Achieving Innovation and Development Speed in Large Structured Organizations: An Ecological View and Case Study

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Submitted to the System Design and Management Program in partial fulfillment of the requirements for the Degree of Master of Science in Engineering and Management.

ABSTRACT

Innovation has been long known to be difficult to accomplish in large companies that have well structured processes. Structured processes (such as the use of Six Sigma) can provide significant benefits in terms of efficiency and productivity. However, it can also hinder innovation in that it zones in on local, incremental solutions too quickly. This thesis explores different strategies corporations may take in incorporating innovation at their organizations. First, background and theory are presented to guide the discussion, grounded on ecological psychology. Second, a case study (VisionPRO Thermostat) is presented that provides insight in how innovation can work in large structured organizations; in this case, outsourcing and the use of common tools were used as the innovation strategy and transfer mechanism. Third, the discussion is expanded to broader corporate strategies that can inject innovation in product development processes. Innovation and structured processes are at odds with each other and need to be managed with different approaches. Innovation processes require creative isolation from high structure to open degrees of freedom and the design space; this can be accomplished through multiple strategies such as outsourcing, buying, injecting, incubating, co-locating, spinning-off, and distributing. Structured processes should rely on a high level of constraints that are highly predictable to push productivity and efficiency; this can be accomplished through Six Sigma and lean processes. Interfaces between the two sets of processes are critical to mediate effective transfer and insertion in product lines; in the case of the VisionPRO, common language (i.e., the common use of certain Six Sigma tools) and people played the interface role. Finally, conclusions, contributions, limitations, and future research are presented.

Thesis Supervisor: Eric von Hippel
Title: Professor of Management

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Introduction

Motivation

World economies have undergone vast and rapid changes with the proliferation of various technological innovations, increased emphasis on efficiency, quality, and safety, and shifting demands. As a response to these realities, markets have become more dynamic. Product innovation and corporate adaptation to change (i.e., adjusting processes and actions driven by a changing market context to support corporate goals) have become issues of greater importance.

Despite these needs, innovation has been long known to be difficult to achieve in large organizations, especially ones that have heavily utilized structured processes. There is a contraction because on the one hand, large companies want to grow. On the other hand, these same companies are risk averse, have organization impediments to change, and predominantly focus on the short term (e.g., quarterly results). As these firms increasingly become global, there are greater opportunities for growth and innovation but it is also anticipated to become more difficult due to issues such as communication, coordination, and distributed and asynchronous development utilizing structure processes.

An example of the above phenomenon is illustrated by a growing practice in business – Six Sigma – which a significant number of large companies have adopted. Six Sigma has been used extensively to improve product and service quality, and decrease waste, costs, and defects. Key goals of the methodology are to decrease variance in product outcomes, decrease costs, improve competitiveness in current markets, and focus

on the best business opportunities. This has resulted in enormous benefits to these corporations by streamlining processes and aligning activities to customer needs and company strategies. It has led to efficiencies for sustainable or innovations and incremental products improvements. However, the methodology has also constrained the creative design process to the point that it is very hard to develop breakthrough innovations – this is what I call the incremental trap. Companies have resorted to other strategies by necessity, such as expensive acquisitions once market signals have emerged, to insert and cross-pollinate step-out product designs.

One way to describe this problem is through an analogy for a company trying to innovate in a changing marketplace. Consider a company moving in a market environment with different constraints, shown in Figure 1.1. The current product space encompasses all available products in the market space. Average customer needs typically overlap this space. There are also edge customer needs that may not overlap current product offering or the average customer needs. In some cases, lead users point to macro-trends and gradient shifts in future needs of the average customer (von Hippel, 2005). The objective is to move from a starting point (current product offering in current product space) to the goal (incremental or breakout innovation). A number of questions emerge: What should the target be (incremental or breakthrough change)? What are the risks and opportunities for each target? How can product transformation be accomplished efficiently and effectively?

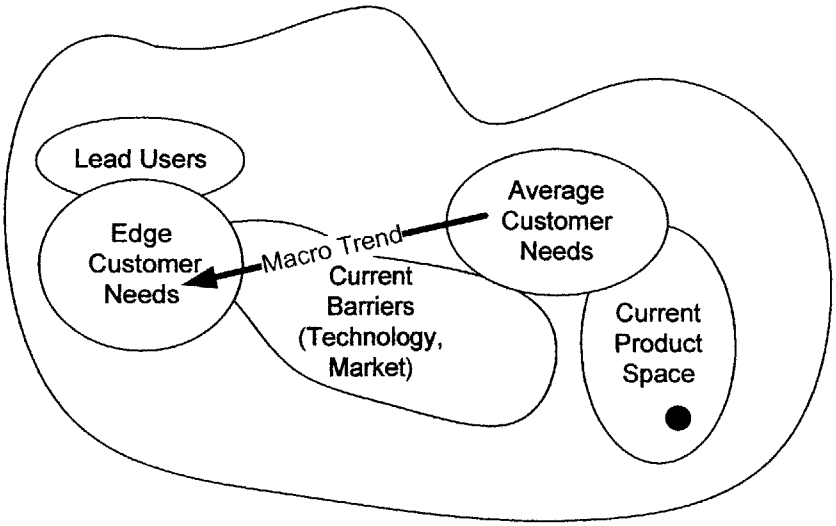

Figure 1.1: Generic problem of a shifting competitive landscape. Current product offering is shown by the green circle.

Two contrasting strategies may be invoked. One strategy may be to find, with a consistent process, what is known about average customer needs (largest driving customer group), competitors, and the current product space (Figure 1.2). Once determined, this path can be encoded as a process or procedure and used efficiently to reach the local goal every time from a predetermined starting point (i.e., market or product position). This strategy is analogous to using the structured processes of Six Sigma (i.e., inputs are generally current market, aggregate customer data, and competitive data) and can be effective when the behaviour of the constraints, customer needs, and market participants are relatively static and predictable. The result tends to be incremental with some variation of what is currently envisioned in the market place because the inputs characterize the target close to the local product space. This approach does not enable companies to anticipate the market and tends to be support follower activity (i.e., continuously tracking and adjusting to the target and competitors).

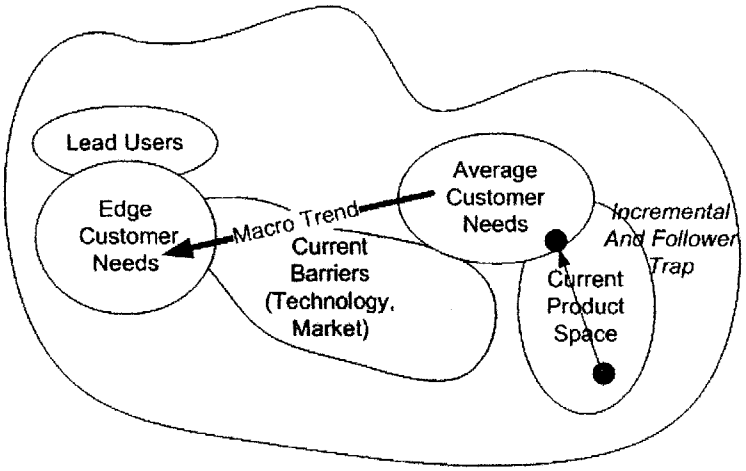

Figure 1.2: Strategies focused on process for reaching the incremental targets – Look at current practices, competitors, and technologies, and implement consistent processes to be a follower. Red circle indicates new target.

An alternative strategy may be to understand the underlying and deep customer problems, trends, and constraints of the market environment in a timely fashion, and leave it up to the product development team to choose any feasible path to get to any selected target or goal (Figure 1.3). Novelty in the process is analogous with breakout innovation processes. The team can certainly look at incremental changes (e.g., pick a localized target), but they can also see where step-out or breakout innovations can occur (e.g., ethnographic considerations, and discovery and assessment of lead users). This strategy can be effective when the behaviour of the constraints and markets are dynamic, changing in predictable and unpredictable ways.

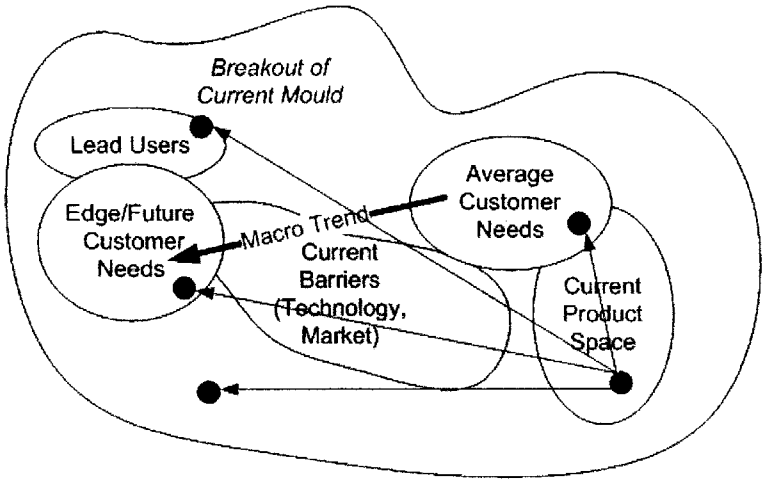

Figure 1.3: Strategies focused on outcomes for various targets – Break out of the incremental mould and enable the anticipation market shifts. Red circles indicate potential new targets.

The above example describes the type of problem found in many product development organizations. People are constantly required to move and align processes to meet the required market demands. Part of the issue with innovation is the clear definition of the target. For example, following competitors may or may not satisfy customers, or tackling average customer needs may not result in a sustainable competitive advantage. When the behaviour of the opportunities and constraints is static and predictable, previously successful procedures may be invoked (e.g., embodied in Six Sigma and heavily structured corporate work processes), but competition can intensify due to the predictability of the market. However, more and more, the behaviour of opportunities and constraints is dynamic and unpredictable, driven by customer demand and market shifts, technological innovations, and competitor actions that disrupt markets,

requiring continuous adaptation for success. Product development teams need to understand the deep customer problems, relevant trends, and solution spaces to innovate.

Figure 1.4 displays the three main parts to the puzzle that can help in reasoning about the innovation and structured processes: market environment opportunities, information, and organizational capabilities. Each part must be studied in the context of the other parts to understand the key success factors in adapting to change and unravel the innovation/structure puzzle. For example, if a corporation is too constrained internally with processes, it will not be capable to attune itself to market environment breakout opportunities (i.e., it will only pay attention to the signals that lead to incremental change). If a corporation is too open, unconstrained, and chaotic, it will not be able to coordinate product development and delivery. The right balance is important – a marriage between creative/innovative processes and structured processes.

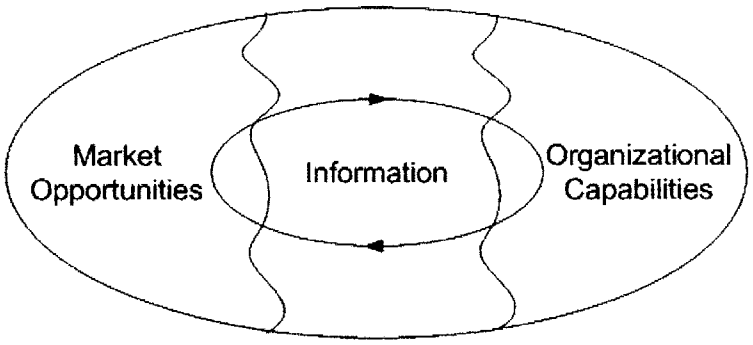

Figure 1.4: An integrated view of the innovation/structure puzzle.

Purpose

This purpose of this thesis is to investigate how innovation can occur in large organizations, in particular ones that have highly structured processes (e.g., Six Sigma), and focus on efficiency to drive performance. I will argue that a complete focus on efficiency results in disincentives to innovate, particularly breakout innovation. On the

other hand, a complete disconnection and focus on the creative process can be risky. A shifting, but balanced view is required. In doing this, I will draw upon the theories in ecological psychology that will help inform how the creative-structured balance, strategic interfaces, and information can improve the chances of success. Through a case study, the VisionPRO Thermostat, I assess how the theory helps explain its success. With not a breakout innovation, it stepped out the current product space and tapped into unmet customer needs resulting in significant market success. I will also postulate how companies can insert innovation strategies in highly structured organizations (e.g., heavy use of Six Sigma), and take advantage of both innovation and efficient Six Sigma techniques to drive product outcomes.

Organization of Thesis

This thesis is organized into four additional chapters. In the second chapter, I introduce concepts and theory in ecological psychology and relate them to business. This provides the foundation for the observations made during the case study and framework for discussion. I also provide a high level overview of Six Sigma in product development, including some key benefits and limitations. Finally, I discuss the role of innovation processes in product development. A number of examples are presented, including the ten faces of innovation, lead user analysis, and organizing for innovation.

In the third chapter, I present a case study of the VisionPRO Thermostat in the context of how innovation happened in a large organization with structured processes. The background, market context, problem, approach, process, organization, and outcomes are presented and discussed.

In the fourth chapter, a discussion of the implications of the results is presented in the context of what companies can do to increase the chances of innovation to drive growth. The results are discussed in the context of foundations in ecological psychology. In addition, insights based on the theory and case study that can inform product development are discussed.

In the last chapter, I provide some concluding remarks and discuss contributions, limitations and future research.

Theory and Background

The theory that is applied to the problem of innovation in large organizations stems from pioneering work in ecological psychology and the concept of the use of coordinative structures (Kelso, Holt, Kugler, & Turvey, 1980; Kelso, 1995). Coordinative structures are the linkages of resources into higher-level functional collectives; they define configuration opportunities to support higher-level functions based on moment-to-moment context. Engaging in higher-level control activates different strategies, approaches, and processes of utilizing these coordinative structures to support higher-level functions in a changing context. As applied to business, configurations are directly mapped to product development organizations, activities, practices, strategies, and their associated degrees of freedom. I will argue that in a large corporate context that is focused on efficiency with structured processes, the degrees of freedom are limited and constrain the ability of an organization to adapt to market changes and create breakout innovations; this will be discussed in the context of observed Six Sigma practices. Strategies to break this mould will be presented that increase the degrees of freedom and provide a higher-level view of the innovation space.

In this chapter, an overview of the underlying theory in ecological psychology and coordinative structures is first presented. Second, this theory is related to business contexts. Third, an overview of Six Sigma is presented in the context of observed practice in product development; I will argue that certain applications can lead to highly structured processes and create disincentives for innovation. Fourth, an overview of a number of effective practices used for innovation is presented. I will discuss that the benefits of the two perspectives (innovation processes and Six Sigma or structured

processes) could be complemented, interfaced, and architected for greater benefit in product development.

Ecological Psychology

Ecological psychology has its origins with the research of Brunswik (1956) and Gibson (1979). It advocates a systems approach for studying the interactions between people and their environments (Meister, 1989). To successfully study adaptation in changing market situations, the human/organization, environment, and their interactions need to be considered together.

Key to ecological psychology is the notion of coupling between a human and the environment; in the case of business, this is the coupling between the corporation and the market environment. At the juncture between the human/organization and environment lies the connector or interface that can help facilitate cognition, perception, and action. This interface can directly or indirectly specify the environment or market opportunity. By becoming attuned to the interface or picking up cues to reason analytically, people can be coupled to the environment, making adaptation, innovation, and coordinated action possible. In cases where interactions with the environment have highly structured processes or procedures, corporations typically behave consistently in actions, predominantly view short term opportunities and incremental changes, and are limited in their ability to adapt or innovate when markets change. Conversely, in cases where interactions with the environment are driven by a higher level perspective (e.g., understanding deeper customer purposes/needs, trends, dynamic constraints), the organization attunes to that higher-level perspective and adapts accordingly (e.g., uses different configurations, approaches, and strategies to meet customer purposes/needs).

A detailed model of the coupling between the human (or organization) and the environment is shown in Figure 2.1. There are three parts to the model: the environment (distal structure), ambient array (proximal structure), and human (Hajdukiewicz, 2001).

The environment consists of substances, surfaces, objects, media, and events (Gibson, 1979); these characteristics define the distal structure of the environment. From a Gibsonian perspective, these aspects of the environment offer the human a large number of action possibilities. These opportunities for action are called affordances (Gibson, 1979). They are described relative to the human or organization, independent of the intentions or goals. These affordances do not need to be perceived by people or organizations to exist. However, they offer them opportunities to act and innovate.

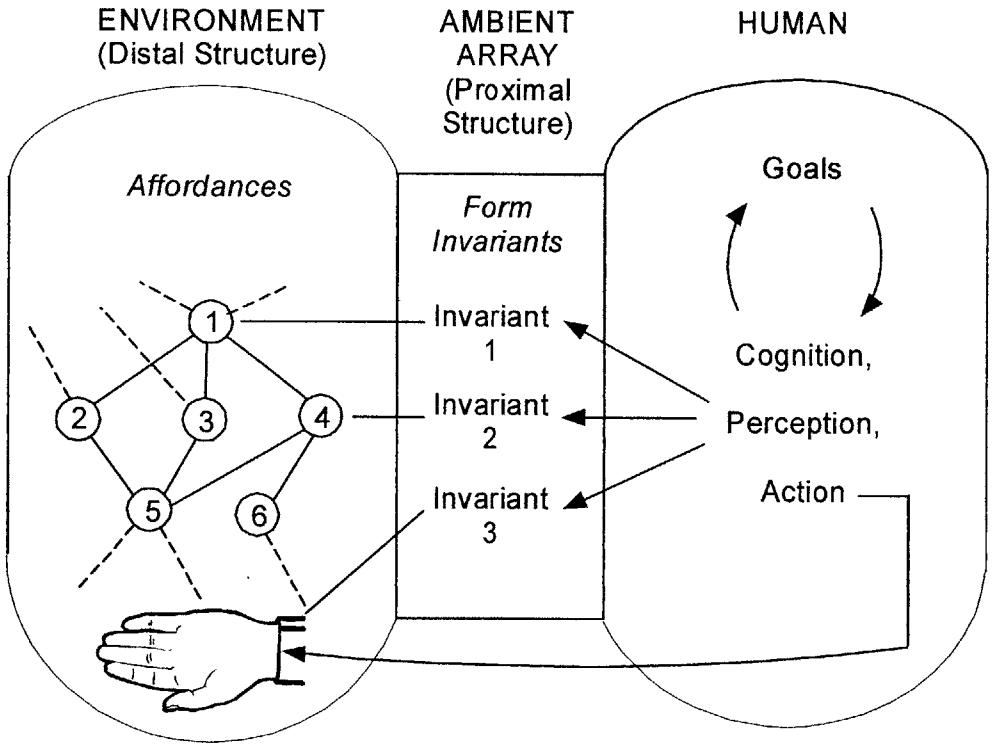

Figure 2.1: An ecological model of human-environment interactions (Hajdukiewicz, 2001; reprinted with permission).

The ambient array is the connection or interface between the environment and the human (or organization) that can facilitate active perception and coordinated, adaptive action. Proximal structure is formed within the ambient array emanating from various aspects of the environment through a medium. From a Gibsonian perspective (Gibson, 1979), the ambient array can have proximal structure forming invariants that can map to various aspects of the environment. Information is a result of a one-to-one correspondence between the proximal form invariants and distal affordances. From a business perspective, the artifacts and forms that users create to fill in latent needs or product gaps can serve a proximal structure to distal affordances.

The human (or organization) is composed of highly integrated and multi-layered systems. From an ecological point of view, adaptation and coordination occur at the levels of cognition, perception, and action, and are guided by goals and intentions. At these levels, the human (or organization) can actively pick up form invariants from the ambient array that map onto affordances in the environment. In this process of picking up form invariants (i.e., attunement to the proximal structure), the human (or organization) acts within the environment (e.g., manipulates objects or moves within the environment). Once this occurs, perception and adaptive, coordinated action are possible.

These concepts have been used to study human coordination. In the research area of motor control, scientists are interested in studying how the body can control and coordinate movement in anticipated or unanticipated situations with relatively few degrees of freedom from a muscular basis of relatively many degrees of freedom (i.e., numerous motor units comprising individual muscles). Bernstein (1967) argued that this

problem of many degrees of freedom may largely be resolved by linking motor units and muscles together in such a way that the individual muscles are reduced to a much smaller set of muscle groups or collectives. Movement occurs by activating these muscle collectives, constrained to act as single functional units. The muscle linkage associated with this muscle collective has been referred to as a coordinative structure (Kelso et al., 1980). This concept fits well in the discussion of the human part of the ecological model in Figure 2.1. From a business perspective, the activation of different muscle collectives is analogous to activating different strategies and processes when interacting with the market.

According to Kugler, Kelso, and Turvey (1980), the coordinative structure concept differs from traditional concepts in the motor control literature such as procedural motor programs. Procedural motor programs presume a pre-established arrangement of muscles or specific sequencing instructions to the muscles. The use of motor programs for goal-relevant movement occurs by controlling the configurations of muscles as a set of instructions for predefined movements (i.e., the specific action process to achieve the movement goal is invariant); this is analogous to what happens with many implementations of Six Sigma (see below). In contrast, the use of coordinative structures for goal-relevant movement occurs by controlling muscle collectives that specify the configuration opportunities as a function of moment-to-moment context; this is analogous to creative, innovation processes. Specific configurations are selected based on the context of the situation to achieve the selected goal or target (i.e., the movement goal or product is invariant). Consequently, the use of coordinative structures is more robust than motor programs for conditions where goals and context are changing and uncertain.

The distinction between the concepts of coordinative structures and procedural motor programs can be discussed more generically and in an integrated fashion by first modelling an environment (or market) in terms of resources, configurations, and functional opportunities that align with its purposes (or needs). Figure 2.2a shows this generic market space (i.e., a goal-relevant subset of the distal environment) with various types of constraints (e.g., technological constraints). Movement in this domain requires adaptation to cope with and take advantage of these constraints to meet the purposes or needs (articulated, unarticulated, latent, or emerging). Figure 2.2b shows a functional representation of this market domain at various levels of description. The lower levels are the physical and concrete resources or components of the market domain or product space, and the higher-levels are the functions and purposes that need to be supported.

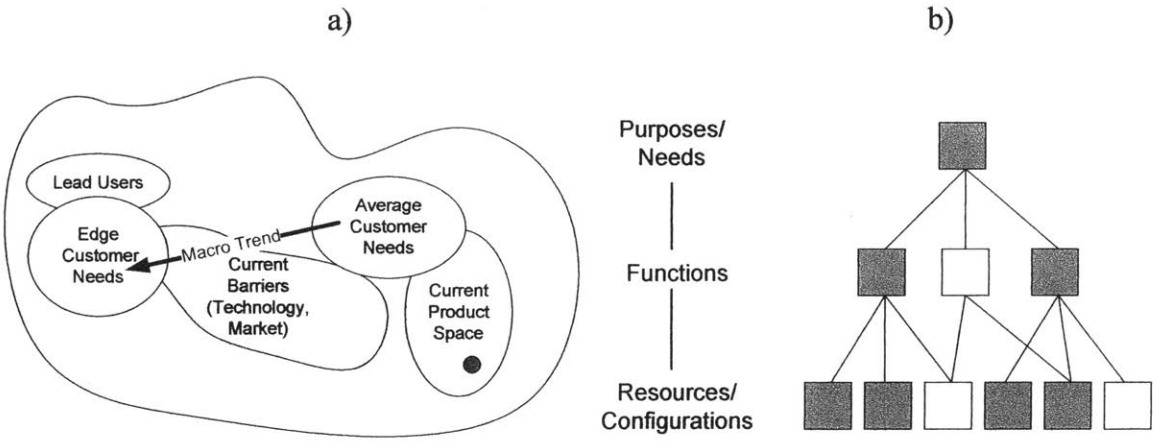

Figure 2.2: a) Generic market domain; b) Functional representation of offering.

This representation can be used to distinguish between the use of coordinative structures and procedural motor programs. The use of coordinative structures (or higher-level control) can be seen as focusing on or supporting the higher-level functions, by

using any feasible resources or configurations at the lower-levels in a context-specific way; the higher-level functions (i.e., outcomes) are invariant (Figure 2.3a). This property of product or outcome invariance is evidence for distal coupling to the higher-level functions of the market or product domain. In contrast, the use of procedural motor programs (or lower-level control) can be seen as focusing on a specific way of using resources or configurations over time in a context-independent way; the lower-level procedures (i.e., processes) are invariant (Figure 2.3b). This property of process invariance is evidence for distal coupling to the lower-level functions of the market or product domain.

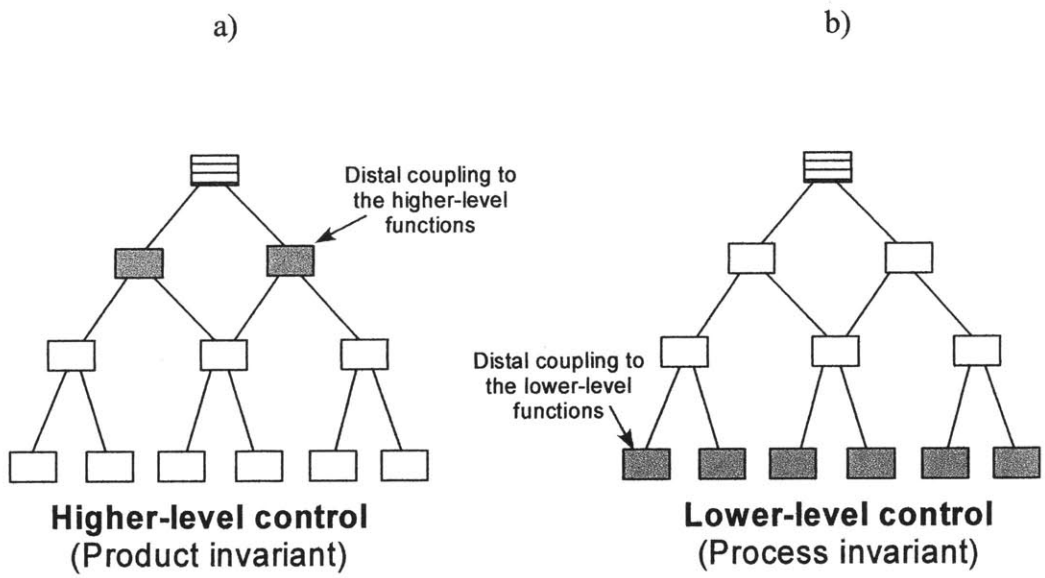

Figure 2.3: Differences between a) higher-level and b) lower-level control, using the functional representation in Figure 2.2b (Hajdukiewicz, 2001; reprinted with permission).

The theory and background in ecological psychology presented in this section can be summarized in Figure 2.4. This provides a theoretical foundation for the study of organizations, structured processes, and innovation processes.

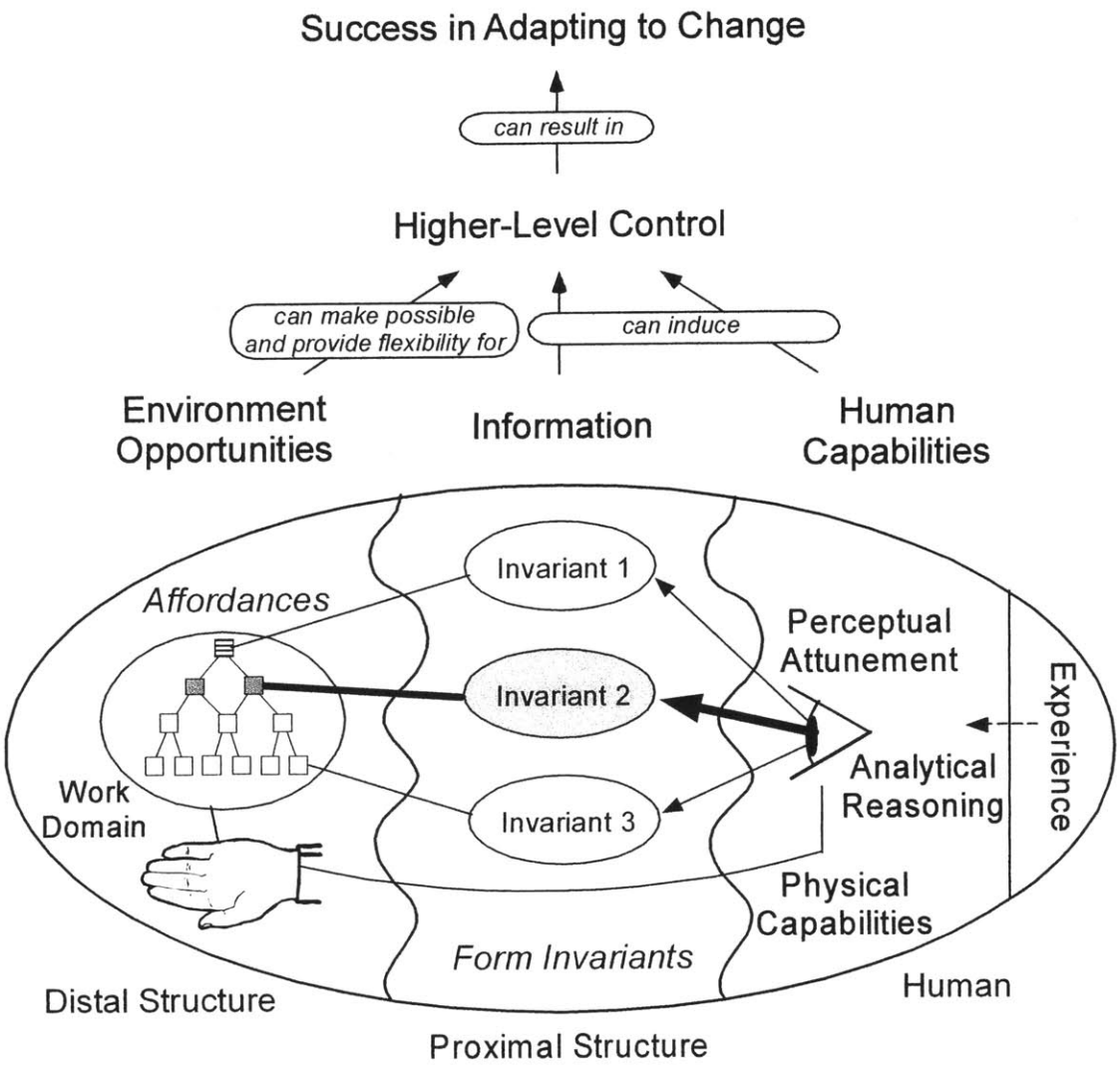

Figure 2.4: Factors influencing success in adapting to change from an ecological point of view (Hajdukiewicz, 2001; reprinted with permission).

From the previous discussions, higher-level control (or distal coupling to the higher-level functions of the work domain) can theoretically lead to successful adaptation to change. Three main factors can help induce and make possible higher-level control. First, the existence of multiple affordances to reach the goals (i.e., multiple structural degrees of freedom in the market domain) is important for making possible and providing

flexibility for higher-level control in a changing environment. If one path or no path exists, the ability for the human to adapt to changes or innovate becomes very limited. Second, invariant forms (especially higher-level forms) in the proximal structure that directly map onto the distal structure of the domain (i.e., information) can help induce higher-level control. They provide opportunities for the human to perceive, as opposed to analytically derive, the affordances and higher-level structure in the distal environment. Finally, human capabilities (i.e., cognitive and physical) in perceiving and acting can induce higher-level control. In terms of cognitive capabilities, perceptual attunement of and analytical reasoning about the higher-level functions can induce higher-level control, because the human can use the higher-level information and adapt actions accordingly as the context changes. In terms of physical capabilities, being able to act on components in the environment in various and flexible ways is required for higher-level control and innovation to occur. Experience interacting with the affordances and form invariants can enhance both cognitive and physical capabilities; thus, experience plays a key role in inducing higher-level control.

Ecological Approach Applied to Business

The above discussion on ecological psychology and coordinative structures can be scaled and applied to business, industry, and markets. The environment relates to the market, competitors, and other external influencing factors. The human can be scaled to an organization or corporation with particular capabilities for product development (i.e., cognition, perception and action). Information relates to the artifacts and media utilized to attune the corporation to the market environment. What companies pay attention to is

dependent on how they are organized, what they perceive, and how they act utilizing information mediated by the interface.

Figure 2.5 shows a high level view of the interaction between corporations and their market environments. This builds on Figure 1.3 with the dimensions of Industry, Tasks, Strategies, Competencies and Social-organizational structure.

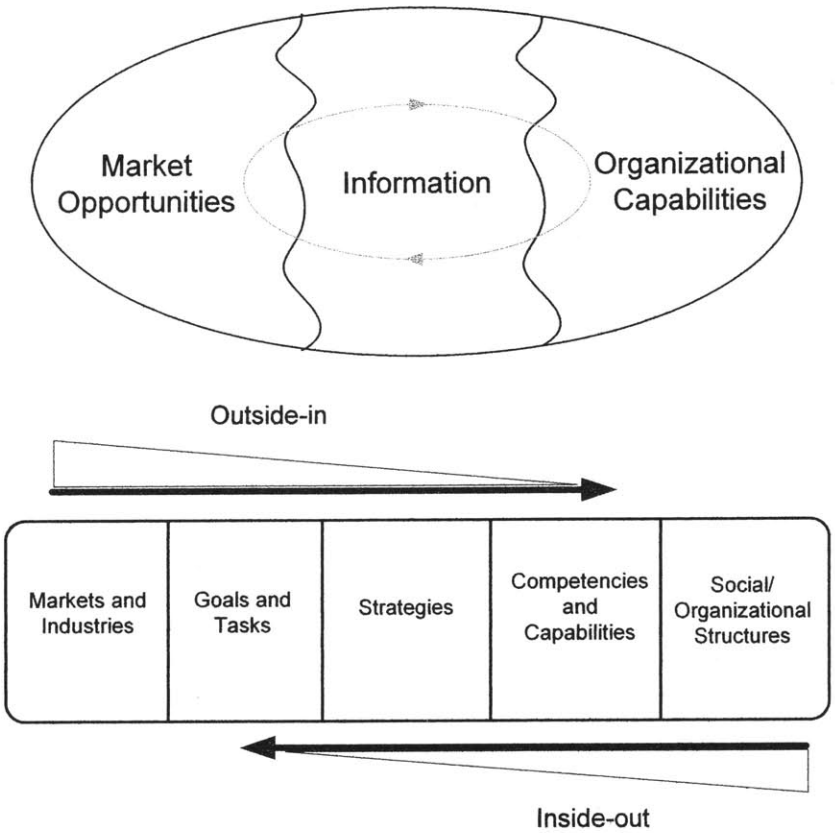

Figure 2.5: The role of information in organizational behavior and the tension between the influence of market opportunities and organizational capabilities.

Strategy is the point where corporate capabilities meet market opportunities. This is where information plays a critical role in informing corporations on signals to innovation, given their capabilities. Corporations that are heavily process-oriented will look at markets and opportunities on very specific ways. There are efficiency benefits to

this but step-out or breakthrough opportunities may be missed. In addition, these corporations will find it difficult to adapt to changing market environments. Alternatively, corporations that are outcome-oriented and effectively mobilize resources to achieve these outcomes can adapt to market changes more readily, switch strategies, and capitalize on innovation opportunities.

Many perspectives from business could be mapped onto this structure (Figure 2.6).

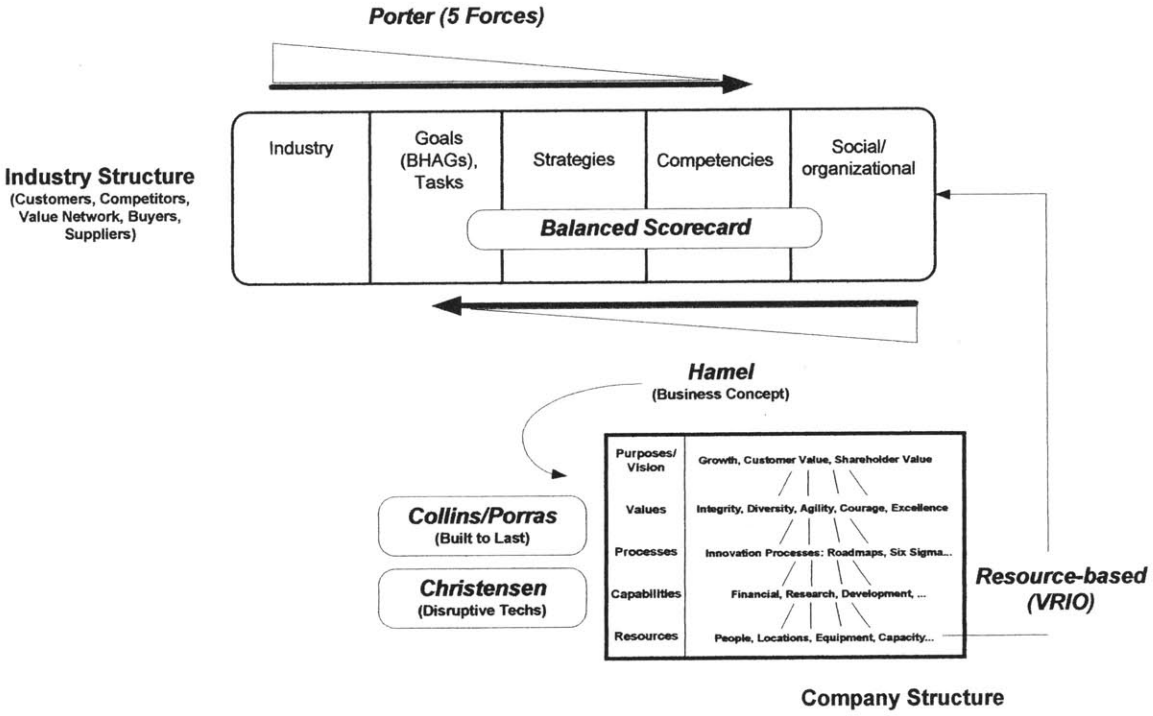

Figure 2.6: Business framework perspectives on the model shown in Figure 2.6.

Mapping of Porter's five forces (1986) is predominantly an outside-in view of corporations, revealing constraints in the market that can shape corporate action. Conversely, the views of Hamel (2000), Kaplan and Norton (Balanced Scorecard; 1996) and Christensen (1997) are inside-out, revealing how companies and their capabilities can

shape markets. Depending on the market context and timeframe, success will be determined on how well a corporation senses the market and which strategies will be most successful based on the context. The importance of how a company interfaces with the world, which lenses it chooses to develop, how it interprets signals, and how it adapts to change will influence its ability to succeed in different situations.

Six Sigma and the Product Development Process

Six Sigma is a business strategy with a set of tools and processes to systematically identify and eliminate causes of errors, defects, or failures in business operations by focusing on outputs that are critical to customers and the corporation. It incorporates rigorous measurement techniques to assess quality, and strives for near elimination of defects (i.e., anything which could lead to customer dissatisfaction) using the application of statistical methods (Pande, Neuman, & Cavanagh, 2000). In the context of Figure 2.5 it is a focus on processes and procedures to identify customer needs and requirements, and delivers these efficiently.

Six Sigma has been incorporated in product development to increase the chances of product success and minimize costs and waste in the process. For illustration, Figure 2.7 shows a typical product development process, similar to the one followed in many large organizations (Fortune 50 companies). Typically there are a number of stages, each with a gate review or screen, which define, align, and assess product milestones, opportunities, and risk. Concepts are transformed, narrowed, and combined through the stages. The development process from beginning to end could take 3-5 years, depending on priority.

Each stage utilizes a number of Six Sigma tools to assess, rank, and channel product requirements based on customer needs and corporate constraints/capabilities.

For example, the "Critical to Quality" and "Voice of the Customer" tools capture customer needs and requirements; "Quality Function Deployment" aligns and prioritized requirements and company capabilities to customer needs; "Failure Modes and Effects Analysis" assesses product risk. Most of these tools are rooted in statistics with an emphasis on 'mean' customer results for development decisions.

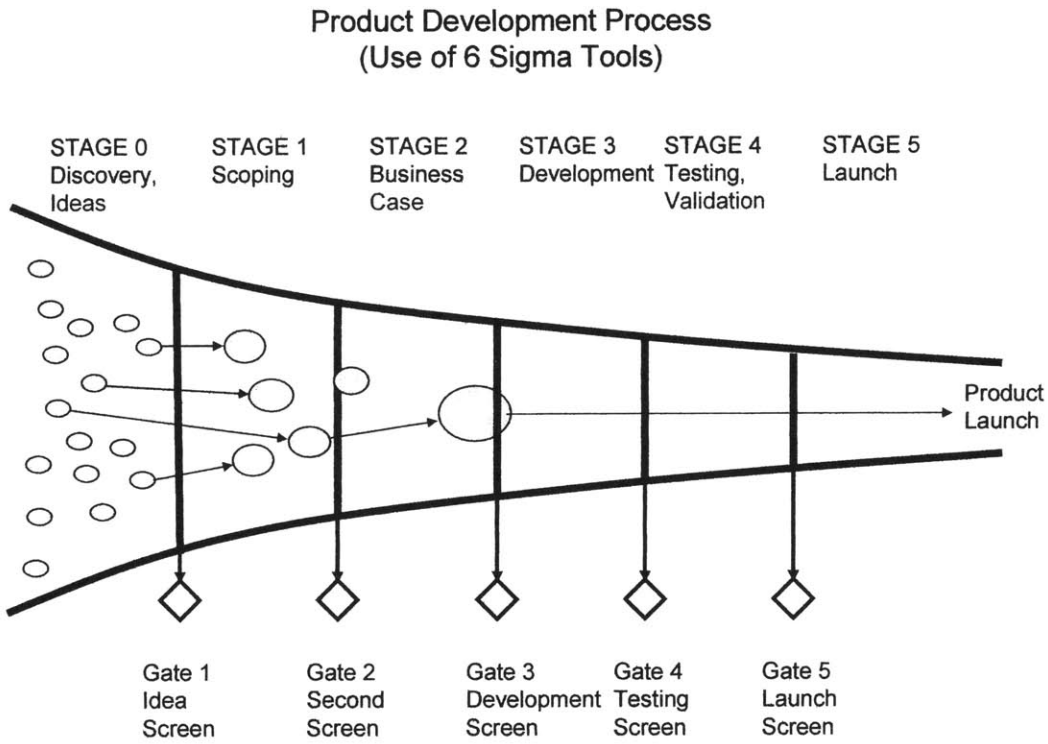

Figure 2.7: Typical stages in a product development process using Six Sigma.

The early stages (Stages 0-2) have high flexibility and require relatively fewer resources compared with development and testing. Ideas are generated based on an understanding of customer needs. Larger organizations typically have targeted their best customers, ones that offer the most revenue and margins; this provides the basis for the business case. From these activities, requirements and concepts are generated and ranked by these customers. At the same time, the company assesses its capabilities, resources,

and schedules in delivery. Once these activities are complete, detailed development, testing and validation occur (Stages 3-4). Finally, the product is launched based on the marketing strategy, positioning, and segmentation (Stage 5). The main levers and flexibility in the process, with minimal impact on resources, are typically at the early stages and launch stages. It is very important to frame the requirements appropriately before development because any errors could significantly increase the risk of product failure and/or increase development costs and time due to rework.

There are a number of key benefits to Six Sigma. First, the processes and tools help ensure product requirements align with customer needs and corporate capabilities, improving consistency and the probability of product success. Second, by making explicit the processes and data on operations effectiveness, product development can be continuously assessed and improved; Six Sigma helps identify opportunities for alignment across businesses and functions, and can improve operations quality and efficiency with the elimination of waste and design defects. Third, this approach has a common product development 'language' that the entire company understands; this will result in fewer problems or errors as product concepts get transformed to end products through different parts of the organization (possibly globally).

In spite of these benefits, there are a number of limitations. First, creativity and innovation are inherently high variance activities (i.e., there could be high variability in generating and combining ideas); Six Sigma may constrain these activities to the extent that primarily incremental improvements occur in internal product development. Second, Six Sigma presumes the company is targeting the 'right' customer. Typically, these are current customers that provide the highest historical revenues and margins; this strategy

will limit benefits to sustainable or incremental innovation. Not much attention is provided to peripheral/edge or other potential customers. Third, many of the Six Sigma tools are statistically-based with a predominant focus on 'mean' customer inputs. This drives the product development process to the average user and does not exploit the outliers (lead/edge users); the company may miss out on disruptive or breakthrough innovations created by these groups already. Fourth, Six Sigma requires large amounts of data for analysis purposes; it is difficult to measure aspects of new and/or breakthrough innovations. Fifth, at times, customers may not be able to articulate their needs (especially latent needs) or reactions to abstract requirements; customers tend to focus on what they are familiar with and incremental improvements. Six Sigma takes these needs and requirements as inputs to the entire product development process. There is a danger of missing breakthrough innovation opportunities.

Given these benefits and limitations, there is evidence that Six Sigma is very good at systematically eliminating waste and incrementally improving products; however, its ability to support breakthrough innovation is significantly limiting. Are there ways to systematically incorporate breakthrough innovation techniques in a Six Sigma context? If so, this could result in higher growth opportunities for large organizations and minimize the risks of missing disruptive forces.

Innovation Processes

Innovation processes can be wide and varied, ranging from accidental outcomes to planned variation exploration. This section gives some examples of practices and processes that occurred to achieve certain innovations. It is not meant to be a definitive review of innovation practices (it is clearly not comprehensive), but provides an idea of

how innovation can occur and some preconditions to increase the chances of innovative outcomes. The main point to take away is that innovation processes can vary, they encourage exploration, discovery, novelty, and surprise, they rely on highly adaptive forces, perception, and coordinated action, organization can have a significant influence on results, and one does not necessarily know the outcome *a priori*. This is in contrast with structured processes that aim to improve predictability and consistency in results.

In the first example, the ten faces of innovation (Kelley, 2005), the author discusses strategies to perceive the world, explore, discover, organize, and build innovations through personas – learning, organizing, and building. Learning personas gather new sources of information by going out to the world and developing a deep understanding of it. Organizing personas figure out how to move ideas through an organization (e.g., for development). Building personas apply insights from learning personas and utilize the capability of organizing personas to make innovation happen.

- The Anthropologist (Learning) – This face observes human behavior and understands how people interact physically and emotionally to products, services, and their environment (ethnography).
- The Experimenter (Learning) – This face creates prototypes continuously, learning by trial and error.
- The Cross-pollinator (Learning) – This face explores other industries and cultures, and translates findings to align with customer or development needs.
- The Hurdler (Organizing) – This face understands that innovation can take a convoluted path and knows how to move ides by going around roadblocks.

- The Collaborator (Organizing) – This face brings people with very different perspectives together to create new alternatives through combinations and multidisciplinary solutions.
- The Director (Organizing) – This face directs and coordinates staff and helps create sparks from their creative talent.
- The Experience Architect (Building) – This face designs compelling experiences that tie to deep customer needs and go beyond a mere list of functionally contained within.
- The Set Designer (Building) – This face creates and transforms the environment from which the innovation team members can do their best work.
- The Caregiver (Building) – This face anticipates customer needs, is focused on service to the customer, and ensures the innovation aligns with customer needs.
- The Storyteller (Building) – This face builds energy, morale, and awareness through compelling narratives that tie to a human value or cultural trait.

Through the above personas, it is clear to see that there is a deep focus on the customer and problem area, a need to understand of human behavior, a need to explore and discover, an emphasis on connecting varied perspectives in teams, a focus on communication across stakeholders, and a commitment to deliver. There is less of an emphasis on [the right] process, and more of an importance on outcomes, perspectives, and personas.

In the second example, user innovations or lead users studies (von Hippel, 2005), innovation is discovered by observing and connecting with lead users. A primary focus in on identifying macro-trends in a particular area of interest, identify people and

environments that are experiencing similar pressures of the anticipated market today, understand how they are dealing with these pressures and fill in product/service gaps, and integrate their perspectives to come up with novel breakout solutions. This approach provides a particular and unique focus and target on the learning personas previously discussed. The activities identified provide a vehicle for discovery and exploration, and a focus on particular macro-trends and pressures. In many cases, there is a separation or isolation from current mainstream market offerings or segmentation strategies, since the target could be characterized very differently.

In the third example, organizing for innovation, there are many advantages and limitations of co-location and distributed teams. Allen (1977) has stressed the importance of both physical proximity and visibility for creating levels of interaction and communication that are necessary for innovative product development; proximity supports spontaneous interactions as creative ideas are generated and transformed. Spontaneous communication decreases rapidly as a function of physical distance, although this effect may be mitigated by creating visible connections to others' work areas (e.g., dedicated and visible project rooms). However, corporations are becoming more global and distributed, due to such factors as pre-existing geographical distribution of personnel, mergers and acquisitions, economic interests, outsourcing, and distributed customer locations. Globally distributed teams can confer distinct advantages by bringing together team members with talents and expertise that are not available locally. Technologies for distributed collaboration can support work habits that actually increase productivity, by allowing easier access to information and supporting rapid decision-making. Finally, distributed teams can integrate the benefits of local networks – each

team member can consult local experts and share their resources with distant team members. This argument is corroborated by Allen's (1977) finding that, when engineers move, they temporarily carry connections from their old locations with them. With these benefits, there are also the following limitations that need to be managed: communication is less efficient and is error-prone and product development team members can be disconnected and poorly coordinated.

From the above examples, there are a number of key benefits of innovation processes. First, there are greater chances to discover breakout innovations because there is an emphasis to look outside current product and service paradigms, explore the design space, cross-pollinate ideas, and focus on outcomes (not process). Second, many of the activities require some disconnection or isolation for creative activity to nurture; this helps the team think outside the current approaches in the market and discover new product and service concepts. Third, there is a shift in the definition of the target; innovation processes can help the team look beyond a local, incremental target, and anticipate market shifts to create competitive advantage.

Despite these benefits, there are also a number of key limitations. First, innovation processes can be unpredictable and take a long time to converge on an effective solution. Second, the processes can vary and need to be adaptive to the product development and customer need context; it is difficult to define a systematic approach that independent of this context. Third, it becomes harder to innovation as the extent of distributed teams increases. This is primarily due to communication problems, disconnected behaviors, and asynchronous or uncoordinated activities; systematic

processes and norms help mitigate these challenges but could also create disincentives to innovate.

The above benefits and limitations of innovative processes help an organization expand the 'field-of-view' for product development opportunities, but can be inefficient from a process point of view. Combining innovative and structured approaches could lead to complementary benefits in product development (see discussion chapter).

Case Study – VisionPRO Thermostat

To investigate the theory and arguments made above, a case study is presented in this chapter – the VisionPro Thermostat – that required both creative and structured processes for market success. As you will read, the road to success was not a direct one; there was initially significant resistance and a number of false starts. The resistance could be attributed to a lock-in to corporate processes, a predominant focus on the cost-side and an aversion to risk. The company went outside its boundaries and outsourced some key aspects of marketing and design to a creative design firm. The results required interfacing back to the main company for effective transfer of designs while taking advantage of streamlined, structured manufacturing processes. This case study dissects the activities that led to the outcome, including some of the lessons learned when innovating in large structured organizations. The results of case interviews with various stakeholders in the program are presented. The next chapter discusses the results in a broader context and relates this back to the theory presented for ecological psychology.

Methodology and Hypothesis

The case study utilized primarily a case interview method and analysis of corporate documentation to assess the factors that led to the success of the VisionPRO Thermostat. Based on the theory and arguments in the previous sections, a key hypothesis is that it is difficult to innovate with highly constrained, structured processes and the mechanisms for innovation will need to be isolated to breed from this culture. Also, success will happen when there are good transfer mechanisms to the corporation for implementation and delivery.

Case Introduction and Background

The VisionPro Thermostat is a Honeywell product that was intended to increase market share and revenues. Honeywell has had a 120 year legacy in the thermostat business with a product line that was stagnating (Figure 3.1). The company was experiencing a 1-2% share loss per year due to competitive pressures from major electro-mechanical and electronic competitors. Also, the number of helpline calls was significant at about 400,000 calls per year, revealing problems in the product line (e.g., difficulty in programming). Honeywell was not the only company that could not create a breakout in the market; the industry did not have a thermostat product or product line that was easy to program or install. Clearly, something different had to be done.

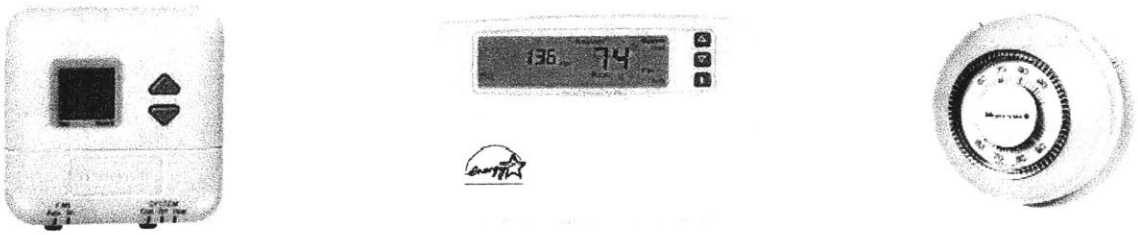

Figure 3.1: Examples of legacy Honeywell thermostats.

During the case interviews, it became clear that the company attempted to improve the product line through internal initiatives but was confronted with some challenges. The business funded product development efforts but the results primarily were in incremental changes and yielded a design that would not conceivably break-out of the current market position. Executives eventually went outside the company and contracted a design firm to work with Honeywell stakeholders to define a program and

breakout concepts for a sustainable product line with platform potential (i.e., ability to create variations on the product to suit different market niches).

The response and result was the VisionPRO Thermostat (Figure 3.2). The goal of the program was to change the homeowner's relationship with Honeywell and the company's role within the home by rethinking the traditional home thermostat. This program was the foundation of a sustainable business strategy that would position Honeywell as a market leader through innovation. The product's features and benefits included optimizing ease of use and increasing consumer awareness of efficient energy usage. The broader goal was to develop a strategy that would become a driver for short and long term profitability within other product lines and systems. This would enhance product and brand loyalty, help establish barriers to entry, and create new revenue streams for growth.

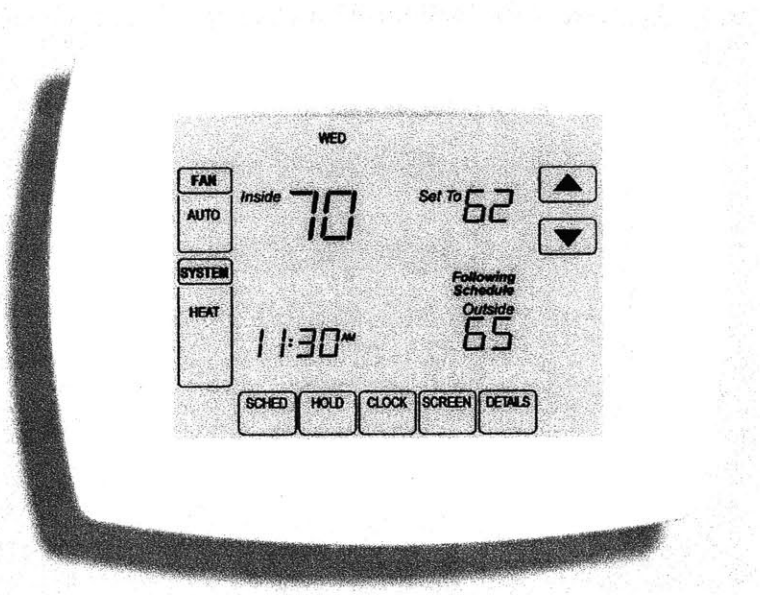

Figure 3.2 Honeywell VisionPro Thermostat.

This program was based on the focus of a developed product category for the high end of the Honeywell product portfolio. This would form the foundation for user interaction metaphors and design principles that would be utilized in the next generation of related products developed by Honeywell. In the end, the VisionPRO was well received in the marketplace and provided significant revenues and profit to the corporation.

Program Summary and Results

The program was divided up into multiple phases with an outsourced design contractor taking the lead for the upfront discovery and concept phases. Honeywell stakeholders interacted with the contractor and ensured that proper interfacing with internal development occurred. A number of artifacts and tools were used and were common across the two organizations; this helped with the transfer between creative and structured processes. Roles were distributed throughout the product development process and involved customers, marketing, engineering, manufacturing, supply chain management, finance, and legal. The activities included conducting comprehensive consumer and multi-channel research, industry analysis, voice of the customer inquires, return on investment assessments, capability reviews, concept development, sourcing options analysis, intellectual property reviews, producibility analyses, design optimization, product requirements specifications, and project plans. The design firm played a primary role in the marketing with extensive customer interactions and concept development.

The product development team spent a significant amount of time in the field to understand stakeholder behavior and deep customer problems. It was an iterative process

with that resulted in validation or dismissing existing data, and the uncovering of new insights. It focused on both the installation contractor and homeowner as key customers. Research was representative and took place in at least four cities to represent different applications, climates, demographics and construction types. The team also used an increasing amount of quantifiable metrics to zone in on the target (Figure 3.3, 3.4, and 3.5) and reduced development cycle time by creating portable, reusable, and easily modifiable software code with embedded user interface models; this code ran on a touch-screen display, Windows, and the target system.

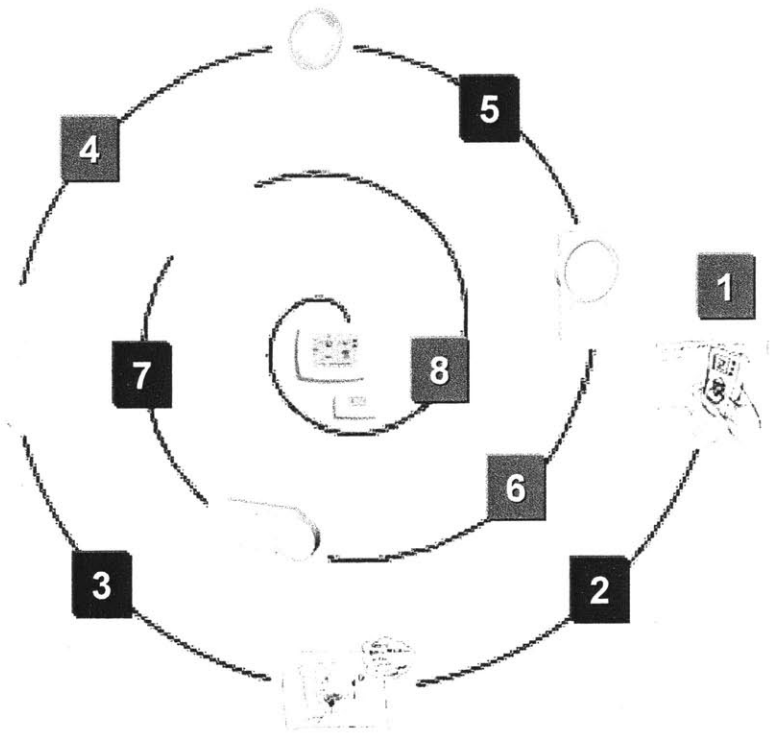

Figure 3.3: Spiral iteration from exploratory concepts to product.

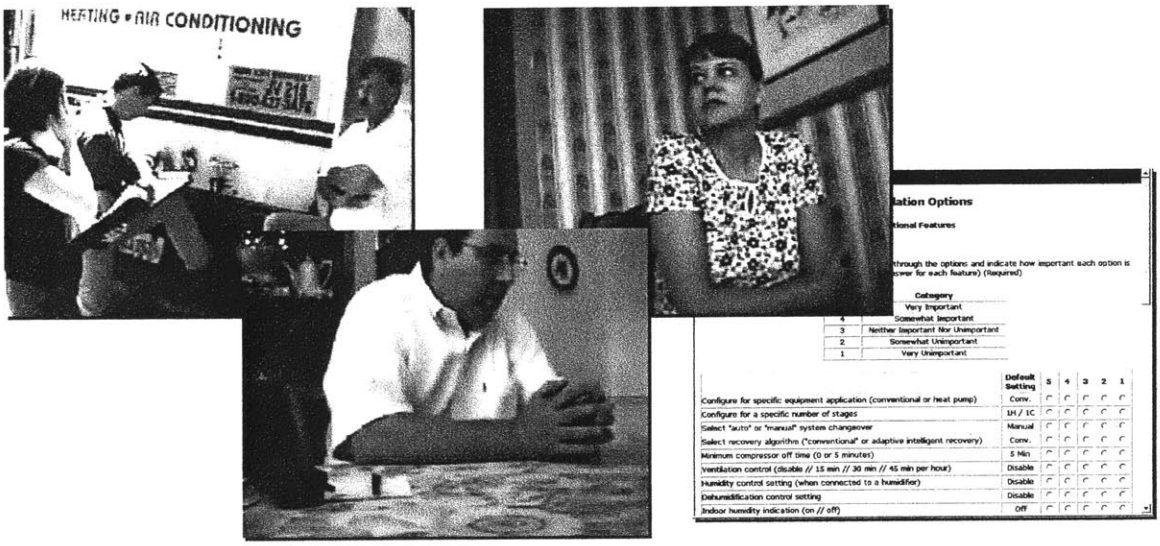

Figure 3.4: Field interviews and observations in various phases.

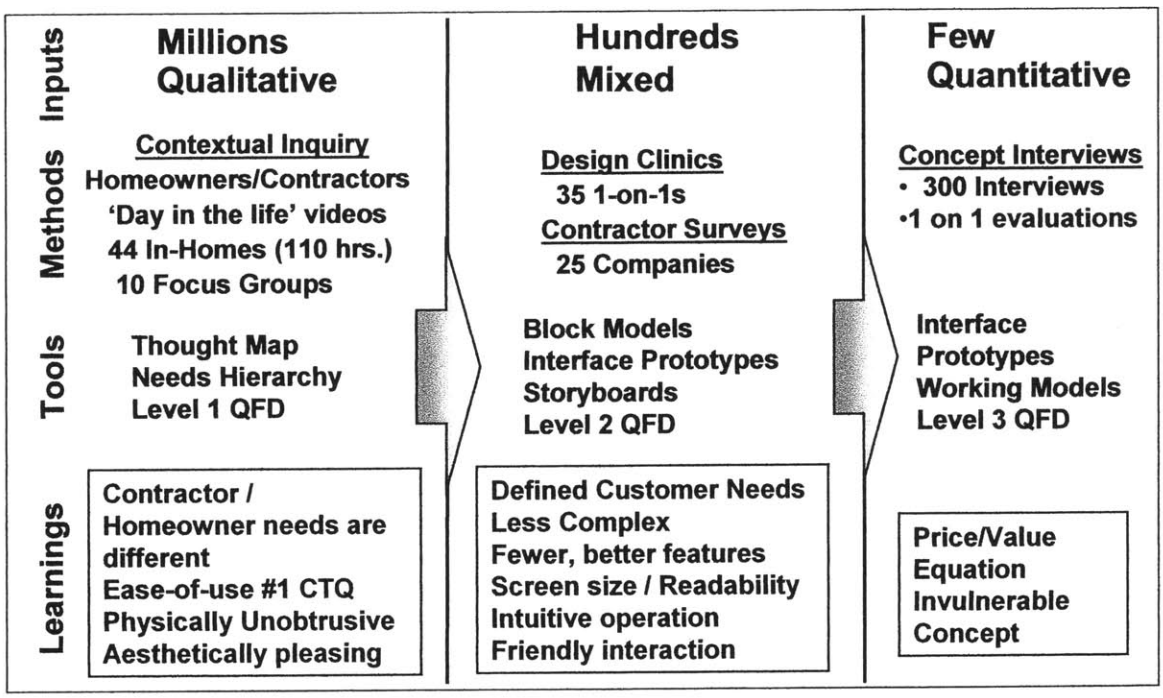

Figure 3.5: Inputs, methods, tools, and learnings from at different phases of data collection.

The following points note the program summary from market research and conceptual design strategy through production design and production. The phases build on the results from previous phases (Note, the numbering of phases is different compared with Figure 2.7, but there are common activities that align):

- Discovery Research and Opportunity Identification – In this phase, the project was initiated, a design firm was selected to fulfill the research (market and user interface) and opportunity identification role. A research plan was developed for the upfront activities. Market research was conducted to gather information that provided the basis for the new, innovative thermostat product(s) or product line. The goal was to identify opportunities for a unique product offering, which will break the industry paradigm and set a new standard for thermostat products. The methodologies utilized for data collection included Discussion Groups and Contextual Inquiry with users and installers of thermostat products. Contextual Inquiries involved observing, video taping, and probing end users in their actual environments. These analyses were very deep and detailed (2 hours each in 44 Consumers homes; 3-5 hours with Contractors on the job; 110 total hours). The team captured what people thought and did as opposed to what they said.
- Needs, Features, Concept Strategy, Development – In this phase, high level Consumer and Contractor research was conducted and the team utilized quality function deployment (QFD) matrices, Consumer and Contractor needs hierarchies, and prioritized functional requirements. The team explored different concept strategies in design sessions based on the insights and discoveries gained. From this activity, it became clear that there were differences in the needs and

prioritization of these needs between Contractors and Consumers (Homeowners). The design firm then developed the most promising concepts exploring different approaches to user interaction, product configuration, product location, use scenarios, and features. The interfaces were intended to provide a unique market differentiation with an architecture that would be the foundation for future products and systems. The goal was to develop an interface that would become the center of the brand strategy for the product line and for the company.

- Design – Design Development – In this phase, the unique interface design concepts were further developed and industrial design concepts were refined in preparation for initial design validation and testing. The industrial design language formalized key product attributes and served as a guideline for future products to establish a visual identity for the product line.
- Research - Design Validation – In this phase, user research was conducted to validate the design concepts developed. From the research, a single design direction was selected for further refinement. This phase focused on measuring the concepts developed against the objectives established in the first phase. Concepts were shown to users to assess how well they fulfilled the value proposition. The team was also able to assess features and benefits at a deeper level, and look at branding, price sensitivity, and user interaction. Design Clinics were conducted as one-on-one concept evaluations utilizing block models, storyboards, and ranking exercises; these stress tested the designs using specific executions of the product.

- Design – Design Refinement – In this phase, the interface and industrial design were further refined. The concept was transferred to working test models. These models were used to validate the functional aspects of the interface and the product's design.
- Research - Quantitative Research – In this phase, quantitative measurements were used when assessing the selected design direction with end-users. Concept Interviews were conducted and provided a more realistic representation of the design concept – a previsualization of the design concept. Product models were used that approximated the final solution as closely as possible in appearance and function. The evaluation helped optimize the product by focusing on relative to specific features, attributes, and value. This phase also included a Web Survey to evaluate user interface issues. This phase allowed the team to perform a final evaluation and validation of product features and intended performance characteristics before prototype development began, providing downside risk reduction for development.
- User Interface and Product Development – In this phase, the user interface and the product design were now controlled. The product specification was frozen. This included capturing the industrial design into a Pro/Engineer database to transfer the industrial design specifications to Honeywell.
- Design - Prototype Fabrication – In this phase, a production-like prototype was developed of the physical product enclosures, integrating the interface design requirements.

- Production Development – In this phase, any revisions were incorporated from the prototype evaluations and testing. The software was designed for reuse and easy modification to enable a quick turnaround in late-stage design changes. The user interaction and product for were then finalized and transferred to the internal manufacturing department. A number of objectives were identified: 1) the design needed to conform to producibility standards (e.g., standard size panels, component spacing, etc); 2) the design needed to conform to the most capable manufacturing process; and 3) process steps and non-value added activity were minimized.
- Production – In this phase, the thermostats were manufactured. Honeywell initiated a strategy to improve the ease of manufacturing. The device required 6 main process steps to manufacture; previous developments took approximately 18 steps for similar devices. In addition there was one board that matched the capability of manufacturing. Finally, statistical analysis showed a high level of quality (0.1% component critical to quality).

Market Outcome

The outcome in the market place was positive and significant.

- The product incorporated a market-driven feature set.
- It was best in class for ease-of user (90% higher as compared with representative competitors).
- Its display clarity was 60% higher than the competition.
- Its appeal was 2 times higher than the competition.
- It was easy to install with one product fitting all applications.

- There was a common design language (or look and feel) across the product line.

For the business, this product re-established Honeywell's thermostat leadership, there were numerous industry awards (Figure 3.6), technology was leveraged and intellectual property was generated, it drove the average selling price up and contributed to a 27% in organic growth.

Air Conditioning | Heating | Refrigeration
the NEWS

•The *News* Dealer Design Award 2005

•Building Products "Most Valuable Product" 2005

•Frost & Sullivan Building Technologies "Product of the Year" Award 2005

2005 FROST & SULLIVAN
Product of the Year Award

Other VisionPRO Awards

•TecHome Builder magazine /National Assn of Home Builders "Innovative Housing Technology" Awards -- (VisionPRO won in both "Energy Efficiency" category and overall "Home Technologies" category

•HVAC Comfortech Showcase Award – "Controls Category"

•2004 TEKNE Finalist -- MHTA

•2005 TEKNE Winner -- MHTA

•"Good Design-2004" award by the Chicago Athenaeum Museum of Architecture and Design

Figure 3.6: Industry awards for the VisionPRO.

Influencing Factors in the Success of VisionPRO

During the study, a number of factors were identified that made the product development process a success and enabled to company to release an innovative product line.

- Outsourcing to Enhance Creativity and Minimize Internal Biases – Bringing in an outside firm enabled the team to break away from an incremental and internally biased product development mode that was predominant in the company. The

company was a design firm with a culture that was in some senses opposite to Honeywell's (i.e., creative and less structure vs. highly structured). They brought in a creative perspective on the design issues, without an inside bias and with a focus on the user experience and market target.

- Market Research – The team conducted multi-dimensional market research and segmented end users to define their specific latent and apparent needs. The significant amount of work observing the end users (Contractors and Consumers) in the field enabled the team to understand the relative priorities and concerns. A key insight was that Contractors and Consumers have different needs and priorities; averaging their inputs together would increase the risk of dissatisfying both groups. This also mitigated the team from introducing too many features on the thermostat that would make it hard to use and not be utilized. This also provided a perspective on what people valued most in the thermostat product lines.
- Collaboration with Cross-functional Teams – Marketing and Engineering groups worked hand-in-hand during the initial stages of the project to ensure good transfer and communicate constraints in development upstream and downstream. As Marketing sorted the Voice of the Customer, that data is used in the Planning in order to produce the critical Features with target specifications. This information was taken by Engineering to start defining potential solutions that could be implemented. In the end, Marketing and Engineering again come together for implementing the launch of the new or revised product.

- Interfaces Between Creative and Structured Processes – Mediating interfaces were created to enable the transfer of results from the design firm and different stakeholders in the product development team. These interfaces were both formal and informal. They utilized Six Sigma as a language for transfer, but did not constrain themselves up front with Six Sigma processes. Figure 3.7 shows the separation between the creative processes (Growth) and structured processes (DFSS – design for six sigma); the interfaces provided the transfer hand-offs across the groups. In addition, transfer happened through people. The team member met face-to-face in design sessions and end-user field reviews. Certain team members also were co-located at specific times in the project.

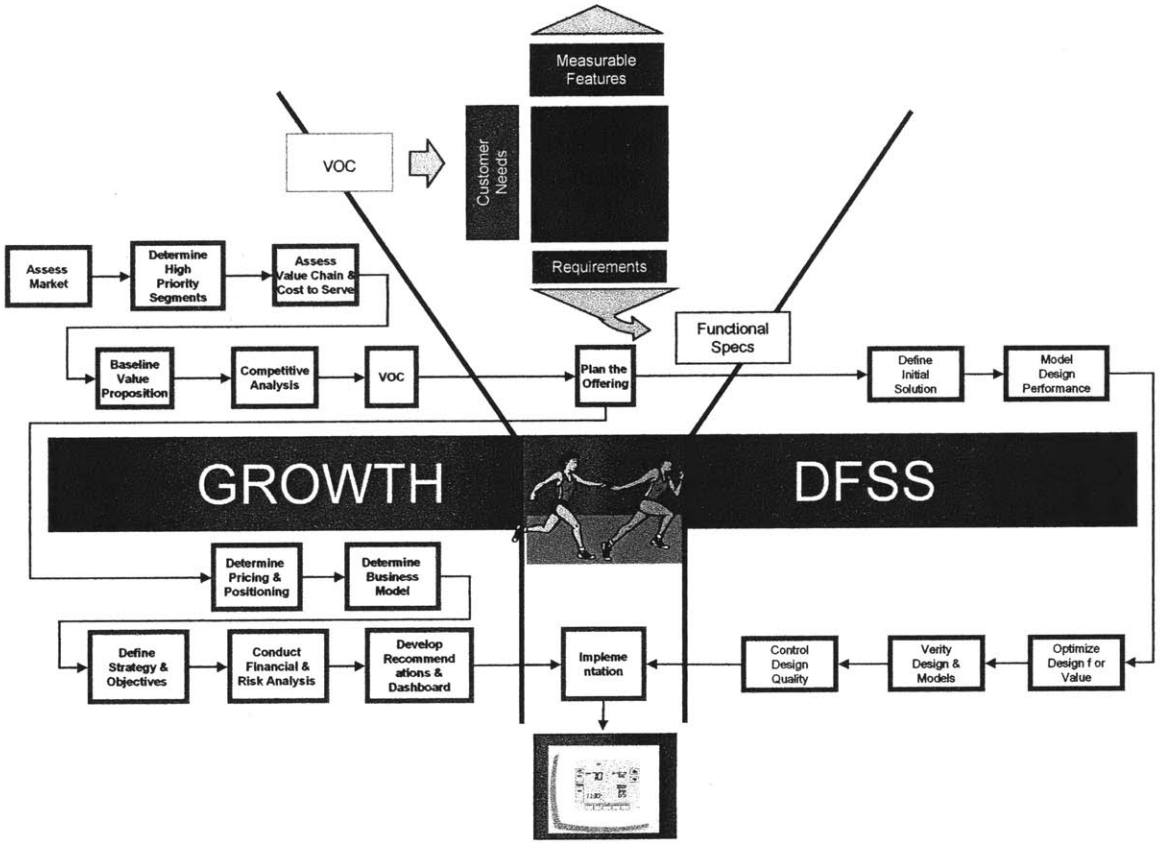

Figure 3.7: Interface between the creative processes (Growth) and structured processes (DFSS – design for six sigma).

- Location – Creative Isolation, Customer Immersion – Many of the focused activities happened outside Honeywell facilities. This enabled the team to focus on the customer problems, alternatives in the design space, and critical needs. The entire team was involved in the design process, which provided both a source of concepts and also served as a communication mechanism for individual perspectives. In this case, a separated, creative environment contributed to an innovative result – a contributing factor that I call creative isolation.
- Previsulization of Product Concepts – The team used various techniques to pre-visualize the product concepts before development. Initially, paper drawings were generated from many ideas for the user interface and device industrial design. These were debated and shown to the customers and stakeholders to get their reaction (market signals). Rapid prototyping, including the use of storyboards and interactive prototypes, enabled greater fidelity in the design that better showed the end user the product concept. These prototypes in the end directly served as the basis for the final design.
- Reuse and Easy Modification of Software in Late Stages – The interactive prototypes that were generated had code that was used inevitably in the final product. The software engineering team was able to create handles that allowed for quick late stage changes in the design without significantly affecting schedule.
- Manufacturing Excellence – The engineering and manufacturing groups heavily utilized Six Sigma and other approaches to achieve high quality in manufacturing with minimal complexity. The number of main manufacturing steps was reduced from 18 representative steps to 6 main steps. In addition, there was one board that

matched the capability of manufacturing. This was essential in driving down costs and improving the reliability of the product.

- Platforming – There was a significant amount of reuse and platforming in the product. In addition to the reuse of code in prototyping, the platform was able to support variations of the product to tailor to specific markets and needs. These variations were implemented at a great reduction in development effort. For example, one variation reused 95% of VisionPRO with a 75% cycle time reduction in development.

Discussion

The VisionPRO case study provides some important insights for innovative product development. Although there is a perception that innovation can be difficult to achieve in large organizations, the case study provides an example of how one may architect the conditions for success. There are clear benefits to combining innovations techniques, with the efficiencies and effectiveness of Six Sigma for product development and delivery. This means bringing together both high variance, creative, and innovation activities (e.g., exploration and discovery in market research) with low variance process efficiencies (e.g., manufacturing excellence).

This chapter discusses the results from the case study at a broad level with potential impacts on how companies can orchestrate more innovation in their product lines. First, some of the conditions that have led to successful innovation results are presented. Second, a number of alternatives for implementing innovation processes in large structured organizations are discussed. Finally, ecological considerations are discussed that tie the results to the theory previously presented.

Conditions that Improve the Chances for Innovation Success

Based on the results from the case study and discussions from the previous chapter, a number of conditions can improve the chances for innovation success and transfer:

- Create an environment that supports innovation processes. These need to be isolated from highly structured processes.

- Integrate highly structured processes for parts of product development that are clear, consistent, and predictable.
- Provide mediating interfaces and common languages between creative and structured processes.
- Match people, personalities, and organizations to product development activities with connected multi-disciplinary teams and social networks.
- Provide incentives to innovate at certain parts of the product development process.
- Develop a deep understanding of the customer and context using with multi-dimensional market research and field study.
- Use pre-visualization techniques to reveal the product concepts and designs at various stages of development.
- Define design languages that encapsulate the brand to guide the innovation approach.
- Implement fast, iterative prototyping with the facility to make changes at late stages in development.
- Implement reusability to decrease transfer effort through development.
- Enable platforming for to improve development cycle time, enable differentiation, and tailor to specific product markets.
- Create a portfolio of innovation approaches (incremental to breakout) to tailor to specific business goals. Apply appropriate strategies in organization and practices based on business goals.

- Create information momentum in product development to minimize the need for excessive communication (especially for distributed teams).

Alternatives for Implementing Innovation Processes

One of the main findings in the above case study is that to increase the chances of success for an innovation, there is a need for creativity and a separation from the highly structured process at certain parts of the product development process. There also needs to be an effective and efficient interface to the structured processes in an organization to take advantage of quality and speed in implementation downstream. There are many ways to support innovation in large organizations. For example, the VisionPro case study discussed how outsourced firms may facilitate a breakout process. There are a number of alternatives that can be chosen based on the situation.

- Outsourcing Innovation – This approach was taken by the VisionPro team for the design. An outside firm, in this case a design firm, was responsible to gather field data and create concepts for the product. They interfaced with the product development team to ensure that effective transfer occurred.
- Buying Innovation – This seems to be a common mode for delivering innovation in large organizations. Some large companies look for small and medium sized companies that have proven technology and emerging market success/potential; this may outweigh the time and risk in developing products and technology in-house.
- Injecting Innovation – In this approach, innovation techniques (e.g., core research, lead user analysis, innovation workouts) are injected into the early stages of the product development process. Innovation techniques are used as analysis

modules that help define technology, trends, customers, requirements, and preferences. The outputs are framed using a common 'language' (e.g., Six Sigma), so that other parts of the product development process can easily translate and absorb the outputs of the innovation techniques used.

- Incubating Innovation – In this approach, a part of the large organization is blocked off to identify and incubate innovations. A team is initially isolated from the product development process and funded appropriately to come up with new, step-out, or breakthrough innovations. Key stakeholders are assigned, collocated, and committed to the innovation process. The outputs are framed for insertion to development and interaction with downstream stages and product launch.
- Spinning-off Innovation – In this approach, a spin-off company (or organization) is created to develop targeted products. This organization is entrepreneurial, small, flexible, self-selecting, diverse, focused, and funded through investment by the parent company. Incentives for the team members mimic that of start-up companies with the challenges/rewards of product innovation and partial ownership options; this motivates team success. The concepts/requirements are fed back to the structured processes of the parent organization.
- Co-location and Dedicated Project Teams – This is one of the main strategies companies have use to speed up development and improve transfer quality to downstream development stages. Co-location and dedicated teams result in many informal, nonlinear, and adaptive behaviors across organizational functions. Communication quality is high and development transfer is fast. To do this well, people need to be interacting with each other frequently to get the "water-cooler"

effect. In cases where the team is distributed globally, face-to-face interactions can help at strategic parts of the development process to take advantage of the speed/innovation potential.

- Using Linked Tools Across Functions and Development Stages – One area companies are exploring is the use of computer-based tools that link different organizational functions and stages in development. The goal is to make transfer seamless and translate knowledge to formats that upstream/downstream processes can build on (and not have to reproduce or translate). Instead of documents, automatic code generation and embedded intellectual property could be incorporated that makes it easy to align and trace the development effort; this could minimize errors, rework, and communication inefficiencies.
- Creative Isolation Sessions – To better facilitate creative thought, product development teams and customers can isolate themselves from their day-to-day activities after they have a good understanding of the target. Dedicated design workshops in a separate location can help the team focus on the design problems, deep customer needs, expand the design space, and assess trade-offs.
- Distributed Teams – With the advent of globalization, there is an advantage to having teams distributed, because it can provide a sense of separation, which allows the group to better engage in creative processes. The challenge is communication. This has been a challenge and primary source of failure in many organizations. Some parts of the VisionPro team were distributed; the design firm was located in California, the core product development team was located in

Minneapolis. To mitigate the communication problem, the team connected face-to-face for extended periods of time.

With the benefits and limitations noted above for each alternative, the path to choose will most likely depend on the innovation, people involved, and customer, market, and corporate context.

Ecological Considerations

In some ways, the above discussion can be explained by the theory presented in the second chapter. The three main areas from an ecological perspective are: market/product environment, information, and organizational capabilities.

The market or product environment can be dynamic, can have barriers, and can afford business opportunities. Within it, end users have existing, emerging, and latent needs that provide opportunities for new product development. When the environment is relatively static, the functions and features that are required are relatively stable. Structured processes can help optimize offerings to localized niches. However, as markets, technologies, and product environments change, the associated needs of customer groups may also change. Companies need to keep track of this and anticipate the dynamics.

A company that is organized with highly structure processes only sees and interfaces with the world in a particular way. The company will have specific processes to follow and only seek and focus on particular pieces of information that drive the design process. Much of this relates to current product offerings, incremental changes to product lines, and competitor offerings. In doing so, they could miss significant opportunities because they are not attuned to the higher-level market or product

opportunity environment and its dynamics. However, this structure is well suited for decreasing variances in quality and providing greater efficiency in delivery. Once product concepts are developed, the organization can mobilize to deliver the product efficiently.

On the other hand, organizations that are predominantly creative and innovative have a wider and higher-level view of the market and product space. They focus or attune to information that is tied to deep customer problems and identify practices and approaches that help solve these problems. The information they attune to is different in the sense they can track market dynamics more readily. This ability to explore the market environment can take more time compared with practices that are highly structured, however the organization is better able to adapt product lines and anticipate market trends.

Bringing these concepts together, it is useful to try and create a balance between the creative processes that are important for innovation and the structured processes that are critical for delivery and implementation. Some methods to do this have been identified earlier in this section. Previsualization and visibility around the product concept can also help tailor and zone in on an effective outcome.

Figure 4.1 shows how this can be accomplished through the product development process. Previsualization reveals the product affordances (i.e., how the product can align with customer needs). Starting from the left, the creative and high variance processes are critical in defining the right targets, discovering requirements, and identifying concepts. Previsualization enables the team to evaluate the product concepts more easily with customers and get market signals. Once validated, the concepts and prototypes are

transformed, reused, and interfaced with the development process. Here, platforms, manufacturing processes, and engineering practices using Six Sigma and other structured processes, can decrease the variances in achieving a quality outcome. Through platforming, differentiation can occur across the product line to tailor to specific customer needs and niches. The added benefit to the structure is that now there is traceability. In this way, the company can be better attune to market opportunities, innovate with high variance to cover the design space, and take advantage of low variance development efficiency and delivery.

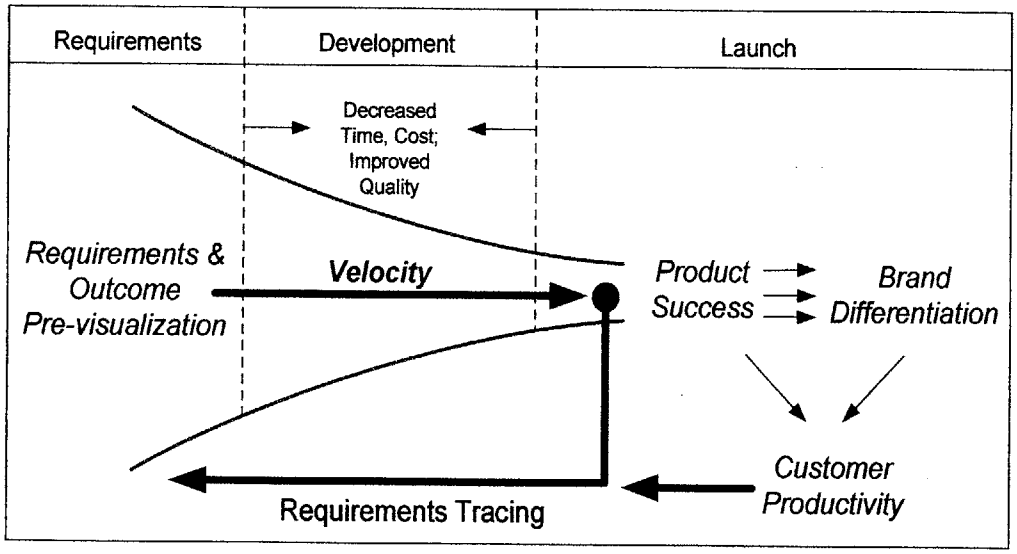

Figure 4.1: Previsualization and development speed in product development.

Conclusions

This thesis set to explore how step-out or breakthrough innovation can happen in large organizations that are focused primarily on stability, risk aversion, and efficiency. Innovation and structured processes (e.g., Six Sigma techniques) each have their strengths in product development. They seem to be at odds with each other. Six Sigma is more focused on quality, efficiency, and low variance with a predominant bottom-line focus (cost). Breakthrough and out step-out innovations are primarily focused on the top-line (revenue), and can be high-variance with inherent 'inefficiency'; this inefficiency can be a source of surprise and innovation. The thesis showed that the complementary benefits of both approaches can lead to significant, sustainable growth in corporations.

The contributions of this thesis include the identification of a need for isolation or separation between innovative and creative processes at certain parts of the development process to take advantage of the complementary benefits, good interfaces between these processes, a common language that facilitates communication across all stakeholders, and a good transfer mechanism through to development and production.

These findings were insightful, however the thesis has some limitations. First, the results were based on an after-the-fact assessment of a product development effort with qualitative interviews. A-priori metrics could not be employed to objectively assess the project as it was happening. Second, the case study assessed a particular product in a particular industry and timeframe; there are limitations in how these results scale or generalize.

These limitations provide insights into future research considerations. First, one may follow a product development effort while it is happening and record the lifecycle while assessing project activities; at the same time, objective metrics can be employed. Second, one can assess two separate teams focused on similar product development efforts and manipulate approaches as development measures are assessed. Third, alternative innovation processes could be assessed (e.g., lead user analysis and user innovations) in terms of their merit and compatibility with structured processes. Finally, one may look at cultural factors in organizing global teams for innovation.

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