Imitation in Large Complex Organizations: When Does Copying Become Learning?

by

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Give peace a chance.

DEDICATION

This work is dedicated to my mom. Julia Mary Pyle, a woman with a warm heart and bright smile who may not have understood what I did or why, but she was always interested and delighted in my accomplishments.

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List of Abbreviations

ASI	American Supplier Institute
CEO	Chief Executive Officer
DFMEA	Design Failure Mode Effects Analysis
DFSS	Design-for-Six-Sigma
DOE	Design of Experiments
EWB	Engineering World Book
FNA	Functional Name Address
FNM	Functional Noun Modifier
GM	General Motors
GMAD	General Motors Assembly Division
GMS	Global Manufacturing System
GPDS	Global Product Description System
GVDP	Global Vehicle Development Process
I/O	Individual/Organizational
IQS	Initial Quality Survey (J. D. Power)
IT	Information Technology
JV	Joint Venture
NA	North America
NPD	New Product Development
NUMMI	New United Motor Manufacturing, Inc

P – D – C – A	Plan – Do – Check - Act
P – D – S – A	Plan – Do – Study – Act
QFD	Quality Function Deployment
RPO	Regular Production Option
TPS	Toyota Production System
TRIZ	Russian Acronym for Innovation
UPC	Unified Product Code
UMD	Unified Model Designator
VAS	Vehicle Architecture Structure
VDP	Vehicle Development Process
VE	Virtual Engineering

Chapter 1

IMITATION IN LARGE COMPLEX ORGANIZATIONS: HOW AND WHY DO ORGANIZATIONS COPY EACH OTHER?

INTRODUCTION: IMITATION IN AN ORGANIZATIONAL CONTEXT

Performance differences between firms put the poorer performing firm under competitive pressure; such differences signal investors, customers, current employees and prospective future employees where to invest, shop, or work. Consequently, performance gaps warrant the attention of the responsible decision makers. A firm that faces a performance gap has fundamentally three options: (1) it can exit the industry, (2) it can develop an entirely new product strategy to regain its competitiveness, or (3) it can attempt to imitate the processes and procedures of its superior competitor in order to level its competitive advantage. Options one and two are primarily strategic, whereas the third one is primarily organizational in nature. In this research I focus on the third option.

A firm attempting to imitate industry leaders in the hope of achieving the same output is a widely observable phenomenon. The widespread use of benchmarking techniques and the identification of best practices are indicators of an inter-firm copying process. Additionally, several academic disciplines provide theoretical frameworks explaining why firms differ and then strive to imitate each other. Both sociology and economics have developed theoretical frameworks to explain this behavior. Institutional theory, provided by sociology, suggests institutional factors are responsible for increasing homogeneity across firms as industry laggards imitate superior competitors (Meyer and Rowan 1977; DiMaggio and Powell 1978; Zucker 1987; DiMaggio and Powell 1991).

An alternative explanation comes from evolutionary economics. Beginning with the premise that firms differ due to managers' inability to foresee an uncertain future and the path dependency of their associated decisions, evolutionary economics predicts firms will adapt or perish based on organizational change contingent on three processes borrowed from biology: variation, selection and retention (Winter 1964; Nelson and Winter 1973; Hannan and Freeman 1977; Nelson and Winter 1982; Nelson and Winter 2002; Warglien 2002). Economists question how a firm will continue to generate economic rent, avoiding competitive forces which are predicted in an equilibrium-based world to drive profit to zero. Teece *et al* (1997)point out a resource-based approach to efficiency focuses on the rents accruing to owners, hypothesizing competitive advantage rests on specific firm technologies and "difficult to imitate resources (ibid, p. 513)." They suggest the concept of a dynamic capability defined as: "the firm's ability to integrate, build and reconfigure internal and external competencies to address rapidly changing environments (ibid, p. 516)." Teece goes on to add such capability on the part of a firm would enable new forms of competitive advantage related to the path dependencies created by each organization.

These approaches offered by the social sciences suggest survival of the firm is believed to increase if it can achieve the performance level of its superior competitor by copying its competitor's methods and practices. They predict organizational change once a performance gap has been detected and provide examples that range in scope from a total enterprise converging to a more promising organizational structure to department level decisions regarding methods like a surgical procedure or manufacturing practices. In each case, once a performance difference has been recognized and an organizational variation detected, there is pressure on the poor performer to mimic the more effective organization.

It does not have to be a poor performer in an industry that imitates. Firms wishing to enter a particular industrial sector will find imitation a means to reduce economic barriers to entry similarly, firms may choose to copy successful versions of their own operation methods to enter other regions. A franchise is a good example of intra-firm copying that seems to work. The franchisees are essentially in the same business and often the equipment and infrastructure are provided by the original core company. Often sharing best practices means copying the best practices as collected by the core company. In circumstances like this where copying seems to make sense, "copy exactly" strategy is recommended by several in order to identify the critical core of each routine necessary to effectively reproduce the original (Nelson and Winter 1982; Winter and Szulanski 2001; Zollo and Winter 2002; Szulanski and Jensen 2006). Work in the copy exactly situation can easily be described as learning, both on the part of the owner of the "original" and the receiver. The recognition of the critical core of the process by the owner and learning the explicit rules regarding the operation of the copy are critical to success.

In general, if there is no effort to change or if attempts to copy are not successful, the theories suggest inferior firms will disappear. There is some literature that describes firms in a "forever failing" mode (Zucker and Meyer 1990); these situations also end in the disappearance of the poor performer. It may surprise some just how many firms fail to successfully copy a superior competitor despite facing the credible threat of elimination. The contemporary theories that explain the differences among firms do not go very far to explain why, once the need to change is recognized, the good intentions of managers and change agents are not realized.

The aforementioned review fits into the sociological perspective of the Interactionist School. Interactionists take the position that it is people who exist and act to create the structures found in society. For the Interactionist, society and its structures are always in a process of being created; and, creation occurs through negotiation, communication and learning. An important sub-category of this school is that of the Symbolic Interactionist. Robertson (1989) says: "the interaction that takes place between people occurs through symbols." He calls a symbol "anything that can meaningfully represent something else." For the purposes of this research, the reader can think of a routine as representing a set of symbols that represent an established way of doing something.

The Interactionists also argue that change is a common feature of society and the reference groups with which people associate. Continuous change, not stable patterns, characterizes the real nature of society and organizations. Change occurs as a result of interaction between individuals. Change from the Interactionist perspective is free-form, differentiating itself (and the school) from the deterministic change of the conflict perspective. The Interactionists say change occurs as people communicate with one another within and between the groups which define society – work organizations, schools, professional organizations or communities. Individuals, then small groups, first negotiate new patterns of social interaction, and then come to rely on those patterns; as the newly defined routines become entrenched, expectations become more fixed within the social structure. Eventually, people come to accept those patterns as part of their reality. Once people accept the new routines in the particular reference group, they become "real," and real consequences flow from the new order.

Change will take place at the firm level, and that change can be characterized, in many cases, as copying or imitation. Further, from the perspective of the copying organization, imitation can be viewed as innovation. Rogers (1983; 2003) explains that innovation is diffused into an industrial landscape in a four-phase process. For him, the diffusion of an innovation is a function of certain characteristics of the innovation itself, the way it is communicated, time and the social system through which it is working. Time, Rogers goes on to say, is a given and the communication process is the mechanism by which people create and share information. Of course, the social system is that set of interrelated units that are engaged in the joint problem solving activity of creating the imitation. Rogers does suggest limitations to the process, yet does not link failure of the imitator with a relationship between the four steps, nor does he suggest any of the problems associated with different types of knowledge. Yet, not all imitation efforts are successful.

Why do so many attempts to imitate fail? One reason put forward in the literature is that the entity doing the imitating does not completely understand the nature of what is to be copied. That is, firms may copy elements of the competitor's system, but the essence of the system is not understood. This situation is characteristic of many firms in the automotive industry in the late 20^{th} and early 21^{st} century. During this period a number of firms attempted to change various parts of their organizations to become more like Toyota (Choi and Liker 1992; Choi and Liker 1995; Cole and Liker 1995; Fujimoto 1999; Spear 2002; Liker 2004). Liker (2004)as well as Spear and Bowen (1999) suggest that many of these attempts have failed largely because the imitators failed to recognize the systemic nature of the Toyota Production System (TPS). Cases have been documented in which the attempt to imitate Toyota failed to incorporate important elements of the complete philosophy, instead imitating only individual technical tools of TPS, e.g., *Kanban* cards (Choi and Liker 1995; Liker 2004).

Yet it seems there is more to a successful copying activity than just recognizing the systemic aspects of the superior organization. In some cases, the copying attempt failed despite extended opportunity to study the copy target, and to understand the systemic nature of its superior performance-providing mode of operation. Fujimoto (1999), Spear (2002), and Liker (2004) highlight the relationship Toyota has had with General Motors (GM) for a period of nearly twenty-five years. During this time Toyota openly shared major elements of their process with GM. In fact, New United Motors Manufacturing, Incorporated (NUMMI) was owned 50-50 between GM and Toyota and GM could see anything they wanted in the joint venture. One would expect some recognition of the whole must have occurred at some point, yet substantial differences still remain. Similarly, Reeves (2005) describes the case of a trucking firm in a joint venture that operates an automotive parts logistics and distribution facility. The major partner fails to recognize the benefits of TPS over a multi-year relationship that ends with divestiture and mounting losses for the parent firm. Again, it would seem likely, some sense of the totality of the system and the various interdependencies must have been recognized in these situations.

Liker (2004) discusses the attempt by GM to learn from NUMMI and observes that it started out initially as mindless copying and ultimately led to ineffective diffusion of intended practices. The situation Liker describes is an attempt to "carbon-copy" the work group structure of the Toyota manufacturing system into various GM manufacturing facilities. At Toyota there are work groups of about 20 to 25 production workers led by a salaried group leader. There are about 4 team leaders in this group who are hourly people who alternate between full time leadership functions and working production jobs. This structure is central to hourly involvement in *kaizen*. GM took this core concept from NUMMI and copied the structure, but failed to recognize the true function of the activity. In the language of Rogers and the diffusion of innovation: GM thought they saw a new technology that offered a relative advantage over current practice; was compatible (at least on the surface) with the GM values, experience and needs; was not particularly difficult to understand; and offered the opportunity for a limited trial. In reality it was a very complex structure that was deeply embedded in the culture Toyota had created at NUMMI. In the end, GM's copy of the team leader role did not perform the leadership functions they did at NUMMI and in fact only spent about 52% of their time doing any type of productive work. In contrast, the same role in the NUMMI facility was supporting the operator and actively participating in problem solving and continuous improvement over 90% of the time.

The significant difficulty in imitating a superior mode of operation is well indicated by the many companies that have been unable to duplicate the success of

Toyota and their production system. A number of companies have tried to implement aspects of TPS with temporary or no success (Womack and Jones 1996). Commenting on the lean production model suggested by Womack, Teece says: “lean production requires distinctive shop floor practice as well as higher order managerial processes.” They suggest this is a case where, “partial imitation or replication of a successful model may yield zero benefits (Teece et al, 1997 p 519).” Yet, the existence of long-term attempts ending with indeterminate or failed implementation suggests there is more to understanding the causes of failure than the breadth of change.

This research proposes another aspect of the imitation process that can explain the persistent failure of copying attempts, that is, a lack of understanding of the process of developing dynamic capabilities or how the organization’s specific path dependency manifests itself in unique learning opportunities and how these are integrated into the organization. Specifically, this research will provide insight as to when mere imitating is acceptable and when it is necessary to migrate from imitation to a situation of deeper understanding and organizational knowledge. This shifts the focus from the nature of the target or of ways of seeing the target to the way in which the target should be recreated. It redirects the view from an outward orientation to the internal change process unfolding within the organization during the imitation process and looks at the different learning activities needed for different contingencies.

RESEARCH OBJECTIVE

The notion a set of actions or the information embedded in such actions could be “carbon-copied” from one organization to another is rooted in a machine theoretic view of an organization. If one was interested in learning even mechanical tasks we would not expect the transfer to be successful if the imitator were to merely study the fine points of the object to be copied. For example, a high school quarterback prospect does not learn how to throw a ball (let alone the more esoteric aspects of becoming a great quarterback) by merely observing and copying the actions of an NFL all-star. It can be assumed that the idea of imitating at an organizational level adds significant complication to the process; clearly, understanding how an organization learns as it goes through the imitation process is important.

This leads to the research question that is the subject of this project: Why does organizational imitation sometimes lead to effective learning and why, on other occasions, does it lead to mindless stagnant bureaucracy? Understanding the answer to this question is interesting from a theoretical and an applied perspective. This research has three major objectives: 1) to propose a theoretical model that integrates aspects of individual and organizational learning 2) to determine, empirically, when, if ever, individual learning is more important than organizational learning in effective imitation and 3) to propose a framework to help managers understand how to more fully exploit the benefits of learning.

A review of the literature related to organizational learning follows in order to frame a theory creation exercise in the next chapter. Specifically, literature on the topic of routines and learning will be referenced in an effort to characterize the imitation process as first an individual learning activity and then an organizational learning activity.

RELEVANT LITERATURE RELATED TO THE CONCEPTS OF IMITATION AND LEARNING

Three themes emerge as important from the literature as it relates to learning and the organization. First, a significant body of literature related to issues surrounding the nature of the information being imitated has been developed, namely the routine. This literature is important to provide some sense of the object of imitation efforts. Second, the role of the individual in developing important basic skills and understanding is considered pivotal to a firm's ability to acquire new business process and will be reviewed from an historical and current perspective. Third, while learning at an individual level is important, organizations are social structures and embody sociotechnical processes; therefore the literature related to learning at an organizational level is considered. The models presented will be summarized to provide an assessment of their strengths and weaknesses in the context of an organization attempting to imitate an existing approach to work.

Learning from an objective point of view – What is imitated?

There is a vast body of literature that identifies work routines as the basis for organizational memory and a contributor to the development of internal networks and processes (Nelson and Winter 1982; Becker 2003; Becker 2004; Becker and Knudsen 2005; Becker 2007). As Cohen, Burkhart, Dosi, Egidi, Marengo, Warglien and Winter (1996) put it,

> firms are not frictionless reflections of their momentary environments, but rather highly inertial action repertoires, responding to - indeed perceiving - today's environment largely in terms of lessons learned from action in days gone by (p. 667).

In this view, organizations exist as the enactment of routines through social groups engaging to get work done. Cohen, Burkhart, *et al* provides the following definition: "A routine is an executable *capability* for repeated performance in some *context* that has been learned by an organization in response to *selection* pressures (ibid, p.683, emphasis in original)." The selection pressure of interest in this work is the desire to imitate.

Cohen (2007) as he considers a more empirical learning approach in conjunction with an organizational routine, suggests a cautious approach. Specifically, he warns of four areas where a restricted definition of routine has hampered academic advancement of learning in the context of common action patterns (routines or habit). For studies considering a routine as an element of a learning mechanism, Cohen identifies the use of adjectives like mundane, rigid, mindless, and explicitly stored as limiting. As such, further use of the phrase routine will follow the advice of Cohen and consider the "recurring action pattern" in a post-modern Feldman (2000), Pentland and Feldman(2003) and even Deweyian (1916) sense; where the routine has a role in an interplay between the "habit" of what we do and the cognition telling us to do it and good sense judging what was done.

In the context of organizational imitation, routines are the object of interest of poor performing firms. The availability of an original on which to base a copy can arise through a number of legitimate mechanisms, including professional associations, consultants, joint ventures/alliances or manufacturer/supplier relationships, supporting institutional and evolutionary theory. Szulanksi and Jensen (2004) argue the availability of the original for review is an enabler to overcome information translation problems (stickiness) when routines are transferred between organizations.

Similarly, March and Levitt (1988) say it is important to effectively encode, store and retrieve the lessons of prior routine activities and later added that simplifying the elements and finding specialists further enhances the chances of successfully transferring routines. In a case study of knowledge transfer between partners in a joint venture, Inkpen (2005; 2008) suggests two important conditions will affect the likelihood of positive knowledge transfer. First, a mechanism for the systemic implementation of knowledge is needed when knowledge embedded in context specific and system bound processes “does not move easily” (2008, p. 451). A second consideration is a change management perspective that allows for trial and error and experimentation will support successful knowledge transfers between partners. While raising important issues of embeddedness and “information stickiness,” Inkpen leaves unanswered specifics about which mechanisms and factors are most important in the successful transfer process.

Similar issues are studied by Winter and Szulanski (2001), Zollo and Winter (2002), and Szulanski and Jensen (2006) as they address replication strategies. In the words of Szulanski and Jensen they recommend a copy exact strategy for initial replication leading to a “cautious and gradual” adaptation, so as to not lose the “diagnostic value” of the original. Further, they add having access to the original provides a template to make comparisons and check.

The aforementioned rules work and the findings are sound if routines are viewed as a combination of easily observable facts, figures, rules, policies and decision criteria and exist in the context of a simple and stable external environment. Routines are, however, made up of unseen attributes acquired and held by the users that provide them with a “feeling” or “intuition” regarding the necessity of specific written instruction and they are executed in organizational contexts other than the special case of a simple and stable external environment. The environmental contingency is important and suggests different rules for different situations. Likewise, a knowledge characterization of routines, discussed in the literature under the headings of tacit and explicit knowledge also demands further consideration.

The concept of tacit and explicit knowledge were introduced and defined by Polanyi (1958). Explicit knowledge can be codified, documented and ultimately taught to any eager learner using the usual and approved methods. Implicit knowledge, however, resides in the deep understanding of various operational situations by someone with significant experience. Such deeply embedded knowledge cannot be easily transferred to even the most eager learner. As such, routines with a significant degree of implicit knowledge embedded in them will be harder to duplicate. Clearly, learning in such situations will be inhibited despite the availability of the original for review as suggested by Szulanksi and Jensen (2004) or how good an organization may be at encoding, storing and retrieving the lessons of prior routine activities as outlined by Levitt and March (1988).

Nonaka and Toyama (2005), and Nonaka, Toyama and Hirata (2008) use explicit and tacit knowledge as building blocks to a theory of knowledge creation. They provide a method to migrate between the two; they say: "through a tacit to explicit knowledge conversion process subjective values are synthesized into more objective, socially shared knowledge (Nonaka and Toyama 2005). In so doing, Nonaka is providing an organization with two things: 1) the opportunity to create codifiable information which can be taught, and 2) a link between individual and organizational learning.

The nature of the information being copied has also been represented in the literature as “sticky” (von Hippel 1994). Von Hippel shows if information required to solve a problem is costly to acquire or transfer to the required location then any problem solving associated with the transfer of knowledge will be inhibited. This characterization of information by von Hippel is contrary to the view of classical economics where perfect information is known by all players and is reproducible at “little or no cost (Arrow 1962).” Inkpen (2004) shows, contrary to von Hippel, if the proper processes are in place, information stickiness does not present an insurmountable problem to imitation. The case Inkpen uses to illustrate his argument is Toyota/GM at NUMMI. He claims a systematic mechanism and a change management mentality that encourages trial and error are two key elements that will overcome stickiness of information. Inkpen’s finding is to some degree contrary to this research, while NUMMI can be viewed as ultimately successful; it took more than 25 years to have a working copy of Toyota’s system installed at GM and even then the quality of the copies varied across manufacturing plants.

Many authors see routines as the process by which organizations learn (Nelson and Winter 1982; Cole 1995; Feldman 2000; Becker and Knudsen 2005). An important additional aspect of the learning process, as seen by Cole (1995) and Rother (2008), is the addition of improvement routines – a meta-routine that operates over other routines. Cole writes: “of particular importance are those learning routines that lead organizational personnel to reflect on the appropriateness of past assumptions and activities and to reflect on what they might learn from failure (1995).” When imitating management systems, the outwardly visible tools and principles are less useful without a corresponding set of management principles and routines. Rother (2008) uses *kata* – "a way of keeping two things in alignment (ibid, p. 16)" – to balance dynamic conditions (inside and outside an organization). *Kata* as a pattern or way of doing things makes knowledge creation possible by providing balance to the contradictions of encouraging creativity and preserving the status *quo*. *Kata* differs from the western thinking of a routine used in evolutionary economics (Nelson and Winter 1982), and is in keeping with the Cohen/Dewey (2007) approach to routine as a somewhat fluid entity. The rigidity of the western definition with its roots in the machine metaphor of an organization is replaced by a continuous "self-renewal process."

The various perspectives on a routine presented here and the shift from routine as object to subject point to the need for a learning perspective. While much has been written on the varied aspects of learning, the next section will summarize the main arguments of certain key discussions as they relate to learning on an individual basis in the broad context of imitating organizational practices.

Learning from the perspective of an individual

The theme of the individual in learning is important in the context of imitation because all organizational learning begins with an individual. There is, of course, a history of academic argument on the fundamentals of learning dating back to Socrates. More recently, Dewey (1938) arguing for a more organic approach to learning in American school systems recognized the role of the individual, more specifically the learner, in the process. Dewey combines cognition, emotion and routine to yield a learning experience that is both rewarding and long lasting. Dewey considered it important to think of the three elements as interwoven and to not disassemble the parts as each component and the interactions contributed to an individual's learning experience. In his model, sustained learning is driven by mental ability, a strong emotional need to learn as well as the emotional reward it creates and the habitual application of a particular set of actions. Each of the three elements combines in an unending cycle of learning. Figure 1-1 shows not only the importance Dewey places on the basic elements, but also their interplay.

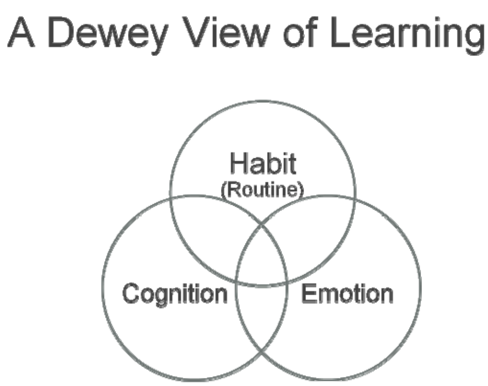

Figure 1-1 A representation of Dewey's thinking regarding the interplay of Habit, Cognition and Emotion on an individual's ability to learn. (From Cohen 2008)

This same tripartite was part of Simon's (1947) early work, although he chose to emphasize the cognitive element to a greater extend, while downplaying the emotive and habitual aspects (Figure 1-2). In this view the routine is a way to package decisions related to re-occurring situations thereby freeing other cognitive resources to be used for non-routine tasks when organizations must choose between multiple goals with limited resources (Cyert and March 1963). Simon includes emotion to provide a value meter on the accomplishments, not as a force in the learning activity. Simon's perspective is important to this discussion because it shaped the thinking in business literature for several decades.

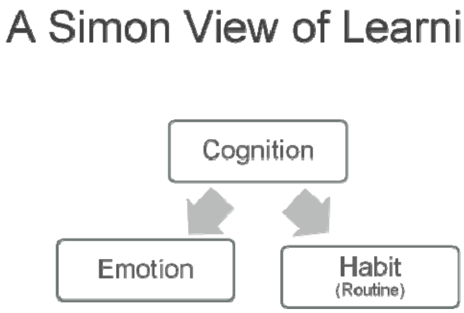

Figure 1-2 A representation of Simon's view of the relationship between Emotion, Cognition and Habit on an Individual's ability to learn. (From Cohen 2008).

A learning model offered by W. Edwards Deming (1986) and used in industrial problem solving in the 1940's through the present, breaks with Simon's approach. With roots in the scientific method, Deming renewed an empirically based theory of knowledge with Deweyian themes. Deming, whether teaching to the masses[1] or in one-on-one conversations with executives at Ford and GM, extolled the importance of a systemic approach to problems solving as necessary to gain a true understanding of the variation inherent in many situations. His system of profound knowledge also provides an academic lens to understand how individuals acquire knowledge and learn. His writing integrates a theory of a system, psychology, knowledge and variation into a comprehensive learning model. For Deming, the four components of the system of profound knowledge cannot be separated; they are interrelated and a true understanding of the needs of the organization (as part of a system) cannot be understood or achieved without a thorough commitment to all aspects.

[1] Deming was retained by General Motors and Ford in the late eighties and early nineties as a quality consultant. In this capacity he went to Detroit once a month often presenting in an auditorium with 400-700 people. On those trips he also held private consulting/coaching sessions with key executives at both firms. The writer participated in several small group sessions and one-on-one meetings with Deming.

Deming incorporated the four elements of his system of profound knowledge into the plan-do-study[2]-act learning and problem solving cycle (Figure 1-3) originally developed by Shewhart at General Electric in the early part of the twentieth century. The never ending cycle is indicative of his thinking that learning was an ongoing process. The simplicity of its form may fool the casual observer into thinking it is not useful if problems are complex; to the contrary, the use of the P-D-S-A cycle has been a mainstay in the most successful companies (Rother, 2008).

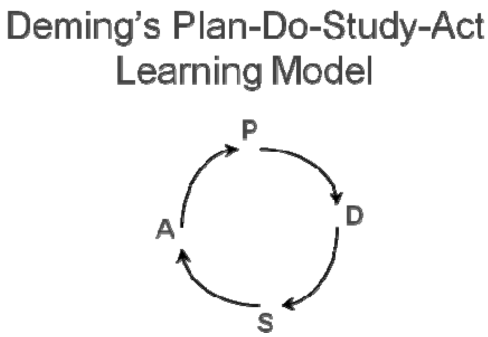

Figure 1-3 Deming's Plan-Do-Study-Act learning and problem solving cycle

Deming's system of profound knowledge, presented as a practical application of the scientific method, can be summarized in the steps of the P-D-S-A as follows:

Plan: Define an hypothesis of prediction of what you expect to occur

Do: Conduct a (small scale) experiment to collect some data to test your hypothesis

Study: Compare the results with your expectations

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[2] Many people still use plan-do-check-act to describe this process, but late in his life Deming did not like the use of the word check. He told me his observation of the usage of check was punitive, something he was uncomfortable with. For Deming, the idea that you are looking at how the plan matched to the result of your actions was a learning opportunity and needed to be couched in words that expressed the idea unambiguously, *ergo* study.

Act: Use what worked to stabilize your process and consider how to begin the cycle again to continue learning.

Dreyfus and Dreyfus (1980; 1986) proposes a developmental approach to learning built around skill acquisition. His process had learners acquire skill sequentially through five phases: beginner, advanced beginner, competent proficient, and expert. In the first two phases, the learner, who “wants to do a good job,” uses a set of “rules for determining action (1986, p. 21).” To begin, the learner acts slowly as at each step when and how each rule is applied must be remembered. As the learner moves to the advanced beginner phase, more “practical experience in concrete situations” allows marginal improvement as “meaningful additional aspects” of the situation not codified by rules are used to make decisions (ibid, 22–23).

In the competent stage, Dreyfus says the learner often feels “overwhelmed,” as if he or she is “on an emotional roller coaster,” having to cope with “nerve-wracking and exhausting” aspects of the practice and feels “overloaded” as too many potentially relevant elements to remember come into play (Dreyfus 2001). The competent learner, according to Dreyfus, will narrow down those elements, and devise a plan that selectively references “relevant features and aspects” of the situation (1986, pp. 26–27). By making these changes, the competent performer experiences “a kind of elation unknown to the beginner,” including “pride” and “fright” (ibid, pp. 117–118).

Interestingly, Dreyfus indicates the learner undergoes not just cognitive and practical transformations but affective ones as well. Dreyfus contends beginners and advanced beginners experience their commitment to a practice as “detached,” while a competent performer feels “involved” in the outcome of his or her performance (ibid, p. 26). This is an emotive response to the learning stimuli similar to what Dewey proposed.

The proficient phase moves the student beyond the “detached, deliberative, and sometimes agonizing selection of alternatives” which typifies the first three phase of skill acquisition (ibid, p. 28). Now the learner’s reliance on rules for seeing what goals need to be achieved is largely replaced by “know-how,” although the proficient performer must still deliberate about what to do to achieve a desired outcome (ibid, pp. 27–36).

In Dreyfus’ fifth phase, the learner is an expert and not only sees what needs to be done, but also how to achieve it without pause or deliberation. The expert immediately, yet “unconsciously,” recognizes “new situations as similar to whole remembered ones” (ibid, 1986, p. 35). Dreyfus summarizes the “fluid performance” of expertise as: “When things are proceeding normally, experts don’t solve problems and don’t make decisions; they do what normally works” (ibid, 1986, pp. 30–31). Dreyfus also says that the expert does not distinguish between subject and object: “The expert driver becomes one with his car, and he experiences himself simply as driving, rather than as driving a car” (ibid, 1986, p. 30). When an expert experiences the “flow” of peak performance, he or she does not devise plans to reach some future state, they are not worried about the future; they are confident in their abilities and know they will achieve a desirable outcome (ibid, 1986, p. 30). By being immersed in the moment, the expert can experience “euphoria,” which athletes describe as playing “out of your head (Csikszentmihalyi 1990).”

Liker and Meier (2007) in describing the process by which Toyota develops people use a framework developed by Perrow (1967) to provide a broad classification of work. Perrow provides four basic job types, each with different training requirements. Perrow's four categories are: routine, technician, craft and nonroutine. When considering an organizational structure to manage the various job types Perrow's categories roughly follow a continuum that goes from mechanistic to organic based on the degree of task variety and analyzability the work presents. While the training requirements do differ between the categories, certain basics can be applied; for example, it is possible to define some degree of standardized work for all jobs, even those that a high degree of variety and analyzability (nonroutine tasks).

Rother (2009) incorporates Deming's P-D-S-A (he refers to it as the P-D-*C*-A) cycle in his discussion of learning in a problem solving setting in Japanese firms. He uses a series of embedded learning cycles by an individual. He introduces the idea that knowledge accumulation can be the act of a collective and can take various forms depending on the complexity of the situation. As discussed earlier, Rother also talks about *Kata*. In his terms it is "a way of keeping two things in alignment (ibid, p. 16)" – to balance dynamic conditions (inside and outside an organization). *Kata* is a way to coach or teach the individual. At some point, as the collective grows it becomes more than individual learning.

Cole (1995), in his study of Japanese technology management practices, provides the following definition of individual learning: "the continuous development of skills necessary for people at all levels of an organization to perform changing job demands." Coupled with this broad definition he also identifies several behaviors the individual must affect, including: openness to change, flexibility, system thinking, creativity, self-efficacy, empathy, co-operative behavior and problem-solving skills. These serve as possible enablers, for Cole, to facilitate learning. They may also serve as failure modes to learning on the part of the individual.

All authors presented see individual learning, even in the broadest terms, as a necessary activity for any organization interested in sustaining or creating a competitive advantage. Yet unanswered is when can the acquisition and availability of individual knowledge move an organization from a below average performer to a top performer even in a narrowly defined context. The next section discusses several aspects of learning as it relates to organizational knowledge acquisition and practice.

Learning from the perspective of an organization

Many consider individual learning the basis for organizational learning. Cole (1995) in explaining the difference between individual learning and organizational learning says "one does not presume the other (ibid, p 362)." Cole goes on to say organizational learning and individual learning appears to exist at various levels in different industries contingent on the environment and management vision. Using a 2x2 framework (Figure 4), Cole describes situations where the combination of individual and organizational learning can exist in one of four extreme cases. Using this frame, he hypothesizes the "modal Japanese Manufacturing firm exists in a state of high individual learning and high organizational learning; while the modal American manufacturing firms exists in a state of high individual learning and low organizational learning. Furthermore, Cole asserts a Tayloristic firm in a stable environment may exist comfortably in a low individual learning and high organizational learning mode and a monopolistic or oligopolistic firm could exist with low individual and low organizational learning.

Individual versus Organizational Learning

		Organizational Learning	
		High	Low
Individual Learning	High	Modal Large Japanese Manufacturing Company	Modal Large U.S. Manufacturing Company
	Low	Tayloristic Organizations in Stable Environments	Ideal Organization for monopolistic labor and product markets

Figure 1-4 Individual versus Organizational Learning according to Cole

Cole provides a definition of organizational learning by adding to his previously mentioned criteria for individual learning. Those criteria: openness to change, flexibility, system thinking, creativity, self-efficacy, empathy, co-operative behavior and problem-solving skills are necessary, but not sufficient for organizational learning. Cole adds motivation, capability and opportunity must be present at the organization level to effectively meld individual and organizational learning.

Nonaka and Toyama, through a body of work, develop the elements of a complex process to create organizational learning (Nonaka and Toyama 2005). Critical to their view is not only on how we learn, but also why we exist. This epistemological/ontological coupling allows them to consider subjective elements facing an organization such as management vision, a firm’s value system, and employee commitment to capture what he thinks of as a dynamic process of knowledge creation. Nonaka proposes that individuals transform themselves and their environment through knowledge creation by interacting with others to “transcend their own boundaries (ibid, p. 421).” In so doing, the individual is creating a “truth” based on a current set of understood values and context from which information is being drawn. This truth becomes so only through social interaction and confirmation; understanding this dynamic, Nonaka's knowledge-creating firm does not see knowledge as absolute, but instead transient. It is created through practice, not by passive individuals held captive by their environment, but by active individuals seeking to learn and better understand why we exist (Nonaka, Toyama et al. 2008).

Nonaka and Toyama (2005) also recognizes the importance of the systemic nature of work (particularly the role of people) to the application of new thinking or organizational practices. They say, some of the concepts are philosophical and may seem to have little to do with business; this may be a reason business has been slow to see the importance, but from an organizational perspective Nonaka emphasizes, we need to answer the "existential question." Doing so invites a person to practice as a way to "embody explicit knowledge by reconnecting it to a particular context to conduct it into tacit knowledge (p. 427)" and reflect, "thinking hard about the essential meaning of his or her action and its outcome so as to revise his or her action (p. 427)". This activity focuses one not only on the object of learning, but also its importance and connection to shared meanings creating knowledge assets in the process.

An important knowledge asset in Nonaka's dynamic theory of knowledge creation (2005) is a firm-specific *kata*. And the *ba* in which it resides. Nonaka defines *kata* as a three step activity that starts with learning basic patterns, then once the basics are mastered a break is made that allows the creation of new patterns. Nonaka's concept of a learning system borrows from Japanese philosophy to add structure and context to explain how *kata* can flourish. Specifically, the *ba* is defined as "the context and meanings shared and created through *interaction* that occur at a specific time and space

(2005, p 428) [italic in original]". Participating in a *ba* learning experience, Nonaka says, is to recognize subjective views are jointly understood in a way that transcends the individual perspective, offering instead an opportunity to see problems in relationship with others in the *ba* and outside. It is through dialogue and practice at the *ba* that an organization creates knowledge assets, but because of the contextual significance "full value" can only be gained if they are used internally – they cannot be readily bought and sold or imitated. Two critical elements of a *kata*: the old patterns are mastered before a break is made and a feedback loop is incorporated to help to modify differences between predicted outcomes and "the real world."

Organizational learning in Nonaka's model is not merely the whole being greater than the sum of the parts; it is not a group complementing each other to overcome the individuals' bounded rationality. It is the process by which implicit knowledge held by the individuals is "externalized into explicit knowledge to be shared and synthesized (ibid, p. 420)." His is a theory that allows an open systems perspective, the firm is able to adapt to a changing environment by processing information efficiently and creating knowledge.

Senge (1994) proposes an integrated model of organizational learning that starts with a focus on the individual. His five interrelated elements are: personal mastery, mental models, shared vision, team learning and systems thinking. Individual learning is the key to three of the five disciplines; it is only through a group understanding that many organizational accomplishments will be met. Senge presents the idea of organizational learning as being like a new technology that must be diffused into a culture; he suggests a 30 year span from "invention" to "innovation" (ibid, p. 7) may be required to fully integrate the ideas into a business culture. His model borrows and builds on ideas like double-loop learning (Argyris, Putnam et al. 1985; Argyris 1990; Argyris 1998) and systems thinking. The "fifth element" of Senge's model, and its binding force, systems thinking is found in several writings before and after his book first appeared.

Senge's five interrelated disciplines both start and end with systems thinking. He stresses businesses, like so many other human endeavors, are systems. It is impossible to take even a small step without consideration for some other aspect of the activity. In his words: "they are bound by invisible fabrics of interrelated actions" (Senge, 1994 p. 7). Of course, the reaction to any particular action is often separated in "time and space," but nevertheless connected. Not a new idea, Senge reminds us systems thinking is a framework that has been around for over half a century. Some things just don't sink in very quickly.

Personal mastery is Senge's label for the discipline to "continually clarifying and deepening our personal vision, of focusing our energies, of developing patience and of seeing reality objectively (ibid, p. 7)." This is both a spiritual aspect of Senge's model and an opportunity for a very tangible connection between the individual and an organization. Personal mastery is the mechanism that directs the individual to live life in the "service of our highest aspirations." It can provide an important link between the organization and the individual when the goals are shared.

Becoming aware of the generalizations and deeply ingrained assumptions that guide and inform our understanding of the world – our mental models – is a way to identify conflict between the explicit and the tacit. This is so, according to Senge, because people are often not consciously aware of their mental models. He goes on to say that an awareness of one's mental models will help to create dialogue that balances "inquiry and advocacy (ibid, p.9)" as people become open to the ideas of other, allowing their thinking to be influenced by others.

Leadership plays a role in an effective organization for Senge, specifically through the ability of a leader or influential person to create a shared vision. Building a shared vision means to create a "picture of the future" that the organization can subscribe to, not because they were told, but because it makes perfect sense. An organization on a mission to create a future in some way better than were they are today – Ford providing transportation for the masses, Apple with computing for the masses – will generally have everyone working toward the same goal. Of course, there are examples of goals that are not sustainable. Some organizations have struggled with a true vision. GM, for example, worked with Alfred Sloan's dictum: "we are in business to make money" as their philosophy and vision. This may have worked when all of the choices available to a manager would make money (maybe not all equally likely to succeed or to make as much as the others. The organization will comply with the intent, but in the face of contradictions about profit and customer satisfaction a manager may flounder.

The last of Senge's disciples is team learning. Similar to all of Senge's disciplines, it builds on the others. Team learning begins with conversations that build an individual's (and team's) ability to suspend the assumptions of their mental models and think together in a true dialogue of ideas. Senge stresses this must be a team activity because it is through teams that modern organizations deliver on their goals. This and all of his other disciples are held together by systems thinking, the so-called fifth disciple.

Senge gives organizations a developmental model through which they can study and master the competencies to become lifelong learners. They are personal, yet must be shared by others in the organization.

Argyris (1985; 1998; 2004) provides two important concepts to help us better comprehend organizational learning. First, espoused theory versus theory-in-use. Argyris identify two kinds of action theories. Espoused theories are those that an individual claims to follow while a theory-in-use can be observed. Argyris makes the distinction between the two theories of action thusly: the theory one says they use and the theory they use. He makes this distinction because a person's action is not by chance or accidental, people act in a particular way because they choose to do so. According to Argyris, "there action is designed (ibid, p. 82)."   A person's espoused theory and theory-in-use may or may not be consistent and they may or may not be aware of any inconsistency. Argyris says, "theories-in-use are the often tacit cognitive maps by which human beings design action (ibid, p. 82)." In an argument similar to Nonaka's, Argyris concludes theories-in-use can be made explicit by reflecting on the actions.

The second construct Argyris provides is that of single and double-loop learning. To illustrate the difference between the two consider the situation when the consequences of a particular action are as intended, In this case, there is a match between expectation and outcome; the theory-in-use is confirmed. If, instead, the consequences are not as intended, there is a mismatch or an error. Argyris contends "the first response to error is typically to search for another action strategy that will satisfy the same governing variables (Ibid p. 86)." In this situation (new action strategies are used in the service of the same governing variables) there is single-loop learning. This action is contrasted with a strategy that changes the governing variable, that is to not “choose among competing chains of means-ends reasoning within a given set of standards, but [instead choose] among competing sets of standards ("frames" or "paradigms") (ibid p. 87).” Argyris calls this second strategy double-loop learning. Pertinent to this work, he claims persistent problems with learning points to double-loop problems.

Argyris and Schön (1974) construct an ideal type that summarizes many aspects of the widely used theory-in-use situation that inhibits double-loop learning and its more difficult to attain “alternative world” of an organization solving complex problems in ways that combine inquiry and advocacy. Labeled Model I and Model II, (Table 1-2) Argyris and Schön contract the governing variable, behavioral strategies and consequences of the two approaches as they inform readers Model I is an almost universal fall-back positions for individuals and groups and Model II is the situation enlightened leaders will strive to take their organizations toward.

The governing variables of Model I: (1) achieve the purpose as the actor defines it; (2) win, do not lose; (3) suppress negative feelings; and (4) emphasize rationality, are in contrast to the more open philosophy presented by the governing variables of Model II: (1) valid information, (2) free and informed choice, and (3) internal commitment. It is with this background that Argyris and Schön define what they call the primary behavioral strategies for each model. According to Argyris and Schön, in Model I the primary behavioral strategies are to control the relevant environment and tasks in such a manner as to protect yourself and others that share your view. Again, these strategies are in contrast to the behaviors of Model II. Here control is shared with those who have competence and who will participate in the test, design and implementation of possible actions.

Argyris and Schön indicate the consequences of Model I strategies will include defensive interpersonal relationships, limited choice, and a lack of validity. Clearly, this is a situation that has negative consequences for learning in part because of the private nature in which ideas are reviewed and tested. Argyris and Schön state hypotheses generated under a Model I regime tend to become self-fulfilling. The solutions and the learning remain within the bounds of what has proven to be acceptable in the past. Double-loop learning does not tend to occur. As a result, errors escalate and effectiveness in problem solving and in execution of actions tends to decrease.

	Model I	Model II
Governing Values	o Achieve the purpose as the actor defines it o Win, do not lose o Suppress negative feelings o Emphasize rationality	o Valid information o Free and informed choice o Internal commitment
Primary Strategies	o Control environment and task unilaterally o Protect self and others unilaterally	o Sharing control o Participation in design and implementation of action
Operationalized by	o Declarations and unillustrated evaluations e.g.. "You seem unmotivated" o Advocating courses of action which discourage inquiry e.g. "We tried that last year and it didn't work." o Treating ones' own views as obviously correct o Making covert attributions and evaluations o Face-saving moves such as leaving potentially embarrassing facts unstated	o Attribution and evaluation illustrated with relatively directly observable data o Surfacing conflicting view o Encouraging public testing of evaluations
Consequences	o Defensive relationships o Low freedom of choice o Reduced production of valid information o Little or no public testing of ideas	o Minimally defensive relationships o High freedom of choice o Increased likelihood of double-loop learning

Figure 1-5 A summary of Model I and Model II thinking (from Argyris, 1985)

Many of the attribute of a Model II organization have been observed by Liker and Hoseus (2008) in their study of culture at Toyota. They assert Toyota's culture can be "best characterized as a learning organization (ibid, p. 73)." This learning culture is based on an underlying assumption that corporations have "broad obligations to the people, partner and society." Liker and Hoseus tell us they are not perfect, but Toyota management works hard to live a culture that is in a continuous cycle of reviewing and improving. The "people value stream (ibid, p. 221)" is part of the continuous cycle. Toyota management believes work is a place for their people to develop and learn. At Toyota, we are told, we would observe small teams, standardized problems solving and energized leaders as teachers and coaches. The leaders have what Dreyfus and Senge would call a personal mastery of the "Toyota Way." They support team members through "the integration of the production and people value streams (ibid p. 337)" by providing a safe physical and psychological environment. The consequence of this cultural structure is "longevity of physical plants and people, complex procedures for discipline, and slow and deliberate career progression (ibid p. 457)." Liker and Hoseus claim an underlying cultural assumption is long-term thinking is necessary to create long-term prosperity for both the company and its people. So, we see in Toyota a possible necessary condition for learning organization – that is long-term thinking. The linkage between individual learning organizational learning is not yet revealed.

It is difficult to separate individual and organizational learning since the organization is nothing but a group of individuals. Yet an integrated learning system that combines individual and organizational learning seems important. This does make sense even as one considers organizational learning will always subsume individual learning, e.g., orgs cannot learn unless individuals learn. The nature of the relationship between the two is important, knowledge of the nature of the environment that encourages both is important to coax organizations into the Argyris and Schön more Model II world.

Summary of learning and next steps

Given that organizational imitation is an act of learning, the academic discussions related to routines lend credit to an argument that places them at the forefront of a study of organizational imitation. Routines are the object of imitation and are seen by many as a mechanism of learning. All of the models discussed have strengths and weaknesses as they relate to learning in the context of imitation; Table 1 offers a summary of the major weaknesses and strengths as they relate to organizational imitation. Specifically, all models related to individual learning are weak in that they do not make explicit connections between the learning collected by an individual and the organization. As this is a study of how organizations imitate the operational processes of others it would seem important to recognize the organizational aspects of imitation. Similarly, the models related to organizational learning while recognizing the role of the individual in the process failed to show any tangible process steps that would link individual and organizational learning.

Learning Models Summary

Model	Focus	Weaknesses	Strengths
Deming	Problem Solving	• No explicit process • No connection between Individual and Organizational learning	• Recognition of systemic nature of learning • Multi-faceted nature of problems
Dreyfus	Individual Competency	• No connection between Individual and organizational learning	• Strong model of individual learning (particularly in early phases)
Liker/Meier	Individual Competency	• Weak connection between Individual and Organizational learning	• Focus on key organizational competitive competencies
Nonaka	Organizational Learning	• No explicit process • Weak connection between Individual and Organizational learning	•Strong connection between individual and organizational learning
Senge	Organizational Learning	• No explicit process • Weak connection between Individual and Organizational learning	• Recognition of systemic nature of learning • Multi-faceted nature of problems • Strong model of organizational learning
Liker/Hoseus	Organizational Learning from a Competency Perspective	• Weak connection between Individual and Organizational learning	• Link between the long term philosophy of an organization and the approach to problem solving • Culture is important
Argyris	Organizational Learning	• No explicit process • Weak link between the Individual and Organizational role in attaining Model II behavior	• Model I and Model II show the psychological approach to learning needs to be combined with sociological

Figure 1-6 A Summary of the learning models reivewed the context of imitation

Taken together and in view of the literature on routines there is an indication of a need to look at "infusion of imitation" through an integrated learning model. Each of the major theories presented contribute to developing that integrated model. The next chapter will begin with a preliminary development of that theoretical model. Real-world case studies will be used, in the spirit of grounded theory, to test the model, refine it, and add nuance. Specifically, the case studies will be looked at to begin to tease out what can be a complex relationship between individual learning and organizational learning. The cases are presented and analyzed in chapters three through five. A concluding chapter proposes a framework to help managers understand how to more fully exploit the benefits of learning from a successful model.

Chapter 2

Conceptual Model Development and Research Methods for the Study of Imitation in Large Complex Organizations

Chapter one outlined the role of learning in the imitation of organizational processes and provided a summary of several important theories of learning. In this chapter a conceptual framework is presented to provide a means to better understand the mechanisms acting at the various stages of an imitation process. The learning models presented in chapter one will be combined to take advantage of the strengths of certain approaches and provide countervailing mechanisms for perceived weaknesses.

Imitation as learning: A Contingency Framework

The integrated model will be a contingency framework arguing that the most effective learning process is contingent on what it is the organization is trying to imitate. What are the characteristics of the routine which the organization is attempting to imitate and what are the goals of this imitation? The contingency model on which to place different types of routines-learning objectives is derived from Brannen *et al* (1999). In its original application, this model was used to show the degree to which organizations "reconceptualize firm offerings as they are uprooted from one cultural environment and transplanted to another (p. 118)."

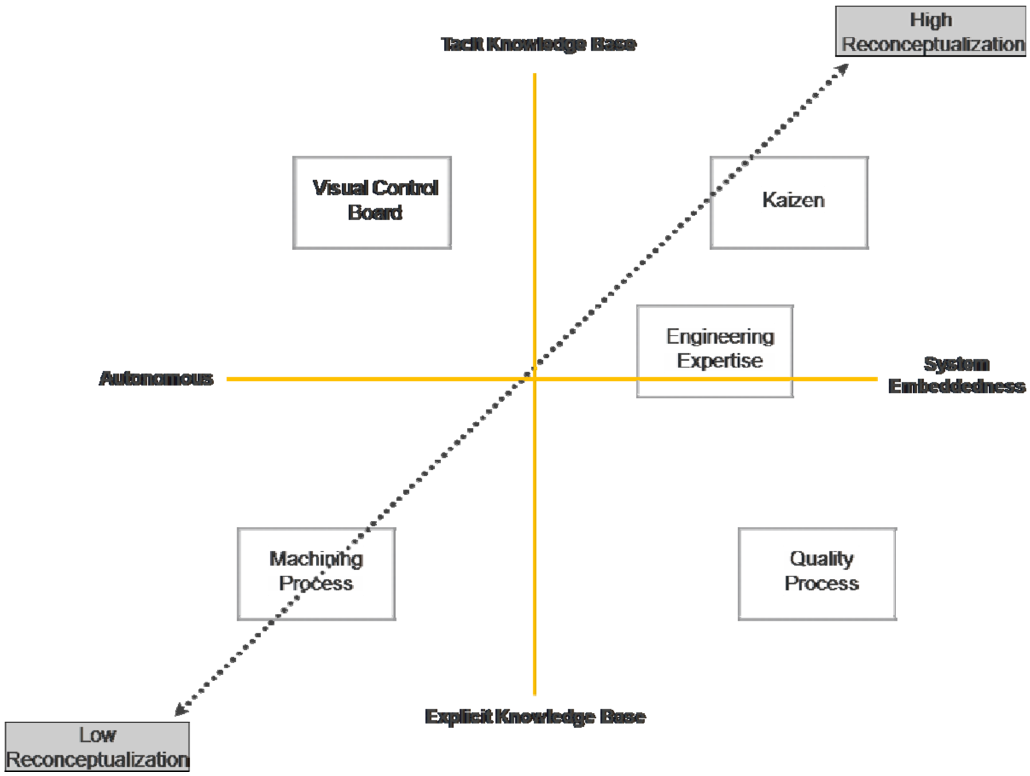

Figure 2-1 Knowledge v. System Embeddedness and Reconceptualization (from Brannen et al, 1999)

The Brannen model is outlined in Figure 2 -1. The study looked at the effect of knowledge type and degree of system embeddedness at a manufacturing facility in North America adopting processes from their Japanese parent. They found going from the simple case of autonomous processes with explicit instructions to a situation of embedded systems with tacit knowledge requirements, reconceptualization of the organizational practices being transformed increases. Japanese firms could transfer stand-alone (autonomous) technology that could be operated with explicit instructions more or less as is, with very little cultural influence. On the other hand, attempts to transfer complex management systems, like bringing the breadth and depth of *kaizen* to the American organization had serious cultural implications. The American culture tended to interpret *kaizen* through its own lenses and ended up with something different from the original in

Japan. Notice that this alteration in what was transferred occurred even though the parent company was Japanese and had Japanese managers come to America to establish the routines who also had formal authority to do so.

In this work, Brannen's framework is adapted to show four potential learning environments. The operating environment of the work process to be imitated (mechanistic v organic) and group focus (individual v organization) will form a 2x2 matrix that is the basis for the development of a learning model. It is postulated that the two quadrants on the diagonal from the lower left to the upper right form a major axis for learning. Two learning models that focus on this diagonal will be presented to look at the effectiveness of imitation attempts based on expected knowledge requirements and complexity of the routines being copied.

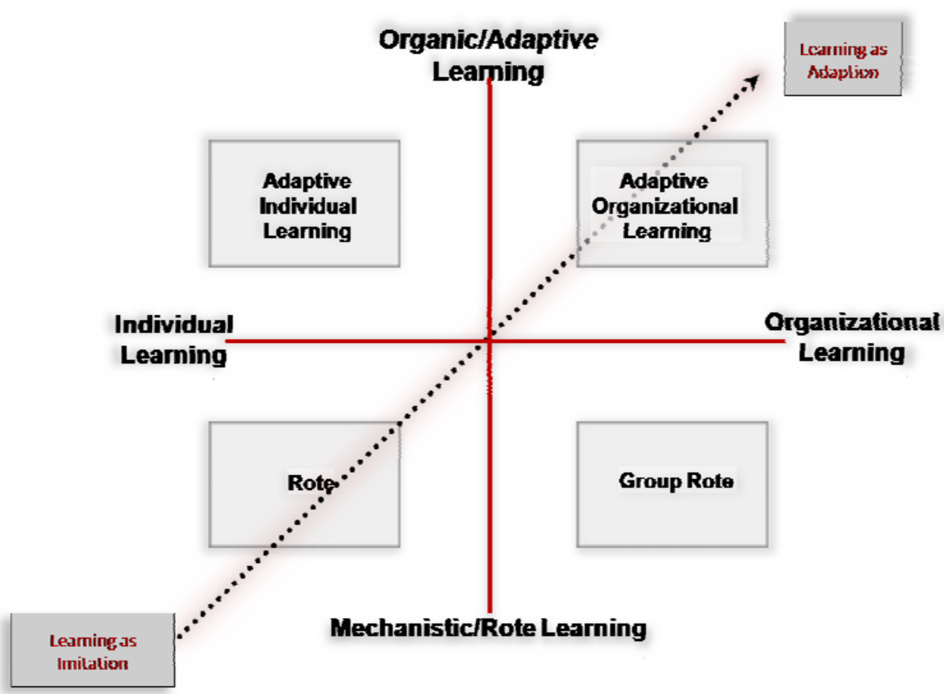

Figure 2-2 Revised Brannen - an Individual/Organizational Learning Plane

We start with the assumption that work processes that are routine in nature, in the sense of Perrow (1967), and embedded in a mechanistic structure are largely autonomous and endowed with explicit knowledge requirements. These situations are characterized by work done by an individual that has low variety and high analyzability; additionally there can be written instructions that convey the required information for the process. For imitations of this type of routine to be effective, structured learning where knowing the rules and other codified instructions are all that is important. Individual learning is expected to be the primary focus, as a strict rule-following approach will solve all problems with few demands of an organizational nature requiring the operator attention. This is the quadrant of "Rote" learning. This is also the situation where an exact copy (Winter 2003) strategy will be most likely to succeed.

Conversely, in situations where work processes are interrelated, with many different people working on the same process have varying functional focuses, yet trying to accomplish a common goal, process rules and codified information are supplemented with more tacit knowledge. In these cases (Perrow's engineering world) (1967), a mere copy of codified information will not suffice and significant organizational learning and perhaps even spontaneous adaptation may be required. This is the quadrant of "Organizational/Adaptive Learning." Situations like this may well have significant cultural overhead, with work groups from dissimilar areas having different norms and perhaps even a different vision. Such is the case with work systems like a new product development process (NPD). Even in small companies, NDP involves many different parts of the organization: marketing, design, engineering, manufacturing and finance.

They will all play a part in bringing a new concept to market. Imitations in this environment will need to be adaptations.

The off axis quadrant are important from the standpoint of this research in that they provide transitional points as an organization moves from one learning environment to another. For example, if a particular process would ideally be in the top-right quadrant, we propose learning will start in the bottom left and migrate along the axis. In some cases it may be that organizations move to an off diagonal position. This may be a momentary placement as they move to their ideal location or it may be the best that can be accomplished given the inhibitors to learning present in the organization. There may be limited situations where being off-diagonal is ideal. A situation were "group-rote" thinking is required may exist in cases like certain corporate standards that require all employees to exercise the same set of rules – timekeeping or perhaps some military inspection standard that is to followed by large groups of people – would be placed in the bottom right quadrant. A case of adaptive individual learning may exist in situations where a process is stable with low analyzability and variety yet a person with a significant sense of the intent of the process and its position in the total organization may be able to change the rules and improve the process. This would be the situation when the individual learning is able to transcend the local needs and recognize a greater good is achievable if the local conditions are sub-optimized. This would be the case if Model II learning dominated an organization, but alas such is not general case.

In the next section, this framework will be used to develop a pair of models to plan an effective learning approach given characteristics of the organizational practice being imitated. The models will be accompanied by a set of hypothesis describing expectations regarding behavior given certain initial conditions.

Learning model development – It starts with the individual

The sophistication of the learning activity will depend on what is being copied. For example, copying a robot implementation may not need as much intimate knowledge, experimentation, one-on-one coaching or a shared corporate vision. In many cases the routines companies attempt to imitate are more complex than this illustration; these situations will likely involve more tacit knowledge, so a more complicated learning model will be required. As a basic framework for discovery, two learning models are developed in this research as a preliminary theory development activity. To define the elements of the two models several ideas reviewed in Chapter 1 will be incorporated into a structure specific to local learning requirements. Both learning model are developed come from a review the literature, the first relies heavily on Dreyfus (1980) and to some extent Deming (1994); the second model will use Dreyfus as a stepping-off spot to incorporate aspects of Nonaka (2008) and Argyris (1985). In all cases the influence of Liker, Senge, Deming, Cole and others will be recognizable.

The model for individual learning, shown in Figure 2-3 is the simpler of the two; its steps represent the growing levels of understanding for an individual guided by the knowledge of a trainer, mentor or coach. This model incorporates the first steps of Dreyfus' model (1980) to develop skills in an individual to a level Senge would refer to as personal mastery. Specifically, the individual would have a complete appreciate of the rules and tools to the point where variations can be used to achieve results when the inputs to a problem are unusual. Personal mastery is defined as having a complete and intimate knowledge of the "original" and an ability to coach or mentor novices in the particular process. This model stops short of the individual gaining a true appreciation of how the process fits into the greater organization. It is proposed that in many simple cases this will be a locally recognized vision as processes being imitated in this quadrant may only have implications for a small group or activity. Capability may only be measured at a process level- *ergo* the final stage is to improve process capability using the existing rules and adding to them in an Argyris(1985) Model I learning sort of way. Such might be the case in the robot implementation example used earlier. This is proposed as a general model for the left side of the model (Individual as opposed to Group focus). It may be that adaptations will be made as knowledge requirements change or as an individual is able to transcend a "mechanical" boundary.

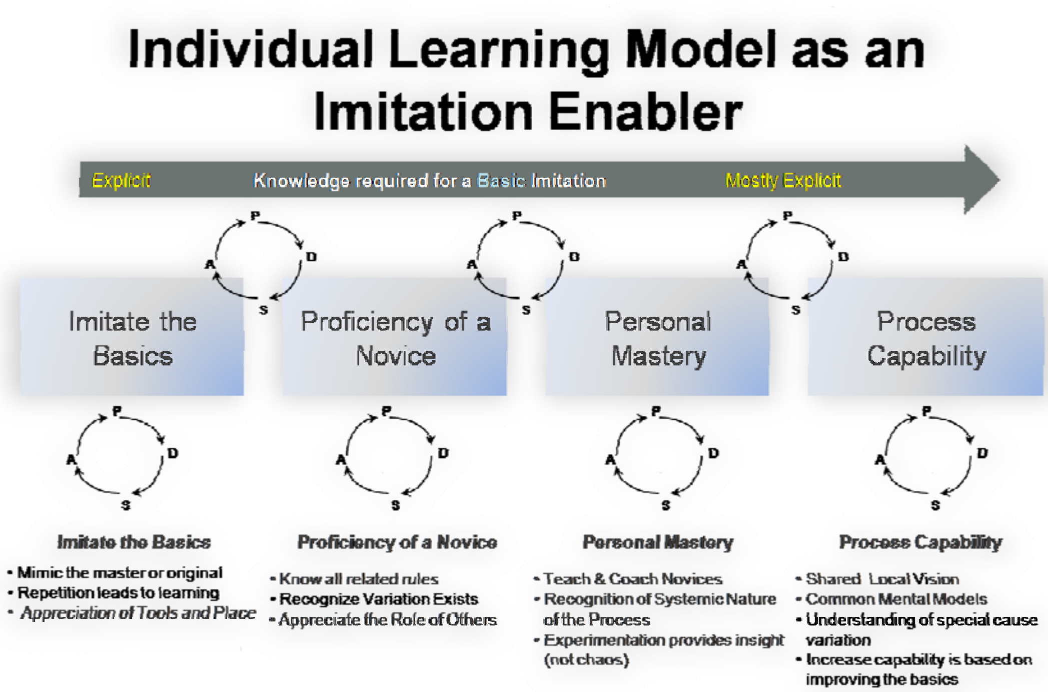

Figure 2-3 Cycles of learning for an imitator whose role is that of an individual performing explicit tasks based on codified knowledge

The steps of the simple individual learning model are bound together and imbedded with the P-D-S-A learning cycle common in the problem solving activities as documented by Rother (2009) and Deming (1994). The intent is to have internal checks for the learner to use as guides to attainment of learning requirements necessary to move from the novice to master and beyond. This addition is meant to provide elements of a *kata* as presented in Nonaka (2008) and Rother (2009) to even this basic learning model; incorporating the idea of small learning steps into the general model.

In this model, an individual's learning is guided through a mechanical process culminating in the learner developing a personal mastery of a particular operational activity base in large part on memorization of rules and process steps. Further, the knowledge acquired by a learner in this activity will be mostly explicit. There is a question as to what degree a mentor or coach is required in this simplest learning model. It is possible that someone with the basic instruction book, even someone who does not have mastery can impart the required knowledge in a training course or seminar; perhaps the learner could even be self-taught. It is likely that as information requirements become more tacit there is a greater need for coaching from a person with a mastery of the subject. As a starting point, it is assumed there is a coach or mentor who has a personal mastery of the original, but a trainer with good understanding of the original could delivers details of the concepts. If the learner expects to move beyond the advance novice an understanding of the routine's place in the context of the organization is required and this understanding can only be advanced with the help of a guide.

This model shows several learning cycles through which a novice may question and reflect on the information presented. This will lead to a full appreciation of the material and where a particular task fits into the individual's understanding of the organization's *raison d'être* and capability.

The final stage of this process is a stepping-off point for deeper organizational understanding and an opportunity to incorporate small scale adaptation and improvement into explicit autonomous imitation exercises. Since few processes are completely autonomous or entirely made up of explicitly codified instructions, the final P-D-S-A cycle is a chance to take the information developed through an understanding of a shared vision and common mental models to create new explicit information with which the process improvements can be made. Such a cycle might be interpreted as reacting to special causes of variation (Deming 1986) or as taking tacit information and making it explicit (Nonaka, Toyama et al. 2008). The underlying process may not change significantly, but sources of perturbation that are unusual can be addressed with new documented procedures. Of course, more complicated situations like inherently systemic processes, that operate based on tacit knowledge, will require additional learning cycles leading to Organizational Learning. Imitation of processes of this nature will require more systemic learning.

If an organization is attempting to imitate an autonomous routine embodied by largely explicit knowledge requiring an individual to understand the documented steps and rules with only minor adaptations this model can yield effective imitation. This operational expectation can be summarized in the following hypothesis:

> Hypothesis 1: In the case of organizational imitation of processes of an autonomous nature governed predominantly by explicit rules, individual learning characterized by a mechanical approach to knowledge transfer is effective with little organizational learning.

Specific to this hypothesis is the assumption that learning will be mechanical, based on the known rules and procedures. If true, one can expect to see effective imitation in situations if they only required an individual to understand local processes and procedures and can rely strictly on known, explicit and codified information.

Learning model development – The role of the collective

A second model is proposed to understand what is needed to imitate an organizational process that occupies the upper right quadrant of the Figure 2-2. This is the end of learning axis that calls for adaptive behavior. Learning (and imitations) that have roots in this quadrant will have a high degree of organizational influence and have significant tacit knowledge requirements. Brennan, Liker *et al* (1999) suggest a process like *Kaizen* fits in this category. To the casual observer *Kaizen* will appear as a set of tools with explicit rules of operation, but to a person knowledgeable in Japanese problems solving methods (and perhaps TPS), *Kaizen* is a highly integrated activity with many steps that can be adapted based on the situation. In this quadrant the knowledge requirements are higher as is the degree of interrelationship between processes and people. More complicated processes are being worked by larger groups of people that may have significantly different skill-sets and backgrounds.

It should be noted the Organizational Learning Model proposed here is the same in its first three steps as the Individual Learning Model presented in Figure 2–4. In fact, it is assumed an organization imitating a process that would, in the ideal, be located in this quadrant needs to begin as if it were located in the individual/mechanistic quadrant. This is addressed in a hypothesis outlined below. The model does differ as the individuals engaged in the learning process progress beyond personal mastery. At this point, it is not process capability, but organizational capabilities that become the focus. Through a shared vision, common mental models and group reflection that is akin to the *ba*[3] of Nonaka (2008) and Rother (2009) that the local interests are supplanted with organizational interest. If such conditions can be attained, Argyris (1985) Model II learning can affect adaptive learning behaviors. Additionally, as this is a place where tacit knowledge requirements are likely high, as adaption and group reflection increases more tacit knowledge will be converted to explicit knowledge (Nonaka, 2009). This socialization of the knowledge development process is also predicted by Symbolic Interactionalists. Once an individual chooses to see beyond the locally constructed reality a new organizational reality is constructed. Choices can now be made within the new reality of a dynamic world. The additional learning cycles of the organizational model are represented in Figure 2–4.

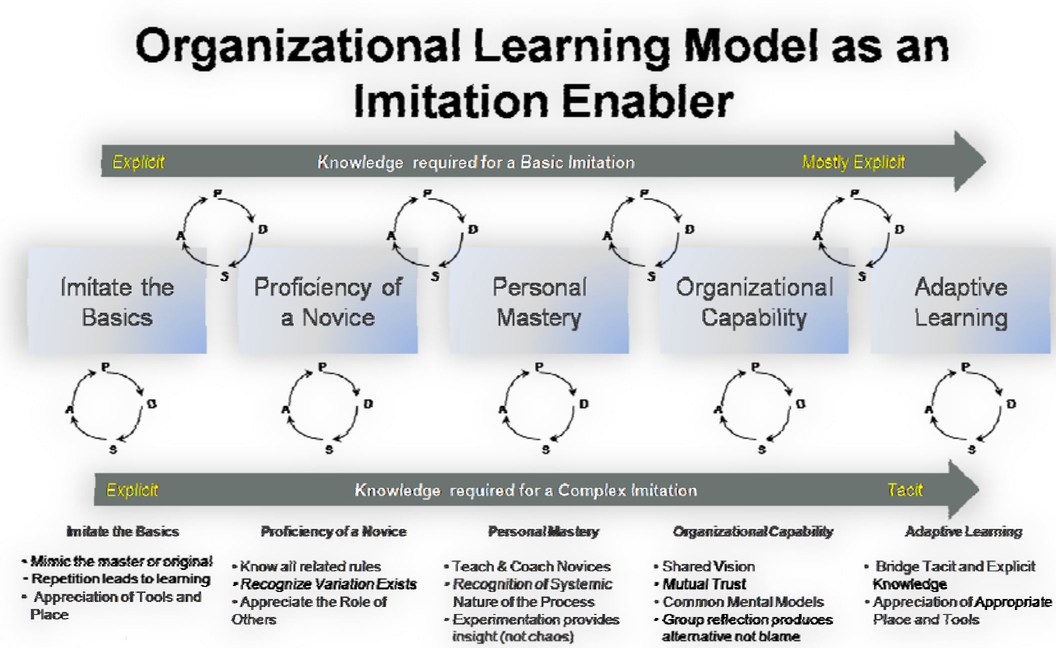

Figure 2-4 Expanded model to include organizational learning that begins with the individual

[3] *Ba* is defined in Chapter 1. Used here in the same context as suggested by Nonaka and Rother.

As indicate, situations occupying the upper right quadrant of the Individual/Organizational Learning Plane call for additional learning cycles. While learning will likely begin with mechanical imitation by an individual, successful imitation of organizational processes of this nature ultimately leads to changes in the organization. This brings us to a second hypothesis to be studied in this research:

> Hypothesis 2: In the case of an organization imitating processes of a highly system embedded nature governed predominantly by tacit rules, learning will begin with the individual and require many cycles of tacit learning with the slow introduction of explicit knowledge all intertwined with organizational change and organizational learning.

The second learning model, shown in Figure 2–5, includes a significant individual element augmented by additional cycles of tacit and systemic learning. As in the first model, dominated by the individual, each cycle involves study and reflection to determine if advancement is feasible. In addition, while an individual attempting to imitate in a mechanical/explicit world (bottom left quadrant) might be able to recognize local organizational limits they may be unable to recognize limiting factors to the development of capabilities that impact multiple systems within the organization. Such a limit may go unrecognized in a individual learning exercise, but now as a part of the organization with broader reach such limitations will be harder to miss. A shared vision comprehending a common mental model of the entire organization will facilitate the development of greater organizational capability; at the same time it will provide the learners the opportunity to truly adapt to solve problems with broader organizational impact through group reflection and the bridging of tacit and explicit knowledge.

As the imitation environment grows more complex and the imitation practice moves from explicit instructions to seemingly autonomous routines toward more complex instructions (of a more tacit nature) to include more systems embedded in each other a successful profile of the activity will change from a mechanistic approach to a more organic approach. A consequence of hypothesis 2 is that the management environment will change from a mechanistic to a more organic organization and problem solving.

> Hypothesis 2b: Individual learning is initially characterized by a mechanical approach to knowledge transfer and as need be is followed by learning displaying characteristics of a more organic organization able to deal with environmental complexity and change.

If supported this hypothesis suggests a learning relationship can be defined based on the degree of complexity expected in the internal environment of the mimicking organization. Using a relationship as illustrated in Figure 2–5, managers will realize the degree of structure required can be defined to facilitate the required learning.

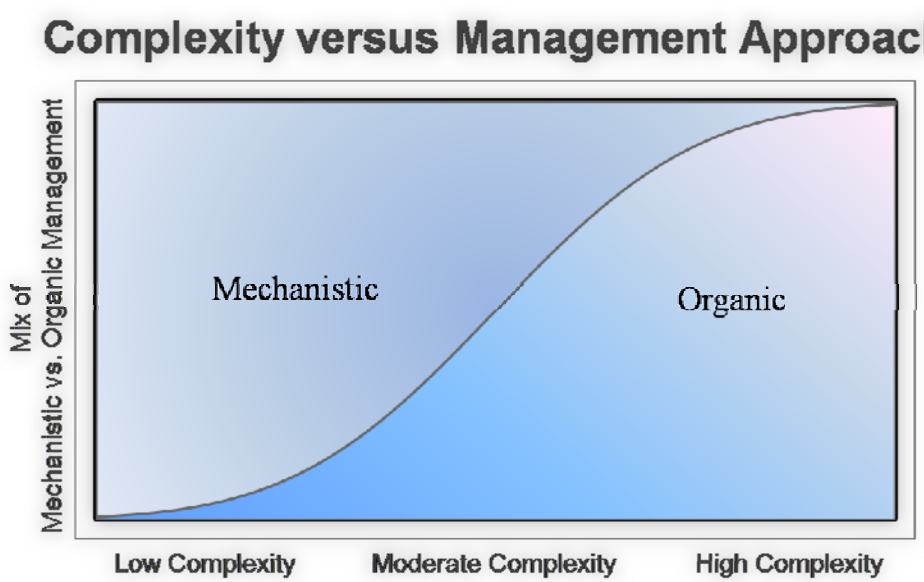

Figure 2-5 Complexity versus Management Approach

The two general models lead to a third hypothesis to address how or when an organization might move between the two learning situations. It is hypothesized the mentor or coach plays a critical role in developing the successful bridge between individual learning and organizational learning. As suggested in the previous chapter, learning by imitation cannot be accomplished by an imitator/learner merely reading a set of rules and observing. A mentor or coach plays an instrumental part in the assimilation process, particularly in the case of tacit knowledge, but also in the explicit case, perhaps to a lesser degree. In either situation, the coach or mentor can act as a guide to the novice to understand what is important; providing what Winter and Szulanski (2001) referred to as the "Arrow Core," and to drive discipline into the learning activity. Additionally, it is hypothesized the mentor plays a role in defining the *ba* for the learner and in so doing providing a necessary linkage between the organization and the learner signaling when individual learning need transcend to organizational learning.

> Hypothesis 3: A mentor or coach with a personal mastery of the original will act to not only ensure a novice learns the important key aspects of any new organizational practice being imitated, but will also define a vision of the future organization that provides context for the learner and facilitates the creation of a shared vision, common mental models and ensure an environment where reflection yield alternative solutions not blame.

If this hypothesis is supported one interpretation is that a knowledgeable coach will be instrumental in creating the environment described by Nonaka and Toyama (2005), an "eco-system of knowledge (Nonaka and Toyama, 2005, p. 430)." Imbedded in the environment are appropriate self-renewal processes – the *kata*, that prevent the routines from hindering creativity, but also from becoming mindless stagnant bureaucratic enactment of the rules.

Each of the proposed models contributes to a theory of imitation that will help address the research question posed in chapter 1: When does organizational copying lead to effective organizational learning, and when does imitation lead to bureaucratic application of process steps required only to satisfy a procedure? The answer to these questions is important not only because imitation and the associated problem solving is a group activity, but also because the required knowledge when an organization is trying to imitate another is not just the act of an individual, but frequently that of a group and therefore involves different thinking.

Research Methods

In view of the nature of this study: a research question in form of “why,” no control over the behavioral events and an investigation of a phenomena of contemporary nature, a case study approach is deemed necessary (Yin 1994). As indicated in chapter One the primary research question is: Why does imitation sometime lead to learning and on other occasions lead to mindless bureaucracy? Yin tells us studies of this kind are candidates for qualitative research, methods like case study. In fact, three embedded cases are presented in subsequent chapters. Each case will be presented and reviewed on its own merit and then a final cross-case discussion will provide an additional theory building opportunity.

Data in the form of interview notes and behavioral observations were collected from managers, practitioners and customers who played principle roles in each case. In general, a key informant approach with snowball sampling is followed. Primary informants were identified using contacts established by Dr. Liker and the writer’s personal knowledge of the each system represented by the cases. As interviews were conducted, a snowball effect resulted in the identification of additional interviewees; that is, as informants were interviewed they suggested other people they knew with insight on the activities under study. This dissertation combines the information from the interviews with knowledge gained by the writer from observation and discovery as an engineer and manager assigned to various activities in manufacturing and product development with GM over a 25 year period. The cases are selected to show both successful and unsuccessful attempts to imitate processes important to the company. They represent a set of work habits that is at once broad so as to provide some sense of greater applicability to the finding; and, culturally similar so as to reduce complexity and eliminate the effect of variables outside the control of the investigation. The reader will discover, one case covers a period of nearly 25 years, a second nearly 6 years and a third case covers an activity that took a little more than 4 years to complete.

Data collection and analysis follows a modified grounded theory approach. Data from informants is compared to the model and appropriate updates to the theory applied. Using this "Bayesian updating of the prior" approach provides a logical (albeit not classical) model building structure. This process will allow for modifications to the theory; avoiding the classical all or nothing "rejection of the null" approach. This approach, modeled after the qualitative methods of Glaser and Strauss (1967; 1993), minimizes error from too close an interpretation of the hypotheses while maximizing validity in a longitudinal study. The theory developed here is drawn inductively from a body of data including the literature reviewed in chapter one, text from interviews and the observation of individuals and their behavior in the context of the cases. In keeping with Strauss, the result fits at least one dataset perfectly (that which we present here).

The cases are intended to reveal both the causal conditions and the properties which govern when learning is taking place. Additionally, the influencing factors and background information that provide context to the active variables and the strategies employed by the agents in each case are identified so as to provide a background for the consequences of particular actions. The analysis is done in two stages. At the end of each case description a discussion will highlight the relevant features of the case and draw conclusions regarding the applicability of the models presented and hypotheses proposed. Then, the final chapter of this dissertation will be a cross-case comparative analysis. Cases similar on certain variables, but with different outcomes are compared to reveal where the key causal differences lie. This approach is based on Mill's methods of inductive reasoning – case outcome are examined to identify common traits, thereby revealing necessary and/or sufficient conditions for an effect to occur (Mill 1843).

THREE CASES AS IMITATIONS

Any organization that deals with a changing dynamic environment should have the ability to efficiently transform inputs to outputs, but should also be able to create knowledge (Nonaka, 1994). As an organization engages in innovation, be it new product development or imitation of a competitor's process, the need to take the information provided and create useful local knowledge is imperative. The answers to the two research questions posed in the previous section are interesting not only from a theoretical perspective, but also promises to contribute to solving a problem often found in practice. There is ample evidence that many firms try, but only a few succeed in copying or imitation. This research provides an extension of the theory on organizational change as well as guidelines managers can use to better steer the change processes in their organizations in order to increase their imitation success rate. In a practical sense, if managers have a better understanding of the limitation to imitation, learning resources could be saved and much of an organization's change-induced anxiety could be avoided. Understanding the various drivers and inhibitors of change in the context of imitating a process would help managers facilitate the changeover to a new process, reducing transition costs and improving employee morale.

To provide some focus to the problems of the effective and ineffective use of copying we draw on three case studies from General Motors. Each case study differed in the complexity of the innovation GM attempted to copy and the approach used. The research will analyze each case and compare and contrast the successful and unsuccessful cases by deconstructing the conditions of the diffusion of the organizational processes into new situations. The three cases are a rather complex opportunity to copy a process from a willing competitor, a problem solving process that is really an imitation of a copy, and the internal copying of an engineering process. Each is briefly discussed below.

<u>Imitation from a willing competitor</u> – GM had access to the workings of the Toyota Production System for a period of nearly 25 years while the two companies worked under a Joint Venture agreement in Fremont, California. NUMMI was an opportunity for Toyota to learn what they needed to do to be successful manufacturing vehicles in North America (having not done so prior to 1984). GM sent managers to participate in the day-to-day management of the plant; they were also there to learn about building small cars (something in 1984 GM was unable to do successfully). The GM managers discovered what many senior managers may have seen as a simple exercise of observing and returning with the findings was far more complicated. GM discovered Toyota had a superior way of managing the manufacturing process; the tools the managers saw became the objects of their interest. Through the efforts of early NUMMI graduates, parts of what is now referred to as TPS were quickly mimicked at GM facilities in the mid-western United States; early results were disappointing, but leaders

and practitioners persisted. This case shows that what may have started as an attempt to copy certain parts of the system turned into a two-decade-long learning experience. Revealed in the case are important mechanisms to transition a copying activity into an organizational learning and adaptation opportunity.

Imitation of an imitator – Design for Six Sigma (DFSS) process was imitated within the engineering environment at General Motors North America new product development engineering operation. In this case, the engineering new product development activity recognized an early quality and long term reliability performance gap between their products and those of their competitor that could be attributed to engineering. Managers were shown the designs of their Korean competitors and told DFSS is the reason. GM had experience with the application of Taguchi methods and other problem solving tools, but a comprehensive system that could be taught to everyone in engineering was appealing. In this case, the tools were copied as a set of instructions taught to engineers and employed in current production problem solving and new product development.

While successful at transplanting a copy of a process into a new environment, DFSS did not deliver on all promises. Successful as a methodology to solve current problems, six-sigma tools were not applied in such a way as to impact future problems (reliability issues). This case is an example of a routine imitated without a true purpose and without understanding of a greater goal; the result is a mindless bureaucratic application of rules to satisfy a procedural requirement. At the time of this study there appears to be no interest in any adaptation that will elevate the imitation to an appropriate combination of culture and operational procedures fitting the technology requirements of the situation. This case, when seen in contrast with the imitation and adaption of TPS in GM's manufacturing environment, broadens the understanding of why some copies remain mindless routines followed blindly in a bureaucratic manner.

Imitation from within – General Motors North American engineering "Information Book" is taken from a common local process to be copied within the North America engineering division, to a global tool to share vehicle information worldwide with all corporate activities needing the details. This activity again started as a copy that ultimately adapted as more and more stakeholders emerged with specific (yet related) needs. Learning was taking place, first locally then to an extended audience as the tool was effectively deployed to a multi-functional global user group.

The selected case, when viewed as part of a collection, illustrates the importance of imitation as a step in a learning process and suggests limitation in relying solely on copying to eliminate performance gaps between organizations.

Benefits from the Case Comparison Method and What can be Learned

The result of the three cases broadens our understanding of the ability for change to be a positive organizational force and suggests a role for organizational copying in the learning organization. Further, the three cases selected will address the three hypotheses selected in the previous section.

The three cases are shown on the Individual/Organizational Learning Plane in Figure 2–6. The graphic represents the ideal position for each of the cases. In at least two of the cases it will be shown that during the course of the implementation process the frame of reference of the imitators either changed or was determined to be different from this initial condition. An analysis of the effect of such shifting forms the essence of an argument as to why imitation fails. Suffice it to say these initial positions, when coupled with the understanding of managers and leaders working the processes, did play a role in the final disposition of the process being imitated.

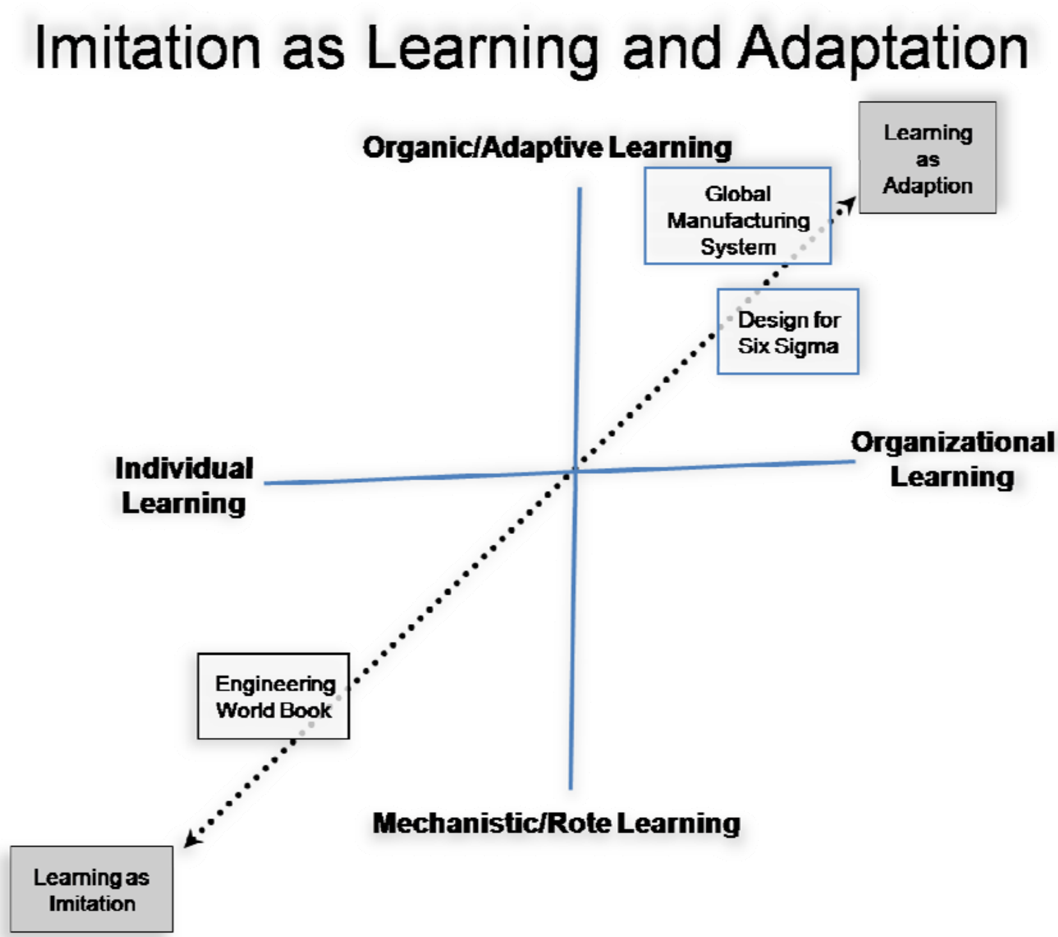

Figure 2-6 Three Cases to be Presented as Learning as Imitation and Learning as Adaptation

On the I/O Learning Plane, DFSS would be in the top right quadrant. It can be imagined a problem solving in a new product development orgainzation would be built on a process-based set of explict rules, but dealing with complex problems might require adaptive thinking. Clearly, the sort of issues an engineer involved in new product development encounters are systemic and cross several engineering and vehicle subsystems boundaries. Interdependence (Daft 1998) would be reciprocal; sharing and coorordinating would be intense between manufacturing, finance, marketing as well as other engineering functions. It can be argued to succeed, the application of DFSS needed a common process that could be easily adapated to local problems requiring knowledge not only of the explicit rules of the problem solving mechanism, but also implicit knowledge that would allow for adaptive thinking.

The Global Manufacturing System, GM's imitation of TPS, is a highly embedded process with many interrelated sub-systems. On the surface it appeared as if the various tools were easily understood and the instructions for using them similarly easy to teach. This is not the case as deeper and stronger contextual relationships both socio-technical and procedural became evident over time. The complexity of the set of tools and the reciprocal interdependences characterized by mutal adjustments and the need for cross-team meetings to effectively coordinate GMS activities places this case in the top righthand corner of Brennan's model.

The Engineering World Book (EWB) is placed opposite to GMS. In this engineering case, a complex set of information and an interconnected multi-functional application are explored It is argued for users of the EWB demand for horizontal communication is low, and divisional stucture and standardized rules will provide adequate governance even in globally distributed work groups. Engineering may be the initial creator of the information, but the usage goes well beyond the influence of the engineer. Marketing, finance, manufacturing, and logistics are among the list of contributing users of World Book information. The embeddedness of the process and the complexity of information processing to create the data are complicating issues in creating the required global copies of this process, but the explicit nature of the knowledge and the relatively autonomous silos of work place this case as an ideal in the bottom left of I/O Learning Plane.

The next chapter will be a case analysis of GM's imitation of TPS. Each case will start with a brief outline of the its context as an historical review of the organizations invilved. A specific review of the case in view of the theoretical models devivied in this chapter will be argued. In addition, an outline of how the data from the case will be applied to the theory is presented, a discussion of the finding will conclude culminating in suggested updates to the theory.

Chapter 3

GM IMITATES FROM WITHIN – ENGINEERING WORLDBOOK GOES GLOBAL

In the early part of the 21st century many companies were thinking globally. One popular writer claimed globalization was an unstoppable wave (Friedman 2005). He argued corporations had started to out-source, offshore and generally manage their supply chains without regard for borders and this has changed economics for the better, putting even the poorest countries on a level playing field with their developed counterparts. Never mind the facts presented since that globalization favors the developed nations, only places value on monetary outcomes, has negative effects on democratic processes and (at least by the end of 2005) has not lived up to its promise (Stiglitz 2006). In 2004 companies like GM saw the opportunities of globalization as not coming from cheaper parts or labor, but from streamlined organizations that can share product around the globe or perhaps have the total organization engaged on a project 24 hours a day. All that was required, it seemed, were some common processes and good management.

Many firms, including GM, were already working around the world[4]. In the late 20th century some, like GM, were organized in a traditional regional structure with an

[4] In 2005 General Motors was manufacturing in 84 and selling in 154 countries, and had an organizational presence around the world represented by four divisions. In countries like Canada and

executive staff located in each region along with and all of the functions of the home corporation represented. With such an operating structure companies would have redundant activities in every region they operated. Common processes would eliminate the overlapping activities thereby reducing the structural cost associated with operating in different regions. The case of GM taking an internal process and mimicking it in several geographically diverse regions is an example of just one of the many efforts companies around the world made to leverage the global reach it already had.

THE PROBLEM

GM Copies North American process at engineering centers around the world

Vehicle development at GM for much of the twentieth century had been done on a regional basis. That is, vehicles were engineered and manufactured in a home region for that region. For GM in North America that meant, vehicles were designed, engineered and manufactured in Canada, Mexico or the United States and sold in these markets. Europe, Latin America, Australia and Asia each had a similar business model. Prior to 2004 few vehicles at GM would have been designed, engineered and built in one region and sold in another[5]. In fact, management of all the various functional activities took place within the region as did decision-making.

One important decision was: What would be built? The long-range build plans or product plans within each region was be based on a set of architectures (prior to 2004

Brazil and the continent of Australia, GM was represented by wholly owned subsidiaries (GM of Canada, GM do Brazil and Holden).

[5] One exception to this rule was a process called Complete Knock Down (CKD). For example, a vehicle built in Europe could be disassembled (or CKDed) in a facility in Europe and then shipped to a South America and reassembled with some local contented added.

unique to a region). Several architectures would exist for different families of product within a region and from each multiple vehicles each with the potential for models and variants would be built. For example, midsize car architecture could provide a basis structure for vehicles from several different lines (Chevrolet, Buick, Pontiac and Oldsmobile), each potentially being renewed as the product aged (Figure 3-1) and each having different models and option levels. Architectures would be replaced over time, but some might linger for 20 years or more (trucks maybe longer).This vehicle architecture logic of product development is repeated in each region for the specific vehicles designed, engineered and manufactured in the particular area.

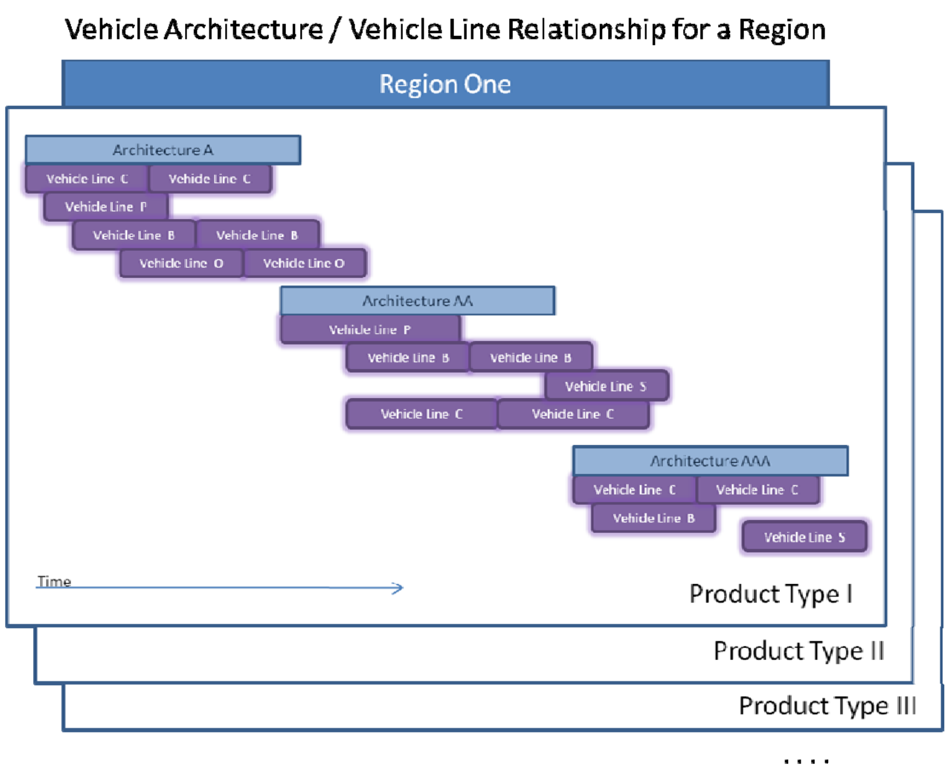

Figure 3-1 Vehicle Architecture for one region

Within a region some part sharing within an architecture could be possible, particularly parts unseen by the end customer, underbody and structure parts for doors or hoods for examples. Marketing divisions would insist on differences in the parts seen and felt by the occupants of the vehicle as a means to provide a unique brand image. Little or no sharing of parts could be expected between different architectures within a product type and none at all between product types. Of course, when a product was designed, engineered and manufactured in one region the sharing of parts between vehicles in another region, even with a similar customer was completely unheard of. To some extent this was a result of a “not invented here” mentality along with communication problems. The communication problems were a result of different regions using different conventions for naming and identifying the characteristics of the parts. Of course, if you were operating as a regional company these habits were acceptable.

This regional structure for product development changed for GM in 2004 with the announcement of its first global architecture. At the time engineering did develop new product using a common process, namely the Global Vehicle Development Process (GVDP). The GVDP, a system engineering approach engages all of the organizational players in the various phases of new vehicle development. The GVDP does not suggest common ways of describing the product or its various models and variants. It does not put rules on part assembly breakdowns, uniform part descriptions or other taxonomy. As a result, when a model was described by one region in its engineering product description system (PDS) the logic to group parts into a vehicle (and the code to describe it) was different from all other region. In fact, according to Ray, an engineering informant with expert knowledge of the system, each region had its own way of describing a vehicle and the parts associated with it, right from the model designation to the part/option groupings.

In engineering this meant part reuse between regions was difficult or impossible and work sharing was always going to be case by case with significant translation required for each part. Of course, once engineering describes a part in a particular way, the downstream users of the information – purchasing, order fulfillment, manufacturing, quality and finance each needed its own regional "decoder ring" to figure out how to source, market, build and track cost for a particular vehicle line so any change would involve these customers as well. A common set of rules would facilitate the ability to communicate product information globally and make part reuse, work sharing and flexible manufacturing possible, but it would mean the disruption of many related processes. Creating a common set of rules to be copied throughout the entire organization would not be easy. Even as what would be copied was an easily codified set of rules regional strengths and poor linkage between the functional groups in the regions made cooperation difficult and without cooperation there could be no original to imitate.

The approach

In this chapter we will look at how GM copied a system for creating engineering information in one region to its other regional divisions. Specifically, we will first see how the original was developed and then how the element, a set of rather mundane codes, were implemented to create a global information book. The "book" would be available to all that needed it and it would facilitate other global engineering processes. In many ways this should be the easiest copy to make happen, an original easily available for review (Winter and Szulanski 2001), the developers of the original available to consult on its workings, a common corporate culture, and a set of explicit instructions governing its use. Moreover, it was a set of standalone instructions, and not require significant change in the broader system of product development.

To study this situation data was collected over several months through a combination of participant observation and interviews. Interviews were conducted with directors and practitioner both in NA and Europe and Korea. Conversations with directors were focused both on creation of the original as well as the change management strategy employed. Additional interviews, with practitioners, focused on the learning process and the execution of the copy in the regions. Training material and other development workshop artifacts were reviewed for clues to develop a picture of how the imitation was received by the regions and accepted. Participant observation in NA also added significant understanding the detail required to create the engineering information described. Additionally, time spent by the writer as an engineering manager in GM over the period describe in this case.

The Original

A corporate global leadership conference held in 2004 included an announcement of the first truly global program at GM. The announcement spawned an increased awareness of the need for common systems required to facilitate the globalization of a new product as well as the opportunities it would bring to the corporation. Ray, a participant at the conference says, at this conference the plan for the first global architecture was shared and the true global nature of the product family began apparent, issues related to how product information would be shared became real. This first product was to have a "home room" in Europe, a lead plant in Korea and second and third models to be launched in the US and Europe over a three year period. Most of the executives charged with the work recognized the need for a level of cooperation between regions never seen before at GM. Before the conference ended there was widespread agreement to move to one global standard for sharing both design "math[6]" and product information. What was harder for the members of the regional activities to recognize at this time was that they would likely have to do something different (and perhaps locally sub-optimal) in order to allow the corporation to benefit from the commonality proposed. Still, an agreement at the highest levels existed and in a matter of weeks an "original" was forthcoming from a group of engineering and planning executives from North America.

For a large complex organization to make common processes occur on a global basis three things need to happen: leadership must recognize the effort needed for the change process and commit to the effort, an agreement must be reached on the "original," and the copies must be shared along with training for all operators. In GM's effort to communize its engineering information, the first and third were surprisingly easy to affect, the agreement of exactly what would become the standard did take some work. In what might have started as a "tell" from then CEO Rick Wagoner, the global leadership (as a group the top 150 executives in the corporation) accepted the need for global vehicle programs and agreed to make whatever changes required locally to participate. The required operator training was also relatively easy to both develop and deliver once an agreement on what was to be deployed was reached. The solution would be referred to internally as the Worldbook.

[6] The part math is the electronic, 3D representation of the part. It is the computer age version of the drawing, and the designer is the equivalent of the draftsman.

What is Worldbook?

To facilitate the sharing of information between regions and enable a global manufacturing strategy, a common engineering approach to storing and sharing the vehicle/part information is important. In fact, a common Vehicle Architecture Structure (VAS) to store and share the part math, materials and specifications; and a Global Product Description System (GPDS) to describe part details like finish, option, and model associations are also required. The set of details described by the two systems came to be called Worldbook.

The VAS is a taxonomy and a depository for all vehicle part geometry; this information is managed by the design group. The VAS breaks a set of parts for a particular product into categories based on the functional relationship to the vehicle. The major functional categories, like interior, chassis, body structure, body exterior are further broken down into sub-functions. Interior, for example, would include seats, door panels, trim, and others. These categories are broken down once more to parts and assemblies. Before a part's geometry can be started a work order indicating, among other things, the model and the UPC FNA must be issued. It is these identifiers that will assist the designer in creating part assemblies or subsystem assemblies to check dimensional and quantity. The experience of design people up to 2005 indicated acquiring the math for parts from different regions of the corporation was nearly impossible without significant manipulation by a designer. This is a result of given the proliferation of systems used to create and store math used around the company.

As a companion to the VAS, the Global Product Description System is a database engineers use to manage any product change, including the introduction of a new part. It is a system that associates parts to vehicles and architectures through the models and options designated in the work order. Once an engineer issues a work order to include a part in a specification analyst will work with him or her to ensure the part is associated with the correct assembly and subassembly. The work order is also used by the designer to create the math for a part. Once the math is complete, the specification analyst records the part release into the Global Part Description System (GPDS) on behalf of the release engineer. This system tracks the release of the part as well as usages[7] and any changes.

The GPDS database is the first place a “paper validation” of the vehicle will take place. The specification group (through the analyst) will generate a “virtual build” by combining parts as specified by the codes. A review with a checking routine will reveal any mismatches, such as missing parts from a specified option or two many parts on a potential build. Typically, an engineer will see several “builds” on paper and will review a list line by line using his or her knowledge of the parts to verify the correct vehicle configuration will be built when a particular model is called for in the assembly build sequence.

The VAS, as a store of the three dimensional geometry of a part can be used to do a similar “paper validation.” In this case the geometry for a set of parts can be compared for build interferences and dimensional correctness. When combined the VAS and GPDS provide the organization with data to do virtual builds and tests using CAE tools, test dimensional tolerances, assess build issues, track costs, contract for parts to build a

[7] A usage informs the plant building a particular vehicle how many, and with which options a part is used. It includes differentiation in the part by color and finish.

vehicle and describe product features to customers. The information in the two databases is required at various times in the new product development process and by many different functions.

Worldbook players

In the GM's Worldbook imitation the players can be generally described based in a regional and functional "home." Figure 3-2 shows the alignment of a typical regionally aligned functional organization chart. In this particular rendition, there are four regions each having its own engineering, marketing, manufacturing, purchasing, finance and quality organization. Each of these activities would have a functional leader, identified at GM as an executive director. These people would report to a local executive. In the Worldbook implementation, each of these people played a key role in defining changes needed locally to be common with the rest of the world. The roll out of Worldbook was led in each region by engineering, and each of the regional engineering leads took their cue from the NA implementation team.

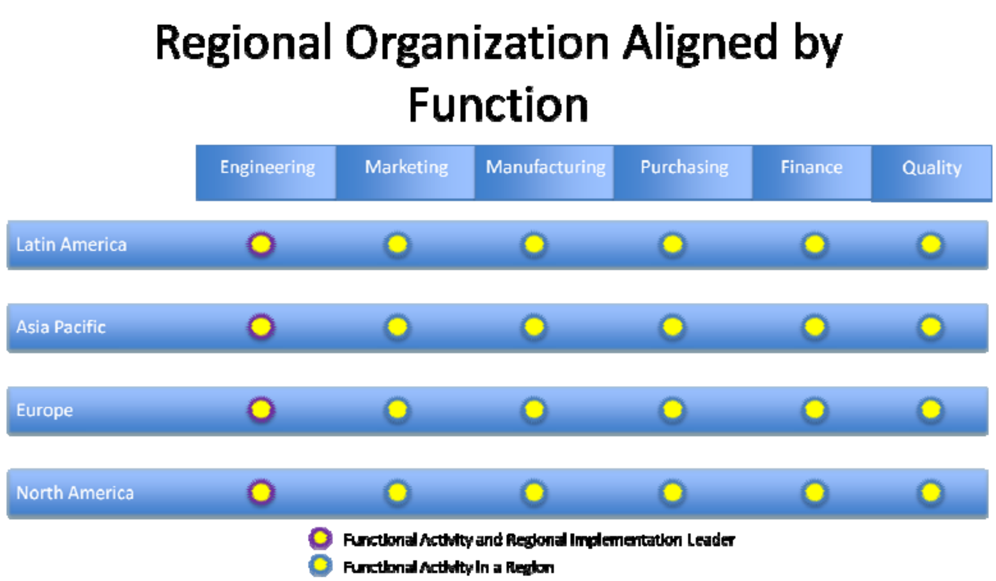

Figure 3-2 A Regional organization with functional alignment

The responsibility for the global deployment of Worldbook fell to North American engineering because of its experience consolidating its own activities in the late 20th century (more about this later in this chapter). This pre-work provided engineering leaders with valuable practice identifying and solving problems related to creating one system. A number of key leaders in NA had a deep understanding of the technical aspects of the release systems and the nature of some potential code mismatches. They had also seen many people problems associated with resistance to change. In short, they had a solid understanding of the technical aspects of the rules and knew of the importance of engaging the stakeholders in the change activity. At the onset of the project no one really understood the time and energy it would take to bring all the regions into line with engineering information.

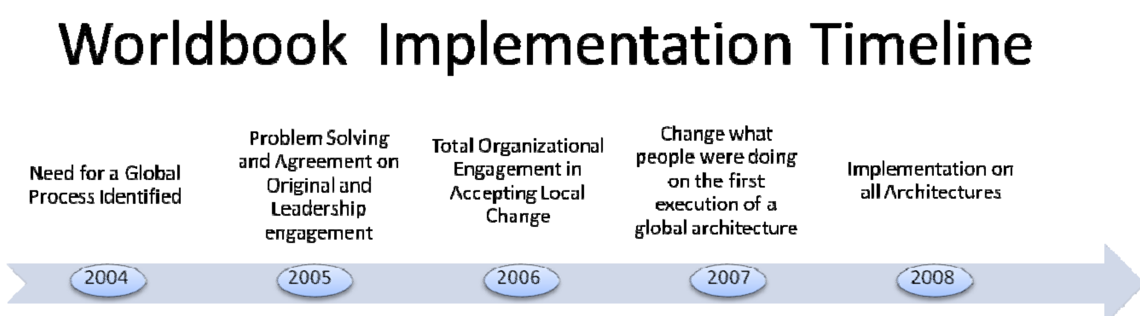

Figure 3-3 Worldbook global implementation timeline

The individual who led Worldbook deployment activity was a mid-level engineering executive with a technical engineering background. He had experience in the structures design group and in the release organization. He was a detail-oriented engineer with a demonstrated ability to solve problems and energize people. He reported in an interview regarding Worldbook: “of course, when I started this thing I didn’t even think it was going to be a full-time project, little did I know it was going to last for nearly five years."

There were operators in the role of specification analyst from each region that functionally resided in engineering. Each of the other functions had users of the information. The change to a common set of engineering information books did not change their deliverables, but as the local imitations began to roll out the managers and executives in each of the regional functional silos played a role in defining the change process. The learning that took place as part of the effort to copy Worldbook started with the individuals involved in the roll-out and ended with users from every functional area spending some time learning a few new codes. A review of how this copy fits into the theoretical model follows.

<u>Wordbook's place in the theoretical model</u>

Worldbook is engineering data that is manipulated and consolidated into information based on a set of codes. Most of what was changed in the regions was behind the scene, in the way a computer program sorted, grouped or associated strings of data. There were new rules for data input and for storing files, but once the specification analysts, designers and some planning people learned and used the new rules Worldbook would exist. There would be no change in how an engineer designed a particular part or how a cost analyst or a warranty engineer or any other downstream data user created their specific work output.

The engineering release data represented by the two sets of information, the part math and the product description are combined to tell anyone exactly what a part or a set of parts should look like and act like. It is information that is shared on a one-on-one basis with individuals needing to know certain details of the part or assembly design or the relationships between parts for the purpose of making a new product ready for market. The users interpret the information through a set of rules based on an explicit codified base of knowledge. In an ideal world, everything needed to create any required report is pre-determined based on well defined and well-understood relationships developed using a common set of codes. From the point of view of the user this simplifies their job. In all likelihood they had been frustrated that they could not easily get access to other designs that they could build from and had to start over So the technology fulfills a real need.

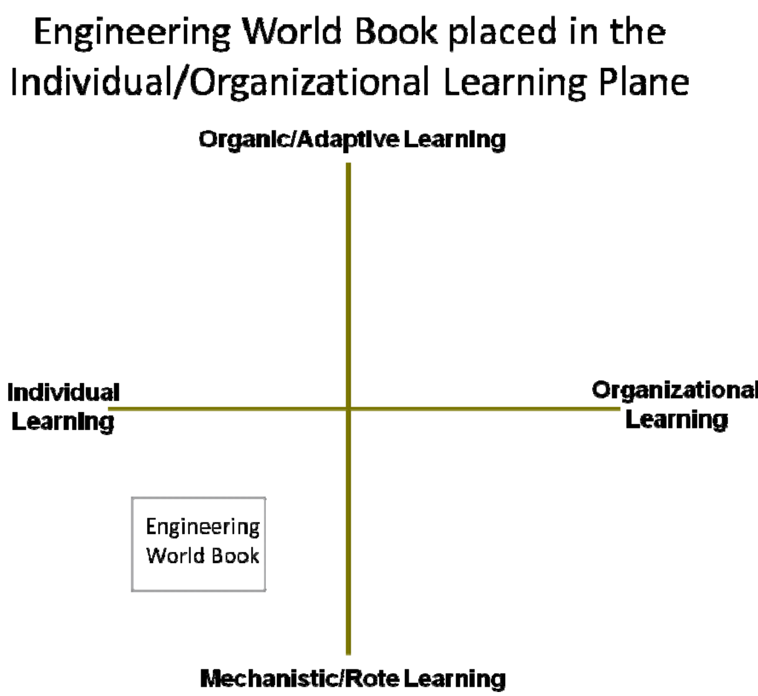

Figure 3-4 Engineering Worldbook on the Individual/Organizational Learning Plane

For example, a specification analyst who has worked the system for a particular product family for several years will know the regular production options (RPO) for their product and the associated options for a particular model. Likewise, they can identify the relationship between parts by studying the relationship between different UPCs and the assembly part structure within a product family. This is to a significant degree the result of memorizing the relationship after several years of use. The combination of the information being so specifically codified and the individual nature of the information sharing make this a candidate for the Individual/Rote quadrant of the Learning Plane (Figure 3-5).

In a typography of innovation, the changes outlined by Rogers (2003) this is clearly a technology change based on information or the software required for decision making. Rogers makes an important link between the hardware, software and social embeddedness of the two that requires "a technological innovation has at least some degree of benefit or advantage for potential adopters (ibid p 13)." Other attributes of the proposed innovation that will influence the ease of diffusion include compatability, complexity, trailability and observability (ibid p. 211). As Worldbook was working off of an existing information retrevial architecture the later four attributes less important than how user interact with the new information and make it part of the working process.

A Worldbook user will acquire the knowledge of the rules through an individual learning process. The process of learning will start with an initial period of repetition of a basic set of instructions resulting in proficiency with all of the rules associated with the system. This "proficiency of a novice," stage is akin to Dreyfus' (1980) early skill acquisition stage and will eventually lead to an individual gaining a personal mastery of the explicit rules and conditions of use. Once a mastery of the rules is attained, knowledge of the rules and the governing process will enable a user to improve process capability. At this stage of learning the individual is able to use an expert's understanding of the rules to identify what Deming (1986) referred to as common and special causes of variation in order to reduce variation and better achieve a process target condition. This progression is summarized in Figure 3-3.

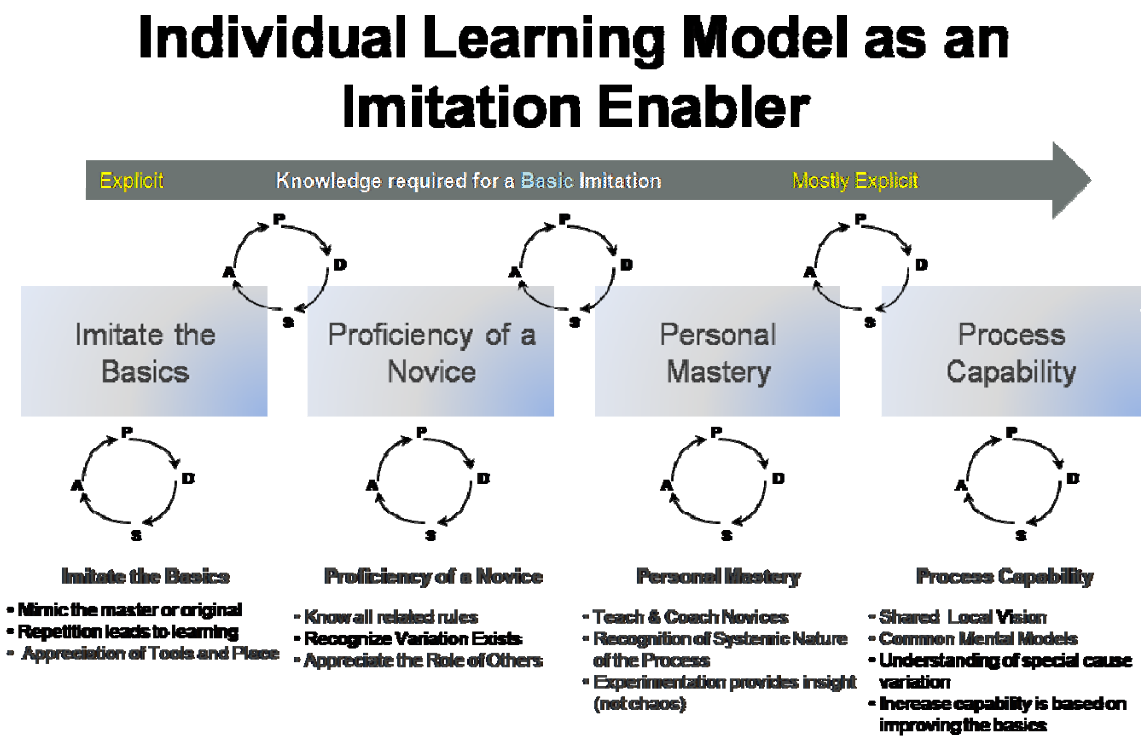

Figure 3-5 A model for individaul learning as an enabler to imitation

As outlined in Chapter two, this is the simplest of the cases an organization will encounter as it sets out to imitate or mimic a set of business processes. The learning starts and ends with the individual. As stated in Chapter 2, if an organization is attempting to imitate an autonomous routine embodied by largely explicit knowledge requiring an individual to understand the documented steps and rules with only minor adaptations this model can yield effective imitation. This operational expectation can be summarized in the following hypothesis:

> Hypothesis 1: In the case of organizational imitation of processes of an autonomous nature governed predominantly by explicit rules, individual learning characterized by a mechanical approach to knowledge transfer is effective with little organizational learning.

Specific to this hypothesis is the assumption that learning will be mechanical, based on the known rules and procedures. If this hypothesis is true, one can expect to see effective imitation if learning is complete and the situation only required an individual to understand explicit codified information.

Of course, some motivation is required by the individual to learn the information and incorporate the new tools into their work routine, but we propose that this does not require a great deal of coaxing as long as the benefit to the individual's work is clear. Thus, top down selling that the technology is important for globalization as endorsed by the CEO should be adequate.

Having described GM's inability to effectively manage a global product without a common engineering information book and its plan to improve on this condition, this paper will now discuss some of the pertinent history of engineering as an organization, the culture that has unified it and the motivation for adopting Worldbook.

CASE BACKGROUND

History of Engineering

Engineering at GM has been an important part of the organization. Bringing new product to the customer is an important activity for any ongoing enterprise. In the automotive industry it is critical to survival as all of your competitors are bringing cars to market regularly and customers get excited by new technologies and styles. While never a profit-center like other division it has long been regarded as an activity that could not be touched during times of economic downturn. After all, this was the center of the future product pipeline. Along with this exalted position has been the responsibility to deliver the new product designs ready for the manufacturing engineers and the plants, a role up until recently executed based on a divisional (product) structure.

GM's original product engineering organization reflects Sloan's classical management philosophy of dividing the organization into specialized divisions and functional groups and allowing them to compete. A hierarchy existed to maintain proper control and ensure effective communication. Over time, the competitive divisions were eliminated and the engineering community found new (less healthy) internal competitors. As the product grew in complexity a division between manager and worker grew. This division manifests itself in non-cooperative and often coercive exchanges. Of reason, according to Ray, many groups were lead by people that did not really understand what happened at the work level in their organization. The directors not familiar with the detailed work of their group established local procedures and systems providing rules with the intent of minimizing potential game-playing on the part of the engineer. An example of such a system is internal review in a functional organization that checks the progress of a design by requiring the engineer to report on the number of DFMEA lines generated since a particular milestone, other examples include analysis runs complete and engineering work orders closed in a certain window of time. These are poor proxies for an engineer's performance. Such activities do not allow for different levels of skill between engineers or act to provide any information regarding the best practice for a design. Instead, a coercive social environment is established (Adler and Borys 1996), one where gamesmanship becomes part of the system for all activities from closing work orders to developing timing plans and budgets.

Based on Sloan's model of strong brands based on competition from strong rivals, engineering at GM was, up until the mid eighties, functionally aligned with the product it supported. In NA for example, each product division, Buick, Cadillac, Chevrolet, Pontiac and Oldsmobile, had its own engineering group. These groups worked largely independent of each other to engineer the content associated with the various models offered by the division. There was one common core of engineering activity at GM during this period: Fisher Body Division. This group engineered the body structure, what might now be seen as the basic architecture of a vehicle, as a separate (unified) organization. Fisher Body Division, was independent of the divisions, but supported each as the sole provider of the body structure from which everything else would be attached. A similar, albeit smaller, organizational structure existed separately in Europe, Latin America, and Asia, complete with a mini version of Fisher Body.

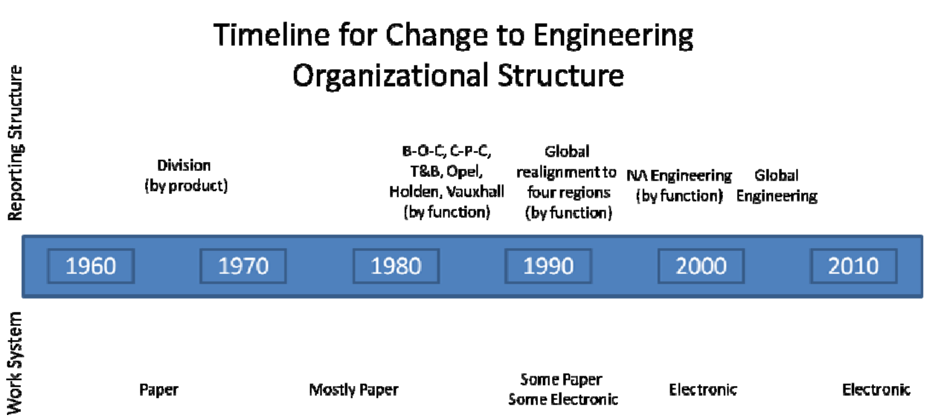

Figure 3-6 Timeline for change to engineering structure

This independent structure went largely unchanged for much of the 20th century. In the mid eighties GM NA went to be three divisions arranged around the aforementioned (and familiar) brands plus truck and bus (Figure 3-7). The organization changed in NA again ten years later to be grouped around the size of the vehicle – small car, midsize car, large car and truck. In Europe the alignment stayed much as it had been prior to this time until the mid nineties when it changed to be regionally aligned. The reorganizations continued in North America as GM's market share was shrinking, by the early part of the 21st century, in NA there was one engineering group for all cars and trucks. The same overall structure was copied in GM's other regional divisions.

During this period the way engineering information was being stored and shared was also changing. In the early years, drawings were on paper, stored in large rooms and microfiche. The detail associated with part breakdown and assemblies were compiled in binders (filled with handwritten and typed pages) that summarized the work orders defining the product and the changes made over its life. The book was kept up to-date by a team of specification analysts assigned to a product line. When the product line was only two or three vehicles for each division this was not an onerous task. However, as vehicle offerings grew and the complexity of the product increased the associated engineering information also became more complex. Systems, electronic and otherwise, were developed to accommodate the complexity. Many local rules were developed to prevent errors and to control the flow of information.

The early systems were nothing more than automation applied to the existing processes and each engineering division had its own version of things like model designators, option codes and functional names for parts. Likewise, they each had a philosophy regarding assembly part breakdown and what responsibility plants would take regarding the purchase of an assembly or building something on site. Seats for example, were built at line side for at many plants in the Chevrolet truck plants long after the car plants were receiving them as assemblies from a trim facility. The result of this thinking was each engineering activity had its own system to track vehicles. However, in NA as the divisional structure was evaporating and the engineering groups came together so did the systems by which engineering drawing and vehicle descriptions were categorized and stored. There may not have been one process for all of engineering, but it was very close, according to one director involved with GM part releases since the late nineties.

NA engineering's twenty-five year journey from paper to computer and from many processes to one had been a transition not only for engineering, but for many downstream users of the information. According to Ray, many changes to the way information was stored or disseminated were driven by engineering, but often only after consultation and engagement with users. During the transition, relationships were developed and ownership and accountability established between many different non-engineering entities that needed to know some piece of the vehicle puzzle and needed the information in a way they could translate it to be used in their local processes.

For example, the Quality group may want to track warranty on a particular new design is used by two different groups and compare the numbers to a prior version of the design. If the groups somehow had different UPCs (Unified Product Code) attached to the assembly, comparison would involve unnecessary coordination. Being common could be achieved merely by informing one group of a change and properly executing the decision. NA engineering discovered unilateral decisions like this were rarely worth the time saved. The transition from many engineering organizations to one in NA taught the engineers to tread lightly and use their connections to ease the transition. By the end of

2003, NA engineering had successfully migrated to one engineering release process and had developed a system to engage other stakeholders that facilitated the implementation.

GM's Motivation and Goals

For GM there were several benefits from creating one set of engineering information. In particular, if a vehicle was developed with a global focus, it could be sold in several markets around the world with minimal change for local conditions[8]. To do so, manufacturing flexibility would be important; an associated goal of the manufacturing organization was to be able to add a given vehicle to the production line in 90 days. With common tools – Bill of Process (BOP), a common set of parts – a Bill of Material (BOM), and a global manufacturing system (GMS) it was deemed possible. In addition, engineering was interested in work sharing across regions, something that had been part of the Vice President of engineering's "one GM" vision. A third objective was financial; if parts could be "reused" from program to program engineering costs could be reduced through a general reduction in development time and piece cost. With the announcement in 2004 of the first global architecture, the need in for engineering to consolidate information to enable these global objectives was apparent.

General Motors was also interested in virtual engineering. A key product development executive said virtual engineering (VE) was a way to reduce lead times, improve the quality of the decision making, and give the firm the advantages of a

[8] Many different vehicle standards exist around the world, based on a combination of political and economic considerations. The rules that govern a county's specific vehicle standard are generally described as Motor Vehicle Safety Standards, the differences from country to country generally translates into several different system designs in any automobile. Additionally, many developing countries require a certain level of local content to be included in vehicle sold in its market. Such rules may result in manufacturers choosing to build using a Complete Knock Down (CKD) strategy.

computer-aided engineering process. At GM, VE is recognized as a huge transformation from where they were in 2003. According to one informant, up until that time, many of the advanced engineering tools of product development were being used haphazardly in an almost *ad hoc* way.

In some cases engineering analysis and virtual builds have been constrained by the number of tracking vehicles that can be created. Sometimes this is based on poor program decisions related to changes to the product (adding features too late in the process), but also because a part from other divisions may need significant electronic "patching" before it can be put into the model from another region. Additionally, engineering leadership in some areas were unwilling to accept the results of a virtual analysis and instead wanted to see parts on a car go through a physical test before a design change is approved. This "test-break-fix" mentality is thought by the more progressive engineers and managers to be a holdover from the days of 72 month program cycles and not the way of the future. Younger engineers and engineering managers seem more willing than older managers to accept the results of a computer simulation of a part and make decisions based on the virtual results to meet the requirements of the vehicle system.

Understanding the customer requirements and the system engineering principles to drive the requirements down to specific parts would be enabled if the information to create the designs is easily available. A functional engineering director involved in the first global product said, "GM should be able to reuse not just the parts, but the customer requirements that have been engineered into the part." Ray, describing a GM design cycle adds: "we often creates a design and then create another design to do the same thing based on ‘a better idea,’ instead of reusing the information in other products, particularly from region to region.” According to him, customer requirements are not that dynamic and if Computer-Aided Design (CAD) tools, Bill of Material (BOM) and Bill of Process (BOP) can be aligned in a work share virtual environment it will facilitate activities like designing a superior part or an assembly one way in any region and build it wherever you wanted with only moderate changes to a manufacturing facility. This according to Quinn, a high-ranking engineering executive and strong supporter of one engineering organization and Worldbook, “is the way to take advantage of the global reach of the organization.”

Potential Challenges of Engineering Culture and Leadership

This case is imitation on a global scale. To succeed would mean cooperation by parties from several geographically diverse groups represented by several intellectually different functional organizations. The culture of managers and workers from different countries is well documented as providing dissimilar focus to relationships, power sharing and respect for authority (citation needed). To a significant degree the effect of these cultural differences were mitigated at the work place. In part, because until recently GM’s regional activities were managed by North Americans. A strong leadership team from NA brought with it much of the corporate culture of GM NA. Corporate goals with a focus on making money were self evident from investment decisions of the late seventies and eighties coupled with plant closures in Europe and Asia at the same time seemed to favor North America. At that time NA was profitable and Europe and Asia were suffering through poor sales in part a result of poor regional economic conditions

(GM Annual Report, 1985). Such decisions making, coupled with a command and control hierarchy centered in the United States, created tension.

The tension in the engineering environment at GM in the early 21st century is best described by Adler's coercive bureaucracy (1996). From the "command and control" hierarchy established by Sloan and reinforced by a Vice President of engineering with a naval officer's training reporting to another ex-navy pilot. A strict sense of how things should work and what needs to get done are not bad things in many situations and implementing a set of routines in a global workforce is perhaps one of those situations. Command and control, but consistently working to ensure the technical solution was correct can become an enabling environment if certain other conditions can be nurtured. Specifically, Adler and Borys suggest managers can help create empowered employees by making rules and procedures enabling tools and develop a sense of learning at the organizational level. Create a place where systems and best practice templates to be improved (1996).

The opportunity and the tension is explained in cultural terms by Schein (1984) who writes: "if a total corporation consists of stable functional, divisional, geographic, or rank based subgroups, then that corporation will have multiple cultures within it (p. 379)." Multiple cultures are not a bad thing, on the contrary when overlaid upon an existing corporate wide culture they lend a certain continuity to different divisions leading to "stable social units (Schein)." This is arguably true when the nature of work between groups is not interdependent and when there is a clear difference in the scope and complexity of the work. In this case the work of one region was about to encroach on all other regions. That was changing and the way it was being changed may have appeared to be global business as usual – North America telling the rest of the world what to do. The following detailed case description suggests Worldbook succeeded despite and because of these conditions.

Case Description

As a consequence of prior work with McKinsey, the engineering executive team in NA had been introduced to a change management model that was both easy to follow and showed results. The basic approach was to start with an agreed upon set of tools and management philosophy (called Q in the consultant's model) and add engagement of the workforce as appropriate (E) which will foster a transformation (T). In an equation form: Q•E = T. In this model, Q is the original, the object of the copying exercise. In many situations of organizational copying the original to be imitated is a given. Perhaps as a consequence of decades of regional bias on how to run a division there was some resistance to accepting this original. Consequently, the first step for the Worldbook team was to come to an agreement on the original coming from North America.

Agreement on adopting the original

The global common approach to Worldbook was based on the system used in North America. Engineering in NA had been working toward one release system for several years and as it was engineering information at the root of the issue; NA engineering had a head start managing the change process. Additionally, engineering functionally had a strong cross-region relationship they were to lead the deployment of Worldbook. They took a five-step approach to demonstrating the tool and engaging the organization. As summarized by Ray:

1) We told them what Worldbook was, then
2) we told them what was in it for them, followed by a
3) a series of workshops to develop an understanding of the mismatches between the current systems and the Worldbook model,
4) a detailed plan to address each problem, then
5) put budget and people in place to make the transition happen.

The early steps involved meeting with key leaders in each region and each function to renew the buy-in achieved at the leadership conference. Despite the agreement made at the leadership conference, this engagement was important to reassure the regional leaders that there interests were being considered and no significant change to the workload and operating budgets would be incurred. Still, even when a particular region recognized the opportunity, not only for the corporation, but also for them locally, there would often still be resistance to adopting Worldbook.

The different regional working groups "liked the way things were done and did not understand the reason they needed to change," according to Ray. This was true in part because of local agreements with plants and to some extent due to groups not wanting to be accountable for even low-level decisions. Based on the relationships developed by NA engineering in its earlier consolidation activity, they were able to leverage its knowledge of the way other functions used the engineering information and the need for agreement within as well as across the organization to convince other regions the logic they had was sound. Regional functional organization came on board, in some cases developing important cross-regional connections within their functions to improve processes. According to Ray, as they developed "a plan for every problem and a team charged with the specific task of solving it, some functions work together across regions in ways that were not necessary before." We kept going back to then asking them to "tell us what you have learned; looking for them to have agreement across all of the users and operators." According to Ray, "even after we badgered them time and time again to go and understand their processes the level of cooperation was high: in fact, it could have been described as not like the GM of the past."

Ray described a set of regional workshops as a way to reveal hidden secrets and areas of shared or missing accountability. According to him, "it was common for a group to agree to a change and then come back and tell us it would cost some absurdly large sum of money to change all the systems." The implementation team saw this as a stalling tactic and a way to resist the change. This was the middle managers asking just how serious was the implementation team.

One of the regional implementation leaders indicated: "we would push back, often debunking their claims with details about the process they had overlooked (or ignored); we asked them to go and look at the problem again." Ray says his experience indicated the teams had not fully explored the issue and did not really understand the problem. An example offered from Europe was the proliferation of the key characteristic designation system (KCDS); this was a code to identify special processing and monitoring requirements for certain critical characteristics. At some point in Europe it became easy for the engineer to apply a KCDS to parts that appeared similar. In one plant almost every weld was given a KCDS, but not all required the same level of scrutiny. In Europe no one could explain why one set of welds needed the KCDS and another did not. Of course, if the assembly did not require such a designation, having one would add work in the plant for no real reason. After eight workshops a system for identifying what really made a part characteristic critical was established and a set of codes were documented that made the process common across all regions.

The regional leaders of the implementation team, as part of the detailed plan for every problem, would ask for a paper validation. This process would be an indication to Ray that all of the regional partners finally understand what had to happen and really understood their part in the process. Once this affirmation was made the next step was to have the teams develop a flow of the information showing how things needed to change. This was a further indication people really understood what was different in their local processes from what Worldbook required and what needed to happen to make it right.

It seems the regional leaders were reluctant at first to dig very deeply into their people's processes to understand what was happening. They really needed the extra push to go and see what was happening and talk to the people working the processes. After they did this they became engaged and committed to the plan. This change in attitude is shown in how a code indicating how bulk materials would be ordered was changed. The codes were originally left to the regions to determine and in some cases they choose to order by volume and in other areas the same bulk material was ordered by weight. There was no engineering reason to have a different metric for a bulk good (like motor oil or anti-freeze), but in some cases local long held practices were hard to change. Regions did it the way they wanted, coding it in the product description system according how local purchasing practice deemed best and no one wanted to change. By having the local purchasing managers and engineers review the reasons they wanted to do it a particular way and having each study the advantages of each they were finally able to agree on a

Worldbook standard. In the words of a regional manger: “the implementation team kept chipping away at the myths about local best practices and preconceived ideas about what could be done outside of the system. We slowly changed the local habits and came to agreements on how all part information would be released.”

Executing the copy

The process as described was rolled out in each region with similar (although not identical) reactions from the various regional functional directors and managers. While resistance was common and the degree of understanding of the local process by the directors varied, the basic process for each region was roughly the same. Regional engineering leaders took their functional counterparts “to the process” to go and learn what was needed in their region then build agreement on what changes would be made. In the end, just as things were aligned and we were ready to push the button to make everything happen a final physical validation was done. According to Ray, this activity was more of an IT play to show the systems were up to-date and the entire organization was able to work the new processes. Of course, this included a review of how the operators would use the codes as well.

Training was provided to the operators as part of the final implementation step. Specifically, a group of specification analysts in the engineering release community and program planning analysts working on the vehicle teams needed to understand the “nuts and bolts” of the new systems. Once these groups understood the new rules then the release engineers could be given the same instruction. Some of these people had already participated in local workshops to identify some of the changes that would be taking place in the local system. All operators would receive the same training, a series of one hour reviews to outline the changes were conducted. In total four sessions were conducted in each area (for a total of four hours training for each person) over a one month period. Managers, supervisors and the analysts participated as a functional group. The training pack was standard across the corporation and the initial versions were delivered with an instructor leading the reviews. The instructor was a trained facilitator with packaged material prepared by a training consultant.

The materials covered in each session were "screen-by-screen" reviews indicating how a new "library of codes" would be used to complete a work order in Global Product Descriptions System (GPDS). The sessions rolled out the transactional data in small batches. Initial changes were made slowly and only after the deliverables were made common. What this meant was that the specification analysts (the people that work closely with the data), the first to require the new information, would be in a position to initiate a work order for an engineer and then follow-up with that person as the information on the work order matured. The engineering community was given the same training material in an "on-line" version. (The material available to the engineering communities differed slightly and was only two hours in total duration).

Some of the early training participants had been part of local workshops to develop the list of changes. They may already have known much of what was about to change, but still each was engaged in a training session that outlined all of the new rules. Ray indicates in some early sessions these people played a pivotal role in convincing their counterparts of the importance of the changes. A review of the material indicates a number of lists were provided as handouts and made available to the specification analysts through a local intranet website. The entire training package was available through this media approximately three months after the initial training session. This I was told was done so any changes and corrections to the material would be comprehended in the stored version.

Several people emphasized in interviews: 1) we were changing codes, and 2) the work process was not changing (initially). Several months after the training was concluded and the new system was running smoothly, the codes had changed for almost all regions and a number of new tools were made available to the specifications community. As plants began to insist on a new level of accuracy for the information it needed, several of the new processes would become standard work for them. As part of a general “do what needs to be done to get the job done” attitude in the plants, if a parts list from the engineer group was not accurate they would develop local workarounds to order the correct parts. This often meant informal agreements between the specifications group and the plants material acquisitions group that were part of some informal list keep by the plant. As manufacturing and other functions became more global in focus and more unified in process such *ad hoc* arrangements would not do. Tools like the specifications cross balance report would help the analyst identify duplicate and multiple part errors for a vehicle line well before the first part is ordered for a build in the plant. This tool was used only after several weeks of “practice” at the new system.

Learning results achieved

Worldbook was a successful deployment of a copy of a NA process to the engineering centers in GM’s other three regions. In 2009 one set of global codes were used to successfully manage all of GM’s new product programs. Learning was accomplished on two distinct levels; first, the operators had learned a new set of codes and some new processes to facilitate global program management. Second, and perhaps the more interesting learning activity was with leaders in the regions outside of NA learned aspects of their processes and the Worldbook processes they might otherwise have remained oblivious to. These learnings were pivotal to the acceptance of Worldbook as an original worthy of imitation and in developing the detailed plans required for the imitation process to proceed.

DISCUSSION: SUPPORT FOR THE LEARNING HYPOTHESES

In this case learning was based on the individual from the start. The theory says in a case with autonomous systems governed by explicit rules and codifiable standards learning would be mechanical and rote. In fact, there was a preliminary step prior to this rote learning and that was gaining acceptance. An expensive and time-consuming process was used up front to hold regional meetings and gain acceptance for the standard. Local regions had an opportunity to push back, be listened to, make some minor modifications, and finally accept the original from North America.

This process was actually similar to the Toyota model of transferring best practices. Whether intentional of by chance, Ray sending the regional functional leaders to “go and see the process” in a *genchi genbutsu* inspired approach, forced them to both learn the process and recognize the opportunity for improvement (at least toward the Worldbook ideal). There was also the process of coming to an agreement by the functional partners that was not NA in nature. Through a process of hashing out the differences in a way similar to *nemawashi* the regional functional leaders learned what was important to their groups and to the organization. This learning activity played a significant role in developing a commitment to the implementation of any local changes needed to make Worldbook a reality.

Once acceptance was gained learning by the operators was rote in nature, with operators having to memorize the important codes as they executed program work orders. The training sessions were established to facilitate the individual operator's ability to learn a small number of rules and applying them to a deliverable. The rules were committed to memory by the analysts through repeated usage in developing their work product and in assisting engineers. This process worked well as designed, with small batches of rules to learn, without changes to the processes, followed up with application to current work.

In terms of the individual learning model, the Dreyfus-like (1980) steps from understanding the basics to personal master can be easily seen. The short learning cycles incorporated in a stable process (while not part of Dreyfus) apparently assisted operators in mastering the list of code changes. Adding changes to the work process only after process capability with the new codes helped to make this learning more permanent.

The study step of the Deming (1994) P-D-S-A cycle was also evident in the paper and product validation activities required of the implementation team. In this situation, the implementation leaders, a group lead by an individual with significant understanding of both the process required to change and the details of the original NA business processes acted as a coach and mentor to many of the regional implementation team members. His deep understanding made it possible for him to challenge the functional owners from the regions when they were using stalling tactics and avoiding responsibility for the change. The learning that took place was individual and the end process now encompasses a set of standard work including tools to improve the flow of information between functions and regions. It is an important cog in a global enterprise.

CONCLUSIONS: IMITATING AN AUTONOMOUS SET OF EXPLICIT RULES IN A COMPLEX ORGANIZATION

Even creating a copy of a set of explicit instructions will involve significant work. Ray confessed in an early interview, when he started this journey he was not sure if this would be a full-time project for anyone. At one point he was part of a small team working to encourage learning and ownership of the process. This was a set of codes that was changed; it could have created a set of mindless bureaucratic rules to follow, but it enabled a new level of corporate capability because the owners of the process understand why the changes were made.

A strong commitment from leadership at the highest levels of the corporation coupled with engagement by a group that recognized an important change needed to be made were important enablers to the final outcome of this imitation. Leaders from engineering exhibited a strong command and control mentality, but consistently worked to ensure the technical solution was correct created an enabling environment. While largely a coercive bureaucracy, engineering leaders did create empowered employees by making rules and procedures enabling tools and develop a sense of learning at the organizational level. Through what Ray called standard work, engineering Worldbook is a set of best practice templates to be improved. This did move the needle toward Adler and Boyrs’ enabling bureaucracy (1996)

Chapter 4

DESIGN FOR SIX-SIGMA AT GM NA ENGINEERING: THE CASE OF AN IMITATOR CREATING A COPY FROM A COPY

INTRODUCTION

In the later part of the 20st century the management of the largest automobile company on the planet was coming to the realization that they were not delivering the product demanded by the market. Some might say this took a long time for the reality to set in as is well documented competitors had been picking away at market share for nearly thirty years. There is also data to suggest long-term reliability was not up to industry standard. Management had not been sitting back and doing nothing; on the contrary, they developed plans, formed alliances, reorganized and restructured in efforts to improve competitiveness and reverse the erosion of market share. Many of the initiatives could be seen, from time-to-time, to be bearing fruit. Management's ideas coupled with a culture with deep roots to its past glory, a strong product heritage, and the can-do attitude of the employees seemed key elements for revival and a return to dominance.

One initiative undertaken by engineering in the early part of the 21st century was to incorporate design for six-sigma (DFSS) in the development activity. In fact, management chose to imitate the DFSS activity employed at other automotive firms specifically a copy of the methods used at Hyundai Motors in Korea. This chapter is a review of the approach taken to adopt DFSS. The discussion will focus on the bureaucratic nature of the organization and how the management and organization culture at the time affected the process used to integrate these methods into the new product development process and the problem solving mind-set of the engineering community.

THE PROBLEM

GM Copying a copy of a complex sociotechnical system

GM intentionally set out to reproduce an exact representation of the process used by a competitor in an attempt to duplicate the results benchmarking studies indicated its competition had achieved. What was to be copied was in fact, a representation of the problem solving methods employed by Japanese manufacturers since the post-war years of the 20^{th} century. DFSS was presented as a "breakthrough management strategy that has revolutionized the world's top corporations (Harry and Schroeder 2000)." The method was to be installed at GM through a supplier well versed in the tools and experienced with automotive application of the methodology, with a set of courses ready to deliver and with a proven record of success. In fact, the American Supplier Institute (ASI), the consulting group managers contracted for the task, sold themselves and the concept of DFSS on their experience with Hyundai and the remarkable improvement in quality and customer satisfaction they achieved over a five year period. Figure 4-1 is a chart taken from the training initially delivered by ASI showing the results achieved by them with Hyundai. The J.D. Power Initial Quality Survey shows Hyundai consistently lagging industry leaders, ranking as high as 36^{th}; then, presumably with the assistance of ASI and DFSS, a rapid and impressive improvement to be in the top ten by 2004. The numbers from Hyundai were startling – in a period of roughly five years Hyundai went from an upstart with a poor quality and reliability record to rank with industry leaders on an important independent quality survey and have an emerging record for long term reliability. If ever there was a system for engineering to emulate this was a strong candidate.

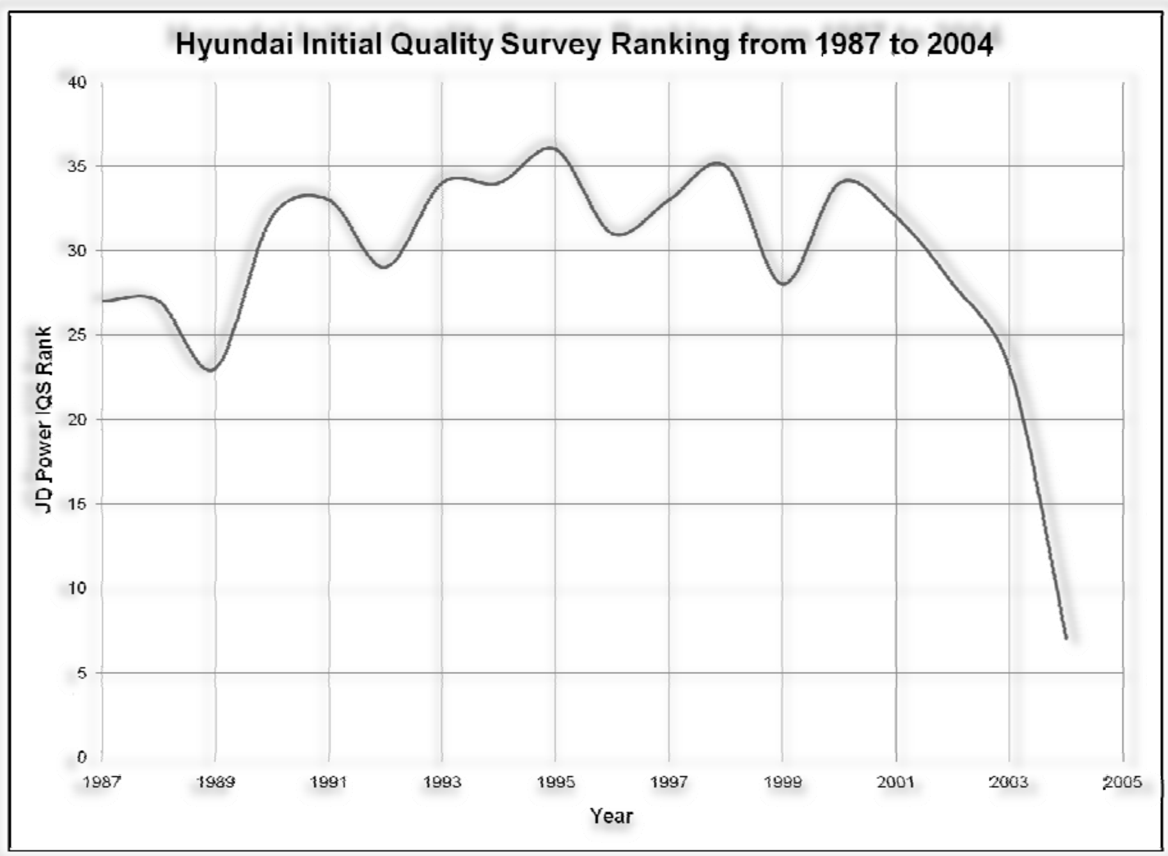

Figure 4-1 Hyundai Motors IQS Rank from 1987 - 2004

The specific tools purported to combine the power of innovation theory, statistics, strategic management principles and problem solving methods with a team's knowledge of product and process to optimize a set of part and manufacturing designs parameters to minimize the cost of quality. Of course, GM had difficult problems to be addressed. Several years of problem solving in the plants revealed several projects that represented issues unresolved (generally after repeated attempts to correct) from previous design versions of a particular sub-system or part. The perennial nature of problems is reflected in high warranty costs over an extended period and in most cases low reliability numbers. Given the background of ASI, the types of problems presented and the aptitude of the engineers that would be involved there was strong indication the methods would produce not only results, but a shift in the way engineering design work was approached. An outline of the original as presented by ASI follows.

The approach

In this chapter we will see what actually happened at General Motors in their efforts to adopt a structured DFSS process. This case study contends they were copying a copy of a process in that DFSS was originally an American company's adaptation of statistical quality control methods used in Japan (starting with Motorola and GE) and then copied by Hyundai which is the basis for GM's copying.

To study this situation data was collected over several years through a combination of participant observation and interviews. Interviews were conducted with directors, managers and practitioner. Early conversations with senior managers and directors focused on the intent of the DFSS activity. Unstructured interviews included questions focused on management and practitioner expectations and how this approach was different from previous problem solving activities in product development. A second round of interviews (also unstructured) was focused on the process as learned and executed by the practitioners. Informants offered detailed examples of certain activities which provide a rich contextual background to the learning. Additionally, various editions of the training material were reviewed and scrutinized for details of the process as well as changes in approach over the seven years of observation. Participant observation has been through participation[9] in meetings (both process and champion update sessions). Additionally, the writer participated in DFSS training in 2010. Artifacts like process diagrams and "pocket cards" were collected and examined for clues as to the nature of the problem solving and learning focus.

THE ORIGINAL

Genesis of the ASI copy

The system known as DFSS and its predecessor 6σ were heavily influenced by the approaches to problem solving used by Japanese manufacturing firms in the 20th century. The basic approach, developed by Shewhart and exported to Japan by W. Edwards Deming in the 1950's has at its root a focus on solving the right problem. The initial steps of the process create a plan that at the core defines the specific problem, a measurement system to communicate the current state and assess any change, a clear understanding of the expectations of the customer (whether internal or external) and a path to the achieve a future state. The ideas, matured and reworked to some degree, were returned to the US by Deming. One approach to disseminate the information was taken by Ford through ASI. As an off-shot of an organization created in the early eighties at Ford Motor Company, ASI made the teachings of Deming accessible to automotive suppliers. Deming choose to teach his philosophy to the automotive industry in North America because, in his opinion the auto industry had the greatest reach and influence in

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[9] The verb participation is used here in a guarded sense. The writer was in attendance at several meetings as an observer (not as an active member of a DFSS team).

manufacturing. Deming also thought manufacturing was in “crisis” in North America, having fallen behind their Japanese counterparts and having lost their way philosophically (Deming 1986).

ASI became independent of Ford, being chartered as a non-profit educational institution in the state of Michigan in 1984. They developed their own model and approach to DFSS (used to create their copy at Hyundai) influenced by their early work with Deming and later with Genichi Taguchi. Independently, companies outside of the auto industry were embracing quality management principles that also had their roots in the basic problem solving approach of the Japanese. Six Sigma problem solving activities at Motorola and at General Electric embraced the essential elements of problem solving for which ASI was applying in the auto industry; but, in addition ASI added a strict methodology for managing projects and reporting savings.

Both Motorola and GE considered Six Sigma a metric, methodology and a management system, with a heavy emphasis on the process and the management of projects and on demonstrated financial returns for each project (Eckes 2001). As indicated, the methodology of Six Sigma is a copy of problem solving approaches popularized in Japan, but that is not the only common thread for ASI. In addition the statistical tools used are variants of those Taguchi began training engineers with in the mid eighties. Taguchi Methods were a good fit with the method as they too offered solutions to complicated problems through a programmatic approach. ASI was able to package these concepts and successfully implement the procedures as Design for Six-Sigma at Hyundai in the late nineties. Figure 4-2 is a representation of various problem-solving technologies, the relationship they had with each other and with ASI along with a timeline indicating the approximate time of their appearance. It is apparent from this graphic that DFSS as adopted at GM engineering has linkages to many methodologies. It is this copy of a copy that GM would implement in the NA Engineering.

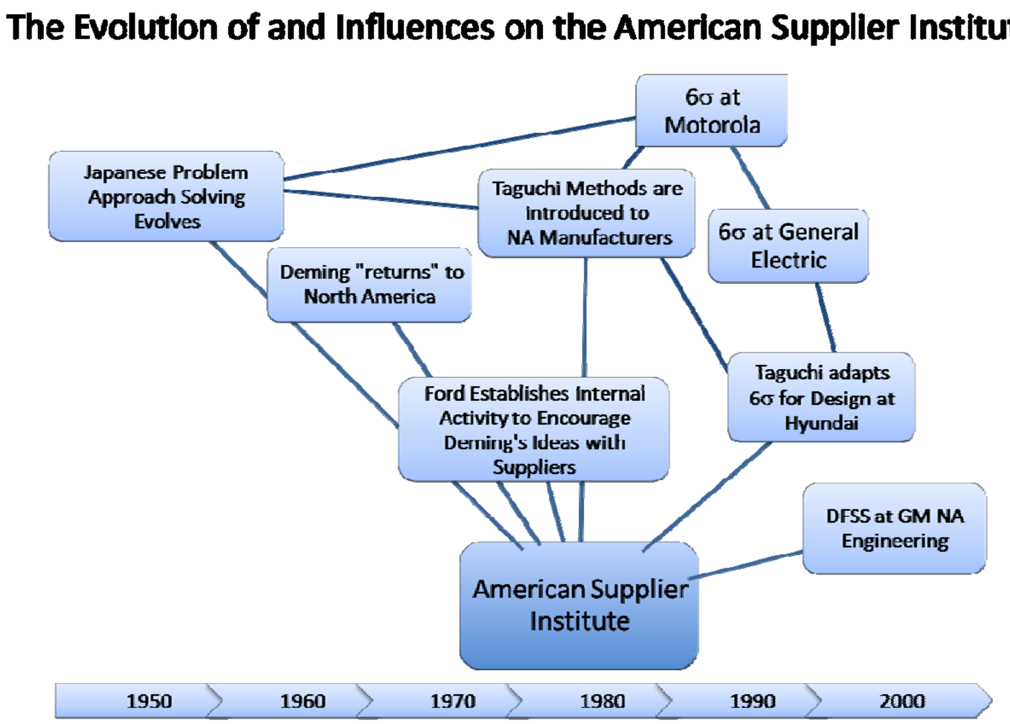

Figure 4-2 DFSS at GM NA Engineering is a copy of the approach used by ASI at Hyundai with influences going back to basic problem solving methods introduced to Japanese manufacturers by Deming

<u>What is DFSS? (DFSS by ASI)</u>

As an off-shoot of the six-sigma approach to quality improvement DFSS was billed as a process and a set of tools founded in traditional engineering practices and sound quality methods that could change the culture of the organization and restore a company’s reputation for high quality and dependable products. DFSS is a five-phase project methodology; each step depends on the successful completion of the prior step. The steps: Define, Measure, Analysis, Design and Verify are adapted from the original six-sigma problem solving methods, but with a shift of focus to the early design activities of new product development activities.

The major themes of the system are 1) prevent errors from transmitting their effect downstream to either internal or external customers, 2) shorten schedules and 3) reduce costs by improving products and processes in the early stages of development (before a product goes into production). An emphasis on sticking to the prescribed methods is structured into reviews and reports. In theory, when followed, the DFSS methods provide optimal designs by deriving engineering system parameter (product and process specifications) that increases product effectiveness in the eyes of the customer. The result is products that provide greater satisfaction in the product for the customer, and increased sales, market share and profit for the manufacturer.

To attain these results ASI offers firms a series of training courses (for both managers and practitioners) coupled with project work. As practitioners gain expertise with the tools they graduate through the ranks from novice to expert. The labels applied to the levels are akin to the *dan* belt ranking system common in the martial arts and modeled after the black belt programs of conventional six-sigma programs. In this typography the beginner is a green-belt, the next level of expertise is a black-belt and the highest *dan* is the master black-belt.

Roles of the DFSS Players

The DFSS project structure defines the roles of certain players. Included in the cast are the champion, project leader, team members, and coach. A champion is generally a senior manager in a particular area – in some organizations a champion may have as many as three hundred people reporting to him or her. The champion would act to select candidates for Black Belt certification, review projects, and mentor the people in the program. A project leader is a person from a functional area that owns the problem. This is often a release responsible engineer, someone with some degree of control over what a part will look like or how it will function. In some cases a project lead will be a DFSS expert (maybe a Black Belt) from a central DFSS group charged with leading a group to solve a particularly difficult problem. The team members are the people providing supporting information or assistance in completing a DFSS project. A team member will be involved in all DFSS training and when a project is completed be eligible for Green Belt certification. A coach is a person with a significant level of knowledge and experience that will provide guidance to DFSS teams and assist in outside the class learning. The coach is generally a Black Belt or a Green Belt with experience on several projects. In the ideal, functional areas will have a number of Black Belts available to provide “local” assistance; it may also be that a Black Belt comes from a central DFSS support activity and will “drop-in” to provide guidance.

Champions are trained in the fundamentals and encouraged to ask tough questions until there are “quantifiable answers that change behavior” (unpublished training material 2003). Engineers are likewise trained to follow the process and provide the answers needed to satisfy their managers and produce the best designs for the customer and the company. The project lead and team members are all trained in a series of in-class lecture type courses and with an OJT type project (which they must have to come to the initial training session).

The course work is divided into sections – DFSS basic training and a series of additional courses are meant to provide specific skills and depth for problem solvers. The project aspect of the training is meant to focus learning around a problem that is easily understood by a group with local knowledge and experience. An ideal project is thought to be one that provides a challenge to the learners and a return to the corporation by way of cost savings on future warranty. The project work that is part of the training is helped along by qualified coaches able to provide additional learning in a practical setting.

When completed projects are celebrated for the savings generated and team members graduate to a new DFSS level. The bottom-line approach to solving problems and saving money with six-sigma fit into the long held philosophy of the senior managers – GM was in business to make money.

The DFSS process

All DFSS projects follow five process steps (strongly emphasized in the training). The first step is to clearly identify the problem. According to the ASI this means to define the characteristics of the problem in a measurable way. Of course, to do so would imply an effective measurement system was in place, capable of repeatable and reproducible assessment of the characteristics critical to quality. Next the project team would define the requirements in terms of engineering metrics – that is, through a Quality Function Deployment activity they would translate the customers' requirements into vehicle and sub-system technical specifications. Once the requirements were defined, the process calls for concepts to be developed. Of course, the team will develop concepts given the constraints of the design and what they know about the parts and processes that can be used. Next the team would optimize the design. This section is by far the most time, labor and intellectually intense part of the process. It will include hardware or software simulation and most likely a designed experiment. The last step in the copy is to verify the result. This is important because experimentation (even with hardware) often does not include all combinations of the factors being studied. Consequently, before hundreds of thousands are spent building a production line the design parameters selected should be confirmed in a trial run to verify the results. Following the process was shown to work in other engineering facilities; GM NA was merely to be the next to make it work.

Placing DFSS in the Theoretical Model

DFSS is a complex set of routines employed by teams of problem solvers to address complex issues often bridging several functional and organizational systems. The system combines specific tools - DOE, QFD, Pugh, 5 Force Analysis and TRIZ[10] - with a team's knowledge of product and process to optimize a set of part and manufacturing designs to minimize the cost of quality. The problems to be addressed are usually difficult. In fact, at GM many initial DFSS projects represented issues unresolved from previous design versions of a particular sub-system or part. The

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[10] DFSS borrows theoretical concepts from a variety of disciples including experimental design from statistics, PUGH form Systems Engineering, Porter's model from strategic management and the theory of inventive problem solving (TRIZ) from innovation literature. In general, the concepts are packaged in such a manner as to make the process as mechanical as possible.

TRIZ was developed in the former USSR. It is the acronym for the Russian name that translates as the 'Theory of Inventive Problem Solving'. TRIZ is based on the idea that problems and their solution are repeated across all industries, and so solutions to many problems that arise may have been solved in some other application. TRIZ attempts to turn invention into a systematic method by reducing it into a series of principles.

perennial[11] nature of problems is reflected in high warranty costs over an extended period and in most cases low reliability numbers. Given the complexity of the issues and the cross-functional nature of the problems, it can be said they exhibit a high degree of system embeddedness.

The tools and routines employed to solve the problems are sophisticated systems engineering and statistical methods that rely on significant understanding of systemic relationships, probability theory, modeling techniques, experimental design, analysis methods as well as some knowledge of strategic management and innovation management. Learned practitioners of the specific methods will confess to using as much art as science in developing models and teasing out relationships. With various contingencies at play as models are developed and conclusions drawn from the analysis[12] one can conclude a significant amount of tacit knowledge is being called upon to make decisions related to tools and analysis.

[11] Perennial is a terms used internally at GM to describe problems that will not go away despite repeated attempts to address the issue.

[12] As a classically trained statistician the writer recalls one of the most common refrains from many of his most admired instructors when clients asked how to approach a problem: “it depends.”

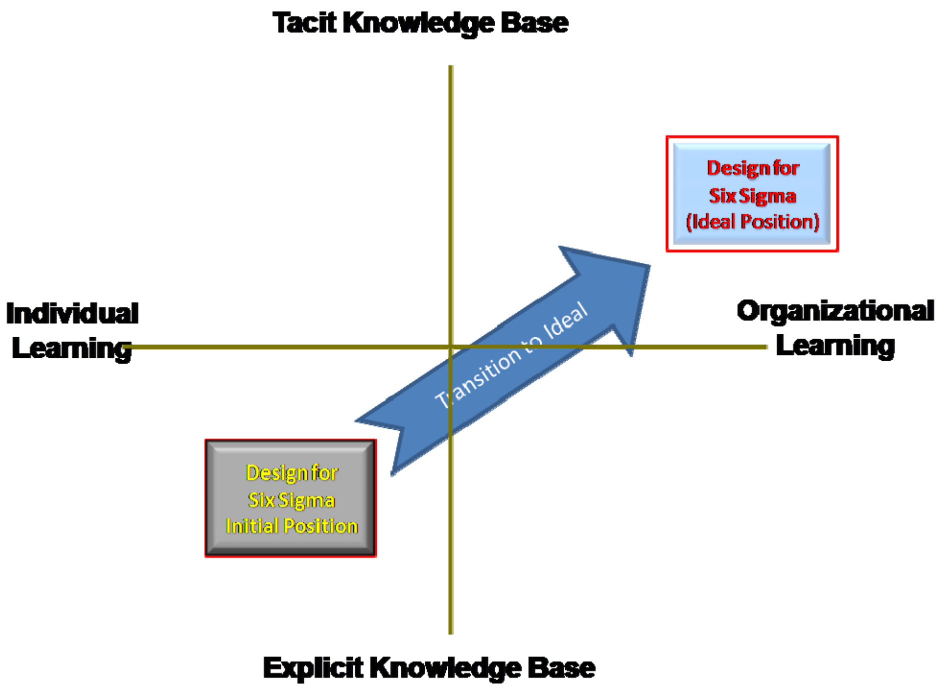

Figure 4-3 Design for Six Sigma as an Ideal and Initial Position on Individual/Organizational Learning Plane

In terms of the model presented in Chapter 2, in the ideal we would expect the DFSS activity to exist in the top right hand quadrant of Individual/Organizational Learning Plane (see Figure 4-3). In this position on the plane, practitioners are adapting methods by employing tacit knowledge of the routines while being supported by the total organization in a systems-wide approach to gaining new knowledge – they are in the Tacit/Organizational quadrant of the I/O Learning Plane. Of course, since all learning starts with the individual one might expect initial activity in the lower left hand quadrant of the model. Accordingly, the implementation of DFSS would start in the Individual/Explicit quadrant and under the right conditions and in time migrate to its ideal position in the upper right quadrant.

For the transition to the ideal position to take place the second hypothesis presented in Chapter 2 should prove to be correct. Namely:

> In the case of an organization imitating processes of a highly system embedded nature governed predominantly by tacit rules, learning will begin with the individual and require many cycles of tacit learning with the slow introduction of explicit knowledge all intertwined with organizational change and organizational learning.

If this hypothesis were correct, in the macro view of the learning activity, over time an observer would expect to see learning at many levels. Initially, learning would focus on the explicit aspect of the routines performed by the individuals doing the tasks. Rules and standard procedures would be memorized and practiced by the new users while managers and directors may initially be occasional observers interested in progress toward results. As the managers and directors saw results they would become more interested in deployment of the methods on an organizational scale. Over time, more individuals would have a solid grasp of the basics and begin to focus on the tacit aspects of the method. In this stage, learning is characterized by Argyris' Model I behavior. Of course, this is the behavior suggested by Dreyfus[13] in his model of individual learning (Dreyfus, Dreyfus et al. 1986). The process described here is essentially that of the learner moving from novice to proficient in the context of the ability of an individual to perform certain tasks. The learner has evolved from a dependence on the rules to "intuitive response" to the situation.

As the transition to the ideal position takes place one would expect the following hypothesis focusing on a more micro view of the leaning would prove to be true:

> Individual learning is initially characterized by a mechanical approach to knowledge transfer and as need be is followed by learning displaying characteristics of a more organic organization able to deal with environmental complexity and change.

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[13] Discussed in detail in Chapter 2.

Observers would recognize learning activities were changing over time. Specifically, one would initially expect to see training material with many rules, strict steps that outline a rigid approach to mastering the material. An individual learner would ultimately graduation through a set of pre-determined steps to competency in a manner outlined by Dreyfus. Again, at the micro level learning has begun with the individual, but as more and more people develop basic knowledge of the new routine an understanding of how the detail fit with an overall organizational culture and company philosophy. A focus on the mechanical aspects of the routine is replaced with a more organic concern for how the routine is applied in the context of larger corporate goals. The value of the basic methodology is widely accepted at an organizational level as the correct way to do business.

As the learners master the basic skills improvisation would begin to take place, likely introduced by a mentor or coach, perhaps developed by the learner. For the individual we are in Dreyfus' Mastery stage. In the context of the organization, in the best cases we would begin to see a shift toward Argyris' Model II behavior as users challenge basic assumptions and adapt the methods toward the organization, i.e., moving to double-loop learning (Argyris, Putnam et al. 1985). While these steps are also indicated by Dreyfus, the focus now changes from the individual to the organization.

If the learning continues to evolve, the lead users would become role models for others. As the adapted methods become accepted they are adopted as organizational routines. Eventually, the routines presented by the imitation are performed without thought; improvisation is encouraged and recognized as the way to expand the organization's capability. Over time managers and directors that may have initially only been interested in the number of engineers trained and the number of projects completed will start to recognize the true value of the methods. They will start to learn more of the basics of the process and eventually lead the expansion and further development. At some point in time engineers well versed in the methods will be promoted and their knowledge of the methods will help the organization "think" as one about how the tools of DFSS can help the corporation achieve its goals. Of course, it is the transition from the individual learning activity to the organizational acceptance and adoption that is the subject of this research. In the case description that follows, we will see DFSS started in the lower right hand corner, but in the end was far from the ideal position proposed earlier; instead, barely moving from the initial starting position.

Case Background

GM's North America engineering was an important part of the prior success of the company and a major player in the development of new product. A change in the way engineering incorporated the combined knowledge of potential failure modes, manufacturing issues, and customer usage into the design of the vehicle was required. The fact that new product had suffered from weak integration over the past several decades has been well documented and recognized internally as an area that required improvement. In the early part of the 21st century a desire on the part of managers and engineers alike to improve the quality and reliability of GM's new product offerings has likewise been identified. The vision communicated to the organization in 2005 provided a clear message – DFSS was a mandated process and it was fully supported by engineering management complete with metrics reported up to the Vice President of engineering. As part of the vision shared by the VP was a first step; namely, to implement the methodology of six-sigma problem solving now adapted for early design activities. In the language of change management the desire to change was present, a vision of the future articulated and understood, and a first step outlined. Change was inevitable, resistance was futile.

<u>History of Problem Solving at GM</u>

Senior engineering management recognized a need for change in the way engineers did their jobs would require significant management intervention at the work site. The "work-site" for engineers at GM is new product development. New product development at General Motors is an activity that involves almost every aspect of the enterprise at some point or another, the process to make this happen in an orderly way at GM is the Vehicle Development Process (VDP). The VDP is a systems engineering approach to new product development that engages various functional player in four imbricated phases of development. In the four development phases a new product idea goes through a research and design period where market appeal and feasibility are studied, then product engineering is engaged to create part and system designs, followed closely by manufacturing development and in the fourth and final phase the new vehicle is in production. In the early years, a product could take six of seven years to go through the process. This was reduced by 2009 to two to three years.

Once a product concept is identified as ready for development, a select team works together under the leadership of one key executive to put the product on the road. This person, the vehicle line executive (VLE), is responsible for a product line for its entire life. The primary activities of the VDP are managed by key executives from each of the functional organizations. Of course, engineering plays an important role. The technical engineering work is lead by the chief engineer who oversees both product and manufacturing engineering activities. The situation as just described has evolved in many important ways. For example, a historical propensity to hand the product design over to manufacturing engineering for them to deal with has been mitigated to a significant degree. Now manufacturing engineering and product engineering work together in the early stages of the process trying to eliminate problems that might be big issues in manufacturing that can be easily resolved with minor design changes. In fact, product engineering takes ownership for many issues well into the production phase of the vehicle development process.

Up until recently, there was a distinct organizational boundary between product development and manufacturing. The divide was made worse in the seventies and eighties when General Motors Assembly Division (GMAD) existed. GMAD was responsible for manufacturing the parts and building the vehicles as designed by engineering. At the time GMAD had stature and power equal to the product divisions at GM like Chevrolet, Pontiac, Buick, Oldsmobile and Cadillac were the engineering took place. Exchanges between divisions could be anything from awkward to difficult as until the mid-eighties, product divisions competed against each other on many corporate metrics. Competition was fierce and people in one division rarely had friends in another.

On the manufacturing side, the plants were fiefdoms ruled by powerful (and usually angry) plant managers. To the outsider the plants seemed dirty and noisy places. Most of the people working in the plants did not have degrees (although some managers did and many process engineers did). It was not uncommon for a middle manager or senior manager in a plant to have worked his way up from the line. The work was predictable and incentives existed so one knew exactly why a person came in each day: to make a specified number of vehicles or parts as the case may – because that is how the corporation made money.

In contrast, the product divisions were powerful bodies managed by men (at least in the early days) in suits with college degrees staffed by associates equally educated and motivated. This was the world of future product and marketing. Managers, engineers or marketing professionals didn't have time or inclination to go to the plant; that world was as far from theirs as one could imagine. Here too was an environment where the work was at least made predicable (in a mechanistic sort of way)[14] and incentives were in place for one to be thorough in the analysis and creative in the delivery. There was little common ground between the plant and the product divisions.

Today, to most students of organizational development, this historic relationship seems as unreasonable as the work structures that once existed within them. In a 21st century plant the autocratic style of a coercive plant manager has been replaced by a more benevolent leader with an enabling approach. Yet, a mechanistic approach to organizing work was the prevailing management practice for much of the 20th century and it was the way young engineers were trained to think and manage. This was the approach fostered by the management style of Alfred Sloan. Sloan was a senior leader of GM for nearly forty years – dividing his time between vice-president, president and Chairman of the Board of Directors (from 1923 – 1956). His approach to managing,

[14] A now retired director described the drafting area as a well disciplined quiet work environment with a supervisor standing as if on guard watching over the rows of workers at their drafting tables as they put pencil to paper creating the drawings for new parts. A bell would announce breaks and the end of day. This work environment existed well into the seventies at all of GM's engineering centers.

organizing and his general philosophy were integrated into the culture of the organization and was a dominant aspect of the heritage of GM well into the seventies and eighties. Accounting practices and incentive systems developed by him were still in use in 2005 and are said to be a factor in the slow adoption of lean methods in GM's manufacturing system (Inkpen 2008).

Strict structural boundaries were important to maintain control and provide the proper incentives for different groups. They would, in the true spirit of capitalism, find the best solution and maximize profit for the corporation. There would be little need for cross-division communication and collaboration. What needed to be coordinated could be done in the classical management style through decisions made at the top; communication was strictly vertical. This approach worked very well during a period when vehicle demand was high and product quality and reliability expectations were low. Vehicles were in high demand and any buyer's concern about quality was assuaged by promises of the repair being done "under warranty." Reliability expectations were likewise low; a car that lasted 100,000 miles was thought an excellent car that had provided good value for the buyer. Customer use-patterns and competition changed in the late 20th century and with the change all automobile manufacturers have looked for ways to improve quality and reliability.

These external and internal influences worked to create a management culture that thrived on order and a mechanistic approach to keeping order. The culture of the organization is a complex network creating the pattern of development and growth that reflected various aspects of society in general. The focus in this chapter on DFSS would appear to be the simple introduction of a tool set to design in quality, but in fact its implications go much further. Evidence from companies implementing aspects of lean manufacturing (Choi and Liker 1995; Liker 1998; Liker 2004; Rother 2009) indicates for DFSS to work as intended it requires a serious cultural adjustment, so engineers look at their work in a new way in the early stages of design. Developing a corporate culture begins with its founding members (Muchinsky 2000). These people generally have dynamic personalities, strong values and a vision of what the organization should look like that provide the required initial strength of purpose to define the culture. Still strong sub-cultures can exist and can evolve as situations change. We will see that because GM copied the tool kit without understanding the needed cultural change DFSS had a limited impact.

Culture of product engineering

The hiring of most of the senior managers and directors in place at GM in the late 20th century took place in the seventies and eighties. These people defined the current processes and transmitted their vision to current employees and customers alike, but they have roots in the management culture of Sloan and other leaders of his era. GM's product engineering reflects Sloan's classical management philosophy of dividing the organization into specialized divisions and functional groups. As the organization grew in complexity the division became more elaborate and detailed. One example is the distinction between the release engineer and designer. The "designer" was once the draftsman who made the blue prints. Over time they took increasing responsibility for the detailed design work itself. The "release engineer" became more of a project manager spending a great percentage of time going to meetings (Hancock and Liker 1990) (Fleischer and Liker 1992). At GM this difference defines two groups and two cultures. This is so even though they work together closely, and share the same corporate goals.

This is explained in cultural terms by Schein (1984) who writes: “if a total corporation consists of stable functional, divisional, geographic, or rank based subgroups, then that corporation will have multiple cultures within it (p. 379).” Schein adds multiple cultures are not a bad thing, on the contrary when overlaid upon an existing corporate wide culture they lend a certain continuity to different divisions leading to “stable social units (Schein).” This is arguably true when the nature of work between groups is not interdependent and when there is a clear difference in the scope and complexity of the work. In this case the designer’s work began to creep up in technical complexity to the level of real engineering (Fleischer and Liker 1992). The gap in pay between designers and engineers began to breed resentment by designers who viewed engineers as managers who did not understand the technical details of design. Yet engineers were making the key technical decisions. The conflict led to communication difficulties and a great deal of waste in the process leading to quality problems and time delays. It is important to note, these fundamental cultural conflicts do not get solved because of a methodology like DFSS.

Another important aspect of engineering’s sub-culture can be gleaned from the observation of daily activities as well as the artifacts left as if on display at a desk. A walk through the work area in any product engineering group at GM reveals common artifacts. The usual tools of the trade for 21st century engineer are visible on every desk – computer, phone charger (no land line visible) reams of paper – process maps, notes about specifications and tests and supplier contact information. Also seen on many of the engineers' desks are parts. In some cases parts clearly in development (unfinished molded plastic parts, swatches of material or color samples), if many other cases production parts are displayed almost as trophies. When asked, the owner will often describe the hard work it took to perfect the part, solve some significant problem with its production or time spent at the plant sweating out the loss of production while leading a problem solving activity. The part is now a prize, a reminder of problem solving prowess. The assumption being that solving problems makes one a good engineer. The part on display provides the engineer with a symbol of superiority as a master of problem resolution. In many cases the product engineer was rewarded by the group manager for a job well done – the plant manager may have even communicated with the engineer's manager, commending the engineer for the commitment to solving the problem and getting the plant running again. The underlying belief is that solving problems is good for the company because it saves the corporation money.

The types of cross-functional problems identified earlier have been a topic in engineering management for decades. The concepts of concurrent engineering and integrated product development were attempts to get different functions to work toward a common goal by putting them into co-located, dedicated teams. Organizational theorists would recognize the problems of integration across functions as one of excessive bureaucracy. Adler and Boyrs (1996) offers a important elaboration of the definition of bureaucracy that can explain how it can be either negative or positive in an engineering environment. By studying Japanese firms operating in the US they found evidence of what they describe as both coercive and enabling bureaucratic structures. Recognizing that both exist, they characterized a coercive bureaucracy as on that uses formal procedures to ensure compliance and effectively allow smooth operation with employees skilled only in the basics and valued for their ability to follow instructions. In contrast, enabling bureaucracies utilize routines to codify and disperse best practices and support work activities. Problems are an opportunity to engage employees to provide solutions that improve the existing processes.

It is a coercive bureaucracy that best described the engineering environment at GM. DFSS was brought to GM in an atmosphere of coercive bureaucratic management practices by a leadership team whose philosophy was to fix problems and make money. Problem solving at GM was reactive and seen as a good way to save money not necessarily to improve the process or the product. At the same time, tracking the efforts and rewarding those who could solve the “most important” problems fit neatly into the established management culture at GM NA engineering.

Reactive problem solving in GM’s Coercive Bureaucracy

Problem solving does carry a significant positive aura and problem solvers are often held in high regard. In product development problems can be broken down along two branches for any good with a long expected useful life. One category is a set of issues that affect a customer’s early ownership experience. Such issues are generally referred to as quality problems. On the other end of the ownership experience, as a product is in use for an extended period, issues of durability and reliability emerge. Quality problems can generally be traced to problems with the build of the vehicle and are a result of something that happened in the plant while durability and reliability issues can be traced to engineering decisions and cost trade-offs.

For much of the 20th century manufacturing owned the build of a product at GM once engineering handed it over. At times there were "buy-off" events were the plant management team reviewed the progress of engineering and when certain milestones were achieved agreed to take over production. Often, plant management accepted the build at some point under the assumption they would be able to fix whatever problems remained on their own. Engineers would say the designs were "nominal[15]" and the build problems that did exist were a result of the variation in the plant. The quality problems that persisted were from differences in operator training and interest. It is not hard to see why a "blame the operator" mentality developed and persisted. Without taking into consideration variation in parts and potential interface issues that should have been part of the development activity ownership of the build quality was a bit of a farce. Controlling the build quality could only be managed up to a certain point and the plants were not well equipped to address problems with any systematic significance.

In part because of the relationship with engineering, but also due to the organizational structure of GMAD, problem solving related to quality issues was episodic. Problem solving was driven by the incentives offered to plant managers; it was generally dedicated to reducing scrap, eliminating rework or preventing the line from stopping – all measure that could be tracked back to the financial reports a plant manager would be required to provide to corporate head office. In general problem solving was

[15] The implication to part being at nominal is that if a part is being built to the specification outline in the drawings it is doing what engineering wants it to do and manufacturing should not question engineering intentions.

directed toward reducing costs and particular activities were directed by the plant manager.

In the mid-eighties and nineties, W. Edwards Deming brought some sense of the systemic nature of problems to the situation. Some plant managers saw useful tools and the potential for a problem solving approach in his teaching[16], but his approach was viewed mainly as a mission to drive a philosophical change in the overall management of the company. Of course, a deep rooted change was something that was needed before any true appreciate of the nature of the problems and the root-cause could be addressed. Still corporations like GM and Ford sent thousands of people to Deming seminars and spent countless executive hours in one-on-one consultations to nudge the American corporate giants into realizing quality did not begin in the plant and if fact the plant is the most expensive place to improve quality.

The initial result of Deming's work was an increased awareness of the systemic nature of all activities in the corporation. At GM small groups sprang up to support the plants and eventually some engineering directors saw the importance of linking product engineering to manufacturing. They created activities like product and manufacturing integration groups to link design activities to the manufacturing engineering activities. These groups were the forerunners to changes in the vehicle development process that integrated the activities under the control of the chief engineer on the vehicle line team. Until this point manufacturing engineering and product engineering only meet

[16] In the mid 1980s some plant managers hired Plant Statisticians and trained vast numbers of their plant line workers to be statistical problem solvers. Of course, the tools were the primary focus. A significant shift in philosophy was years away. The writer was there in the beginning and participated first hand in these activities.

organizationally under a vice-president. This structural linkage, in place since the years of Sloan, did not work well to create communication and shared vehicle vision. The mere appreciation of a systemic approach was not accompanied by the required adoption of a more enabling bureaucratic structure. Still in place was a sub-culture that appreciated workers ability to follow the steps of a process more than their ability to appreciate the organizations common purpose and do what needed to be done to achieve the goals indicated. In the words of Adler – GM continued to be a coercive bureaucracy.

At the same time Deming was starting to have an influence on GM, a joint venture between GM and Toyota was just starting. The New United Motor Manufacturing, Inc (NUMMI) was just reopening the doors of the GM Freemont, California assembly plant. NUMMI, the subject of a third case in this work, was the starting point for GM's Global Manufacturing System (GMS). GMS would bring a common framework to what was once GMAD, incorporating the most important aspect of the Toyota Production System including problem solving activities that incorporated the product engineering's part ownership with manufacturing's process ownership to effectively develop designs that minimized problems before they got to the plant.

In the spirit of Deming, engineering took ownership of certain problems in the plants in the late nineties. Still focused on plant problems, product engineering had engineering problem-solvers in the plants to work with the plant to resolve issues that are design related. A group of statistical engineers work with the plant, suppliers and release engineers to solve problems that become apparent only after the vehicle was in full production. The combination of these activities provided tangible results. The number of problems reported by customers on J. D. Power Initial Quality Surveys for GM vehicles has dropped in the past 15 years to levels comparable to all domestic and import competitors.

GM's work on improving their manufacturing activity, particularly in the area of problem resolution is impressive. Albeit a twenty-five year journey, the initial quality of GM vehicles improved steadily over that period and is comparable with the best of the competition. This effort has happened in light of and perhaps in spite of a coercive bureaucracy in plants that was built around incentives that prevented an easy transition to the new culture and working environment. Yet, as this was being done no real effort was directed toward the extended ownership issues described in the opening paragraphs of this section. The long-term reliability and durability problems that at one time occurred outside of the warranty period (once set at one year and 12,000 miles changed recently to five years and 60,000 miles), in the early part of the 21st century started to become part of the balance sheet. These were now costs not for the customer to bear, but the corporation. Despite the hard work and best intentions of the product engineering community only half of the quality equation was being solved. A mindset and a set of tools to address problems associated with the months and years at the end of the ownership experience was needed and it seemed some suppliers had the thinking and the tools to achieve impressive results in addressing these problems.

The case detailed below is meant to offer further insight into how individual and organizational leaning must be coupled to develop people and create processes capable of continual growth. As indicated in the opening of this chapter GM decided to imitate certain engineering processes of one of its more successful competitors. It is the copying/learning activity that is of interest here, but it is important to view this activity in the context of the culture and the structure of the organization into which the copy is being presented.

CASE DESCRIPTION

Based on conversations with executives involved in the early phases of process adoption, DFSS was viewed at GM as a set of tools that managers thought could be copied and transplanted in to the "tool-box" of every design release engineer in the organization. It was clear from the discussion management was looking for a process that could be copied exactly – leaving no room for misinterpretation of the rules or the intent. Senior managers expressed concern for an over reliance on "high-powered statistical methods" and instead wanted a recipe and well-defined process steps even inexperienced engineers could follow. Driven by these concerns and by projected increased warranty costs, the Vice President of Engineering sought an approach to problem solving that was: 1) in-line with system engineering concepts used in the industry, 2) off the shelf and could be purchased, 3) easily taught to a large number of engineers in a short period of time, and 4) highly likely to improve the long-term reliability of new product designs. Design for Six-Sigma (DFSS) satisfied all of the criteria and when coupled with a consulting contract from the supplier, it was thought could be implemented with a minimum effort in a short period of time.

GM NA engineering had tried to incorporate various quality improvement initiatives into a comprehensive training package as early as 2001. Pockets of expertise with the different methods developed within the organization, but little was done to integrate the activities. Whether it was Quality Function Deployment (QFD), Design Failure Modes and Effects Analysis (DFMEA) or Design of Experiments (DOE) each was used as seemed appropriate by the engineer owning the problem. These methods offered spotty results; some managers think because engineers did not really understand the basics of any one of the tools and instead relied on a consultant for help. According to one engineer it seemed like “the flavor of the month.” To paraphrase the comments of this design responsible engineer it depended on who you worked for and what tool was in vogue at the time as to what analysis was required. When coupled with the poor reliability numbers it seemed apparent a consolidated approach to the tools was needed. The version of DFSS that ASI was offering seemed an appropriate data-driven approach that addressed a variety of problems. An approximate time-line showing how DFSS was implemented is shown in Figure 4-4.

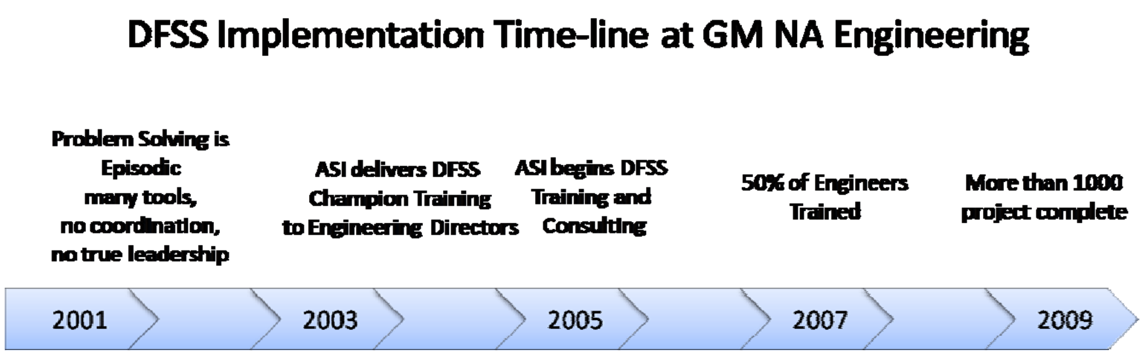

Figure 4-4 DFSS Time-line shows a progression from disorder to order as measured by the number of projects complete

What the engineering leadership wanted was an “exact copy” of the process and associated management system used by Hyundai to implement DFSS in their new product development activity in the mid-nineties. ASI did have intimate knowledge of the technology employed at Hyundai; the president of ASI led a consulting team that supplied the training and coaching to the Koreans. In keeping with a model that had been successful in Korea, ASI offered GM a series of course they replicated from the Korean experience. According to the trainers, the exact sequence of courses for managers and engineers for GM was not just similar to, but the same as that used in Korea. Two important parts of the package were a rigid process adopted from the problem solving approach of Six Sigma and a requirement that no one would be able to take the training if they were not part of a team with a viable project.

<u>What Really Happened with DFSS at NA Engineering?</u>

The initial training for Champions

Based on the experience of the consulting group that went to Korea, ASI provided on-site training, coaching and project management at GM NA engineering for an initial contract period of three years. Prior to training engineers, a series of three-day "Champion Workshops" were delivered to the key leaders and functional directors within the engineering organization. With an introduction and wrap-up by the Vice President of engineering, the workshop focused on the role of the engineering director as DFSS champion in the successful deployment of the tools. Specific lectures on identifying the right projects and selecting and mentoring the right people were included along with training in the fundamental technical aspects of DFSS. Perhaps as a way to provide a break from the lengthy technical sessions, some general management theory related to change within an organization was also included.

A review of the training material for the three-day course reveals the would-be champions were reminded of the importance of following the strict DFSS process flow and their roles as human resource specialists (selecting the potential "Black Belts") and arbitrator for the removal of roadblocks (political and otherwise). Additionally, they were given guidance to ensure the Black Belts would be dedicated to their projects and they would be driving cultural change in the organization through the DFSS methodology. On the technical side their training included introduction to the methodology, basic statistics, some Statistical Process Control theory (including capability and measurement systems analysis) and an introduction to some statistical software. Each day incorporated technical tools and their specific application to DFSS and guidelines to help select and manage the six-sigma “students” and their projects. A major part of the last day of training was spent on the softer side of managing DFSS, including financial guidelines for projects, suggestions for developing a supportive infrastructure, and managing DFSS practitioners at all levels. The ASI training for DFSS champions stressed the key role they would play in the selection of individuals with “responsibility for the business” and to ensure Black Belts have the support they needed to succeed.

It was shortly after one of these three-day workshops that the writer spoke with the then executive director (called Bob for identification purposes) of engineering in charge of DFSS implementation. This role was on top of the responsibility he currently had. In a candid conversation the executive stressed that a strong process focused on the key steps of problem solving that defined the requirements and problem statement coupled with process mentoring would yield the desired results. To him, deep technical mastery of all the DFSS statistical tools was not as important – leadership and the process were critical. This particular executive was in charge of implementation for less than three months before he was replaced by a director trained by ASI as champion.

According to Bob, the idea was to have a central group initially trained and supported by ASI available to support engineers from the functional area as well as to provide training and coaching when ASI's contract ended. The initial plan also included training for the engineers in the functional engineering organization; from this group select DFSS practitioners would become part of a central DFSS support group. Ultimately every engineer was to be given DFSS training and each engineering group was given targets for training over the next year (subsequent targets were given in the following years). Additionally, according to a manager interviewed (Margaret) for this work, targets for a specific number of Greenbelts, Black Belts and Master Black Belts as well as the associated projects were rolled out by the Vice President of engineering. It is estimated in the initial contract period approximately 50% of all engineers in GM North America had taken the Green Belt training. As of April 2010 there were approximately 2,100[17] certified DFSS practitioners in GM. A knowledgeable source estimated this to be roughly half of the people that went through the Greenbelt training.

The initial training for Practitioners

Prior to being enrolled in the first DFSS training class participants were required to present, as part of a team, a summary of a project they planned to conduct to complete the training. Each project would have several team members, but one person would be considered the lead. This person was generally the one that had the biggest stake in solving the problem presented by the project. Of course, the project would provide participants with hands-on experience to enhance the lecture and provide a frame to make the material as practical as possible. The projects were screened by the area champion

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[17] Data provided by a DFSS manager indicate 47 Master Black Belts, 259 Black Belts, and 1,785 Green Belts were in the engineering organization as of April 2010. This number reflects the attrition experienced by NA Engineering during a period of significant downsizing during the bankruptcy of 2009.

with help, at least initially, from the ASI consulting team. As indicated earlier, the three-day training provided to the champion included material to assist them in selecting not only the best candidates for the program, but also the best projects. The plan was to select the engineers most likely to see the project through to the end and to have projects with significant monetary return.

A review of the training material for the one-week (four day) Green-Belt course shows ASI provided the basics for applying the DFSS process. Particular emphasis was placed on Quality Function Deployment, Pugh Selection Methods, and Taguchi Methods of DOE. These activities would all be in the early stages of design called front-end loading by Morgan and Liker (2006). The training was highly interactive, with full teams present and able to apply newly learned concepts directly to their projects. Project review criteria were presented (not surprisingly there was a direct relationship between the champion training and the green-belt material). A review of several quality models was incorporated over the week long session, including principles from Deming (1994), Crosby's "Cost of Quality" (1979), and the Kano Quality model (Kano, Seraku; et al. 1984). There was also an array of confirmation and implementation methods described including Red X Discovery - a technique to isolate the one cause of your problem and the six-pack technique - a methodology loosely based on a two-population test of means to statistically verify your result (Bhote and Bhote 2000).

Greenbelt learning cycle

As an example of the learning cycle my Canadian informant, a person with considerable problem solving experience assigned at the time to a regional engineering center, provides the following. Mark started his Green Belt training as one of ten people on a project team trying to improve headlight aim and front fascia interference on a Suzuki vehicle. After the project was approved, he attended the first four-day training session. He reports: the course involved in-class activities including lectures on technical topics and some simulations of the concepts. Additionally, there was a significant concentration on the process and some DFSS reporting forms. After the initial course work was completed they returned to their regular job assignments and worked on the team project on the side. One person, the project leader, would organize meetings and assign tasks in an effort to keep the project moving ahead. Normally, the meetings were updates and tracking of actions against a project plan. Sometimes in the meetings discussion would break out about why a certain approach was taken or why a particular factor was included or dismissed. Generally, one or two people would lead the review of material covered in the DFSS training. Mark says on no occasion was a mentor or coach involved in such discussions. After several meetings the leader and a couple of the team members that had taken a real interest finally finished the work and came up with some conclusions. Mark indicates some coaching might have helped, but his experience with other problem solving activities probably helped his team where if he had not been present the team would have floundered. In total the time to complete the project, including the pre-work prior to the formal training was 12 weeks. Mark thought some teams took a lot longer.

Mark indicated a DFSS coach did participate in one meeting. The coach seemed very interested in having the project completed and having the appropriate DFSS documentation done as well. He said the coach's comments at the meeting were focused on whether the team followed the correct process steps and had the proper report ready.

Mark's assessment of the coaching they received was that it was not very deep and did not help the team really learn the reasons behind the process or understand any more of the specifics of the tools, only that the process was important. In Mark's case the person assigned as coach was from ASI and came to visit a few project teams every month or so. Of course, Mark did work in a regional engineering center, not the Vehicle Engineering Center.

To complete the academic requirements of the Green Belt certification, Mark also took several classes through the local Tech Centre. For him, credit was granted for prior courses (that were on the curriculum), but in total he spent an additional 80 hours doing in-class training over a period of eight months. This training he says was again largely lecture with some "canned" examples. There were no assignments and no exam for any of the courses. Mark says "the training focused on many of the tools we needed to use as part of the DFSS process, and did provide some good background into why we did certain things." While this seems less of a learning cycle than a project cycle, Mark confirmed he was learning and expanding his knowledge through these classes as he applied the tools and concepts to additional (different) problem areas.

Participants who completed the project (plus review) and took an additional four classes from the DFSS curriculum available through the GM training group were granted a DFSS Green Belt. There was no stipulation regarding the order of the project completions and the additional course work required. It seems many took the courses as they were working on the Green Belt project. The additional classes included technical offerings like "Design Failure Modes and Effects Analysis (DFMEA)" as well as nontechnical courses like “Facilitating Effective Meetings.” There was no time limit imposed on the completion of any of the requirements.

Coaching and certificate candidates

As the previous example illustrates, project teams continued to work on the problem they brought to training for several weeks after the formal training. In most cases coaching was provided by ASI to help with the newly acquired technical skills. One informant (Ratt) told the writer it was more likely project team members that if you were in one of the vehicle engineering groups you would get assistance from an ASI Master Black Belt. If you were from a central DFSS support group you did not get the same attention.

Another example of a coaching activity is offered by Cesar, an informant that went through DFSS training in the early part of the implementation process. He also describes the mentoring he received from the DFSS not so much superficial as just plain consulting with a bit of telling at the end. He remembers having a problem with his team not knowing which design to use as part of the DOE. Their DFSS coach came and reviewed some material with them and then told them what design to use. Mark, in Canada, had a similar experience with material related to developing engineering metrics as part of the QFD analysis for their project. “We had a discussion of the problem, but in the end we were told what to do” Mark reported. In these two situations, coaching as a means of reinforcing basic tools and assisting in an individual’s learning was replaced by a push from the coach to complete a particular DFSS process step and move on. The coaching seemed focused on clarifying the technical tools and being sure that the process was followed as prescribed, including proper filling out of paperwork.

When a Master Black Belt was asked what approach he takes coaching would-be green belts or black belts he said it depends on the group and how much they are struggling. “If they are really close to understanding the issues, I will try and lead them as if we were doing an in-class exercise.” The approach differs for those teams struggling to get the project complete, in this case he confesses to generally giving them help as if “I was a paid consultant.” Being a paid consultant can mean many things, but in this case it implies acting as an expert and telling them how to solve the problem.

Of particular interest in the broader context of problem solving approaches taken at GM, my Canadian informant candidly reported that to him the difference between the problem solving systems he had learned through earlier GM programs and DFSS was, mainly following the specific steps laid out by ASI. He added we were not just encouraged to follow the process, it was to be done without questions – as students in the class room and as practitioners working on a project we are told this is a logical and well-founded process; there is no other approach that will work as well. Mark did not see the value to him in his job to pursue the Black Belt certification, but continues to practice problem solving using various tools.

The champion reviews: Case Examples

When a project was completed the project team (or at a minimum the project leader) would prepare a prescribed set of slides for review by the champion and a Master Black Belt. Of course, in the first years the only Master Black Belts were from ASI. The presentation template included a review of the project and the step-by-step execution of the DFSS process, including a brief explanation of how each process step was closed out. The writer observed two reviews in 2008, and in each case, the project team was asked general knowledge questions about the process and how it was executed. The documentation required may have been the most onerous part of this review, but was a required step in achieving the first DFSS *dan*.

A composite of the two reviews observed will serve as an example of how local leadership acted to reinforce the process. The two director reviews of projects witnessed were hurried affairs with little attention paid to the particulars of DFSS; both were witnessed in the later part of 2008. These reviews took place as part of an engineering design review. One was a report on an interior door trim project with 26 weeks to the program production date; and a second, the review of trunk carpet color and appearance optimization with timing to start of production similar to the door trim review. The DFSS teams were represented by the project leader alone in one case and in the other the project leader was accompanied by one project member. Each leader presented a summary of the project that was prepared from a standard (20 slide) template for such reviews including original motivation for the project, cost of quality, and other key DFSS process step milestones.

The reviews never covered technical aspects of the DFSS work and the directors (different in each) both asked general questions about the choice of design alternative (something many engineers - manager or otherwise - would enjoy addressing). Both times the engineer was questioned regarding the timing of validation, rather than technical issues of the study or how the thinking of the team as they thought about the problem. One director asked: “Is the current release level being comprehended in the validation tests?” Later in the review the same director wanted to know: “Will the part be validated in time for the release date?” These are issues of importance to a manager

Know Your Design & Interface Questions
1. Who are the external and internal Customers of the design?
2. What are the Customers' Expectations of the design?
3. What are the required Functions/Performances of the design?
4. What Concepts have been considered and which Concept was selected (lowest cost, most robust solution)?
5. How Competitive is the design?
6. How does the design perform to the Warranty, APEAL, CR metrics? Cost and mass targets?
7. What is the Manufacturability (ease, rate, repeatability, to print) of the design?
8. What is the Assembleability (ease, rate, repeatability, to print) of the design?
9. What is the Serviceability of the design?
10. What materials have been considered and which material was selected?
11. What are the Validation results including Reliability and Durability for the design?
12. What are the Design Parameters (Control Factors) for the design and their allowable range?
13. Which Design Parameters (Control Factors) have the largest influence on the design's function/performance (nominal, range)? What is the variation of each Design Parameter?
14. What are the environmental, aging/wear, interface and manufacturing factors (referred to as "Noise" Factors) that affect the design performance? What is the assumed range of variation for each "Noise" Factor?
15. Which "Noise" Factors have the largest influence on the performance (nominal and range)?
16. How much do the functions/performances that the customer cares about the most (customer-critical performance variation), vary due to these Noise Factors?
17. Which design parameters (Control Factors) affect the nominal performance? Which parameters affect the performance variation? Which affect both? Which affect neither?
18. What are the potential Failure Modes of the design and how has the impact on the Customer been minimized/managed?
19. What are the Design (Physical, Electrical, and Software) Interfaces and who are the Stakeholders?
20. What are Supplier (Tier 1, 2 and 3) answers to Questions 1 through 19?

Figure 4-5: DFSS Pocket Card for Champions. 20 Questions to ask of candidates for a DFSS Green Belt

wanting assurance the program timing will not be adversely affected. A question about the supplier of the component was also raised, but it was more an issue of trust in the choice Purchasing had made rather than a specific technical issue or an issue of how they worked together on the project. Neither review lasted more than twenty-five minutes and never really challenged the engineer to think about the project nor offered an opportunity for the director to really demonstrate his understanding of DFSS or to act as a mentor in any way. At the end of the two reviews all team members from both projects were granted the Green Belt certification.

I was told by a central office DFSS informant that some directors (why only some is not clear) have pocket-cards with a series of questions to help them in formal and informal project reviews (Figure 5 – 4). The questions, if asked would represent a thorough interrogation of the engineer and the process. In the reviews observed it is not clear if the directors did not have the cards or choose not to use then for some reason. As seen in the list, if addressed in its entirety this would cover the significant aspect of all phases of a part design. Good answers to the specific questions would include details about the customers (both internal and external) and their specific requirements, as well as information about the design and interfaces that would require considerable knowledge of a properly designed experiment. The directors did not seem to have the understanding or interest to delve into any detail on the quality of the actual work that was done or what the project teams learned by doing it.

A DFSS project example

An example of how a DFSS Green Belt would approach a project seven years after the imitation process began is given by Cesar, a wheel engineer with a special projects group at the Vehicle Engineering Center. In his job he would normally be involved in the development of new wheels for a program from the very beginning. He said his first steps would be to review the Vehicle Technical Specifications (VTS) and the Sub-System Technical Specifications (SSTS) to understand the vehicle requirements as initially understood. He would then engage the program team in a discussion of the specific needs of the new wheel – he would be particularly interested in the vehicle weight class, size of the tires to be used, expected driving profile of the particular vehicle and any special esthetics the team expected to gain from the design[18]. He would take the initial drawings from the studio and identify any obvious problems using his experience and information from a wheel design failures database – a database compiled by engineers from previous programs that identifies wheel failures, both structural and cosmetic that impact performance in the field. The information he assembled would help him assess the likely failures of the proposed design and work with the studio on any known issues before any serious discussions with a supplier begin. This is the beginning of a formal DFMEA.

This stage of the project was to a significant extent individual – Cesar was relying on his knowledge and some documented "best practices" to come up with a starting point for the design. He tells me, he is generally successful in convincing a designer a particular wheel design with a thin spoke while perhaps looking stylish is not feasible for durability reasons. Still, he must work with a supplier to further develop the design and cosmetic elements of the wheel. The alternatives he develops at this phase he says are mostly superficial; different material mixes are usually open for consideration, but changing the thickness of a rim, a spoke or an opening are going to be the last option (changing the appearance of a part is tough battle to fight – designers will always fight for the look they want arguing they have already given in at an earlier stage and this is now the look that is required). Some aspects of this give and take may have been better accomplished during the systems engineering activity that is the QFD process. This is the process by which high level customer requirements (like the appearance of the wheel)

[18] A performance vehicle is expected to have a more intense profile than a luxury sport vehicle or luxury sedan.

are balanced with other technical requirements earlier in the process as part of the VTS and SSTS development. At this point Cesar and team cannot question the assumptions nor attempt to change the design direction.

At next stage Cesar indicates he is to a significant degree dependent on his supplier to pick the best approach to optimize the design. While the selection process for the supplier would have included criteria based on its ability and interest in assisting in developing an optimal design; he says time and available manufacturing resources make doing a perfect job difficult. Cesar says he works very closely with the supplier to select design parameters to include in a DOE, but he relies on them to conduct the experiment and analyze the results. He has reviewed experimental results with many different suppliers' development engineers and in every case the primary concern will be safety – the wheel is a critical part and a failure could be catastrophic. Secondary consideration is given to the finish of the wheel. He indicates he is comfortable reviewing the experimental results from the supplier; he also said he has a good relationship with most of the suppliers, after nearly eight years working on wheels he knows the engineers and trust them.

For Cesar, the final step of the DFSS process is executed as part of the final design validation. The validation schedule for wheels is comprehensive and includes a series of strength tests and several laboratory tests for finish durability against salt, temperature and extreme UV and humidity some lasting 32 weeks. His wheel will not generally be on the critical path and after the initial runs of the DOE and the work on establishing the design parameters he is confident of the final design.

Several years after the DFSS implementation process began at GM there was considerable pride in the accomplishments. A large display just off of a major hallway at the main engineering center displayed the names of the Black Belt and the Master Black Belt holders. It also summarized by indicating the number and dollars saved for projects each year up until the current. The display indicated in 2009, XXX projects were completed with savings of $Xxx,xxx.

To progress to a higher *dan* a schedule of additional classes and projects exists. For example, in order to move to a Black Belt the individual would lead 2 projects and take 4 additional courses from the DFSS curriculum. A Master Black Belt had to coach or lead 6 projects (with at least 3 as coach) and take an additional 6 classes. In addition, once the course work and project requirement were met, the Master Black Belt candidate underwent a one-hour oral defense by other Master Black Belts.

Less than a Green Belt

What happened to the hundreds of people trained and not certified? The exact number is not known, but what is known is a large number of people that went through the training did not complete the certification process. To be fair, not all of the people trained by GM and not counted in the 2100 as certified at GM dropped out of using DFSS. According to Wanda, a chassis validation engineer with many years of experience, she knew many that are using the methods very effectively, but not in the strict steps of a DFSS process. This person indicated that after the initial training and a few years of experience she has the ability to rapidly focus on important aspect of certain parts' potential failure modes and quickly turn these issues into design criteria. Wanda has been involved in all of the DFSS training and several projects, but has never attained the basic level of certification. She says her projects were generally handed off to a design release engineer, frequently being dropped because they do not have the required "payoff" to be considered a true DFSS project or because the engineer is too busy to complete the required work to have the project deemed complete by the Champion. This person was a central validation resource, respected by her peers and recognized by the junior engineers as a person to go to for help with a problem.

Wanda told about a meeting with a junior engineer working on a front suspension issue for a heavy-duty half-ton truck. It was a durability problem, with significant customer issues for vehicles with 60-80,000 miles. Wanda met with a young engineer who had no DFSS training; she completed a major part of a DFMEA with him and set him on the path to learn more about the part from the supplier and review some warranty data for different vehicles. The DFMEA is an important part of identifying potential problems early in the early design stages of new part development. It is a tool taught as part of the DFSS process. As she described the meeting, the young engineer was aware of some of the issues related to part life in other vehicles, but he was unsure of design attributes that would solve the problem without adding cost to the design. A DFMEA should help an engineer sort out the potential problems and provide a starting point for a list of factors that may contribute to the improvement of the design. By itself, DFMEA is a good tool engaging engineers in conversation with their suppliers and the manufacturing people. When used in the framework of a DFSS project it provides some of the important information needed to develop alternative concepts and then provide an optimal design.

Wanda used her extensive knowledge of the chassis system of full size trucks and her considerable experience in validation to help the young engineer with his designs. What he did with it next is not known with certainty, but without training in DFSS it is likely the engineer used the DFMEA information to improve the design, but not necessarily to provide an optimal design. Wanda would seem to be in an excellent position to influence young engineers. She is able to use her knowledge of DFMEA to teach them how to investigate their design and understand the part. She also has the in-depth engineering knowledge and credibility to coach young engineers and coax out of them actions that will improve their understanding of the parts they are working on and improve the performance of the systems they are part of. It seems that while using only part of the DFSS process her actions encourage and improve the understanding of the junior engineers on only a very small part of the total process. In this case, Wanda candidly told the writer she knew the engineer would not use any of the other tools of DFSS, but felt strongly that the DFMEA would serve him well as he continued the design work for the suspension component.

DFSS "infusion" into the reporting structure of GM engineering

In the early part of the 21st century GM was facing a financial crisis and many people, some willingly some otherwise, left the corporation. Many green belts and some black belts left and took their certification with them (perhaps even using it on their resume as an important engineering credential[19]). Many stayed with the company and a

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[19] The GM DFSS certification is recognized by other firms as similar to publicly available programs. The writer spoke with one engineer that left GM prior to the bankruptcy, he spoke frankly about

handful of these people have attained a personal mastery of DFSS. In an organization focused on spreading the use and understanding of these concepts into the organization, they might become the leaders. Theoretically, as more leaders gained personal mastery of the tools they would be able to coach and mentor the engineers in their employ, encouraging them with more than good questions, but also helping them to learn the basics of the tools and incorporating the learning into an organizational philosophy.

If a firm is serious about encouraging a particular philosophy (or tool use) and leaders play an important part in the diffusion of that knowledge within an organization, it is reasonable to expect that after some time more and more managers and directors in such organizations will have credentials associated with the methods. A survey of thirty engineering managers and directors (drawn from a stratified random sample balance by the two basic levels indicated) conducted in 2010 revealed the following: none of the directors had any DFSS training beyond the initial three-day Champions' Training, and none of the managers had the Master Black Belt, none were Black Belts and 18 percent had a Green Belt designation[20]. Clearly, little adsorption of DFSS talent into the management ranks had occurred by that time.

Discussion – Support and Contradiction of the Learning Model

In the theory section of this chapter it was suggested if the learning model proposed was correct an effective imitation would follow if two things would occur. First, many cycles of tacit learning with the slow introduction of explicit knowledge

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an interview with his new employer that talked about how he might called on in the new position to use his DFSS knowledge.

[20] Three out of five managers that had a Green Belt Certification indicated they had earned it as part of a project team and were not promoted into their job with the credential.

intertwined with organizational change would be common. Second, organizational learning and individual learning, initially characterized by a mechanical approach to knowledge transfer, would be followed by learning displaying a more organic approach to problems including double-loop learning. In this imitation environment what was seen was a series of individual learning activities that were strictly mechanical in nature and little evolution beyond that.

In the DFSS imitation, learning was individual in nature; it closely followed the first two steps of Dreyfus' model with little or no growth beyond the point of understanding codified instructions. Additionally, there was a very mechanical approach to knowledge transfer; even the problem solving process itself, the subject of the training, was mechanically followed. After five years of practice and repetition, we did not learn of any double-loop learning. In most situations the procedures of following the ASI process seemed more important than the result. This may have inhibited a deeper use of the tools for challenging the design. For example, the DFSS tools were used to rigorously analyze the design targets already defined by the engineer and the customers, but there was little attention in questioning the design targets and considering alternatives.

Executive champions did not receive much training and there is little evidence of effective mentoring from ASI leaders. With only one three-day session and no experience running projects executives were ill equipped to show real leadership in DFSS deployment. There was little follow-up post training; apparently they did have coaches available for early project review, but whatever mentoring received left the champions unprepared. Directors and senior managers who got their jobs by being good problem solvers seemed unwilling to change their approach. The general culture of problem solving at GM engineering was not altered, some evidence from the project reviews indicates engineering managers and directors were curious about the design (the engineer in them) and apprehensive about timing (the manager). The role of a coach is to challenge the thinking and problem solving process to develop the engineers, not jump into discussing solutions and management issues.

Reviews did not focus on the important aspects of the DFSS project and did not offer the champions any opportunity to demonstrate their leadership on the initiative or their support for the use of the process. The individuals preparing for the review may have learned something from putting together the presentation, but indications are this was just another set of paperwork required for certification. The twenty-question pocket card sounds like a good idea, but it was a little late and not thoroughly executed. Why did only some directors have this card? With the card it would seem coaching could be more consistent and focus less on the results and more on the DFSS process.

This case does not follow the expectation for learning as suggested by the ideal model, namely that the learning patterns and habits would migrate to the Adaptive/Organizational quadrant of the I/O Learning Plane proposed in Chapter 2. Learning did not move in the predicted direction, resulting in an ineffective imitation.

Where are the learners placed on the I/O Learning Plane? In one of two situations of the map: either having not moved from the initial position in the Individual Rote (Individual/Explicit) quadrant, or perhaps a subgroup moved into the Group Rote (Organizational/Explicit) quadrant. Far from being standard work for an engineer, DFSS is a set of tools that have formed a common language for practitioners. The current training methods continue to present the explicit aspects of the tools and the mechanical aspects of the process. As this is true, there are an increasing number of engineers that understand the words and the rules; few, if any, have advanced beyond personal mastery to be able to improvise and adjust as conditions call for different thinking. Such situations would include thinking about changing the target and not just optimizing the current situation. What has not taken place is an organizational "threading" of people that know the tools (even those with only a personal mastery) into the ranks of managers and directors.

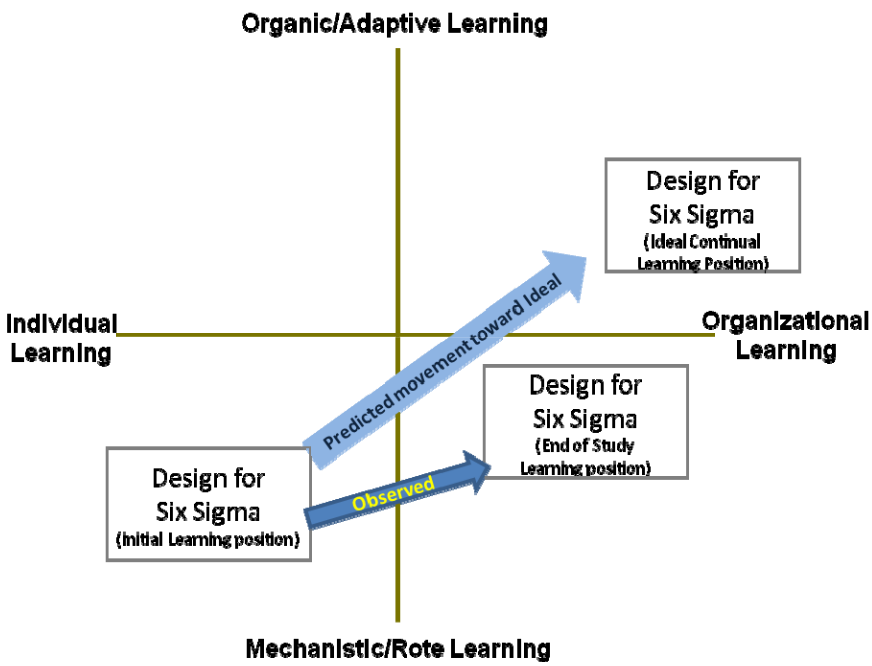

Figure 4-6 DFSS at NA Engieering - Predicted path versus observed

If it is granted the learners have moved beyond the Individual Rote quadrant then at best they have moved to the Group Rote Quadrant. Being in the Group Rote quadrant is not a good place to be given the type of problem and organizational commitment required to excel. Additionally, being in this quadrant may "feel good" to an organization experience with counting to see results (# of cars produced, # of engineers trained, # of projects complete, etc.), but instead of a measure of accomplishment, this may be providing a false sense of progress. If additional energy does not go to putting the learning back on track to its ideal position in the I/O Plane the endeavor may ultimately fail. As will be seen in the next case this is a place GM has been before, stuck in a transitionary phase until other condition draw the organization together to move closer to the ideal.

ANALYSIS – IMITATION WITHOUT ATTEMPTING TO INFLUENCE THE CULTURE

The mechanistic approach to problem solving offered by DFSS fits well into the management culture of GM NA engineering. The rigid approach to the process steps seemed well suited to the always-on-the-run executive champion charged with meeting the numbers. All project teams, particularly those run by the Green Belts and Green Belt apprentices, were provided some consulting and coaching from a Master Black-belt. This coaching focused to a significant extent on following the process steps. In the design phase of the projects, however, less experienced learners were coached on appropriate use of the tools, in particular technical aspects of the Taguchi methods. It is not clear, given the significant technical nuances presented by the tools, if they were ever fully grasped by the users. This is particularly evident when talking to Green Belts that had not been involved in a project for some time. One practitioner interviewee proudly displayed the credential, but also privately confessed to being ill equipped to conduct any future DFSS project without significant assistance.

There seemed to be an appreciation for certain tools by those not going all the way through the certification process. This may be an indication the tools they discovered were either more applicable to the job they were assigned or perhaps the easiest for them to gain a personal mastery. A follow-up conversation with informant Wanda indicated in her case it was the former – the tools most appropriate to her job function were those she uses most. The fact that she did not get the certification does not concern her, she is happy being the "go-to DFMEA person." She happens to be in the validation group within new product development and the use of DFMEA was useful in communicating potential problems with the engineers she worked with and developing a test plan to ensure the designs were not subject to failures they did foresee. She has gained a personal mastery in this tool (and others) that is part of the DFSS portfolio. Clearly some of the people that did not make it through the process knew some tools very well. It may be that many of these "drop-outs" were key influencers and may have made excellent process mentors had they been guided to integrate more of the learning into a good project and complete the certification. Alternatively, less focus on a rigid process and instead attention to where specific tools will help engineers may be more important that the strict adherence to a protocol.

Few true champions of DFSS present themselves; most directors were interested in achieving the numbers set out as their quota. This behavior did more to reinforce the established culture than to create a new one. The counting and reporting seemed endless. Each quarter functional directors were expected to report on the number of engineers trained as Green-belt, Black-belt and Master Black-belt. In addition, project reviews were counted by the directors and reported to a level just below the VP of engineering. In the post bankruptcy period at GM, with a new VP of engineering in place, there is an indication the process will change – less counting has already occurred. The technical knowledge of the tools and process held by the champions is too shallow to provide any meaningful direction regarding problem solving.

Generally, in both the early and late stages of implementation far more Argyris Model I behaviors were evident. Namely, rationalization of the process and "covert attribution and evaluations" using canned tools instead of explaining answers in terms of the theory they represent. The process as defined by the ASI consultants was presented as logical and "the best way" to approach the complex problems participants were asked to bring forward. While the process has roots in some of the most well reasoned methods, strict adherence seemed at times to be merely a "box checking" exercise for project team members. No one this writer spoke with would suggest the basics were not important, in fact prior to the DFSS training manager and practitioner alike confessed to having jumped to solutions only to discover the result, albeit a good one, was not the correct answer given the true problem.

The student/mentor relationship offered opportunity for sharing of control, but difficult aspects of the process were never really explored by the student; instead the mentor or coach was relied on for these steps. This is indicated in cases where Green Belt students would come to a Master Black Belt for assistance and instead of being guided to the answer, would instead be told what design was appropriate for a set of design factors. While experimental design is a non-trivial statistical tool, the opportunity for learning was lost not only for the design set-up, but for subsequent analysis and interpretation of the results. Having not fully participated in the selection of a design, the analysis would often be above the limits of the student's understanding. In the spirit of completing the project this task would be done by "an expert." Problem solving choice was limited and seldom was employed in an approach that allowed questioning of the target; instead, single-loop learning was focused on improving the situation without questioning the direction.

Missing from the problem solving approaches and the general application of the tools is a long-term strategy or philosophy. A reason repeatedly given for selecting projects and solving the problems was to reduce cost. This is a variation of the “we are in business to make money” philosophy of the Sloan era. It is not a sustainable long-term philosophy; it does not present the customer in a positive light (merely as a source of cash) and can lead to short-term objectives being maximized at the expense of more important issues that have a payback in the future. Without long-term thinking even problem solving focused on improving reliability (a future problem) can be sidetracked. It is proposed that a sustainable philosophy that includes a focus on the customer is a necessary condition for growth beyond individual learning.

Chapter 5

TPS/GMS THE CASE OF LEARNING FROM A COOPERATIVE COMPETITOR

INTRODUCTION

In the early part of the 1980's the world was coming out of an economic downturn triggered by a global oil crisis. This was of course a second oil crisis, and the spike in prices and long lines at filling stations sparked political action. The US government targeted automobile fuel economy using Corporate Average Fuel Economy[21] (CAFE). Car companies, at least in the US, under the assumption that their customers could not be interested in a small car and believing "small cars mean small profit[22]" attempted to use technology to increase the fuel economy of its large vehicles. The solutions employed, ideas like improved engine calibration or exhaust would, at least in the early years led to mixed results; often leaving customers and dealers feeling like they were part of an experiment. In firms, that at the time routinely took five to six years to bring a product to market, these "quick" fix ideas may have been a reasonable initial strategy, but in retrospect the real solution the North American big three car companies

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[21] CAFE is a set of regulations first enacted by the United States Congress in 1975. It was intended to improve the average fuel economy of cars and light trucks in the US. It is calculated based on the sales-weighted harmonic mean fuel economy (expressed in miles per gallon) of a manufacturer's fleet of current model year vehicles.

[22] This expression was originally attributed to a GM Vice President (unnamed) from the seventies, more recently quoted by Jurgen E. Schrempp (CEO) quoted in Business Week (2000).

needed was to replace their portfolio with more fuel efficient vehicles, like those of overseas competitors.

At the same time Japanese auto manufacturers were reacting to the effects of the oil embargo at home by reducing waste in the assembly plants and offices and by improving their cars. The vehicles they produced and sold in their home markets were mostly small and fuel efficient, similar to the vehicles they sold in the US market. Several Asian manufacturers were selling vehicles in the US, but in the early eighties there was only one Japanese manufacturer building vehicles in North America - Honda. Toyota and many other Japanese companies had a more conservative approach to expansion. Still, pressure from the US government on off-shore automobile companies was growing at this time and a presence from foreign manufacturers in the US was called for by congress. In the case of Toyota, they choose a plant in Northern California, a facility with a 20 year history as an auto plant, and a Joint Venture (JV) with General Motor (GM). GM, at the time was a company with an eighty year history of engineering, building and marketing vehicles in North America and seller of the more vehicles than any other manufacturer in the US or otherwise.

THE PROBLEM – GM COPYING TPS THROUGH FIRSTHAND EXPERIENCE AT NUMMI

The expansion of foreign companies in the manufacturing sector of the North American economy invites many opportunities for reflection and learning, but one stands out as significant in the context of imitation in a large complex organization. While not originally part of the motivation for the JV, GM was given the opportunity to copy the Toyota Production System. This research explores the pitfalls encountered by GM, a large complex and bureaucratic organization, as it attempted to copy through observation and first-hand experience a comprehensive sociotechnical system and transplant its essence into its own culture.

As indicated the true opportunity presented to GM by the JV was not initially recognized, creating a further issue in trying to bring a copy of another company's operating system to a new home. Senior managers at GM were not entirely convinced they had much to learn from Toyota. Still, it was not long after production started at NUMMI before some people recognized Toyota did things significantly different from the then typical GM approach. Originally sent to learn about Toyota's cost structure and something about building small cars, the GM managers instead discovered Toyota had a superior way of managing the manufacturing process. Initially, the "tools" they used became the objects of their interest and how to quickly mimic them at GM facilities in the mid-western United States a near obsession for a select few. The fact that the tools were embedded in a complex social network of tradition and organizational philosophy was at first lost of observers. The tools were seen as standalone things easy to learn and with significant apparent benefit.

The allure of the tools would prove to be another problem for GM: always looking for the "silver bullet," the quick fix and the easy way out, the tools looked like they could be mimicked anywhere. Time and trials would reveal this to be more than an easy copying ritual. The case that follows shows pitfalls in the path from a copying activity into an organizational learning and adaptation opportunity. It will also show a copy exactly strategy will not work in cases like this if the groundwork is not set for long-term thinking and some less visible support systems are not in place.

The Original: The Toyota Production System

While it may not have been widely known as such in the early 1980’s, the Toyota Production System (TPS) is Toyota’s overriding system to develop their people and processes to manufacture high quality, high value automobiles. Up to the time of NUMMI, TPS was 40 years in the making and still evolving. It is the learning and development process for Toyota and has been referred to as the DNA of the company (Spear and Bowen 1999). As the DNA, it is part of the thinking and action of everyone at Toyota. It is part of the job of every executive, manager, engineer and line-worker to understand, live and work the TPS and it is passed on from generation to generation. So, what is TPS and why does it present as such a compelling object to copy.

What is TPS?

TPS is part of a complex sociotechnical system to build high quality products and get them to the customer quickly and at a competitive cost. It is often represented graphically as a house, because TPS like “a house is a structural system” Liker (2004.p.). The various parts of the TPS house are critical, but the elements support and reinforce one another and the structure will collapse if any part is weak. The system starts on the roof with a standard set of goals, namely: best quality, lowest cost, shortest lead time in a safe environment with high employee morale. The outer walls – two pillars providing support for these goals are just-in-time (JIT) production and *jidoka* or in-station quality. The foundation is a set by supporting systems to provide level schedules and stable and reliable processes. The various technical systems supporting the goals of the organization surround the people systems, at the center of the house, responsible for continuous improvement and waste reduction. (ibid, p. 32)

Liker (2004) provides a broader view of Toyota's management principles, organized into four categories, called The Toyota Way. The first category and the first warning flag for most NA manufacturers: "base your management decisions on a long-term **philosophy**." This behavior is manifest in actions that "bring the company to the next level" even at the expense of short-term profit. The second category encompasses many of the well-known TPS tools; it is to strive for the most waste-free **process**. Methods like continuous-flow, pull-systems, standardized work, and a level workflow are critical to a stable, quality process, but there biggest benefit is in surfacing problems in a visible way so people are forced to solve the problems. The next category provides a people perspective: develop your **people** and your **partners**. In so doing, an organization will develop leaders as well as exceptional people who are committed to and learn how to think clearly about solving problems. People are the key to problem solving and innovation and who turn the static processes into an adaptable organization responding to challenges from the environment. The final category is **problem solving** which translates to continuous improvement through organizational learning. These are the methods by which people solve problems, challenge the status quo, learn, grow, and the organization shifts from individual learning to a learning organization. This group of activities includes "relentless reflection," decision making through consensus and an eagerness to learn by going to the source.

Of course, bad processes and poorly developed people will yield bad results, but even with the best people, weak processes will yield only mediocre results. With good process, and the right tools a company can get by without the best people, but the results will be middle of the pack. Toyota strives for excellence processes continually improved by exceptional people, which over the long term will give the best results.

The explicit tools of TPS to copy

We can see in this brief description it might be possible to confuse TPS with a set of basic tools that can be codified and taught explicitly. In fact, many aspects of TPS, like how to calculate *kanban* quantities or and how to create a standardized work sheet, can be taught. Given the basic assumptions, each of these can be a simple industrial engineering task assigned to a junior employee. In fact, several physical tools fall into this category, they are the tools that are the easiest to see – both the set-up and the effect.

Some of the tools that fall into the explicit rules set include many in the JIT pillar of the house. On the surface they may lend themselves to a copy exact strategy and include: takt time planning, creating continuous flow, comprehensive pull systems and quick process changeover (e.g., changing a tool in a machine). As suggested earlier, these concepts have a mechanical nature and are governed by a set of rules. Consequently, those with a "factory physics" outlook will readily pick up and endeavor to implement these tool into a process (Hopp and Spearman 2001).

In the general category of "in-station quality" several other tools may seem apparent copy-exact candidates. Tools like the andon system used to alert a team leader of a problem or error proofing mechanisms and Poke-yoke systems to prevent simple but costly mistakes from occurring are easily visible artifacts of a more complex system. There is a set of rules that process engineers can learn to develop and install such tools on a particular manufacturing line, but there is also a set of hidden and more subtle rules that support the operations. As Liker points out, as part of a system, if one part is weak or unsupported it will cause problems in other areas. Such is the case with these tools that on the surface seem simple and autonomous – they are part of a system that relies heavily on people with a commitment to continuous improvement. The tools are not mere problem prevention tools, but methods to draw the organization's attention to more problems. To really make the tools work tacit knowledge of the interplay between the tools and people at all levels is required.

The tacit knowledge needed to make TPS work

Nonaka tell us knowledge is more than a simple collection of information codified into tools and processes (2008). In a firm, knowledge is created and shared through practice by individuals influenced by their beliefs and judgments. Whitehead (1933) says knowledge is created based on "value judgments" that are based on how one perceives goodness and truth. An organization will acquire knowledge as it adapts the interactions of the many individual into "practical wisdom" that advances the goals of the firm (Nonaka 2008). The aforementioned "process" is not the same for everyone or every time it is executed. It is circumstantial and driven by the perceptions of the individual and inferred or implied by a single characteristic of the situation. These, the tacit aspects of knowledge, are driven by individuals.

Take for example standard work. Here is a tool that appears on the surface to capture the mechanical aspects of a particular workstation. It can be interpreted as a tool to develop a systematic way to do a particular task specifying steps to follow, how to do them, and how long each should take. The standard work can be developed in a non-coercive manner with the cooperation of all parties involved. Training can be provided to level the understanding of all in an effort to maximize the input from each person and ease the transition to the standard. Training might also include important considerations for how the standard work will be used for problem solving and process improvement. Often, standard work will become nothing more than a document posted at a workstation to indicate such a task was undertaken. The practical wisdom created from the interaction of the individuals referenced in the earlier paragraph has not been achieved. Somehow the implied tacit aspects of the process are lost and instead of a standard approach to a set of tasks there are several methods none the standard. As a result the tool is unsuitable for it true purpose; problem solving and process improvements go undone. The tacit information can take many forms, including underlying assumptions about the relationship between managers and workers, ways of leading on a daily basis, and how people are selected and developed to fit into the organizational culture.

The tacit knowledge needed to make TPS really function as intended is something that comes with the development of personal mastery akin to the learning method described by Dreyfus (1980) coupled with a strong commitment to a philosophy of improvement that includes development of the people, including leaders, that understand and embrace the tools and the position tools and people play in the process. It is a combination of philosophy, people, leadership, and tools that change based on the circumstance to create a learning environment focuses on improvement. More importantly, a company trying to implement TPS needs to recognize that it is not merely about imitating the tools used by Toyota in a particular manufacturing process (Liker 2004). Liker adds it is quite possible to use a number of TPS tools and only follow a select few of the principles by which Toyota governs itself; such behavior, on the part of an organization, will invariably yield some performance gains that are not sustainable in the long-term.

Consider again Liker's TPS house; a considerable portion is not made up of tools. However, a foundation of behaviors and a long-term philosophy built around developing people create the heart of the system (2004). We can see much of the broader description of the principles of TPS focus on how people think and how leaders lead which is much more ambiguous often inferred or implied from some understated action yet revolving around continual improvement and driving toward a common long term goal. Thus TPS is not easily transferred from one organization to another. Toyota management knew this when they agreed to the JV with GM.

Placing TPS in the theoretical model

This case is characterized as imitation from a willing competitor in that GM had access to the workings of the Toyota Production System (TPS) at NUMMI for a period of nearly 25 years. The nature of any production system, TPS included, is complex and the apparent concepts on the surface only tell part of the story. The environment is dynamic and information is at different times and circumstances both unambiguous and also inferred from a situation, but unspoken. The unambiguous is explicit knowledge that could take on the form of well-documented and codified best practices and methods that can be taught in a classroom. The unspoken is tacit information that can take many forms, including underlying assumptions about the relationship between managers and workers, ways of leading on a daily basis, and how people are selected and developed to fit into the organizational culture. The situation described is that of the top right hand corner of the Individual/Organizational Learning Plane (Figure 4-1); as such, we can position the Toyota Production System, as an ideal, in that quadrant.

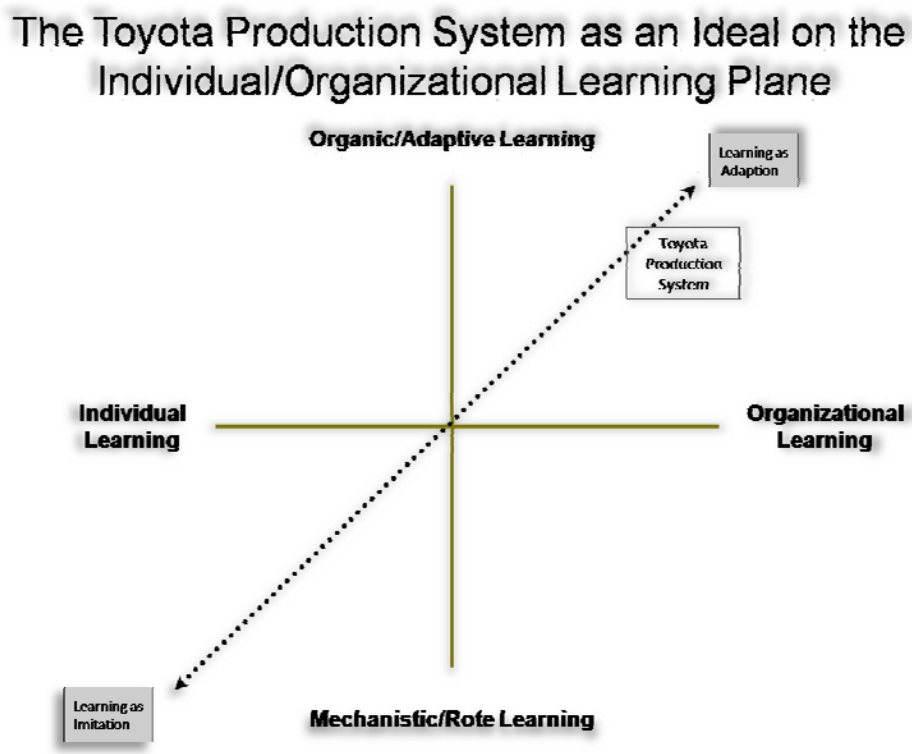

Figure 5-1 The Toyota Production System placed in the Organic/Organizational Quadrant of the I/O Learning Plane

As indicated, TPS is a complex system of people, processes, and tools and as such learning all of these interrelated systems would be very difficult for General Motors. So, as suggested by the propositions in Chapter 2, effective imitation would begin with a mechanistic approach to learning by copying many of the explicit aspects of the process and integrating them into a plan that would migrate an organization toward an ideal position as suggested by the location of Toyota on Figure 4-1. In fact, what we will see in this case is an early attempt to imitate TPS at GM that begins in the Individual/Mechanistic quadrant followed by a second attempt at imitation that is more characteristic of the Organizational/Mechanistic quadrant and ultimately a migration toward the ideal as shown by TPS. The details of this three-stage migration/imitation will be discussed in the case description.

As a caveat I am not arguing that GM used an ideal process for learning. The fact that it took over twenty years and ultimately GM went bankrupt suggests they did not do a very good job at many points. On the other hand, we will argue that eventually they did in fact learn quite deeply in many parts of the company.

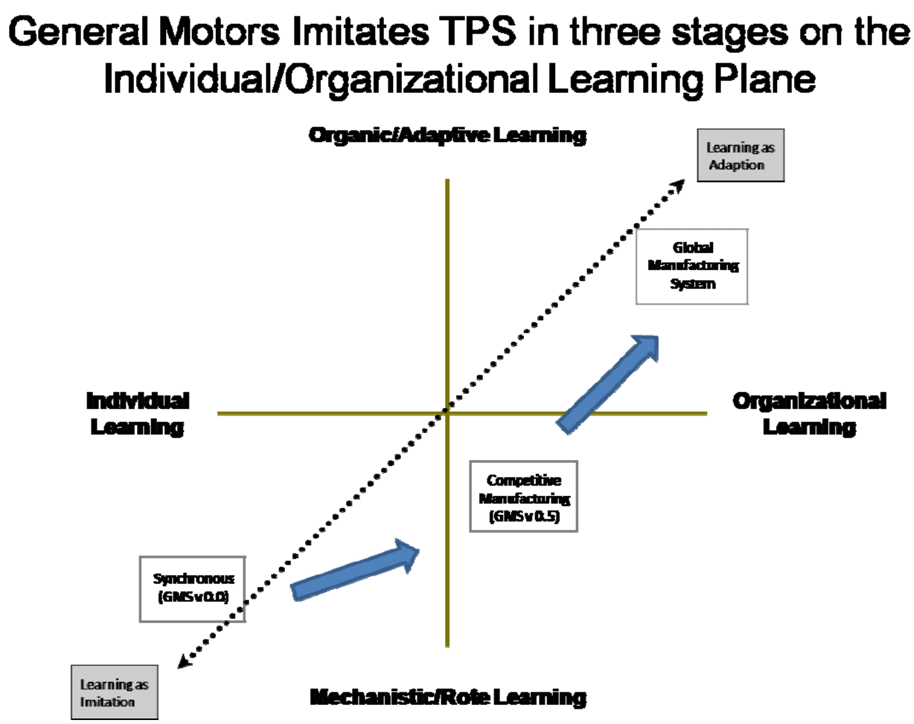

Figure 5-2 General Motors' Three Learning Phases to an Imitation of TPS

Three hypotheses introduce in Chapter 2 apply to this case. Specifically, chapter Two says three things about how an imitator will move about the I/O Learning Plane in situations like this: 1) learning starts as a mechanistic task focusing on the individual; 2) movement along the axis is facilitated by mentors or coaches with personal mastery of the concepts; and, 3) many individuals with common mental models and shared long-term goals will be able to exchange and codify tacit knowledge that will enable organizational learning and adaptation required to reside in the upper right hand quadrant of the learning plane. Such behavior is captured in Hypothesis 2 from chapter 2 as:

> In the case of organizational imitation of processes of a highly system-embedded nature governed predominantly by tacit rules, learning will begin with the individual and require many cycles of tacit learning as there is a gradual shift to organizational learning.

Prior to seeing the data from the case, it is assumed imitators are able to accomplish this, at least in part, because a group of people with a common understanding of an organization can increase their knowledge of a particular concept through sharing mechanisms. Sharing, if properly facilitated can lead to reflection; thinking about past successes and failures and ultimately can produce better future alternative and in a global sense a better understanding of where routines fit in an organization. Of course, individual reflection can lead to changes in an individual's understanding of a situation as well, but without outside knowledge (Deming would say this is profound knowledge) the individual is destined to flounder and only stumble onto a correct approach.

If an organization is a complex imitation environment and the copying activity moves from explicit instructions governing seemingly autonomous routines toward more complex instructions of a more tacit nature a successful profile of the copying activity will change from a mechanistic to a more organic approach. Again, prior to seeing data from the case it is assumed one consequence of hypothesis 2 for routines located in the Adaptive/Organizational quadrant is that the management environment will shift from mechanistic to more organic. This is stated as hypothesis 2a, in chapter 2:

> Individual learning is initially characterized by a mechanical approach to knowledge transfer, and as need be, is followed by learning displaying characteristics of a more organic organization able to deal with environmental complexity and change.

If supported, this hypothesis suggests a learning relationship can be defined based on the degree of complexity expected of the routine being copied and the mimicking organization's ability to change and adapt as the learning needs become more complex. Behavior consistent with this hypothesis would include leaders and managers with more direct observation at the work site, greater individual refection on true goals, and shared appreciation of a problem.

Along with Hypothesis 2 and 2a, observers of an organization attempting to imitate routines ideally positioned in the organic/organization quadrant, may think the imitators need a catalyst to move it along the learning axis toward a more organic organizational learning environment. Hypothesis 3 summarizes the expectation:

> A mentor or coach with a personal mastery of the original will act to not only ensure a novice learns the important key aspects of any new organizational practice being imitated, but will also help define a vision of the future organization that provides context for the learner.

This hypothesis defines the role of the mentor or coach in keeping the organization on the learning axis.

In situations where the ideal is in the adaptive organizational learning quadrant, a transitional phase that places the activity in the organizational rote quadrant (as we saw GM was shifting) may be detrimental to the planned imitation. This situation would arise when an organization in this position would have a false sense that things are proceeding well. This may occur as more and more people are learning the tools, but true success is not being made on the work floor because the total system is not understood. An organization stuck here would be characterized by few incentives to openly experiment and single-loop learning, both stemming from defensive positions adapted from a mechanistic approach to problem resolution. It is proposed here, that without some force to move to the adaptive level of learning (and draw out more Argyris' Model II behavior) eventually the imitation will fail. The GM case offered a set of conditions that facilitated the advancement of the imitation toward its ideal.

CASE BACKGROUND

The culture of a North America manufacturing facility

An automobile manufacturing and assembly facility is generally a very large and complex organization. In the late 20th century a big plant was the standard – large facilities producing many vehicles with few stoppages would bring average cost down. Big facilities also represented barriers to entry for competitors – a plant could represent a 500-700 million dollar investment. The plant manager had the important task of keeping the plant running. That generally meant 24 hours a day, six days each week, with as many as 5,000 workers each with their assigned tasks, deliveries of raw material coming in every 30 minutes, and a new vehicle coming off the line every minute. An auto plant was like a small city, its technical infrastructure bound by all the social problems of a culturally diverse community.

Of course Toyota knew and understood the technical aspects of a modern auto plant. The situation Toyota was entering at Fremont had other complexities that presented potential roadblocks. The work force was one of the worst in GM's system, and manufacturing management (that group they would be most involved with) resented the idea of working with them. This section outlines some of the cultural aspects of the work environment in play at the Fremont plant prior to NUMMI starting operations.

Adler and Borys (1996) in there comparison of bureaucratic approaches to management use the expression coercive to describe relationships like that between the United Auto Workers (UAW) and plant management in most automotive manufacturing facilities. In fact, to say an auto plant was a coercive bureaucracy might be stating it mildly. In the seventies and eighties relations between management and the UAW were at a low. Artifacts that attest to the state include contracts that outline hundreds of job classifications rigidly enforced by both sides; a grievance procedure overwhelmed with complaints; a manufacturing system designed to keep control of production out of the hands of hourly workers and management performance standards focused on assigning blame for poor performance.

The culture of the typical manufacturing facility in North America has changed in the years since, but the antagonistic environment of the pre-NUMMI period was entrenched in the culture. An us versus them mentality that saw winners and losers at each exchange and any sharing of information meant a loss of control for either side. The corporate mindset dealing with other firms was also a well-established set of twisted values. This was a period when GM and other large auto manufacturers made decisions "with a parochial Midwestern mindset" (Briody, Robert T. Trotter II et al. 2010). At GM, this thinking led to a general lack of "sophistication in its understanding of foreign competition" (Keller 1989) that made its invulnerability seem a given. It also fostered a network of sub-cultures at GM that may have been effective in maintaining control in large facilities in the early years, but not in the new competitive world of firms that focused on quality improvement and "masters at reducing waste and cost, reducing lead time to market, and learning effectively from their mistakes" (Briody, Robert T. Trotter II et al. 2010).

In the seventies, three major sub-cultures existed in most NA manufacturing facilities: a worker class hired as a "pair of hands and legs," a technologically knowledgeable engineering group and a team of managers. In the spirit of a coercive bureaucracy, communication between the groups was mostly written – work orders, program plans, drawings, meeting minutes, contracts and schedules are just a few of the formal communication documents. Many of these documents represent the belief that members of the other groups needed explicit instructions, the assumptions being they could not be trusted to understand nor even have the same interest in what needed to be done without a trail of detailed instructions spelling out the steps to be taken and the expected outcome. This impersonal communication method also served to isolate the people within their sub-groups, making engagement between them difficult and sharing of information and learning almost impossible[23].

Engineers saw themselves as different from the hourly workers. They thought of themselves as smarter than the hourly workers; they were mostly degreed engineers. In many cases they also saw themselves as smarter than the managers. This attitude was also the product of the education: engineering school is tougher that business school –

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[23] As part of a number of problem solving teams sent to plants in the late eighties the writer naively invited hourly workers to brainstorming sessions to complete fish-bone diagrams and generally to learn from the people closest to the problems. The initial reaction from management when told the operator was needed in such sessions was disbelief and stubborn rejection of the idea. The operators often reacted cynically with some latent "why haven't you asked me before" attitude mixed in. In some facilities it would take weeks or months to gain the full co-operation of the organization on task as simple as sharing information with each other. It would take an outsider to create the bridge.

they knew how build and how to improve a plant. Engineers solved the real problems and generally thought of managers as part of the problem – imposing financial or time constraints on a situation and preventing them from providing the optimal solution.

Hourly employees were the most vulnerable and worked in the harshest conditions. Many of the jobs they performed were monotonous, dirty and physically demanding. This was a tough world; you got respect from your co-workers when you didn't take any guff from the man trying to make you do more work. This is a world where a first line supervisor probably got the job because he could throw a good punch. Liker (forthcoming Toyota leadership book) describes a former GM line supervisor that was rehired by Toyota for NUMMI as just this type of individual. He earned his stripes in the back of the parking lot at shift change, teaching some ornery assemblyman some respect. This is the world Toyota was most interested in understanding and developing.

History of NUMMI

NUMMI was a Joint Venture between General Motors and Toyota that lasted 25 year; on the surface the purpose was to build vehicles together in Fremont, California. In reality, this JV was far from an arrangement to share manufacturing capacity. In fact, Toyota and General Motors both had important reasons to join forces in 1984; both may even have internally used similar language to describe their reasons. In broad terms, Toyota needed to know how to be successful in manufacturing vehicles in North America; to do so they set out to learn from a firm doing business in the United States. Some in GM wanted to learn as well, but the true opportunity was apparently not as well understood at GM as it was at Toyota (Inkpen, 2008). NUMMI was a partnership between Toyota and General Motors, but GM was not Toyota's first choice. Toyota has long admired and in fact emulated Ford Motor Company and when the need to establish a JV in North America was first discussed at Toyota it was Ford they approached (Keller 1989). Talks with Ford broke down and Roger Smith the CEO of General Motors stepped in.

Toyota's Motivation

Toyota's need to learn was a consequence of pressure from the US government in the early 80s to produce vehicles in the United States (and perhaps in true Toyota way, they were not going to start something without understanding the implications). In general, the JV was a low risk partnership that allowed each party access to information the other held. The extent to which this would help one party over the other could not have been understood at the onset. For Toyota, an experimental laboratory to learn how to work with an American workforce, for GM a partner with small car design and manufacturing capability willing to share.

NUMMI was an opportunity for Toyota to learn what they needed to do to successfully manufacture vehicles in North America (having not done so prior to 1984). This is not to say they were learning from GM, on the contrary the JV would provide an infrastructure to build vehicles with someone that understood the basics of the local environment. One of the things that concerned the Japanese auto manufacturer was "transplanting" its production system into a work environment famous for hostile and militant workers. Prior to NUMMI, Toyota had no experience with a unionized workforce and, at the time, American autoworkers had a very nasty reputation. Of course, Toyota's operating system was far more than a set of tools and procedures: it was "its way of cultivating employee involvement" (Shook, 2010). From Toyota's perspective, the GM plant in Fremont may have represented a worst-case scenario with respect to the hourly workforce. According to Shook (2010) “the work force at the old GM Fremont plant was considered to be an extraordinarily bad one” (p. 64). Shook indicates absenteeism routinely hit 20% in the years GM ran the plant and grievances[24] were a commonly used tool for political purposes, often exercised to merely bring GM’s hulking bureaucracy to a grinding halt – a power play by the people with the least formal power.

There were various motives to create the joint venture called New United Motors Manufacturing Incorporated (NUMMI). Toyota clearly wanted to build product in North America, but had questions about whether the Toyota Production System could function effectively in America with its different culture and some of the logistics issues that would challenge its famed just-in-time (JIT) system. So Toyota decided they wanted an American partner for their first major U.S. manufacturing venture. General Motors wanted a source of small cars, but also had some interest in learning about the Toyota manufacturing principles.

Toyota chose to work with GM because of GM’s connections in America to the legal system, the financial system, the supply system, but not to learn from GM how to work with Americans. The labor history at Fremont would have indicated to Toyota leaders GM had little strength in establishing strong relationships with its workforce. Toyota knew they had to do the hard work of learning how to develop Americans to

[24] In a labor union, a grievance is matter filed by an employee to be resolved by procedures outline in the union contract. A grievance may arise from an alleged violation of the collective bargaining agreement, or violations of law, such as workplace safety regulations. The grievance procedure is one form of power for the lower level workers to exercise when they feel unfairly treated.

understand and live the Toyota way and that was their primary focus in the early years at NUMMI. They knew they had a major task to take what was developed in Japan and socialize it into the culture.

General Motors' Motivation

For GM, the early eighties saw the production of some of the worst quality vehicles the corporation would ever produce. In addition, their cars took longer to build (in 1986 – only two years after NUMMI opened – labor hours per vehicle in NUMMI were found in an independent study of plant efficiency to be 20.8, in what used to be a comparable GM plant (at Framingham, MA) 43.1 hours of production would be required. These numbers should have suggested something, yet high-ranking manufacturing people in GM still argued they had nothing to learn from Toyota. Interviewees in a study on knowledge transfer in international joint ventures that featured GM and Toyota at NUMMI indicated a strong aversion on the part of GM managers to collaboration with a Japanese company. The GM managers claimed to have had "confidence in their own capabilities" (Inkpen 2008).

Smith started the JV with Toyota at a time when GM's market share in NA was 44% and world-wide employment was just under one million people (General Motors 1985). GM had made an astounding $3.5 billion profit the year before. On the surface, things looked pretty good at GM. Smith had big ideas; the task environment of GM in the mid eighties was dominated by a philosophy of his making; namely, technology was the way to solve all problems. Smith's pervasive outlook seemed to see everything from poor product quality to awkward labor relations as solvable by finding the right machine or robot to do the work[25]. A JV with Toyota seemed an odd fit.

Still, Smith was said to be interested in learning “Toyota’s cost structure and how they managed its plants” (Keller 1989), and so GM sent an initial sixteen managers (ironically called advisors) to participate in the day-to-day management of the plant beginning in 1984. Learning in a broad sense was not a primary GM goal, and there was no general agreement within the organization as to the need to learn from Toyota (Weiss 1997). The advisors were there to learn about building small cars and observe the manufacturing system.

A Gradual Realization

In the early years, the GM people assigned to NUMMI were on two-to-three year assignments. They were there to learn and observe, and according to Miguel, one of the managers in the first cohort, “GM did not enter into the arrangement thinking they were interested in the Toyota Production System.” As indicated before, he and his compatriots were there to learn, but not about something as mundane and basic as the production system. Even as the GM advisors to NUMMI “discovered they were doing things on the shop floor with their manufacturing system many of us felt were things we could deploy in our own plants and improve efficiency,” the presentation of these concepts at the early home visits each manager made back to Detroit had little effect on the perspective of senior GM executives. One of the GM advisors in the first group of NUMMI graduates

[25] In 1981 GM started a JV with Fujitsu-Fanuc and became the largest manufacturer of robotic equipment in the world. Over the Smith reign, GM invested nearly $90 billion in “remaking itself.” One capital plan during that period was reported to be an amount equivalent to the book value of both Toyota and Nissan combined.

says about these early visits home: “we would talk about TPS and the linkages between the mission and strategies they employed in the total system and how it defined the culture of the organization to no avail.” Interest in structural cost advantage and occasionally quality remained the focus in Detroit.

The GM managers at the *gemba* in Fremont discovered what many senior managers thought was a simple exercise of observing and returning with the findings was far more complicated and far more interesting than the cost structure of an activity or accounting procedure for specific tools they were sent to learn about. GM discovered Toyota had a superior way of managing the manufacturing process; the advisors almost immediately saw methods being employed that changed the dynamic of the manufacturing environment. These “tools” soon became the objects of their interest.

<u>Timeline of GM’s learning from NUMMI</u>

In the early NUMMI years, the advisors were joined at Fremont by people from various plant locations for short visits. The tools of TPS could be seen around the plant and the impact easily identified. This was the first glimmer of an interest in learning something from Toyota. The tools were mimicked at GM facilities in the mid-western United States, but early results were disappointing. This did not stop practitioners or GM leaders as more GM/NUMMI advisors went through the system and returned to their GM homes. GM took 28 years, but on the brink of bankruptcy in 2009, knowledgeable observers and independent assessment indicate their manufacturing methods were approaching world class. If results are a measure of the methods, this supposition is supported by IQS data from J. D. Power (see figure 5-3). This figure shows two GM brands over a twenty year period. A premium brand is show initially above the industry average, but suffering in the early nineties and then recovering to be well above the industry average by the early part of the 21st century. The volume leader is shown to be below the average for most of the later part of the 20th century, recovering to be well above the industry average in the 21st century.

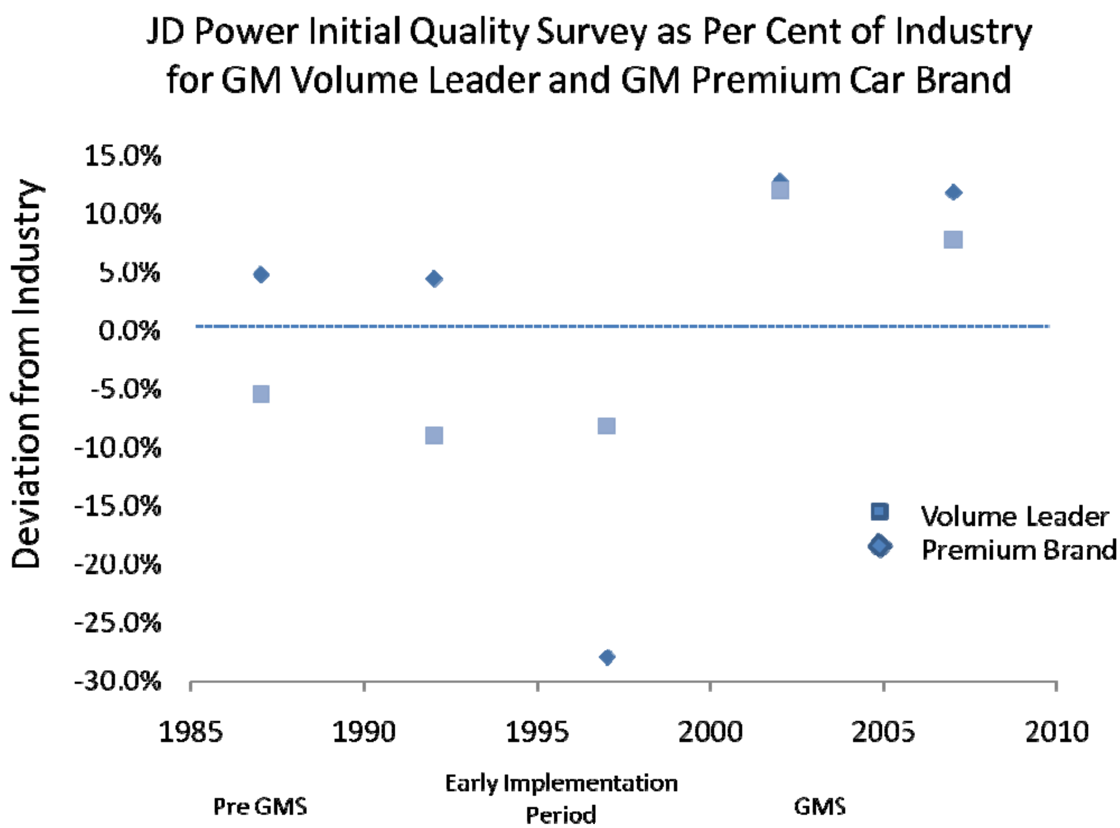

Figure 5-3 J.D. Power Intital Quality Survey as a Percent of Industry for a GM volume leader and a Premium Product

A general timeline for GM's TPS imitation activity is shown in Figure 5-4. Superimposed are key events that contributed to the various stages of lean development. The graphic is divided along the horizontal axis into activities that took place in NUMMI and activities taking place in Detroit. Importantly, the top portion of the graphic shows an increasing openness at NUMMI until the early part of the current century. The end of this period of openness ends with the TLO closing. The bottom elements reflect the increasing number of people returning to GM ending with the corporations filing for bankruptcy. Along with these key events that will be discussed in the case description section are the three major phases of lean implementation that took place at GM facilities. These phases are reviewed in the case description as critical periods on GM's learning path.

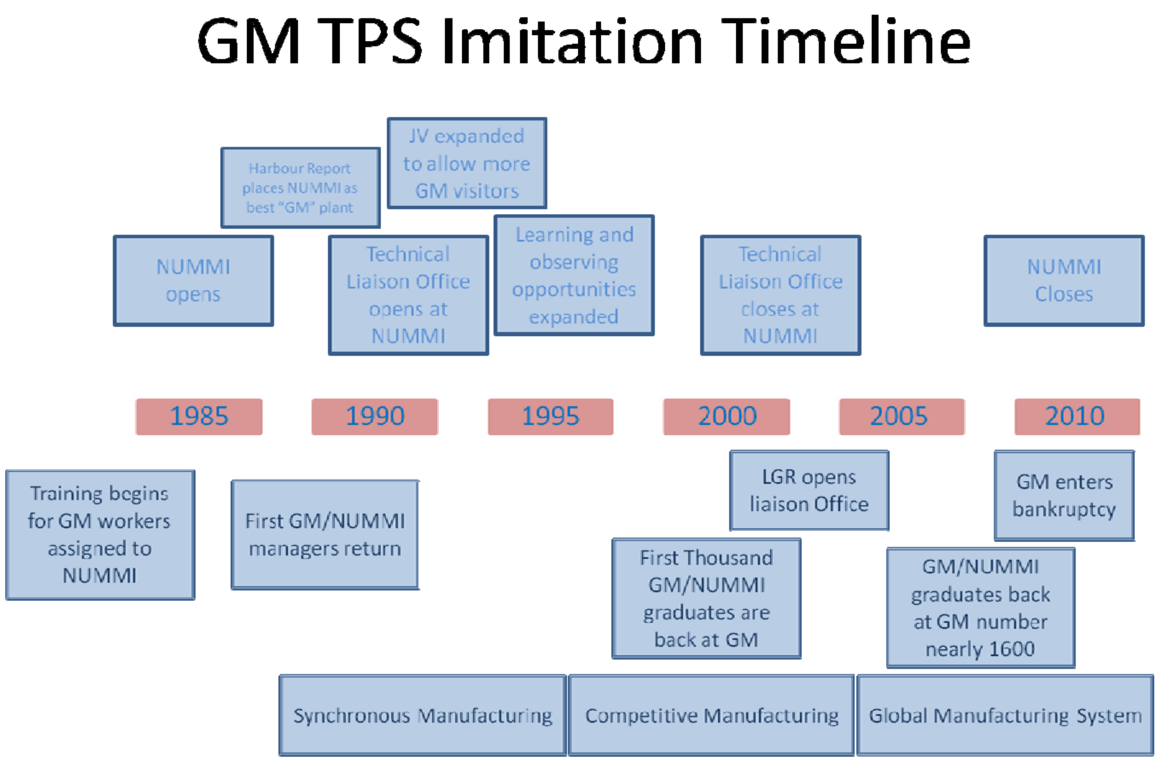

Figure 5-4 GM' GMS Imitation Timeline

Case Description

The case description will follow chronologically from a time prior to NUMMI starting production through three distinct phases of learning. The activities prior to NUMMI starting provide an interesting baseline for subsequent learning activities at GM. The case is broken down into three sub-cases; each a distinct attempt at establishing certain aspects of TPS within the GM manufacturing structure. The three phases of growth in GM's path to its Global Manufacturing System (GSM) provide examples of both advancement and declines in learning. First, what did the GM/NUMMI advisors experience when they arrived in California?

<u>How original "advisors" learned TPS at NUMMI</u>

The learning opportunities for the plant workers and the GM advisors at NUMMI were extensive, starting with trips to Japan for training and direct experience with TPS. "Every worker in a supervisory capacity, including hourly team leaders, visited Toyota City for two or more weeks of training at the Takaoka plant" (Shook 2010). GM managers that were to assume the role of GM/NUMMI advisors were sent to Japan for six weeks. The training included both classroom lectures and in-plant on the job training (OJT). Plant workers from NUMMI would work with a counterpart to learn not just elements of their jobs, but also important cultural aspects of the Toyota Production System. Shook summarizes the training as providing the correct action to facilitate the cultural change workers would be experiencing at NUMMI. Among the important shifts in thinking included a "Japanese" view of a problem. For the GM worker a problem is often seen as an opportunity to assign blame or demonstrate how smart they are; in the new environment of TPS, they began to see problems as the opportunity for further understanding and improvement.

The learning experience for the GM advisors was rigorous, particularly in contrast to the training they were used to receiving at General Motors. One informant to this study recalled no other time in his GM career where the emphasis on learning was so great. One senior manager from GM recalled the training as "starting with the fundamentals" and taking "baby steps to establish a common base-line," but it did not stop with the basics. Once the concepts were firmly established, a mindset that the principles of the Toyota Production System wouldn't be compromised in any way by anyone was engrained through mentoring and OJT.

The training each person received at Toyota City in Japan, the home of NUMMI's sister plant, was augmented at Fremont by a Toyota manager assigned to NUMMI as a partner to the GM manager, referred to as a "coordinator." Many of the Toyota managers were very senior executives from Japan. According to the GM operations director assigned to NUMMI in the late 80s, the executive coordinators would take teaching and coaching as an obligation of their position, teaching in the classroom and doing one-on-one coaching. From the "executive leadership all the way down to group leaders and team leaders they were not just leaders, but they were teachers" one informant reported.

Each GM advisor was assigned a coordinator who acted as a *sensei* (teacher), a personal mentor, and TPS coach. The role of the *sensei* was to develop the knowledge and ability of each GM manager. A typical approach would be to challenge the learner by providing a tough situation and then let the person struggle through the learning opportunity. The *sensei* would provide only basic guidance, withholding answers to specific questions from the learner who was seeking a quick solution. Other managers described an alternate approach a *sensei* might use. Occasionally a person would be given a TPS concept and asked to go out to apply it to a problem area; the solution would be discussed and reviewed with the sensei as the project advanced. Similarly, other senior GM managers described their training as relying heavily on going "to the source and see it yourself and internalize it." In general, the challenge would be based on the ability and inclination of the student. A senior GM manager at NUMMI as the GM operations' manager indicated the relationship between the Japanese coordinators and the American executives was essentially "collaboration and communication." He added, "they typically would not challenge a team member unless he or she showed some real promise and they wanted to grow them."

To most GM managers who went through the training the differences between GM and Toyota were stark. Again, the GM/NUMMI operations manager comments:

> Toyota was so well organized and process-driven and methodical and consistent in the way they executed processes. I think that probably was a big eye opener for all of us who weren't necessarily used to such rigorous and consistent processes.

This is different from the environment of GM, different in both philosophy and process. The plant systems in the GM manufacturing and assembly division were developed by one group still, differences between plants in processing methods and operating culture were prevalent. Toyota presented a very different competitor and an opportunity to learn and copy many good habits.

<u>Phase 1 of GM learning: Copying the tools of TPS through Synchronous Manufacturing</u>

After a deployment to Fremont the GM/NUMMI managers returned home excited about what they had been doing and the opportunity to affect change back in the GM system. One informant for this study, Miguel, upon returning to SE Michigan became one of four divisional leaders of the movement to integrate NUMMI learning into the GM manufacturing activity. Some years later, Miguel became the director of industrial engineering; from this position he was a key player in GM's early lean efforts. He comments about the early days and the reaction of his not yet indoctrinated co-workers:

> There were no welcoming parties when we came back, we discovered that we were trying to inject this new way of thinking onto the brains of the company and the immune system was reacting - the organization was not receptive.

Apparently some of the negative feelings were mutual, with many resenting the NUMMI graduates who were perceived as having a superiority complex. One director commenting on the returning GM/NUMMI managers said: "they all seemed so full of themselves, they knew everything and we knew nothing." Others referred to them as "NUMMI zealots" in part because they were so passionate about what they saw in TPS and their approach to sharing the information – according to an early student, at times it seemed a little like "proselytizing."

In the broader scope of things a strategy for repatriating the NUMMI returnees was not completely developed. Key senior managers (including Smith) were still the same as when the managers went to CA and in general, manufacturing leadership was still only partially sold on the idea GM could learn something from the Japanese. A few less senior executives did recognize the importance of NUMMI and worked to spread the knowledge. Some GM leaders thought the group should be kept together and sent to a plant were they might establish a copy of what they had experienced without negative influence from people that had not yet seen TPS at NUMMI. Others believed the greatest impact would be from spreading the returnees out within the divisions and sending them off to willing facilities to install some of the tools of TPS. In the end, they were split into four groups and sent out into the GM manufacturing wilderness.

There was some interest in what they had learned; early attention came from GM plants with enlightened managers and a least one key vice president of manufacturing. This VP wanted his plants to use more of the tools and encouraged his plant managers to call on Miguel for help. Some plant people had been to NUMMI on short visits and they saw some things they liked. Of course, what they saw were the physical pieces at a surface level, not the methodology and culture that keep the pieces working together. Being invited to the plants was an opportunity for the GM/NUMMI graduates to demonstrate some of the "magic of TPS." The first group of GM/NUMMI returnees did so under the umbrella of an activity referred to at GM as Synchronous Manufacturing.

Goals of Synchronous Manufacturing

As GM's first venture into implementing a lean approach to manufacturing the goals of Synchronous were modest. The former NUMMI advisors developed some TPS basics training, based on simulations and hands-on activities, and set out to establish demonstration projects at places that were either openly eager to try out the new concepts or were directed to do so. The first training sessions stressed waste reduction and teamwork. As opportunities in the plants expanded they would install some of the tools of TPS around a general theme of "optimizing the actions of the operator." Miguel says "we focused on driving our waste by taking walking out, taking waiting out, and taking the non-value out wherever we could." Supporting the operator was a theme few could argue with – gurus from Deming (1986) to Juran (1988) had been preaching to the big three for years about the operator being the only one really adding value to the production process.

The theme of supporting the operator by eliminating non-value added work drove Miguel and his team to install pull systems and other JIT material handling concepts from NUMMI that resulted in significantly less walk time and less confusion by reducing parts complexity. Visits to these model installations by plant managers from other plants in the executive's control were arranged to generate interest and enthusiasm.

What Really Happened with SM?

The GM/NUMMI managers initially used what they called a "discovery technique based on the Socratic approach" to work with their plant customers. They piloted the approach in workshops at the plants where people had requested their help. According to Miguel, in the early training they tried to incorporate a team environment into everything. People were put in teams and exercises were set-up using 5S and visual management tools to make all of aspects of the process as visible as possible. The classroom would be set up to demonstrate the concepts, for example the material would always be neatly arranged, equipment positions marked so as to indicate when one was not available, and reorder marks prevalent on containers. Along with the continuous demonstration of the concepts, the GM/NUMMI managers acted as mentors and coaches to provide guidance and wisdom to the new learners as they went into the plant to identify waste and other opportunities.

Leadership for the incorporation of TPS concepts into GM at this time was from the single enthusiastic group vice president. At this time, GM was divided into three groups, Chevrolet-Pontiac-Canada, Buick-Oldsmobile-Cadillac and Truck and Bus. To have one VP from one of the groups as your champion fell short of the high-level leadership commitment most believe is needed to drive deep cultural change. Additionally, this man had only been to NUMMI as a visitor. Since he had not gone through the indoctrination Miguel and his counterparts had gone through his understanding of TPS could be at best described as elementary. Yet this VP did recognize the need to develop the capability of GM's manufacturing facilities in a way that was different from the current approach. This man was able to use his reach to influence plants and the senior managers in his manufacturing plants to start pilot projects in the facilities and "try out the tools." Additionally, through his leadership the GM/NUMMI people continued to get exposure in high-level meetings. Miguel and his counterparts gave regular updates and the VP used these opportunities to "drum up" more work for the lean team. By Miguel's admission, they were only "causing an awakening." He said "there was a bit of a sense of urgency, but no real focus."

Synchronous Manufacturing implementation in the plants initially meant better utilization of line-side space. For example, prior to the use of a pull system for parts in a trim area of the plant operator installing a set of door trim might have had to walk fifty to sixty yards up and down the line to find and retrieve the required part. Another example, from a plant in SE Michigan supported by Laurence, an early convert who had not been to NUMMI as an advisor, talked about a chassis area installing struts. Initially the operator installing this part would read a manifest on the front of a vehicle to identify the specified strut. The operator would then walk down the side of the line through the line-side inventory stacked eight to twelve feet high (on each side) until he found the required part. Having found the part, he would then return to the (moving) vehicle, install the part and then look to see what strut was required on the next vehicle. The total travel time for a "find and install" cycle could be as far as sixty yards. This writer had witnessed operators in other areas dangerously crawling across skids full of parts hurrying to get back to a vehicle before it left the install area. In each case, the next vehicle was always only a few seconds away, presumably the operator installed the given part hoping the one required for the next vehicle was easier to find.

According to Miguel, when his team came to a place like this with the opportunity to improve they would begin with a workshop to help the local managers recognize the waste. A thorough assessment of the non-value added/value-added activity would often be done in conjunction with a rebalancing of work in the area. Frequently, as with the aforementioned area, parts would be removed from line-side and placed in a “shopping center” in the middle of the plant. For certain types of parts that were bulky with limited variation a pull system involving a light board (called “call parts” at NUMMI) would be established for the delivery of only the parts needed for vehicles in the next two to four hours (depending on the space available). After the lean team had worked over an area like this, the line-side part storage was reduced, finding the required part easier, the operators’ walk time was shorter and the risk of installing the wrong part almost eliminated. Many positive very visible effects could come from something as simple as proper part distribution in the plant. In fact, it was often the case that once it was demonstrated that significant waste could be removed methods like standardized work could be adopted. Again according to Miguel, as one “piece fell into place you could just see the other pieces falling into place and it would just flourish from there.”

When the GM/NUMMI people would move on to a new plant and new projects they would leave behind a small group of rookies with some training in the basics. The expectation was that these people would provide coaching in the plant for additional projects. In reality, in the Dreyfus model, these people would be in the first stage just barely able to emulate the steps as a novice and with no real reference to fall back on to help them remember why certain things were important. They would try their best, but were helpless against a more senior person in the plant who at the first sign of a problem would abandon the new system for the old ways (after all – that is what got the manager to his current position and his bonus was likely at stake). When the GM/NUMMI consultants returned they would find the gains they had worked hard to achieve were not sustained. If, for example, a part would not be there when required by the operator and the line stopped, the area manager would insist on more inventory at line side. Eventually, what was a compact footprint for installing some parts grew nearly to its original pre-workshop size.

At the time there were less than 30 GM/NUMMI graduates. Some got disillusioned by all the conflict and either left or would not fight hard for their beliefs. Some of those had not been serious students when they were at NUMMI and seemed to prefer to sit on the sidelines. At Toyota TPS is a career long journey. Plant managers, directors and vice presidents all have mentors continuously. Yet, the GM/NUMMI grads, while knowing so much more about the tools and system than their GM contemporaries, were really TPS neophytes. It is hard to believe that after only three years of OJT (along with the other job related duties of an area manager in an assembly plant) each had really attained a personal mastery of the concepts.

At this point, Miguel and other members of GM/NUMMI cohort had a solid understanding of the rules of SM, recognized variation existed and needed to be managed, and even appreciated the role of a greater learning community in making results occur. In some circumstances they may have been adequate coaches to complete novices. In fact, after the GM/NUMMI coaches left the original plants they worked in to implement SM, few projects survived.

Eventually, plant managers started to say: “we don’t need that training, we tried (this tool) and it doesn’t work.” The complaint was to some extent understandable. They had indeed “done the training” – GM had seen Deming seminars by the hundreds and various quality-of-work-life initiatives had come and gone. What was missing from those programs was a philosophy that facilitated making the whole process work. In general, the plants were an inconsistent environment in which it was easy to make mistakes, too difficult to identify how or they were made, and impossible to notify a supervisor or team leader in time for them to do something about the immediate problem.

The issues being surfaced were not just technical problems that could be fixed with more training or better tools; there were also significant social issues, many that were a result of the relationship between management and the union. Again a long standing us versus them relationship was an inhibitor to the trust required to truly integrate TPS into the GM system. Working in the plant, Miguel and his fellow “NUMMI zealots” would run headlong into this cultural legacy. Their attempt to implement the Technicolor[26] version of TPS into the black and white world of GM assembly and manufacturing was going to take a tremendous effort. For example, there were extensive job classifications and often a “lean solution” would require someone doing jobs that cut across classifications—a definite taboo in the labor-relations

[26] An analogy often shared with friends, Miguel would compare his early years back from NUMMI as someone who had been living in a black and while world being introduced to color and then coming back to his colleagues (still only able to see in B&W) and trying to explain it. (Yes, a variation of Plato’s Cave).

environment of the time. It was also common practice for union members to resist having any work elements added to their jobs, preventing rebalancing the line when waste was eliminated.

According to Miguel, the GM/NUMMI graduates recognized they were dealing with an entrenched culture and its associated behavior. What they encountered was a traditional manufacturing approach that saw the world as a set of interchangeable parts and tools – this mind-set would prove to be a barrier to an organizational understanding of how TPS worked as an integrated whole. The plants were at first willing to put the tools to work and for a while it seemed like some impact was being made. Reports to the VP and his staff routinely recognized plants that had made some improvement. What was recognized only later was that implementing the tools could not sustain the effort – the tools themselves did not cause other parts of the system to change.

Role of NUMMI during GM's Synchronous period

During this time-period GM's relationship with NUMMI continued to be positive. The NUMMI facility was a source of new knowledgeable managers and engineers as GM continued to send people to act as advisors. Additionally, as a means to influence key decision makers, senior executives were often escorted through the facility (frequently by Miguel) to show them how differently Toyota did things. It was during this period the JV was realigned; one result was the establishment of Technical Liaison Office (TLO) at NUMMI. This was an actual office several miles from NUMMI run by GM managers. The TLO was responsible for establishing some rigor in the plant visits and providing some training in basics as part of the tour. Seeing was believing and those who went out to NUMMI came back with a greater appreciation for TPS and started to think about how it might apply to their jobs.

Learning Results Achieved

After the first seven years of the JV some influential leaders at GM realized Toyota did have something to teach them. The managers that acted as NUMMI advisors came back to GM with their eyes wide open, having learned not only of the potential a system like TPS offered, but also about the competition. According to Miguel, as he and his colleagues continued to try and deploy the tools they continued to learn from missteps and mistakes. He says it was a discovery process. The learning during Synchronous Manufacturing from his perspective was a result of trial and error.

Most of the learning in this first phase was about the tools and how to teach them. Material was presented in a friendly and encouraging classroom environment that was not what the participants knew to be true outside the classroom. Team concepts and cooperation were key themes and made sense in the classroom, but were not openly demonstrated on the plant floor. The focus on the tools of TPS was so because that is what the plant people wanted.

Almost any plant could quickly see the value of some of the tools, but they also saw it was hard to sustain the use of the tools and the results. The advisors knew the system was an integrated set of tools, culture and philosophy. After being in Fremont and seeing what could be done with one of the most uncooperative union workforces they may have thought it would be easy in a less hostile environment with a cooperative workforce. They learned all three subcultures present in the plant needed to understand

and buy-in to any significant change. Synchronous manufacturing was a significant change and the critical mass of knowledgeable engineers and managers was not there. It was too easy for someone without a personal mastery of the basic tools and little knowledge of the philosophy to fall back to old habits and lose any gains made by the tools.

Even the learning that took place through the TLO was focused on the tools and how they might be taken back and introduced to another facility. The TLO white papers included ideas for specific processing techniques (like doors off processing) and just-in-time systems like kanban for replenishing parts distributed line side to the operator. Few of the white papers went beyond a basic understanding of the tools and they were only shallow representations of what could be done if more aspects of the system were understood and embraced.

Reflection on Synchronous Manufacturing

In the early to mid 90s the typical GM assembly plant might have sent a group to NUMMI, and almost always got excited about something they saw (likely something very visible like the tools of TPS evident on the NUMMI shop floor – Kanban, 5-S, the *andon* system or quality circles). Upon returning to their home plant they would have engaged Miguel (or one of his counterparts) for help with the tools. After some training the plant would attempt to imitate the elements of what they saw and were taught, to no avail. In a few months of the training the efforts would be either gone without a trace or bastardized to such an extent as to no longer be recognizable as a tool of TPS.

An example of the dramatic difference in operational approach between NUMMI and a GM facility is given by the observations of the GM/NUMMI operations manager.

> If you went to trim and final in a GM assembly plant and you were putting in some garnish molding in the vehicle, at GM, if there wasn't an exactly perfect fit, for whatever reason—maybe a fastener wasn't in place right or maybe for whatever reason, the trim on the garnish wasn't done well. More often than not, the operator—because they were instructed to do so at GM—would probably just kind of jam that piece in and the fit and the gaps might not be what the specification was and the thought was you'd either try to finesse it at the end of the line or let it through. At NUMMI, trim and final operators would see very clearly that if for some reason a piece of garnish molding didn't fit well, that operator or team member was obligated to pull the *andon* cord, stop the line and fix the problem so that they had a piece that was dimensionally correct and had the proper fit and finish.

The operational infrastructure at GM was not in place to support the *andon* system, so if one was implemented it would not have survived the first week of operation – the operators would have feared ramifications of stopping the line and whatever problems existed to cause the trim piece to fit poorly were never addressed. The various pieces the plants attempted to copy from NUMMI were merely the visible artifacts of the TPS culture. Within the coercive bureaucracy of a GM plant they were like museum pieces collected and displayed without an understanding of the true position they held in the operation. Like pieces in a museum without a knowledgeable curator, the true value in the context of the TPS culture was lost and the artifact eventually discarded. This was the situation in dozens of plants after the initial rounds of Synchronous Manufacturing training and implementation efforts. Many abandoned the TPS tools with a general feeling on the part of middle management was that they "tried that and it didn't work in our facility."

Another problem in the SM years, according to George a successful plant program manager, was GM would take respected individuals from a particular field of expertise, make them low-level managers and send them off to the plant – frequently uninvited and have them consult to the plant on Synchronous Manufacturing. He says, they were seen as "spies." An entire plant saw them as outsiders and people that didn't understand the plant operator or why it was there – to most of the plant people they knew this is where the company cash register rang – they made the money they didn't spend it like engineering or marketing. According to George, a plant manager would often hold the attitude that "nobody – particularly some peon from central office – was going to tell him how to improve his plant." Under the Synchronous Manufacturing model critical knowledge came from outside – plants had little ownership in SM and little incentive to disseminate the thinking and incorporate it into its organization's thinking.

Synchronous Manufacturing was a very mechanistic approach to implementing lean. Whether in the copying of an *andon* system, team leader structure, *kaizen* activity or some other artifact of NUMMI, plants saw in the tools a set of rational rules and a structure to process parts and information. Nothing was done to break down defensive relationships or to encourage the open sharing of information and trust; these are some of the things required of any of the aforementioned tools to operate effectively. These softer aspects of the processes were avoided in this first round of TPS copying at GM. Local plant leadership were the unilateral owners of the system and only saw winners and losers in the adoption of SM, they lost control and allowed someone else to win – to paraphrase a comment from George, that was something "no peon from central was going to do it to them." The Synchronous period lasted less than five years, it opened the eyes of many and showed GM that TPS could work, but the company needed focus.

Phase 2 of GM Learning: Implementing a Deeper Rule Book through Competitive Manufacturing

History of Competitive Manufacturing

As the shortcomings of the Synchronous Manufacturing approach to a lean manufacturing system were becoming obvious, some executives still recognizing the importance of TPS, asked for a master plan. The group VP that initially charged the first GM/NUMMI grads with the task of taking TPS to the plants (in what became Synchronous Manufacturing) now saw fragmented execution of a subset of the tools used at NUMMI being applied in an *ad hoc* manner. He may have also recognized his plant managers were not likely to give up control without an across the board approach to implementation that somehow included them. He turned to the most knowledgeable people in the corporation regarding TPS and asked them for a new approach.

The leaders from the initial group of GM/NUMMI advisers took on the challenge to reflect on their experiences and create a new approach. They saw, in retrospect, a process that needed more focus and clarity. They also recognized the limitations of having only a small group of experts and the limitation of spreading out the knowledge so thinly around the corporation. The new plan was to document an implementation process and implement a complete system in selected plants that would become models, called "vision" plants. All personnel at the plants would be trained and they would provide coaching and mentoring throughout the implementation and beyond.

The major difference in the approach taken at in the Competitive Manufacturing (CM) period as opposed to the prior Synchronous Manufacturing years was consistency. Miguel and his compatriots spent time reflecting on the successes each of them had had to create a flow of initiatives that was logical and achievable in any plant. The collaboration resulted in the publication of what is still now referred to with reverence as the "Green Book;" so named only because the first one had a green cover. For many, the Green Book became the bible of lean manufacturing at GM. Its publishing also influenced training and mentoring, as it provided a set of documented rules and procedures and the recognized the need for local expertise to sustain the process.

Even as the era of Competitive Manufacturing was coming to an end consistency across plants was still missing. Miguel says "that was a challenge; we had variation. We had people with different aptitudes and different capabilities." What went smoothly in one facility did not necessarily go smoothly in another. Personalities clashed and local leadership often exercised their power to make things go the way they wanted. In some cases, the decisions were based on long-held beliefs (superstitions in some cases) about the way things needed to be done. Despite the empirical evidence indicating CM was the right way to go, in some plants a manager would insist on doing something a particular way, likely because of a stinging memory of how not doing so resulted in a plant being shut down for several hours. One informant suggested each plant's unique culture created a problem with a common approach. He said: "in North America, each plant had its own pride and kind of *esprit de corps* and it was a little more difficult to implement something across the board." Still, the positive effects of CM were easily identified; tangible results that were not lost on senior managers outside the plant.

Goals of Competitive Manufacturing

One of the goals of Competitive Manufacturing was to provide a consistent plan for all plants to follow — a playbook that would detail initiatives complete with operational definitions universal to all manufacturing facilities. One of the arguments against SM was that things did not look the same from one plant to another: How could we know if we were a synchronous plant without a standard with which to compare.

One of the other complaints plants had about SM was that it did not come with instructions. Consequently, a goal of Competitive Manufacturing was to provide written documentation for plants to learn about the various lean processes and the relationship between them. In addition, they also wanted to be able to provide a fair and objective way of assessing themselves. Plants wanted to know how they were doing against expectations.

Plant managers also wanted some level of local control over the implementation process. Even if specific rules would be followed to achieve a particular standard, area managers and plant managers wanted to exercise some power over how the standard was achieved. For example, they might select one *andon* technical system over another, where both met the standards. In the early years some plants preferred what was referred to as a double pull *andon* over a single pull *andon* system. As the name suggests, a second pull of the *andon* would be required before the line actually stopped (as it was practiced at NUMMI).

What Really Happened with CM?

After several months of reflection and some serious debate the "Green Book" was published. Here was a document plain in appearance and austere in content and intent. Its official name was the "GM Competitive Manufacturing Planning Guide" (1992) and it contained some "high level stuff and operational definitions." In fact, it contained details on some fifty Competitive Manufacturing initiatives. For the first time at GM the various lean tools and the initiatives plants would be implementing were clearly defined and the relationships between them explained. Things like an *andon* system was defined with specific criteria so as to make it clear exactly what the plant would need to do to incorporate such a concept in the line and what supporting tools were required. More subtly, the Green Book helped to establish the linkage between the various tools and develop a picture of how the ideas worked together.

The Green Book was more than a set of definitions for new users. It provided the plants with its first view of the tools as a system. The detailed definitions were important for the novice, as they provided a clear outline for how things should look and operate after a lean intervention, but it was more. In providing the linkages between tools, managers and practitioners could use the Green Book to understand what things worked together and what would need to change in sequence if a successful competitive manufacturing change event were to unfold. This provided a view of the change process that was far more systemic than what was perceived of in the Synchronous Manufacturing period. Still, the level of knowledge presented in the Green Book was explicit and the deep understanding that some of the GM/NUMMI graduates were starting to acquire could not be outlined in a simple handout.

The Green Book was also used as criteria for the processes plants would need to put into practice as they started to implement lean. It was a teaching tool. As indicated, training for people in the plant working on the implementation process in the CM period was also different from the first five years of TPS copying. Miguel explains: “what we did do was start on the inside (with the operator) and optimize moving out.” Each plant had a set of key people assigned including some internal – from the plant – and at least one from Miguel's growing group of GM/NUMMI alumni. According to Miguel, the philosophy used was to get down to the fundamentals with each plant, but still provide depth from a key contact so at any plant they would be "several questions deep." That became a buzzword. A one-question deep person could answer a superficial question about the tool or method, but would stumble when a second follow-up question was asked about a subtle point or the reason for the method.

The Competitive Manufacturing people in each plant also had to train other people in their plants. So they needed to be knowledgeable not only in terms of the CM concepts, but they also had to have the ability to train and mentor others often answering challenging questions. These people assigned to CM in the plants had a hands-on approach with the tools and with people both above and below them in rank. One of their responsibilities was to alert the managers in the plants when they were leaving the path.

To develop the people that would ultimately become part of the plant organization Miguel and his group took an approach that was similar to their initial training at NUMMI. He explained: "First we had to immerse them in the Toyota Production System. One of the first things we did was to take them to NUMMI and used that facility as a laboratory." Similar to the approach the original GM group sent to NUMMI experienced the CM recruits would learn from working in the system and from the people who were actually assembling the products. In fact one of the programs they evolved had GM managers and workers doing a job at NUMMI or one or two days. They took a hands-on approach to training, but in a shift from SM they would focus more on standard work and problem solving. The people selected for the task had more of a focus on sequencing and logistics – there was a combination of industrial engineer, production worker and logistics thinking that the CM teams looked for.

From an organizational standpoint the person leading CM reported to the assistant plant manager, all the others worked for him (or her). Miguel reports there were usually four or five others, including UAW members, assigned to the Area Managers of the plant in Body, Paint, General Assembly and Trim. Additionally, the plant group would get visits from Miguel and his lieutenants; they would come to the plant and mentor them. At the local level, it would still be easy for a CM person assigned from a central function like Miguel's to either have no credibility or slowly fall into the plant's political structure and acquiesce to the plant manager's wishes (which of course may have been different from the objectives of CM). Even with a comprehensive playbook, the plant manager could still fall back to old habits – if the line stopped there was generally yelling, screaming and finger pointing. The writer visited several plants in this period and saw large repair areas with vehicles (many with the same problem) waiting for a fix to be placed before the vehicle would ship. Problem solving based on true root cause analysis was still rare; instead getting the line running (even if it meant filling a repair bay) was the most important thing to do. Few arguments were won by the low-level CM "expert" whose new system may have caused the throughput to fall. It took close personal attention on the part of a mentor to see to the development of the plant people. In addition, the plant people needed a strong commitment to stay true to the objectives and philosophy of CM.

As the CM teams went through areas in the plant it was obvious they "were compressing time and space. You could see areas where once conveyors used to be as long as a football field now took up 40 yards or so." They also became more technically sophisticated about the *andon* system realizing they needed to separate segments of the assembly line with buffers so only part of the line would stop at a time giving some margin to fix the problem before the whole line stopped. Miguel goes on to say "we wound up shortening the space that was required and discovered that we needed to decouple conveyors so *andon* systems could function independently so we wouldn't hurt the plant throughput." Indeed, pieces were falling into place as more tools integrated into the plant operation.

Senior managers with an interest in the lean approach of TPS also developed a deeper understanding of its potential impact on efficiency as they saw inventories fall and plant space requirements reduced. This was in part because of changes at the top from leaders who had no really grasp or appreciation of TPS to leaders who embraced it. Roger Smith was replaced by Robert Stempel who still did not have a strong commitment to TPS, and who within a few years was replaced by Jack Smith as GM came close to bankruptcy.

Smith formed a management team that included several executives who had spent time at NUMMI. He had a strong interest in NUMMI. Smith was part of the negotiating committee that established the JV nearly ten years earlier (Inkpen 2008), made many visits to Fremont, and saw the potential of TPS. Smith was a leader with a clear vision, while also trusting the counsel of his senior staff; as a leader he both developed his subordinates and then trusted their opinion and abilities. To further deepen CM he placed several executives with strong NUMMI experience in positions to lead implementation. Among them, Mark Hogan was given the opportunity to lead GM *do*

Brazil in a Greenfield development of lean in South America. According to Hogan, the South American experiment with lean was a success in part because of its isolation from the bad habits of North America and an *esprit de corps* that he says was difficult to foster in North America. He says he was able to get the Brazilians to embrace new concepts and adopt them quickly through leadership, a good implementation process, and effective teaching and mentoring of the team members. Hogan explains if you take time to cover the basics you can transform an entire operation.

Competitive Manufacturing was very effective to a point; it took over where Synchronous Manufacturing failed and gave GM several working "laboratories" in which to teach and learn. According to Laurence, after personally spending several years working and developing lean as an area manager he saw CM was successful in that it was able to shed the aura held by Synchronous Manufacturing as a corporate program to be used to solve specific local problems. Competitive Manufacturing was a system that incorporated various tools in a total plant perspective. Yet Competitive Manufacturing still needed more leadership to overcome the powerful local plant managers and make this an organizational tool set with a purpose. Again, according to Laurence "NUMNI graduates kept coming, other plants kept doing things, it was as if a snowball had started to roll down a hill;" but, he goes on to say, what really changed things in the lean community at GM was a Jack Smith's directive – he wanted one manufacturing system and directed it be done in the next four plants being built. Laurence said that was a game changer – it was interpreted as the CEO being on-board with CM, but he wanted more.

Competitive manufacturing at GM took plant management away from a world of their total control toward an environment where process improvements became shared ventures. Still, by this point the main sharing of ideas was between senior leadership and middle management, with relatively little direct involvement of hourly workers. CM avoided some of the less tangible aspects of TPS instead focusing on providing a comprehensive set of tools that work together. It was a step forward from SM, but still a mechanistic view of the process. The strengths of CM were the public demonstrations of the new ideas in the model plants and a higher level of engagement of local leadership.

Role of NUMMI in this Phase

In the early years of Competitive Manufacturing, NUMMI continued to play a vital role in filling the pipeline with knowledgeable engineers and managers sent to Fremont as advisers or on training programs through the TLO. A growing number of GM/NUMMI grads became part of an Industrial Engineering group managed by Miguel. All of the GM/NUMMI grads had spent at least two years at NUMMI. In addition some plant people also spent time in Fremont, but usually for one or two weeks.

By this time the TLO at Fremont had developed a set of activities for various groups of people to indoctrinate them into the TPS way. Some people would only visit NUMMI for a couple of days; executives would come to see what was happening or what was new. Others would stay anywhere from a couple of weeks to a couple of months. And there were some on one-to-two year assignments. Each person would be given a set of learning objectives that fit the timeframe and their specific role at GM. The TLO played an important role in creating a plan and helping each person document their learning to share with their home plant and as a record of personal accomplishment. By the end of the Competitive Manufacturing period at GM an estimated 800 people had been through the TLO at NUMMI. This group became an essential part of the critical mass of TPS students needed to begin to sustain the activities at the plants that had been through a CM transformation.

Learning Results Achieved

Miguel sums up the developmental approach thusly: “between training at NUMMI and having would-be CM people work the line at one of the vision plants and having close encounters of the first kind learning was great, but the constant mentoring was very important.” A second informant, Laurence used similar language as he talked about the value of learning by doing. He said few things were as revealing for a learner as to go on the floor and make a change and watch how that affected various other initiatives.

Knowledgeable leadership outside the plant was just as vital as inside. The GM/NUMMI graduates knew this from the start, but may not have had access to the people at the highest level of the corporation before. Leaders like Rick Wagner (who was about to take over from Smith as CEO), and several other key executives, had excursions to NUMMI and to the Toyota facility in Kentucky. This raised the understanding of the senior leadership not only of the tools, but also how far ahead the competition was compared to GM. It was this group that was needed to continue to push plant managers toward a common approach and philosophy. That approach to lean at GM was about to have a new name: the Global Manufacturing System (GMS).

Phase 3 of GM Learning: Delving Deeper into Cultural Change

History of the Global Manufacturing System

While an edict from the CEO may be the spark that ignites action and gets a big new program going, in the case of GMS the transition was not abrupt. In fact, to many in the enterprise the change from Competitive Manufacturing was subtle and went largely unnoticed. GMS used the core process that was put in place with Competitive Manufacturing, but a corporate focus on globalization was the key driver to change the lean implementation approach. CM focused on the few pilot plants; GMS changed that and focus to all plants worldwide in the GM system.

There were also changes in approach; the most obvious was in the level and intensity of the initial training given a plant and the commitment to the process from leaders. Global Manufacturing System training was more comprehensive and involved everyone at the facility. Executive staff and shop union executive lead the training and participated fully in the delivery. George, a man who acquired his lean knowledge as part of Miguel's early team and then working in manufacturing leadership roles at various facilities, indicated the leaders he worked with took the job very seriously. In keeping with the learning at CM facilities, a structured approach to the technical aspects of a lean plant system was closely followed under GMS. The "Green Book" was still followed. There was also a people side that involved teaching and coaching that according to George was in some ways similar to what might have been seen at a Toyota facility. While it may be that at NUMMI and other Toyota facilities the learning would be mostly hands-on, learning by doing with a coach, this was not the GM way. However, what made it like Toyota was the commitment from GM leaders to have a deep understanding and share their knowledge through teaching and coaching subordinates.

Competitive Manufacturing and the “Green Book” explained what a plant should look like if it was lean. Lacking for many people, including those in the middle and the top of the plant structure was a deeper understanding of the reasoning behind the concepts. According to George, it was as if we were just going to the book and copying the elements. He says, many plants were very good at it and could adapt the layout for local conditions, but a real depth of understanding was missing. CM had established the foundation and the core leadership pushed the implementation to a point, but GMS started to fill in the blanks and help explain why things were being done a particular way. On the same theme Miguel adds, “we may have played it wrong at the beginning, but GMS expanded out beyond the plant into manufacturing engineering, the supplier base and for the first time into the language of the UAW contract.” This was the first version that was a joint action between management and the union.

Goals of GMS strategy

The goals of GMS were modest - build on the successes of Competitive Manufacturing and take the process global and make them common across all plants in the corporation. Competitive Manufacturing had brought a degree of consistency to the implementation process, but some variation in approach still existed. Additionally, at this time, GM and other large corporations were thinking globally. GM did have manufacturing facilities in some 114 countries at the time, but did not behave like one globally integrated company. It was as if there were four GM’s operating in four different regions of the world, each would have its own product plan, new product development system, manufacturing system and marketing schemes. At least in manufacturing, GMS offered the opportunity to have a common approach to making parts and vehicles.

What Really Happened with GMS?

The Global Manufacturing System was the way manufacturing was to be done at GM from the early part of the 21st century. To see how GMS happened at GM an example plant is explored, through this example the role of training, plant leadership and support can be seen. A plant in Lansing, Michigan was a brand new plant and became a model for GM, but the vision was for any GM plant to operate in a similar manner. The plant, Delta, was a Greenfield facility with a Brownfield workforce. George, a career lean trainer and coach now in a key staff position at the plant, had the opportunity to select almost his entire staff (a task shared by him and the plant manager (PM)). Along with the PM he selected a group of very knowledgeable people that been through CM and early GMS and knew, in his words, this was the way to do manufacturing. The hourly workforce was made up of UAW people from the area – they came from the jobs bank[27] or people bumped from their position in another local plant. George indicated selection here was not an option (similar to NUMMI), but the UAW represented workers in the Lansing area were some of the best hourly people in the GM system (not the case at NUMMI). Few of the labor problems that existed at other plants were found in Lansing. This would seem to be a major workforce advantage as compared to Fremont and by this

[27] The Jobs Bank was a contractual arrangement from a GM/UAW agreement of the mid nineties. It placed people whose jobs had been eliminated on a list. The list was the first source a plant would use to fill a required job. (It also guaranteed two thirds of a union worker's take home pay and benefits while waiting in the bank for a nominal commitment to the program).

time a more cooperative relationship existed between GM and the UAW. Better labor relations had been a priority of Wagner. Concessions and conciliatory comments from both sides coupled with new economic realities changed the labor landscape for GM and may have facilitated more cooperation by the hourly ranks even in productivity improvement.

George says he participated as an instructor in hundreds of hours in training that was part of every employee's introduction to the facility (it was brand new). They started with forty hours of training on GMS; the introduction was facilitated by members of the plant executive staff and the union shop committee. The material was divided between classroom and hands-on work in a simulation area. It was more than the nuts and bolts of GMS, George also took this as an opportunity to as he says, "look every new employee in the eye and tell them this is how we are going to run the plant." On top of the GMS overview each line worker would get an additional 100 hours of training, and a team leader 160 hours on topics like team building, conflict resolution, standardized work, moving line scrolling and other detailed GMS training. This training also included classroom lectures as well as role-plays, simulations and some OJT with coaching. Once the plant was up and running training continued through activities like a layered audit process.

George and Laurence spoke of the layered audit process at GM facilities as an active learning opportunity whereby a Deming-like "Check" (or study) event is invoked.

According to George, layered audit[28] is one way to help prevent the GMS plant them from slipping back into the old GM manufacturing habits of counting defects and assigning blame. It involves line mangers and plant staff engaging at the operator level to understand that proper attention was being paid to the way work was being done on the floor. As an example, torque on certain fasteners is attained with a calibrated tool. A first-level check is part of the standard operating procedure for an operator and is generally designed to prevent problems from leaving a station. The team leader will check on the operation using a systematic sampling plan that captures data for process capability. The group leader will follow-up with one of his team leaders and the area manager will likewise perform a "layered" check involving various tasks in his sphere of control. If at any point along the way a deviation from either process limits or standardized work will result in a study that involves reflection on the process, the operator's performance and the team leader's support. An important aspect of the audit according to George was the ongoing opportunity to have a dialog with every member of the organization – from top to bottom. For him it was a way to provide redirection and improvement ideas and to keep knowledge of the process growing and leadership commitment front and center. It was a visible commitment. George's model was:

> You must be true to what you taught and the layered audit was the way this became obvious. If we did not walk the talk someone would call us out. The learning and coaching that needs to take place cannot stop when the traditional training ends.

[28] It is perhaps cases like this that made Deming want to rename "check" to "study." This throwback label – an audit – invokes the sort of thinking that Deming wanted all to avoid. This is a chance for those involved in the process from the line worker to the plant executive to study a specific situation and work together on a solution to any problem.

Of course, Synchronous Manufacturing, Competitive Manufacturing and now the Global Manufacturing System all had the same expectation of the managers driving the system. But with GMS there was a deeper understanding of the system and management's role. This deeper understanding manifests itself as a shift toward a less coercive management style. Managers were less interested in meeting the daily numbers and more interested in making the system work through an understanding of how problems occurred and what was needed to prevent similar problems in the future.

Learning opportunities exist in a GMS plant for everyone – not in a traditional sense. George says, "sometimes for some people in the plant it is hard to think of learning as something that can occur outside of the classroom. Learning comes down to: did you do something differently today because you were challenged to think differently by what you saw or heard." At George's facility this was part of sustaining the process.

Once the tools of lean were in place and initial training concluded the effort to sustain the progress was achieved through the entire team's effort to accept the challenge of seeing something different. For George, a man whose career was almost entirely spent in some form of lean activity at the plant, the way to understand the opportunity is through PDCA. George indicated he was involved with key initiative in the early years of GMS without the check piece of PDCA. He now sees this reflection as a necessary requirement. Layered audits were not limited to production processes. Other detailed reviews of operational procedures like quality systems, work place organization and material systems also took place. At a staff level the process would be reviewed for adherence to standardized work, not just at the operator level, but through the entire process up through the hierarchy looking for opportunities to provide additional support to an operation.

Another example of how GMS was engrained into the staff's approach to operating was provided through an activity at joint management staff and union shop committee meetings. At such a meeting George says they would break into pairs and do a deep dive into a team leader's area to verify work is being done as prescribed. These session involved reflection on the positives and at least one "problem." Of course, this was a departure from the traditional approach of the manager to hide problems from their superiors and to not lose face with the union by bringing up what might be considered a shortcoming. Such joint activities were unthinkable in the eighties and nineties where both management and the union kept information secret until they could use it to exploit an advantage in bargaining with the other.

Success at GMS plants like Delta was not a constant upward path George confesses. Sustainability is the hardest part according to him.[29] The real energy to counter natural degradation of the system, according to George, was in continually working on checking and corrective action. George says: "it is easy to fall back into counting defects and assigning blame and doing some yelling and screaming. The effort to sustain is incredible and easily equal to any initial investment in training." Among

[29] During our interview George drew a graphic with effort on the vertical axis and implementation activities on the horizontal. He explained many people used to think the energy needed to be high early as initial training and tools were brought to a new work area. He contends the energy needed to be as high or higher in what he referred to as the sustainability phase. Without high levels of energy during the ongoing business phase it would be too easy to fall back into easier Type A patterns of doing business.

other things he says, this provided the “check” piece of the PDCA cycle so often missing, according to him without the check, it is too easy to lose focus on the process.

A manufacturing engineer also volunteered that the layered audit was critical to sustaining GMS. Her reaction was almost one of shock when asked how the layered audit affected her job. To her it seemed so natural as to wonder why I would not understand. She used an example of designing a new machine, indicating the operator must be considered in the design, when doing so, the standardized work is also considered and that will be part of an audit. She offered the following details:

> A system to integrate the cells of the battery for a new hybrid will consider operator’s safety of course, as well as ergonomic issues that will cause rapid tiring (such as long reaching or frequent bending motions), but more importantly what are the necessary steps a person must take to ensure the machine is going to continue to produce a part with a certain key characteristic, like the gap between plates. If something does go wrong how will the system show it? How will the operator react and is there a chance for improvement? I know this will become part of the layered audit.

In the case of a new machine like this, the manufacturing engineer is expected to participate in an early design review with the plant and engage in what might be considered a mock-layered audit. This is one of many a dry runs to see if anything is missing before the machine is turned over to the plant and the operators.

The strategies employed in the layered audit reflect a change toward a system that works hard to reveal problems. Open channels of communication characterize the relationships between the operator, team-leader, and higher levels of plant management particularly as related to data from the process. Control over the process is governed by strict standardized work, but reflection is part of the layered audit “check” activity and works to open the process to change based on information from the floor. While it may not always be taken, at least there is an opportunity with the layered audit to question the assumptions and the targets themselves – in short, there can be a movement toward double loop learning and a more open sharing of information. We should note that the open sharing of information does not just happen with the layered audit. In fact, without an atmosphere of trust, a fundamental cultural change for GM, the layered audit becomes a control mechanism to place blame and punish.

One key measure was introduced that reflects a philosophical change in the view of plant efficiency — the plant run rate — a standard measure at all Toyota plants. It measures the percent of cars that are built on schedule right the first time, without deviation into repair bays. Thus it is an assessment of the first-time quality as well as the throughput of the facility. A plants run rate would measure how well a facility achieves in-station quality through the facility. This change from a focus on cost and simply producing quantities of vehicles to instead assess the ability of the process to deliver good product on a consistent basis is an important shift toward putting the customer first.

Recent changes at the facility that George had originally opened would indicate some of the gains may be slipping away. George left GM in 2008 and shortly thereafter the plant manager was also replaced. What happened next was, to George, an indication of the importance of key leaders maintaining the focus on GMS and how hard it is to sustain the early gains of lean tool implementation. A GMS knowledgeable operations manager replaced George; the new plant manager did not share the level of understanding of GMS held by the previous manager. After nearly 25 years of implementing a lean manufacturing approach, George felt if one or two key people leave it is very likely the replacement will not have the depth of knowledge of GMS their counterparts had. He indicated the “deep and wide” understanding of the competition when it comes to lean is not present in GM. The implication of the shallow pool of knowledge showed after he left Delta. With some new members joining the staff it was apparent to him a significant loss of momentum was being felt. He had already heard stories of people being allowed to fall back to old habits – the daily production count was now very important. He remained optimistic this was a temporary setback during the rebuilding of GM. Eventually the critical mass that seems to be in place will draw the enterprise back on course; pockets of old-school thinking would dissolve.

As a validation of how well GMS was working in this timeframe, data from the Delta plant reveals the plant initial quality and manufacturing measures were near world class. Delta was a Greenfield facility with a new product. Historically, this combination would have been problematic for GM. In the late nineties even established plants launching a new product would take months to achieve acceptable quality levels, usually at the expense of additional workers on the line and engineering attention on the process taking the bugs out. Delta was producing at near benchmark levels. At the same time internal assessments indicate Delta to be within 11% of the benchmark hours per vehicle in the first year of operation, which placed them in the top five plants in the vehicle category. This metric improved over the next two years to be within 7% of the world class facility, now in the top three. The program team’s initial target was to be world class, but the fact that continual improvement brought them closer to the (moving) target is evidence GMS was being used as a process improvement methodology, not just a set of tools. Initially quality data supplied by GM also indicates a gradual improvement over the same time period. IQS data shows the program team did not achieve their initial goal of best in class, but, a gradual improvement over three years is observed. Figure 5-5 provides a summary of the product quality and manufacturing efficiency. As indicated earlier, the initial quality assessment of the Delta product is an internal plant assessment, the benchmark is from J.D. Power for the best in class for the comparable vehicle. The hours per vehicle assessment is also internally calculated, in this case by manufacturing engineering and compared to Harbor Report values for similar product (with estimates of most recent competitor values).

Initial Quality and Manufacturing Efficiency Metrics for Delta

	IQS – Problems/100 Vehicles		Hours per Vehicle	
	Delta O+A	Benchmark	Delta	Benchmark
2007	132	123	25.06*	22.58
2008	123.5	120	23.60*	21.99
2009	118.5	118	22.41*	21.75*

* internal estimates

Figure 5-5 Initial Quality and Manufacturing Efficiency Metrics for Delta Products and Plant

Role of NUMMI in this Phase

NUMMI's role diminished somewhat in the GMS period. The TLO closed in 2004 and a support office like the NUMMI TLO opened in a GMS vision plant in Lansing called LGR. GM wanted one of their own plants as a learning laboratory, and one located in the Midwest to reduce travel costs. Seen as the GM plant closest to the model provided by NUMMI at the time, LGR was an incubator for lean thinking. Still, NUMMI had been host to 1600 GM managers and engineers and had played an important role in developing a critical mass of people that understood the basics of TPS.

Significant learning and awareness of TPS was the trademark of the NUMMI TLO until it closed.

Learning Results Achieved

Approximately 15 years after the JV started as many as 1,600 GM people had spent time at NUMMI. Many returned to GM and became area managers, assistant plant managers, plant managers and even key executive positions in the central bureaucracy of GM. A few were lured away to work for other firms trying to become lean, while some even went to Toyota. This would seem to indicate a degree of success in acquiring the necessary knowledge and skills to implement a lean operation. George sees a dark shadow in this story of success: GM’s base of understanding could not compare to that of a company living the lean philosophy for 50 years. He recognized the understanding of TPS at Toyota was deep and wide at the highest levels of the company. At GM, if one person retired or moved to another company, the loss was significant.

Training offered to the people in the plants was extensive and all indications are that it was thorough and meaningful. As a by-product of the training the instructors (many senior and middle managers) had the benefit of acquiring a significant base of understanding. The leaders also served in the capacity of mentor, but it seemed from the informants most of the mentoring and coaching was between managers. Little TPS coaching seemed to take place between group leaders and line workers. They may have had the support of the managers, but it is not clear if any additional learning by the team members was encouraged.

GMS training became part of the basic skills of a new engineer. The training may have been less meaningful without activities like layered audit or regular plant contact. The layered audit provided an opportunity to enhance learning, at least in the engineering and management ranks. It also served to provide a link between the early manufacturing engineering work and the plant production floor. Engineers, not located in the plant, recognized the linkage between their action and the work of the plant. Their work had been incorporated into GMS.

Chapter Discussion: Support and contradictions to the learning hypothesis

When the cases were place in context of the learning models three hypothesis from Chapter Two were considered. Specifically, 1) learning starts as a mechanistic set of activities focusing on the individual; 2) movement along the axis is facilitated by mentors or coaches with personal mastery of the concepts; and, 3) many individuals with common mental models and shared long-term goals will be able to exchange and codify tacit knowledge that will enable organizational learning and adaptation to move toward the upper right hand quadrant of the learning plane. The three will now be considered in view of the data provided by the case.

There are several indications that learning did indeed start as an individual activity focusing on the mechanistic aspects of the process. Even the early training in Japan and at NUMMI for the new American workforce focused initially on the tools. Evidence from the first phase of the imitation activity (Synchronous Manufacturing) also indicates learning activities focused on individuals gaining skill in a basic set of tools; however, there is some indication the essential elements of the lessons did not stick with the learners. In essence, the learners did not advance beyond the novice level. This may be an indication that there was not sufficient ongoing support for individual/rote learning to take root as learned patterns of behavior or there were insufficient repetitions of the basics to encourage the deep connection to the rules. In each of the other phases this hypothesis is supported as basic training did begin with the tools and learners could be seen to progress to possess the skills of a novice and in some cases over time they progressed to have a personal mastery of the material. There may also be an indication of the importance of coaching and mentoring as hypothesis 3 suggests an individual cannot progress to be part of an organizational learning activity without sufficient coaching.

The second two phases combined with the first allows a Mill's (1843) method of difference[30] approach to confirm mentoring does indeed have a positive effect. As mentoring was not an important component of the first phase, but was in the second two and learning and (some) advancement along the axis of the learning model did take place this provides evidence that mentoring was important. This is further supported when the case details are interrogated and we see the NUMMI *sensei* working with advisors and the advisors using similar tactics with senior managers. In each case, learning was advanced and enhanced to incorporate the ability to work together in a double-loop learning manner to reflect on and solve complex problems involving many people.

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[30] The method of difference is one of five methods of inductive reasoning proposed by J.S. Mill in 1843. Specifically if an instance of a phenomenon occurs and an instance in which it does not occur have circumstances in common and one not the circumstance by which they differ can be considered the effect, the cause or an indispensable part of the cause of the phenomenon. For example, if

A B C D occur together with w x y z, and

B C D occur together with x y z. Then A is the cause, or the effect, or a part of the cause of w.

The third hypothesis suggested tacit TPS rules and knowledge would over time become codified. The data is not clear on this situation. The green book was codified knowledge that was critical in the CM phase, but it was mainly focused on the basic tools and infrastructure. The GMS took some of the learning and codified it further, but even in this case it may be an over estimation to suggest any adaptive learning was taking place.

CONCLUSIONS: IMITATING A COMPLEX SOCIOTECHNICAL SYSTEM IS HARD

Initial quality data from J. D. Power support the claim that GM was on a path to significantly improved product and manufacturing systems. Comparing average rankings for major Brands over four periods as shown in Figure 5-6 indicates an improvement trend[31]. This table shows a trend and a statistically significant difference between the early years and the Competitive Manufacturing and GMS periods.

Average Rank on J. D. Power IQS
GM Major Brands
(by lean epoch)

Pre NUMMI	Synchronous Manufacturing	Competitive Manufacturing	Global Manufacturing System
15.5	15.1	13.7	9.6

Figure 5-6 J.D. Power Initial Quality Survey averageBrand rank for the time before NUMMI's inflence and the three lean learning periods after.

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[31] J.D. Power assesses initial product quality and reports the problems per one hundred (PPH) vehicles and a brand ranking. Over the period from 1987 to 2006 J. D. Power changed the questions related to the PPH part of the survey. This would make comparing PPH from one lean epoch to the next difficult. Comparing Brand ranking does not introduce the same issues and is a better way to use this independent assessment of product quality.

Why did it take General Motors 25 years and why are there still setbacks? In the early years of the NUMMI JV few leaders grasped the true opportunity a partnership with Toyota provided. The early years of the partnership were financially profitable years for GM and the leaders of the time had a vision of factories without people – automation as the salvation of manufacturing. Years of wasted investment on plant systems like automated door processing lines, Automatic Storage and Retrieval Systems and countless other robotic processes that just didn't work put the more basic approach of TPS on the back burner. TPS seemed too low tech for the leaders at the time and poor relations with the union made something like TPS seem unattainable. Additionally, in the early years there were few people who really understood the total system. These few people confronted the gigantic task of changing a manufacturing empire that even when counting only the NA facilities numbered in the dozens with hundreds of thousands of employees. This is the definition of a large and complex organization and its key players were not open to change from "outsiders." Even when true leadership emerged baby steps were required and constant proof and reproof was the only way to keep the process moving forward—at least until a critical mass of people who understood the basics were in place. Direct experience at NUMMI helped provide that critical mass.

Many factors outside the parameters of the learning model discussed in this paper have contributed to problems in effective implementation. At various times during the Competitive Manufacturing and the GMS phases of development, GM offered attractive buyouts to senior managers. Many of the managers that had been to NUMMI in the early years were offered and accepted the packages. This "brain drain" occurred at a point when these managers had truly achieved personal mastery of TPS. Some were the brightest and most committed lean people in the firm. This was occurring just as the all important critical mass of people knowing the system was occurring. The loss of these people likely contributed to some delays in achieving the level of organizational learning required to sustain lean at GM.

Similarly, GM's bankruptcy of 2009 had the effect of reducing the number of talented lean people in the organization. While the evacuation at the higher levels may not have been as significant as earlier staff reductions, at this time many middle-level managers and engineers who had become socialized into the GMS way of thinking left the corporation. The overall size of the company shrunk and at the same time the proportion of good lean thinkers went down.

Is this an example of adaptive organizational learning? The short answer is almost. This imitation of TPS from NUMMI evolved to be a significant improvement over the makeshift one of a kind manufacturing facility of the seventies and eighties. Every GM manufacturing facility worldwide uses a common approach to developing technical aspects of its facility, which is the Global Manufacturing System that was born out of TPS at NUMMI. The social system that encompasses GMS is not common across the corporation, a result of local adaptation and inconsistent understanding of the how people are developed and drives learning and improvement in the Toyota version of the system. GM started with the things that were the easiest to see – tools, the people systems and the importance of knowledgeable and capable people is not as easy to see, particularly if you are coming from a system that was trying to eliminate them from the process.

Real change came only once senior GM management provided a global focus. True leadership and a vision of manufacturing that was centered on a lean philosophy emerged at the turn of the century. Coupled with the structure provided by the “Green Book” the vision and focus of senior management provided an opportunity for learning to become more than a bunch of individuals all working on the same thing to an organizational view of the relationship between different systems. GMS training provided a picture of how different parts of the system work together to consistently make it difficult to err, easy to identify such an event and then use the issue to learn how to improve the process and provide support for the person putting the part on the vehicle. These are the essential elements of a lean process and the NUMMI way as described by Shook (2010); after twenty-five years GMS was starting to deliver on the real learning opportunity.

It took eighteen years for General Motors to learn enough about TPS to change its manufacturing approach to become competitive and another seven to learn how to learn; to most organizations interested in copying a complex process that would seem a long time. Should another company interested in imitating TPS expect it should take that long? GM may have been slow learners and another company, perhaps more adept at learning, could do it in less that time. Regardless, TPS is a complex sociotechnical process ultimately requiring an adaptive learning organization to flourish. To become one if you are not is a challenge to achieve and to sustain.

Chapter 6

CONCLUSIONS AND DISCUSSION OF LEARNING IN A COPYING CONTEXT

Three cases were evaluated using a comparative study approach. This methodology is appropriate for the question studied and a research environment with no control over the behavioral events and an investigation of a phenomena of contemporary nature (Yin 1994). All cases are taken from a single large complex organization over a thirty year period. While the details of the cases indicate a change to some degree in operating philosophy and culture over this period, there are aspects of general management approach and style that are fundamentally unchanged. In general, the corporation exists to make money. This along with a long held division between hourly and salary ranks continues to foster sub-cultures with significantly different goals. Likewise, within the non-union employees additional sub-cultures continue to exist separating the functional activities and managers from workers within the organization. From these perspectives it is argued any temporal change in variables not directly considered that might influence the dependent variable is inconsequential.

THE PROBLEM AS INITIALLY IDENTIFIED

In Chapter One research in economics (Arrow 1962; Winter 1964; Nelson and Winter 1973; Hannan and Freeman 1977; Nelson and Winter 1982; Nelson 1991; Teece, Pisano et al. 1997; Nelson and Winter 2002; Warglien 2002) and sociology (Meyer and Rowan 1977; DiMaggio and Powell 1978; Zucker 1987; DiMaggio and Powell 1991) was outlined indicating organizations will mimic or copy one another. Additionally, routines were presented as objects of copying (Winter and Szulanski 2001; Zollo and Winter 2002; Szulanski, Cappetta et al. 2004; Szulanski and Jensen 2006). Sadly, for most firms imitation often ends with a company not getting the expected benefit.

Rogers (1983) in explaining the diffusion of innovation sets a path for understanding change in the context of imitation. His basic model tells us innovation is diffused into an industrial landscape in a four-phase process. For Rogers, the diffusion of an innovation is a function of certain characteristics of the innovation itself, the way it is communicated, time and the social system through which it is working. Rogers suggests limitations to his model process, yet like the prior literature, does not link failure of the imitation with possible problems associated with how firms and individuals acquire knowledge and manage change.

Gap in the Literature

This research proposes an important aspect of the imitation process that can explain the persistent failure of copying attempts; specifically, a lack of understanding of the process of developing the detailed technical and contextual knowledge that is the basis of the work processes being copied. This is a shift of focus from the nature of the target to the way in which the target should be recreated by the organization doing the copying. It redirects the view from an outward orientation (what does the routine look like in its native environment) to the internal change happening within the organization during the imitation process (what does the organization need to know to operate a routine). This research looks at the different learning enablers needed for different contingencies created by the varying knowledge requirements of the routines being imitated.

The literature does provide a basis to understand the problem and the landscape of the organization. For example, we know organizations establish routines (Cohen, Burkhart et al. 1996; Becker 2003; Becker 2004; Becker 2007) and through the routines they deliver work product. As routines become established in an organization so resistance to changing them increases (Becker and Knudsen 2005). In part this resistance is because most changes of technology are part of Rogers' "social system" and in part because the true value and potential for the firm from the change is not recognized or the value varies for different constituents (Rogers 1983). The later can be dealt with by showing the opportunity from change for individuals, groups or organization. The former indicates a complexity to organizational change (and learning) that is in part a consequence of the "level' at which the change is required to take place. The nature of the knowledge required dictates the nature of the learning for change to be effective.

RESEARCH QUESTION, OBJECTIVE AND HYPOTHESES

The literature reviewed in Chapter One saw imitation as inevitable for a substandard firm to survive and as the cases presented in Chapters Three through Five suggest copying can take many forms. These cases also show the object of the imitation as a set of tools and ideas identified as being different from those used by a particular organization and as yielding superior results. Yet, the three cases presented here also show that in even the most basic situation copying the tools is not sufficient. This leads to a short answer to the research question initially proposed for this project: why does organizational imitation sometimes lead to effective learning and why, on other occasions, does it lead to mindless stagnant bureaucracy? It depends on the nature of the process and the extent of the interaction of the process being copied with other processes in the organization.

This research began with the following three objective: 1) a theoretical model that integrates aspects of individual and organizational learning; 2) an understanding of when, if ever, individual learning is more important than organizational learning in effective imitation; and, 3) a framework to help managers understand how to more fully exploit the benefits of learning from a successful model. Further, four hypotheses were identified to clarify the contingent nature of the learning, and a theoretical model was proposed to integrate the individual and organizational elements of learning with the object of the process. In the context of the model, three cases were reviewed that indicate the importance of individual learning as part of a chain of learning events. The final deliverable of this research, a framework for managers, is teased out of the model and the case observations and presented in the penultimate section of this chapter.

Figure 6 – 1 show four quadrants representing the combinations of learning that might be expected in organizations. Learning is identified as being either individual or organizational on one axis, and either mechanistic or organic on another. Additionally, a major axis connecting the lower left and upper right quadrants divides the space. For the purpose of this research, these two quadrants are proposed to be of the greatest interest to an organization attempting to imitate a business process. This is reasoned to be so based on current understanding of how learning spreads in a organization (Cole 1995) and the

fact that interesting business processes are organizational in nature and require significant tacit knowledge to effectively execute.

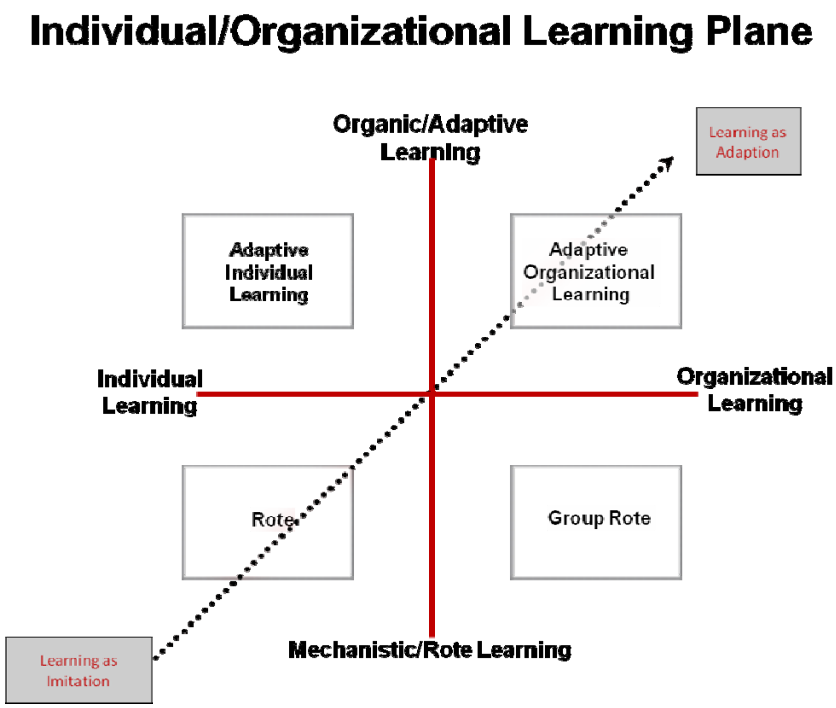

Figure 6-1 The Individual/Organizational Learning Plane

The lower left hand quadrant locates processes of an autonomous nature requiring individual learning methods to master. Such work processes would be routine in nature, in the sense of Perrow (1967), embedded in a mechanistic organizational structure, largely autonomous, and endowed with explicit knowledge requirements. This is a situation where an exact copy strategy (Winter 2003) has a reasonable chance to succeed. Conversely, in situations where work processes are interrelated, with many different people working on the same process have varying functional focuses, trying to accomplish a common goal, process rules and codified information are supplemented with tacit knowledge. In cases like these, Perrow's (1967) engineering world of high task analyzability and high job variety, a mere copy of codified information will not suffice and significant organizational learning and perhaps even spontaneous adaptation may be required. In this quadrant, that of Organizational/Adaptive Learning, imitations will need to be adaptations, based on the specific knowledge of how the copy functions.

Two learning models, presented in Chapter Two, synthesized several individual and organizational learning theories. The learning models provide a link between the I/O Learning Plane and required action. An individual learning model with a focus on the mechanical aspects of learning the basics and establishing capable processes has roots in Dreyfus (1980) and Deming (1986). This individual learning model is shown in Figure 6-2. A companion model, shown in Figure 6-3, builds on the individual model, adding aspects of Senge (1994) and Argyris (1985). In order to understand how an organization might navigate the I/O Learning Plane and integrate the two leaning models, four hypotheses are considered in view of the data from the cases.

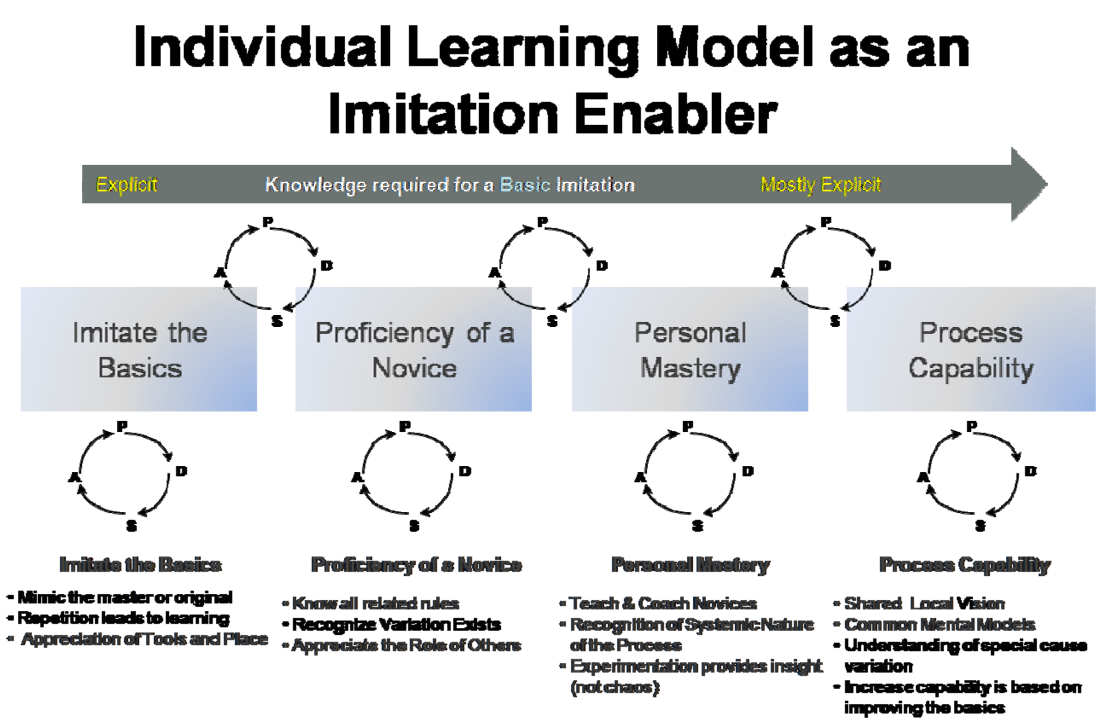

Figure 6-2 Individual Learning as an enabler to imitaiton

An organization attempting to imitate an autonomous routine embodied by largely explicit knowledge will require an individual to understand documented steps and rules with only minor adaptations. This operational expectation can be summarized as follows:

> Hypothesis 1: In the case of organizational imitation of processes of an autonomous nature governed predominantly by explicit rules, individual learning characterized by a mechanical approach to knowledge transfer is effective with little organizational learning.

This hypothesis assumes learning will be mechanical, based on the known rules and procedures and follow the steps outlined in the individual learning model (Figure 6-2). If true, one can expect to see effective imitation in situations requiring an individual to understand local processes and procedures and can rely strictly on known, explicit and codified information.

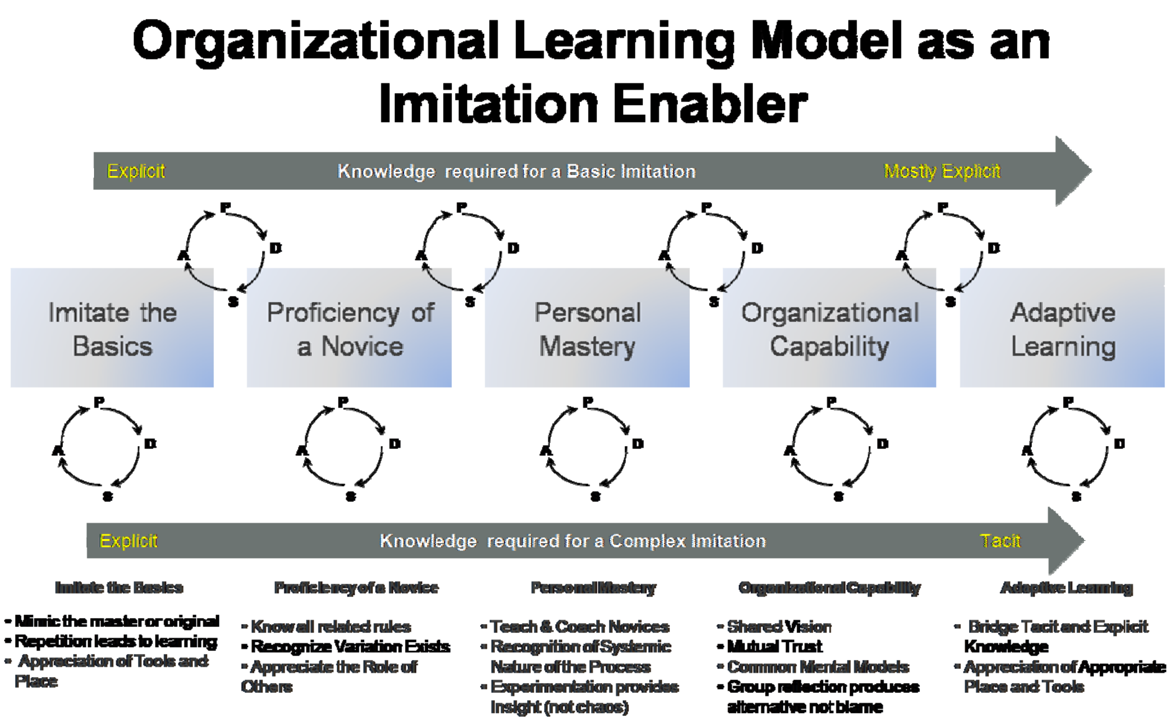

Figure 6-3 Organizational Learning as an enabler to imitation

Situations occupying the upper right quadrant of the I/O Learning Plane call for additional learning cycles. Learning begins with individual learning, but successful imitation of organizational processes of this nature ultimately leads to change requiring a perspective that supersedes the individual or group. Therefore,

> Hypothesis 2: In the case of an organization imitating processes of a highly system embedded nature governed predominantly by tacit rules, learning will begin with the individual and require many cycles of explicit learning with the slow introduction of tacit knowledge intertwined with organizational change and learning.

Cycles of learning involve study and reflection to determine if advancement is feasible. In addition, an individual imitating in a mechanical/explicit world (bottom left quadrant) might be able to recognize local organizational limits, while an individual working in organic/organizational world might be unable to recognize limiting factors to the development of capabilities that impact multiple systems within the organization. In the copying context, a shared vision comprehending a common mental model of the entire organization is needed to facilitate the development of organizational capability. At the same time, a shared vision will provide the learners the insight to truly adapt and solve problems with broader organizational impact through group reflection and the bridging of tacit and explicit knowledge.

In the complex imitation environment learning moves from explicit instructions governing autonomous routines toward more detailed coaching (of a more tacit nature) to include more systems embedded in each other. A successful profile of the activity will change from a mechanistic approach to a more organic approach. A consequence of hypothesis 2 is that the management will change from a mechanistic to a more organic organization and problem-solving environment.

> Hypothesis 2b: Individual learning is initially characterized by a mechanical approach to knowledge transfer and as need be is followed by learning displaying characteristics of a more organic organization able to deal with environmental complexity and change.

In a successful imitation, management can be expected to become more enabling and less bureaucratic (Adler and Borys 1996). One aspect of the enabling environment is the role of manager as mentor and coach, not just arbitrator of company policy.

The role of a mentor or coach is a critical role in developing the successful bridge between individual learning and organizational learning. A mentor or coach plays a part in the assimilation process, particularly in the case of tacit knowledge, but also in the explicit case, perhaps to a lesser degree. In either situation, the coach or mentor can act as a guide to the novice to understand what is important; providing what Winter and Szulanski (2001) referred to as the "Arrow Core," those aspects of the routine that are vital to the copy and must be learned by the new users. As well, a mentor can add discipline to the learning activity. Additionally, this research proposes a mentor or coach will play a role in defining the *ba*[32] for the learner and in so doing providing a necessary linkage between the organization and the learner signaling when individual learning evolves to organizational learning.

> Hypothesis 3: A mentor or coach with a personal mastery of the original will act to not only ensure a novice learns the important key aspects of any new organizational practice being imitated, but will also define a vision of the future organization that provides context for the learner and facilitates the creation of a shared vision, common mental models and ensures an environment where reflection yields alternative solutions not blame.

If this hypothesis is supported one interpretation is that a knowledgeable coach will be instrumental in creating the environment described by Nonaka and Toyama (2005), an "eco-system of knowledge (ibid, p. 430)."

[32] *Ba* and *Kata* are discussed in detail in Chapter 1 of this work.

The two off-diagonal quadrants are proposed to be transitional positions that provide an indication of progress toward the ideal. Being in these off diagonal positions will indicate whether additional energy needs to be applied to the imitation activity. Three cases provided insight into what could happen in the four quadrants. Each of the cases studied identified certain enablers to imitation at various times in the copying lifecycle.

SUMMARY OF THE FINDINGS FROM THE THREE CASES

Worldbook

This is a case of GM internally imitating an autonomous system governed by explicit rules and codifiable standards. Worldbook learning was individual in nature. Operators addressed new information by rote methods, memorizing important codes. The training focused on the individual operator's ability to learn a small number of rules and apply them to a deliverable. The rules were ultimately committed to memory by the analysts after repeated usage in developing their work product and in assisting engineers. This process worked well as designed, with small batches of new rules to learn, without changes to the processes, followed up with application to current work.

In terms of the individual learning model, the Dreyfus-like (1980) steps from understanding the basics to personal master can be easily seen. Short learning cycles incorporated in a stable process (while not part of Dreyfus) apparently assisted operators in mastering the list of code changes. Adding changes to the work process only after process capability with the new codes helped to make this learning more permanent.

Learning on the part of implementation leaders and the regional functional groups was also significant. Important in what was created, the original and a migration plan toward this ideal, the learning of the functional leaders was less mechanical, but still individual. Here the data shows a somewhat Eastern approach. Observation from the case showed Ray sending the regional functional leaders to “go and see the process” in a *genchi genbutsu* inspired approach. Whether intentional or by chance, this forced them to both learn the existing process and recognize the opportunity offered by Worldbook. Through the course of working out the differences in a process similar to *nemawashi* the regional functional leaders learned what was important to their groups and to the organization. This individual learning activity played a significant role in developing a commitment to the implementation of local changes as the regional change leaders relied less on their technical support managers (many responsible for developing the local practices and reluctant to change) and could see beyond local concerns and politics.

In addition to Dreyfus, Deming’s (1994) study step from the P-D-S-A cycle is also evident in the validation activities required by the implementation team. In the Worldbook case, the implementation was led by an individual with significant understanding of both the process required to change and the details of the original NA business process. He was informal coach and mentor to many of the regional implementation team members. His deep understanding made it possible for him to challenge the regional functional owners when they were stalling and avoiding responsibility for the change. The learning that took place was individual and the end process encompasses a set of standard work including tools to improve the flow of information between functions and regions.

In summary, this was a successful copying activity that exhibited individual learning of a mechanistic nature, but still required major top down support and change management skills. Strong leadership with knowledge of process and change methodology led an important peripheral learning activity with leaders of regional activity to develop commitment to copying the original and the change process. Mentorship or coaching played a minor role in achieving the working copy and developing personal mastery of the end users. However, coaching and mentoring of leaders played a significant role in their learning and commitment.

Design for six-sigma

Design for six-sigma is a case of on organization copying a copy. DFSS was to be implemented across engineering based on a model developed by the American Supplier Institute. As outlined in Chapter Four, DFSS is a complex system of interdependent processes executed in cross-functional problem solving efforts on issues that present with high variety and low analyzability. DFSS being copied into the new product development activities is by this description ideally situated in the Organic/Organizational learning quadrant of the I/O Learning Plane.

In the DFSS imitation learning was individual in nature; it closely followed the first two steps of Dreyfus' model with little or no growth beyond the point of understanding codified instructions. Additionally, there was a very mechanical approach to knowledge transfer; even the problem solving process itself, the subject of the training, was mechanically taught and followed. After five years of practice and repetition double-loop learning was not evident.

Executive champions did not receive much training and there is little evidence of effective mentoring from ASI before its contract ended. With only one three-day session and no experience running projects executives were ill equipped to show real leadership in DFSS deployment. Directors and senior managers who got their jobs by solving problems through skilled fire fighting seemed unwilling to change their approach. The general culture at GM engineering was not altered to facilitate a problem-elimination mentality.

DFSS can ultimately be placed in one of two positions on the I/O Learning Plane: either having not moved from the initial position in the Individual Rote quadrant, or at best a subgroup moved into the Group Rote quadrant. Far from being standard work for an engineer, DFSS is a set of tools that have formed a common language for practitioners. The training presents the explicit aspects of the tools and the mechanical aspects of the process which resulted in a large number of engineers that understand the words and the rules. Few, if any, have advanced beyond the basics to personal mastery. Additionally, there has been no significant "threading" of people that know the tools (even those few with a personal mastery) into the ranks of managers and directors.

At face value DFSS is a system to surface conflicting views operationalized by an open and easily observable objective testing and evaluation methodology. In fact, the strategies employed by the ASI consultants were focused on controlling the problem solving environment and protecting the interests of ASI. The commitment to the system was weak and they did not foster a learning environment; instead, project owners were either pushed to complete their projects or left to abandon them when it appeared there would not be sufficient payback to report a "good" DFSS project.

In summary, this failed attempt to mimic DFSS does not follow the expectation for learning as suggested by the ideal model. The learning patterns and habits did not allow a migration to the Adaptive/Organizational quadrant of the I/O Learning Plane. Learning started as individual and mechanistic and did not move in the predicted direction, resulting in an ineffective imitation. Mentoring and coaching were weak or non-existent as leaders did not really understand the system.

A Global Manufacturing System from Toyota

In this case, a twenty-five year joint venture provided GM with training and easy access to Toyota's production system. The Toyota Production System is an integrated set of tools and philosophy requiring a sophisticated view of manufacturing and its role in an organization. The ideal in the I/O Learning Plane for GMS is in the top right hand corner. In three distinct phases, (Synchronous Manufacturing, Competitive Manufacturing and Global Manufacturing System) first the tools and then the philosophy of TPS become part of a global production system at GM.

In the GMS case many cycles of tacit learning were observed. In fact, tacit knowledge was a cornerstone of the first two phases of the long imitation process although only weakly grasped in the first phase. The original GM managers who were sent to NUMMI to learn were coached deeply over several years and developed a good deal of tacit knowledge, but found it very difficult to share that with others when they returned to GM. The introduction of explicit knowledge that included a deeper understanding of the philosophy of GMS and a noticeable organizational change occurred after fifteen years of learning the tools. Individual learning, initially characterized by a mechanical approach to knowledge transfer, was followed by learning displaying a more organic approach to problem solving that includes double-loop learning.

There are several indications that learning was an individual activity with initial attention on the mechanical aspects of the process. Evidence from the first phase of the imitation activity (Synchronous Manufacturing) indicates learning focused on individuals gaining skill in a basic set of tools in a Dreyfus (1980) inspired way; however, there is some indication the learners did not advance beyond the novice level making only very weak connections with the material. This may have been because of insufficient support for individual/rote learning to take root (early support from local management was weak) or insufficient repetitions of the basics to encourage the deep connection to the rules (at the first sign of trouble the tools would be abandoned for business as usual). In each of the Competitive Manufacturing and Global Manufacturing System phases training did begin with the tools and learners could be seen to progress to possess the skills of a novice and in some cases they progressed to have a personal mastery of the material. This may have been supported by more acquired knowledge and experience (as the initial coaches had more chances to experiment and learn) and more NUMMI graduates were returning to GM and locating in the plants where CM was being implemented. Regardless, this action follows the expectation of the individual learning model.

There is evidence to suggest a more adaptive learning environment was developed over time. The Green Book documented a set of codified knowledge, and was critical in the CM phase. Of course, it was mainly focused on the basic tools and infrastructure; it was very mechanical in approach and content. GMS started with the Green Book, then codified additional aspects of GMS, and combined this “book learning” with more spontaneous learning events. This is suggestive of adaptive learning, but not conclusive as no evidence of double-loop learning was observed. What was indicated was the importance of coaching and mentoring; as when individuals developed their understanding beyond the basics it was with the guidance of knowledgeable coaches and mentors.

A strong commitment from leadership did emerge over time, in part because of the perseverance of early practitioners and through attrition. Many managers spent considerable periods of time working at NUMMI and developing tacit knowledge and after they returned to GM many advanced rapidly to become leaders in the manufacturing organization. While not a universally held belief, many of these leaders saw part of their role as teacher and coach to the next generation of GMS practitioners.

In summary, GMS as a copy of TPS is a limited success. Limited in that it took 25 years and key managers are routinely superannuated and replaced with people that do not have the same commitment to the philosophy of GMS. Learning did begin with the tools and through repetition the coaches and practitioners developed personal mastery. Mentors and coaching played an important role in developing people. With respect to the timeframe involved with this imitation: many things happened at GM over the course of this transition – near bankruptcy (and ultimately bankruptcy) leadership changes and slow shifts in philosophy. While this suggests the time observed here is likely extreme we know from Rogers (1984) time is important in the diffusion of innovation and given the complexity of the task being imitated some significant time will be required for effective imitation to happen.

The cases taken as a whole

The observations of the three cases are summarized in Figure 6-4. The hypotheses discussed in Chapter Two are indicated in columns with each case occupying the rows. The final column is an assessment of the degree of success for each imitation. The previous discussion, and that of Chapters Three through Six has been focused on the rows; the subsequent material will considering the cases based on the columns of this table.

General Findings and Summary of Cases

Case	Explicit Knowledge Acquired	Tacit Knowledge Acquired	Adaptive Management Style Adopted	Active Mentor or Coach	Successful Imitation
Worldbook	Yes mechanically	None required	Not as part of operation	No, but a very knowledgeable change leader	Yes
Design for six-sigma	Yes mechanically	Not at system level	No (theory suggests it would happen)	Present, but not effective	No
Lean Manufacturing System from TPS					
ϕ1 Synchronous Manufacturing	Weak	No (model suggests it is required)	No (theory suggest it would happen)	Attempted, but not effective	No
ϕ2 Competitive Manufacturing	Yes mechanically	Limited (mentors and coaches)	No (theory suggest it would happen)	Yes (limited scope)	Partially
ϕ3 Global Manufacturing System	Yes mechanically	Yes (managers and leaders)	Yes (limited degree)	Yes (managers and leaders)	Yes (with reservations)

Figure 6-4 Summary of Case Findings

One of the least surprising results is that learning in all three cases started with the individual and was operationalized by a mechanical approach to understanding specifics tools. A close look at the GMS case reveals a failure of SM (GMS phase 1) and weak learning of the explicit aspects of the tools; regardless learning began as the act of an individual in SM and continued in the next phase as individuals learning and mastering the basics. In addition, we can conclude individual learning is necessary, but not sufficient to effective imitation as even as individual learning did take place as hypothesized in the DFSS case, this was ultimately not a successful imitation.

While Worldbook did not require the acquisition of significant tacit knowledge to be a successful imitation (as it resides as an ideal in the Rote/Mechanistic quadrant), the theory does suggest both DFSS and GMS should have in order to move to their ideal positions. The observations from the final phase of GMS did show some adaptation of tacit knowledge and a more organic management style. In the GMS case exchanges were observed between managers and directors not so much between leaders and workers and not at all in the DFSS study. Of course, of the two GMS was a more successful imitation; this suggests the importance of the mentor in developing tacit knowledge in an organizational context.

From these cases the argument for the effectiveness of coaching and the importance of an adaptive environment is complicated. There is an apparent non-linear effect from these two factors as related to the effectiveness of imitations requiring a high degree of tacit knowledge. An adaptive management style may be necessary but not sufficient to allow effective coaching or mentoring. In the cases involving significant tacit knowledge to be transferred, coaching and mentoring is effective only if an adaptive management style is present.

When viewed as a whole in the context of the enablers presented by the four hypotheses, the observations from the three cases also indicate two additional findings.

First, when a knowledge requirements of a routine are simple (explicit rules only) less sophisticated methods of knowledge transfer are necessary; whereas, if the knowledge requirements of a routine are complex (requiring both explicit and tacit knowledge), more sophisticated methods are required. Second, there may have been a benefit to a protracted development activity. While not indicated in Figure 6-4 significant time was involved in each case. One thing time allows is repetition. Worldbook observations indicate repletion was important to master the various rules of the book. While during the SM and CM years learning was taking place, perhaps with insufficient repetitions to ensure details were captured by the learner. Taking time to understand and learn the explicit aspects of the process seems important. To similar effect, significant pre-work done in the Worldbook implementation prepared the managers and directors for the change required by having them learn the basics of the processes they managed and the essence of the change required. These observations strengthen the view that individual understanding of the basics is an important first step regardless of the ultimate level of knowledge required. Being able to manipulate the parameters of a process and achieve greater capability can only come with intimate knowledge of the "nuts and bolt," and it could be argued in the GMS and Worldbook case it was only possible to recognize tacitly understood aspects of the process once the details were engrained in the user and managers.

The learning as "pre-work" in the GMS and Worldbook cases may be characterized as adaptive/individual (top left hand quadrant). It is indicated in situations where the individual requires significant learning to understand why the particular change is necessary. Interestingly, this is an off-axis move not indicated by the theory, but enabling the successful imitation. It can also be said that considerable energy (coaching, mentoring and managing change) was required to get back to the ideal position for the particular copying activity. It has been said that DFSS is not a successful imitation and this particular change action is in the Group/Rote quadrant (a position once held by the SM/CM/GMS imitation). If sufficient energy is applied to the DFSS effort, perhaps this imitation could also become successful.

The importance of a knowledgeable mentor or coach is also indicated from a viewing of the three cases as a whole. In the Worldbook the knowledge of the change agent Ray, led other managers and directors to grasp the essence of the processes they owned. Unwilling to agree to the change without coaching from a person with intimate knowledge of the original and the pitfalls of the change process, the only way to enable change was to help them learn what had to be done. In the GMS case without some coaching plants would never have come to see SM or CM as positive changes. Only through continual prodding, exploration and experimentation with plant management could GMS have evolved. The players all needed to learn the basic pieces, but they also needed a coach to help them practice the right things and recognize when their adaptations were good and when they were just slipping back into old habits.

These findings also suggest a framework for managers to use when implementing a change. A successful imitation is a function of learning regardless of the nature of the routine being copied, but the nature of the learning will differ depending on the ideal position on the I/O Learning Plane. In general, one can expect one of two learning "paths." The first, perhaps not exactly a path is the simplest type of routine, one which is largely autonomous requiring mostly explicit instructions. The second path is taken when dealing with more complicated system with many organizationally embedded parts requiring tacit and explicit knowledge to master. Deviations from the path will require additional energy (leadership intervention, additional coaching or more learning on the part of the operators) to achieve an ideal position.

In general, successful imitation requires knowledge of the learning path, individual understanding of the basics and engaged learning coaches and organizations willing to adjust management style if need be. To be successful imitating new work processes managers need to understand complexity of the routine being copied as it relates to the knowledge required to master the basics of its operation. Additionally, detail of the mechanical steps that are the basis of the routines need to be codified for new learners. Change leaders must have a personal mastery of the routine being copied and be effective coaches to properly convey the tacit knowledge required of more complex imitations. And finally, organizations will need to adapt as knowledge requirements grow.

FUTURE RESEARCH

By its nature qualitative research is theory building; the data from participant observation and other case based ethnography allows hypotheses to be explored, but not tested. One avenue for further research is to confirm the findings of this work. The data presented in Chapters Three through Five supports the various hypotheses, quantitative methods and the more rigorous approaches offered by inferential statistics allows testing. Of course, such testing will require the acquisition of data on similar types of copying activities. While this may be an onerous task, statistical analysis need not be overly sophisticated, initial studies and analysis can rely on simple non-parametric tests. Such evaluations will require less data and can provide directional insight into the viability of said hypotheses.

Other possible confirmatory research would be a quantitative verification of enablers to learning. One such enabler is repetition. In the analysis of the GMS case it was suggested the lack of repetitions may have been a cause of failure in the SM stage. Repetition is seen as an important component of rote learning (Colvin 2008), how much is enough when this is part of a path toward the ideal. Additionally, an exploration of the role of repetition in a tacit knowledge learning situation may help to explain how organization learning is achieved.

Additionally, a confirmation of the nature of learning in the off-axis quadrants may explain these areas as more than transitionary. Although it was suggested the group/rote quadrant was home to several less interesting examples (learning the corporate time-keeping system or a set of instructions for a group process), the quadrant identified as individual/organic is seen strictly as a learning plateau in the Worldbook case. Is this true or can individual learning be organic? Is this perhaps a special case of personal mastery that leads to a greater understanding of how autonomous process can change in an otherwise dynamic organization?

These cases indicate tacit knowledge sharing and adaptive management style occur together. An investigation of additional cases may address the cause and effect confusion over the two constructs. Specifically, is tacit knowledge sharing an enabler of an adaptive management style or is it the other way around?

Another possible extension of this work in related to change management processes as used by managers and change agents. In the context of an imitation, management perception can drive seemingly logical actions that are suboptimal for a given copying environment. How can change management models be fine-tuned to incorporate aspects of individual and organization learning into the steps so as to assuage the anxiety of people in the midst of change as to its true merit?

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