does it differently, and we're trying to figure out from the software team what the best solution is here." (Interviewee 4, Product Development)*

Interviewee 7 described the early-stage informality of quality processes and also supports the findings from Interviewee 4 that the quality management practices at OTO operate in a hybrid form, partially structured, partially emergent. This description reveals that the PDSA cycle is functioning, but not in a fully formalized manner. The 'Plan' and 'Do' stages were found to be driven by developers and management primarily. However, Interviewee 7 also emphasized that this informality is transitional rather than ideal:

> *"Which is okay to start with for a first prototype, but that's still prototype. That's not going to be a product this way. So, we need to move on to a more process-oriented (approach)… we're looking into reviewing the requirements, have clear design inputs and clear required outputs and have a test procedure output, which is what we call verification and validation phase." (Interviewee 7, Management)*

This indicates a gradual shift toward structured quality governance, particularly in hardware development. Here, the organization strategically chooses which elements of the quality cycle to formalize and which to streamline, depending on regulatory positioning and speed-to-market pressures. Thus, the PDSA cycle at OTO is not absent, it is selectively compressed. Iteration is prioritized, while formal validation phases are strengthened as the organization matures or as risk increases.

4.3.3 Source and Impact of Quality Decisions

Quality decisions were found to originate from multiple sources: regulatory requirements, customer feedback, algorithm performance data, and internal reflection. Importantly, quality improvements were described as enabling innovation by preventing user distrust. Innovation without credible output risks was identified to risk undermining future adoption. In the case of algorithm refinement, quality validation ensures that innovation does not compromise scientific integrity. Without quality safeguards, learning-driven innovation could damage long-term viability. Innovation without quality safeguards was considered risky, especially related to the concept of user trust:

> *"If we do have it (the product) fail… they lose faith in the app if it's inaccurate." (Interviewee 4, Product Development)*

The impact of these sources of quality decision extends beyond defect prevention; Interviewee 7 framed quality decisions as inherently strategic:

> *"There will be trade-offs… which could be different trade-offs. With the example I just mentioned is trading off maybe the usability of the product…maybe not it's as usable, not as nice looking, not as consumer-friendly. But that's what we need to do to get the signal and the assessments to get to market faster." (Interviewee 7, Management)*

This underscores that quality decisions influence not only product reliability but also learning depth. Incomplete quality cycles may preserve speed but reduce reflective insight. Here, the source of product quality does not translate purely from technical excellence, but instead quality is derived from business-driven compromises balancing usability, performance, and speed. Interviewee 7 further highlighted long-term implications of early shortcuts, while also acknowledging the resource constraints need to be always kept in mind.

> *"Because of speed to market, we trade off on the quality management, and we don't do as much. And sometimes, yes, it could pass, but sometimes the consequences could be some issues with the product… So as opposed to spending time perfecting it and making sure everything works during using a good quality management, we're speeding up that, but then we're spending the time later on by getting feedback from customers and fixing things as we go." (Interviewee 7, Management)*

This statement reveals a temporal shift on the source quality decisions: decisions to relax quality upfront may increase downstream correction cycles. Innovation is therefore not halted, but stabilization becomes reactive rather than preventative. OTO perspective on the source of product quality illustrates how decisions can destabilize user trust and continuity when not properly aligned with customer context. Interviewee 6 described how achieving product robustness creates room for exploration:

> *"I think building, getting to that point where the product's at a really high quality to where you don't need to be doing development and fixing what you've built, you can be building new things." (Interviewee 6, Quality Assurance)*

Therefore, based on the responses, determinations of quality decisions at OTO were found to influence innovation outcomes in two distinct ways. It was found that quality management at OTO does not necessarily drive innovation capabilities, but instead acts as the guardrails or foundation for the manner in which innovation outcomes occur. Firstly, when quality decisions are insufficient to address a true quality issue, innovation outcomes become reactive and unstable. Conversely, when quality decisions are robust, innovation outcomes shift from reducing product defects to opportunity exploration.

4.4 Summary of Findings

This chapter examined how strategic learning and quality management interact to shape innovation capabilities at OTO. The findings reveal that innovation capabilities are not the product of a single dominant mechanism, but rather the outcome of how different learning dimensions are prioritized, constrained, and balanced within a fast-moving and resource-limited startup environment.

With respect to the relationship between strategic learning and quality management, the **findings confirm that synergy is strongly identified, while the trade-off dynamic was seen as conditional and resource dependent**. Strategic learning informs quality improvements by identifying where refinement is necessary and Quality management stabilizes and legitimizes innovation by ensuring safety, credibility and maintaining user trust. However, it was identified that quality processes must be calibrated carefully. Excessive rigidity risks slowing innovation and limiting adaptive learning, while insufficient structure risks regressions and reputational damage. Innovation capabilities at OTO emerge most effectively when learning is rapidly absorbed and selectively institutionalized within flexible quality frameworks.

A central insight emerging from the respondents' responses is that a **strong precedence is given to the speed of knowledge absorption within strategic learning**. Across roles, respondents consistently emphasized the importance of rapidly identifying and internalizing new information from customer feedback, algorithm performance, user engagement data, and operational failures. New insights are quickly understood, discussed, and translated into product adjustments. This high absorptive capacity appears to be the strongest contributor to innovation capabilities within the organization. The firm's ability to rapidly detect signals from its environment and act upon them allows OTO to iterate quickly and refine product-market fit. In this sense, the speed of knowledge absorption is not simply present, it is the main capability that enables OTO to have innovative capabilities.

However, the findings also indicate that other dimensions of strategic learning are less developed. In particular, **organizational memory and structured reflection were identified as the most underutilized** aspects of learning. While reflection does occur, it is often informal and embedded within ongoing project work rather than codified into systematic processes. Respondents implicitly acknowledged that institutionalizing learning, documenting lessons, conducting structured post-mortems, or building knowledge repositories is currently a lower priority. This is largely due to the organization's emphasis on speed and organizational flexibility, as well as resource constraints. The drive to move quickly can compress the 'Study' phase of the PDSA cycle, leading to partial integration rather than full institutionalization of lessons. As a result, knowledge adaptation and the durable embedding of insights into organizational routines remain an ongoing challenge.

In terms of knowledge alignment, the interviews revealed a nuanced dynamic. **There are challenges associated with sharing information across roles**, particularly given the absence of highly formalized systems. However, there is also a strong organizational expectation that lessons be communicated rapidly. Respondents indicated that when new information emerges, there is an implicit norm that it should be shared with the broader team as quickly as possible. This expectation partially compensates for the lack of structured organizational memory. Alignment, therefore, depends heavily on interpersonal communication and team culture rather than formal documentation systems.

The findings also reveal that the balance between **exploration of new knowledge and exploitation of current knowledge is influenced by resource constraints and organizational maturity.** Exploration of new knowledge such as new algorithmic approaches or product features competes directly with the need to exploit and refine existing knowledge. Respondents suggested that limited personnel is a notable constraint to the extent to which either motivations for knowledge exploration or knowledge exploitation cannot be fully optimized. As a result, prioritization decisions are frequent

and often driven by immediate product demands. Organizational maturity further moderates this balance. As a relatively small company, with a high precedence on agile company philosophy, OTO benefits from flexibility and rapid iteration, and the innovation capabilities are reflected high as a result. Early-stage conditions allow focus groups and user feedback to function as dynamic testing environments. However, respondents acknowledged that as scale increases, greater formalization of learning retention and quality processes will likely be necessary. What is currently adaptive informality may become structural vulnerability if not gradually institutionalized.

Overall, the findings suggest that innovation capabilities at OTO are driven primarily by strong knowledge absorption capability, moderated by informal alignment mechanisms, and constrained by limited organizational memory and resource capacity. Strategic learning is present and active, but uneven across its dimensions. Knowledge absorption dominates, knowledge adaptation and knowledge alignment are encouraged but structurally imperfect, and underdeveloped. Quality management, in turn, provides the stabilizing boundary conditions within which this learning can translate into sustainable innovation. In conclusion, innovation capabilities at OTO are not the result of maximizing either learning or quality independently. It is the result of prioritizing rapid absorption, navigating resource trade-offs between exploration and exploitation, and progressively formalizing quality and memory structures as the organization matures.

The revised framework in Figure 9 below outlines the noted connection between strategic learning and quality management as identified through the interviews. The framework now identifies a bidirectional and reinforcing relationship between strategic learning and quality management, as well as a main unidirectional arrow between innovation capabilities as leading into the PDSA cycle. This revision of the theoretical framework was completed through the main theme of the respondents being centered around strategic learning within the organization driving innovation capabilities and having a positive effect on the strategic learnings necessary to improve the quality management PDSA cycle.

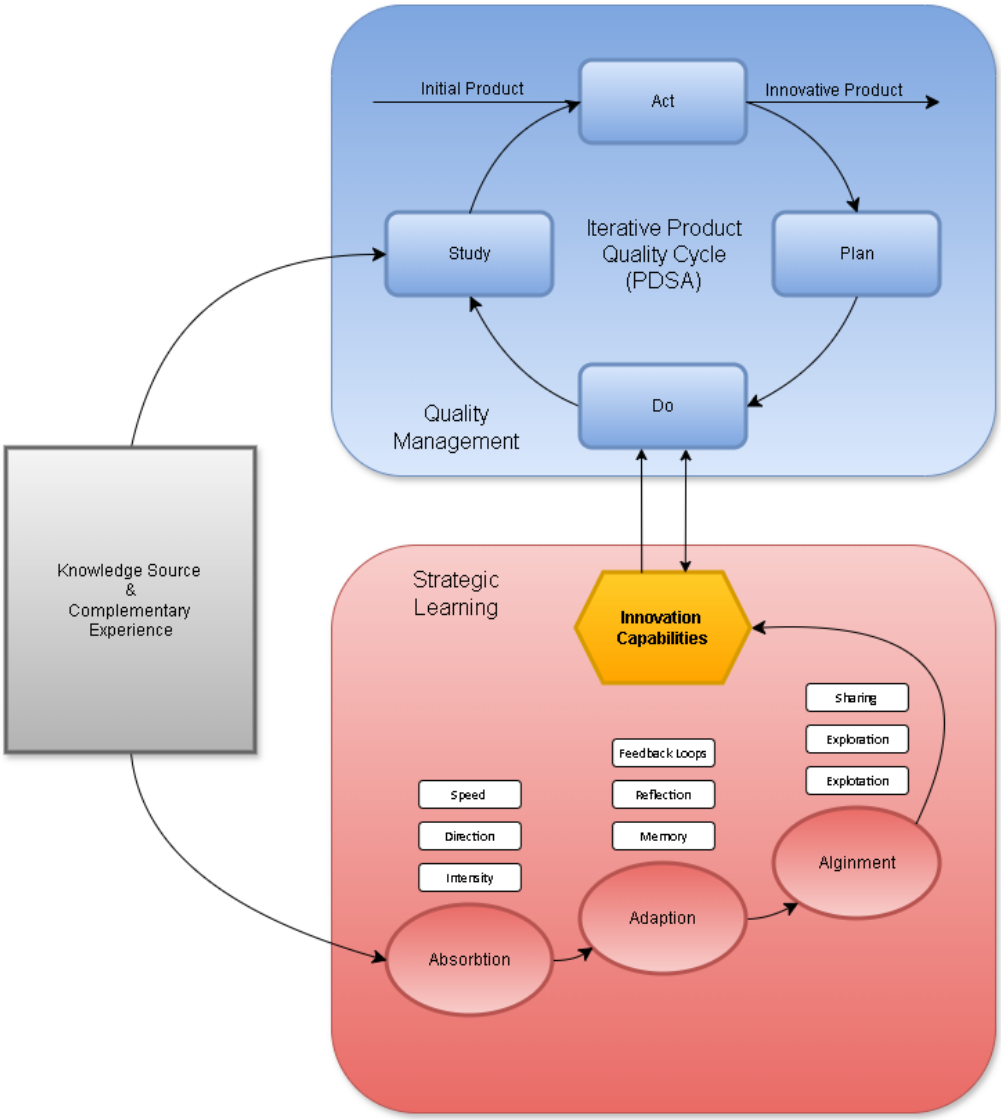

Figure 9. Revised theoretical framework.

5 Discussion

The findings demonstrate that innovation capabilities at OTO do not emerge from the isolated strength of either strategic learning or quality management processes. Instead, innovation capabilities are enabled at OTO through the dynamic, yet thoughtful interaction of these different processes under conditions of speed, regulatory constraint, and resource limitation. Three central patterns emerged. First, strategic learning is highly active with knowledge absorption clearly dominant. Second, quality management provides necessary stability and acts as the guardrails for which positive innovation outcomes can materialize. Third, organizational maturity and resource constraints significantly moderate both strategic learning and quality management processes, shaping how innovation outcomes ultimately unfold in practice. This chapter interprets these findings in relation to existing theory, outlines practical implications for managers, identifies avenues for future research, and acknowledges the study's limitations.

5.1 Theoretical Implications

A key theoretical contribution of this study is the differentiation of strategic learning into its constituent dimension's knowledge absorption, knowledge adaptation, and knowledge alignment and the observation that these dimensions do not develop evenly within early-stage firms. The findings suggest that within the contemporary business environment in which startups operate, the speed of knowledge absorption functions as the primary driver of innovation capabilities through strategic learning. OTO's priority on speed of knowledge acquisition reflects the level of importance within the company and also demonstrates strong absorptive capacity directly in line with the very definition first articulated by Cohen and Levinthal (1990, p. 128): *"the firm is able to recognize the value of new information, assimilate it quickly, and apply it to commercial ends".*

However, absorptive capacity alone does not equate to improved innovation outcomes. Teece (2007) conceptualizes dynamic capabilities as comprising sensing, seizing, and transforming, and while OTO exhibits strong sensing and seizing capabilities, transforming remains comparatively underdeveloped. Considering that the transforming capabilities necessitate fully embedding or reconfiguring acquired knowledge at a systemic level, and embedded, enduring organizational routines are still emerging. Organizational memory and structured reflection are much less formalized, suggesting that the transformation of insights into enduring routines is still emerging. This uneven development highlights an important theoretical nuance: early-stage firms may exhibit high absorptive capacity without fully developed adaptive institutionalization. Thus, strategic learning may evolve sequentially, with knowledge absorption preceding formalized adaptation.

The findings also contribute to theory by reframing quality management not merely as a control mechanism but considering quality management as a boundary-defining dynamic capability, reinforcing Masaaki Imai's early arguments on quality being foundational for innovation to occur. Traditional quality literature as identified through the TQM research and PDSA cycle often emphasizes compliance, standardization, and defect reduction (Deming, 2000). However, in a regulated health technology context, quality management establishes the legitimate parameters within which innovation can occur and thereby influences the themes of innovation outcomes that are likely to occur.

At OTO, this traditional quality management literature is challenged since quality management does not solely serve the purpose of standardization yet, quality management does not directly generate innovation. Rather, it stabilizes experimentation by ensuring that learning driven changes do not undermine credibility. In this sense, quality management functions as a protective enabler around which innovation outcomes can occur. It aims to preserve user trust and protect reputational capital. Innovation capabilities are therefore enhanced not by eliminating constraints, but by operating effectively within them. This supports the conceptualization of quality management as a dynamic capability when it enables the firm to repeatedly innovate

within compliance boundaries. However, the study also shows that excessive rigidity may suppress exploration, reinforcing the need for calibrated flexibility.

5.2 Managerial Implications

Prioritize absorption and speed of knowledge acquisition, and only formalize reflection gradually. The findings generate several actionable implications for managers in health technology and similarly regulated innovative environments. Competent knowledge absorption capability with a high priority on speed of knowledge acquisition is seen as an even greater competitive advantage in startup contexts, as compared to what was previously understood. However, this study shows that reflection and organizational memory are often underutilized. Managers should incrementally introduce lightweight documentation systems, structured post-mortems, or knowledge repositories before complexity overwhelms informal processes. Institutionalizing lessons reduces repeated mistakes and accelerates long-term capability development.

Quality processes should scale proportionally to risk exposure rather than uniformly across all functions. Managers should consider designing hybrid quality systems, as it is understood through this study that rigid quality systems can slow iteration, while informal systems can introduce regressions that can enable innovation outcomes, but risk undermining user trust if adequate quality decisions do not take place. The hybrid approach observed at OTO, rigidity in high-risk areas and flexibility in exploration domains, offers a practical model. Managers should identify which components require strict validation and which can remain iterative and then prioritize the speed of those iterations to support innovative outcomes.

Managers should make trade-offs explicit rather than implicit. Explicitly manage trade-offs because implicit resource constraints make innovation outcomes more challenging to achieve in early-stage startups. Allocating protected time for refinement exploitation,

while preserving exploration capacity reduces reactive oscillation between the two. Without deliberate allocation, immediate product pressures will dominate, potentially undermining strategic balance.

5.3 Limitations

Several limitations must be acknowledged. First, the study focuses on a single organization within the health technology sector. While this allows for deep contextual analysis, it limits generalizability. Second, data were collected through interviews, which capture perceptions and interpretations rather than objective performance metrics. Although variation across interviewee roles strengthens diversity of organizational input, responses may still reflect subjective bias. Third, the firm's early-stage status shapes many findings and the dynamics observed may differ significantly in mature organizations who have formalized governance structures. Fourth, the absence of longitudinal data limits the ability to observe how learning and quality processes evolve over time. The findings represent a snapshot within a particular developmental phase. Despite these limitations, the depth of cross-functional semi-structured interviews provides rich insight into the perceived interaction between strategic learning and quality management's impact on OTO's innovation capabilities.

5.4 Suggestions for Future Research

This study opens several avenues for further investigation. First, longitudinal research could examine how the speed of knowledge absorption is perceived and actioned at later organizational stages. Considering the speed of knowledge absorption was seen as the main capabilities of OTO, we do not yet understand the particular transitionary period that is required in order to transition from the product innovation into the process

innovation phase. Understanding the particular organizational stage that may constitute a prioritization on process innovation would require longitudinal research to underscore the characteristics of strategic learning, as well as quality management that are important to maintain innovation capabilities into the future, as well as the particular decisions dedicated to understanding what precise organizational phase the organization is in.

Second, future studies could explore the mechanisms for how organizational memory institutionalizes lessons and improves innovation outcomes. Considering the research organizational memory identified within the literature review was not specific to health technology, instead the study outlined organizational memory as related to innovation within the post-secondary setting. Future research may benefit from understanding how organizational memory could be maintained specifically within the fast paced and technologically dynamic environment of today's startup environments. Identifying features of technological choices and record keeping practices that could serve to improve startups organizational memory could serve a highly beneficial purpose within the innovation literature

Third and finally, future research within the innovation capabilities field could explore what specific cultural attributes have the most positive impact on innovation outcomes. The context of this study did not focus on cultural components present within businesses that may help or hinder innovation capabilities. However, further work within this area of research could uncover important cultural qualities that certain organizations have related to enabling positive cultivation of the mechanisms underpinning both strategic learning and quality management as it relates to innovation capabilities. The mechanisms identified throughout this study all be strongly impacted by organization culture, which may enable or inhibit them. Therefore, organizational culture may thus enable or inhibit positive interaction between the area of strategic learning and quality management and therefore, may impact the organization's innovation capabilities.

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Appendices

Appendix 1. Interview Questions

Strategic Learning & Quality Management Relationship

1. Have you ever encountered tension between maintaining quality standards and trying to innovate quickly? How is that balance managed? Please provide one example.

2. Do you think that synergy between SL and QM exists? That they improve and reinforce one another, or is it simply a trade-off between them?

3. Do you believe that innovation is pursued at the expense of quality?

4. Does strategic learning influence how quality standards are defined or updated over time? Or are quality standards mostly fixed and externally defined?

5. Do the quality improvement decisions in the product development cycle have a positive impact on the innovation capabilities within the organization?

Strategic Learning

1. How does the organization identify, prioritize, and quickly absorb new knowledge from customers, testing, or the market and what determines how fast that learning turns into action?

2. Once new knowledge is gathered, how does the organization reflect on it, integrate it into decision-making, and ensure that lessons are retained rather than lost?

3. How is strategic knowledge shared and aligned across teams, and how do you balance exploring new opportunities with improving existing products?

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Quality Management

(Product-Level Focus, Integrated with Learning)

1. Outside of compliance, how do you personally define quality in the context of our product? For example, is it performance reliability, customer value, or something else?

2. In your role, does the PDSA cycle operate more informally and flexibly, or is it formally structured and rigid — and which approach do you find more effective?

3. Given your definition of product quality. In your opinion, where is product quality generated from?