

DESIGN RULES, METAROUTINES, AND BOUNDARY OBJECTS –
A FRAMEWORK FOR IMPROVING HEALTHCARE DELIVERY
SYSTEMS

by

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Manimay Ghosh

August, 2006

To my loving wife, Shrabani

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ABSTRACT

The healthcare industry in the United States has been fraught with medical errors, rising costs, and wastes for many years. Despite widespread adoption of Total Quality Management and Six Sigma programs, healthcare's woes continue unabated. The Toyota Production System (TPS), progenitor of lean manufacturing, is widely regarded as the most effective production system ever devised. It has been successfully adopted by manufacturing firms worldwide resulting in significant gains in efficiency and quality in companies of all sizes. The goal of this research is to determine whether principles from the Toyota Production System could be applied to a healthcare environment to improve its delivery systems.

Following an action research methodology, the work reported here describes how TPS principles were adapted and applied to generate sustainable improvements to hospital work processes. Using a combination of qualitative and quantitative research methods, the results of the intervention were scrutinized, resulting in several important contributions to the existing body of knowledge on TPS and organizational problem solving. First, the design rules to construct work processes were found applicable to healthcare and were associated with better process outcome. Second, the systematic problem solving methodology adapted from Toyota, a metaroutine, prompted individuals to jointly validate and create knowledge to improve work processes and adopt long-term, instead of a short-term, solutions. Third, a problem-solving tool (also adapted from Toyota) provided a common language of solving problems in a cross-departmental setting and thus acted as an effective boundary object by members from different functional disciplines. These three elements were tightly interwoven during the problem-solving process, suggesting a framework for the design of any quality or process improvement program for helping organizations make efficient use of resources while improving quality of service. The implications of this work are significant not only for hospitals, but for many other non-manufacturing sectors where improved work processes are desirable.

CHAPTER 1

DISSERTATION OVERVIEW

Healthcare is one of the most important sectors of the United States (U.S.) economy and also possibly the only sector that has persistently raised concerns for the people of the United States. The reason is well known – it has been ailing for many years. The most widely cited numeric that portrays the current state of affairs in healthcare is the Institute of Medicine's report that 44,000 to 98,000 people die annually of preventable medical errors (Kohn et al., 1999). Medical error is the eighth leading cause of death in the U.S. (Herzlinger, 2006). Other studies report that 770,000 people are injured or die in hospitals from adverse drug events every year (Classen et al., 1997; Cullen et al., 1997).

Despite uneven quality, healthcare costs are rising (Herzlinger, 2006; Porter and Teisberg, 2004). A recent paper states that the U.S. has the most expensive healthcare system in the world (Bodenheimer, 2005). In 2002, the U.S. spent \$5267 per person for healthcare. In comparison, Switzerland spent \$3445, two-thirds of the U.S. amount. The U.S. healthcare expenditure is expected to increase from \$1.6 trillion in 2002 (14.9% of the gross domestic product, i.e., GDP) to \$3.6 trillion (18.4% of GDP) by 2013. Health insurance costs have increased so much in recent years that many employers have shifted their cost burden onto to their employees. In fact, CEOs in the U.S. have categorized healthcare costs as their main economic pressure (Berry et al., 2004). In simple terms, the healthcare sector seems to be in crisis in terms of high cost and unsatisfactory quality, and needs to be revived.

Some experts attribute many of healthcare's woes to its work systems. They suggest that healthcare work systems are broken (Thompson et al., 2003; Begun and Kaissi, 2004), and therefore, suffer from operational inefficiencies (Tucker, 2004). In an effort to address the problems associated with the work systems, healthcare leaders have adopted various well-known quality improvement techniques from the industrial sector. For example, Total Quality Management (TQM) was imported in the mid 1980s to revamp the healthcare system but the existing literature suggests limited success (Huq and Martin, 2001; Blumenthal and Kilo, 1998). Furthermore, our understanding of the efficacy of TQM in healthcare is limited because most studies of TQM reported in the literature are prescriptive or anecdotal (Bigelow and Arndt, 1995, 2000). Similarly, Six Sigma, another quality improvement technique, was borrowed in the later half of the 1990s, but existing literature reports that few healthcare organizations have implemented it (Revere and Black, 2003). Like TQM, the literature on Six Sigma also reports scarcity in empirical research (Linderman et al., 2003).

Thus, it appears from the literature that systemic issues in healthcare in the U.S. continue unresolved and there has been little empirical research to address them. This lack of empirical research, and my desire to help healthcare through improving systemic issues, motivated me to conduct this research on the application of Toyota Production System (TPS) principles.

Background

TPS, which evolved in Toyota Motor Corporation, has been lauded as the most efficient system of production in the history of manufacturing. In fact, some experts use

the term lean manufacturing instead of TPS for its ability to produce more for less (Womack et al., 1990). It has been credited for propelling Toyota into one of the best car manufacturing companies in the world. Similarly, many other organizations have achieved superior organizational performance by adopting TPS (Liker, 1998). There are multiple explanations for why TPS is so successful. Some scholars (Ohno, 1988; Shingo, 1989; Womack and Jones, 1996) suggest that it is successful because it strives to eliminate wastes in all possible forms from the system. But how to find waste in a system is not so readily apparent, and therefore, its elimination becomes difficult. A second explanation for why TPS is successful stems from the fact that it uses specific tools indispensable for production, such as Just-in-Time (JIT), Kanban, and Level Scheduling (Cusumano, 1988; Krafcik, 1988). However, some of these tools are production-specific and may be applicable in a manufacturing context but may not be applicable in a healthcare context.

There is a third explanation, which seems to provide a fresh and novel perspective on why TPS is successful. Spear and Bowen (1999), from their extensive field research in different manufacturing plants, find that its success derives from four rules. The first three rules concern how to design production systems in organizations. The fourth rule concerns solving problems that arise in the course of work. They suggest that problem solving should be done scientifically, in as close proximity to the work as possible, and under the guidance of a mentor. These four rules are embedded in everything Toyota does (Spear and Bowen, 1999). In a parallel research effort, some other scholars, while investigating Toyota's product development practices, note that Toyota uses a general problem-solving tool called the "A3 Report" (Sobek et al., 1998). From subsequent

investigations, Sobek reports that Toyota has certain norms or expectations in approaching problems that could form the basis for a problem solving method (Sobek, 2004).

Prior Work

This research is a part of a collaborative project between Montana State University and a mid-sized hospital. Prior to my involvement in the project, in mid 2001, Sobek and Jimmerson, the two principal investigators of the project, introduced the rules to the staff members in the hospital. They also adapted a problem solving method from Toyota to produce sustainable change in work processes using the TPS design rules. They named it the “A3 Process.” For convenience of the users and for aligning their focus in problem solving, they adapted the A3 Report (named after the A3 paper size of 11”×17”) from Toyota and encapsulated the A3 Process in the form of a template (Sobek and Jimmerson, 2003, 2004).

They tested and refined the tools, methods, and training materials in two organizational units within the hospital and found encouraging results. They then taught the rules through hands-on training to individuals in the hospital using the A3 Process and the A3 Report. Two years into the project, I joined the research site. I participated in various problem-solving exercises with the individuals from the hospital to get first-hand experience using the problem solving method and the tool, and helped redesign their work processes using the design rules. This action research, over an extended period, motivated the research objectives and research questions that guided my work.

Research Objectives

Consequently, this dissertation reports on three specific research objectives: (1) to transport and test the three rules Spear and Bowen developed for the design of production systems (i.e. the TPS design rules) in healthcare and explain reasons for their efficacies, and to refine the rules in light of their applicability in healthcare; (2) to examine the efficacy of the A3 Process, a metaroutine, and explain the reasoning for its efficacy; and (3) to evaluate the characteristics of the A3 Report that made it an effective cross-departmental problem-solving tool. In the next few sub-sections, I present the objectives, the research questions, and the associated research methodologies.

First Research Objective

In their observations of Toyota Production System at work in multiple manufacturing facilities, Spear and Bowen (1999) note that redesign of production system seems to follow some deeply rooted but unspoken rules. The first rule concerns how work activities in a process need to be specified. The second rule involves how a customer and a supplier should connect in the process chain unambiguously. The third rule pertains to how the routings of the goods and services should be in the process chain. Interestingly, these rules evolved in a manufacturing context. Little was known about the efficacy of these rules in a non-manufacturing context, which prompted the first research question:

Research Question 1: *Are the TPS design rules applicable in a healthcare context, and if so, why?*

Previous work on the application of the TPS design rules was exploratory and provided a preliminary understanding on their efficacy (Thompson et al., 2003; Sobek and Jimmerson, 2003). Therefore, there was a growing need for examining these rules empirically. Because no empirical research existed in the literature, a qualitative research approach was adopted for the study. Primary data were collected by interviewing informants. These subjects underwent training on TPS principles, and applied them in improving work processes. To validate findings, several other artifacts (A3 Reports, minutes of meetings, email communications) were also collected. Based on all the documents collected, a case report was developed for each problem studied. Eighteen such case reports were developed for data analysis. The data were analyzed by a combination of qualitative and quantitative methods to measure the degree of change in each of the above parameters as a result of problem solving. The literature review, the research methodology, and the results related to this research question are presented in Chapter 2.

Second Research Objective

One of the primary ways process improvement can be achieved is by using systematic problem solving. Use of such problem solving necessitates deep investigation into a problem and addressing its root causes. The use of the rules to design work can be one way to address such root causes. The A3 Process described earlier starts with problem definition followed by current state representation, root cause analysis, target state representation, implementation plan, and ends with a follow-up study. Hence, the A3 Process provides a mechanism to help the problem solvers investigate a problem

systematically and in depth, and seek a sound solution. Some scholars call such structured techniques to improve existing processes metaroutines (Adler et al., 1999).

Adler and his colleagues maintain that Toyota has been successful in the market place because it continuously improves existing routines, and that the use of metaroutines is at the heart of such improvement. Interestingly, the concept of metaroutines is still not well understood in the academic and practitioner literatures. Therefore, although metaroutines appear important to produce sustainable change, it is unclear what characteristics of a metaroutine are important and how to make them effectual.

Sobek and Jimmerson (2003, 2004) applied the A3 Process in the participating hospital and found it to be effective. However, their studies provided only preliminary and anecdotal evidence about its effectiveness. Therefore, I wanted more explanation for why it worked, which created the impetus for the second research question:

Research Question 2: *Why is the A3 Problem Solving Process potentially effective for producing sustainable improvement in work processes?*

To address this question, the data were first analyzed using a systematic case comparison to ascertain how well the participants adhered to the steps of the A3 Process. Based on all the artifacts in the case report, an objective assessment was made between the steps followed and the degree of improvement.

Then a grounded theory analysis was performed (Strauss and Corbin, 1990, 1998; Cresswell, 1998), as no empirical research existed that examined the efficacy of the A3 Process. Two conceptual models emerged from the data that explain the behavioral and cognitive processes of individuals in the absence of a metaroutine, and when the A3 Process was adopted. The first model describes the individualistic behavior and

superficial understanding that promoted quick fixes to a problem in the absence of a metaroutine. The second model describes specific activities that prompted deep contextualized understanding of work and collaborative problem solving in the presence of a metaroutine. The literature review, the research methodology, and the results related to this research question are presented in Chapter 3.

Third Research Objective

In order to make the A3 Process easily usable by the problem solvers and align their focus in problem solving, the principal investigators encapsulated the A3 Process on one side of the 11”×17” paper and called it the “A3 Report.” Thus, the A3 report acts as a template for the A3 Process and documents the key steps. I, and other individuals in the research site, jointly used the A3 Report in multiple cross-departmental problem solving efforts to improve work processes. While participating in the problem solving exercises, I observed that the tool provided a common language to the problem solvers to understand the problem and promoted shared understanding about the deficiencies of the current process. This shared understanding stimulated them to develop new collective knowledge to resolve the problem. These field-based observations, over time, shaped my understanding of the A3 Report as a potential boundary object (BO), a physical artifact used in inter-disciplinary problem solving.

The majority of the empirical research on BOs focuses on new product development. Based on my review of the literature, there has been very little research on the use of BOs in process improvement activities, even though process improvement is

inter-disciplinary in nature and vital to the well being of the organization. Thus, the third research question was framed as follows:

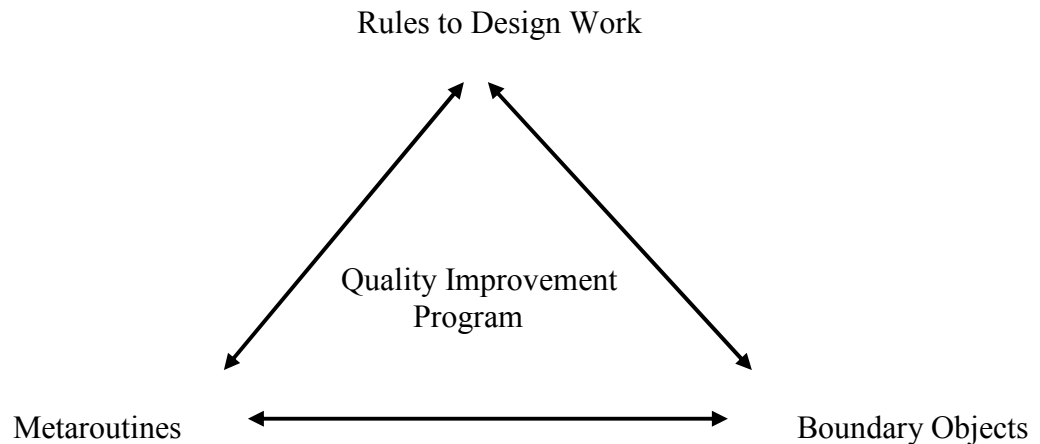
Research Question 3. *What explains the reasons for effectiveness or ineffectiveness of the A3 Report as a boundary object in process improvement-related problem solving?*

To investigate this question, the key characteristics of an effective BO were developed based on the extant literature and my action research. A field-based survey was then administered to collect data from the research site. A quantitative analysis was then applied to examine which characteristics explained its effectiveness as a BO. The literature review, the research technique, and the results related to this research question are presented in Chapter 4.

Contributions

At the end of investigating these research questions, this work points toward a new program of organizational process improvement (or quality improvement). The design rules are invoked during problem solving using the A3 Process to construct new processes for effectiveness. The A3 Process provides a structured approach to the problem solvers to investigate a problem. The A3 Report facilitates collaboration among the organizational members and stimulates development of common knowledge to resolve the problem amicably using the A3 Process. The A3 Report helps contextualize the design rules for specific problems. Thus, these three ingredients are tightly woven together to produce sustainable improvement in work processes. This further suggests a general framework in which to base the design of a quality improvement program as depicted in Figure 1.

Figure 1. Proposed Framework for Developing a Quality Improvement Program



However, quality improvement programs do not necessarily need to have the TPS design rules, the A3 Process, and the A3 Report as their three key ingredients to qualify as effective programs. In fact, it could be any *design rules*, heuristics, or principles that could be used to design work for higher effectiveness. For example, Rother and Shook (1999) suggest certain guidelines to design lean work systems such as developing continuous flow, creating a pull supermarket, and leveling production. The *metaroutines* are systematic problem solving procedures to improve existing work processes or routines. Plan-Do-Check-Act (PDCA) in Total Quality Management and Define-Measure-Analyze-Improve-Control (DMAIC) in Six Sigma are typical examples of metaroutines. Scholars argue that systematic problem solving requires investigation of all issues germane to a problem and can lead to a better solution (Tyre et al., 1995). The *boundary objects* are physical artifacts, which a number of researchers have found to be powerful tools to bind individuals from different functional disciplines to participate in cross-departmental problem solving (Henderson, 1991; Carlile, 2002; Bechky, 2003).

Prototypes and engineering drawings are classical examples of boundary objects that are used in manufacturing organizations.

Therefore, during problem solving using metaroutines, the rules provide general guidelines on how the new process needs to be constructed to address the root causes and achieve better outcome. The BOs facilitate the problem solving process by creating a common ground for the problem solvers to reach a solution based on consensus. The BOs help the rules to play out in the context of specific problems. Taken together, these three ingredients interact and reinforce each other during the quality improvement process to achieve satisfactory improvement in the efficient use of organizational resources, reliable outcomes, reduced costs, and improved customer satisfaction.

In addition to the emerging framework above, another contribution of this research is that the TPS design rules are applicable to hospital systems. This implies that they may be universally applicable. Contingency theory suggests that standardized work practices are suitable for a stable work environment and an organic form of work is suitable for an unstable work environment (Scott, 2003). Many experts argue that the healthcare work environment is typically unstable because there are many players – customers, suppliers, regulatory agencies, social organizations, insurance companies, the federal government, and physicians – that govern its work environment (Begun and Kaissi, 2004). This research, based on its investigation in all areas within the hospital, except direct patient/clinician interface, seems to suggest that the rules are applicable in unstable work environments in healthcare as well.

The next contribution of this research is the articulation of the key characteristics of a metaroutine so that individuals are more inclined to participate in root cause analysis

to produce sustainable change instead of using the most preferred approach, i.e., putting a band aid on the problem as some researchers have observed (Tucker and Edmondson, 2003). Such band-aid approaches result in a recurrence of the problem. This finding is significant because scholars report little empirical research about the effectiveness of quality improvement programs (Tyre et al., 1995; Bigelow and Arndt, 1995, 2000; Ovretveit, 2002) or how to make them effective (Ovretveit, 2002). Additionally, the present work connects research with practice on metaroutines.

The emergence of the A3 Report to act as a problem-solving tool and a boundary object is an under explored area, i.e., process improvement, is another contribution of this work. Furthermore, this research quantitatively validates and strengthens the findings of prior qualitative work on BOs.

Finally, this research contributes to the lean manufacturing literature from a broader perspective. Tradition literature on lean manufacturing suggests identifying a problematic process and adopting a set of lean manufacturing tools to address the problems. However, lean tools evolved in a manufacturing organization, and therefore, most tools (Kanban, Single Minute Exchange of Die or SMED, Level production, Just-in-Time or JIT, Poka Yoke) are best suited for a manufacturing environment and may not always be relevant or replicable to a non-manufacturing environment such as healthcare. Furthermore, many processes in healthcare are human intensive, which make the task of translating some of these tools even more difficult. For example, the JIT approach of supplying materials at the right time to a workstation in a manufacturing environment may be an acceptable proposition from a production and inventory control point of view, but can be disastrous in a healthcare context if they are not available. In contrast, this

research suggests that empowering all individuals, including the front line employees, with the fundamental concepts of designing work processes and training them with the problem solving skills using a tool may be a better and pragmatic alternative to cut wastes from the system and become lean.

Dissertation Outline

This dissertation is organized around three research objectives. Because the investigated issues differed enough that relevant literatures and the research methodologies did not overlap, each of the subsequent three chapters present the pertinent background, research methodology, and results for one of three research objectives independently. Therefore, following the introductory chapter (Chapter 1), Chapter 2 presents the empirical research on rules to design work, Chapter 3 focuses on metaroutines, and Chapter 4 is devoted to boundary objects. Finally, Chapter 5 concludes the thesis with summaries of the findings of the research study and their implications. It also presents the limitations of this research and how it could be augmented, and offers directions for future research. The chapter and the dissertation end with some final thoughts.

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CHAPTER 2

A TEST OF THE RULES-IN-USE IN HEALTHCARE

If any issue has gained the attention of the United States government, businesses, and people of the United States at large over more than a decade, it is healthcare. There are legitimate reasons for such concerns. The current picture of healthcare looks grim: mounting operational costs and diminishing reimbursements from payers, un-even clinical and service quality, overworked staff, high attrition rates, shortage of skilled human resources in various service lines, and very complex and uncoordinated processes with little standardization. Wastes, errors, and duplication of efforts abound in the entire healthcare system (Uhlig, 2001; Berry et al., 2004; Waldman et al., 2004; Porter and Teisberg, 2004).

Today, the growing body of literature suggests that the healthcare industry is in a serious crisis and does not have sound systems in place. Perhaps the most notable of all these studies and most frequently cited in the literature is Kohn et al.,'s (1999) study that reports that nearly 100,000 people die of preventable medical related errors annually in the U.S.

Hospital errors (ordering, administration, transcription, diagnosis) have received considerable attention in recent times because of high defect rates (Merry and Brown, 2002). Despite such high defect rates, caregivers such as the physicians, over the years, have consistently emphasized their individual skills to address errors. However, many experts (Uhlig, 2001; Merry and Brown, 2002) argue that human beings are prone to

errors no matter how knowledgeable they are, and suggest systemic change to address medical errors.

Many scholars attribute this poor performance of healthcare organizations to their inability to manage operations (Mango and Shapiro, 2001; Thompson et al., 2003; Tucker and Edmondson, 2003; Green, 2004; Tucker, 2004). Some maintain that simple everyday functional tasks are still at their infancy in healthcare (Patel et al., 2002). A medical practitioner even concludes that healthcare leaders have marginalized process innovation in favor of product innovation (Uhlig, 2001). In sum, lack of focus on work processes and its ultimate effect (operational failures) appear to have had a deleterious effect on the smooth functioning of the healthcare industry, ultimately exposing the patients to significant risks.

This is not to say, however, that healthcare leaders have remained oblivious to their industry's problem. Decades earlier, in order to fix the broken systems, healthcare leaders adopted different continuous process improvement initiatives such as the Total Quality Management (TQM), or Continuous Quality Improvement (CQI) but have met with limited success (Bigelow and Arndt, 1995; Westphal et al., 1997; Blumenthal and Kilo, 1998; Shortell et al., 1998; Huq and Martin, 2001). They have also adopted Six Sigma (SS), another continuous improvement initiative, to address medical errors and to improve processes but its application has remained confined to very few healthcare organizations (Revere and Black, 2003; Torres and Guo, 2004). In short, systems in healthcare are still broken, and the industry needs a model to address them.

A third continuous improvement philosophy, lean manufacturing, also called Toyota Production System (TPS) as it originated in the Toyota Motor Company, has been

gaining popularity in the U.S over the past 10 or so years because of its ability to produce the same output with a fraction of the organizational resources. Some scholars believe that TPS succeeds because of its relentless effort to eliminate waste in any form (Ohno, 1988; Shingo, 1989; Womack and Jones, 1996). Others (Sugimori et al., 1977; Cusumano, 1988; Krafcik, 1988) reason that Toyota succeeds because it uses specific tools indispensable for production. In a recent study, Spear and Bowen (1999) discovered that Toyota's success is not due to the specific tools. Rather they attribute its success to four so-called Rules-in-Use (we call the first three "TPS design rules" in this paper) that it uses in designing and improving work processes.

Even though TPS, or lean, is accepted in the management literature as the most efficient production system developed to-date, little is known about its applicability outside manufacturing (Hines et al., 2004). In fact, based on the review of the literature, its application in healthcare is scarce, and has only very recently been applied. The focus of this research, therefore, is on the application of the TPS design rules outside the manufacturing arena. TPS seems to be a good fit to healthcare because of its ability to transform organizations into successful enterprises through process improvement.

The central purpose of this research, therefore, was to apply the rules in a healthcare setting and find if the three TPS design rules are indeed applicable, and if so, why. The second objective was to refine those design rules in light of their applicability in healthcare. Thus, my primary interest lay in investigating the transportability of the design rules outside manufacturing.

This chapter is structured as follows. It starts with a review of the relevant literature, and a review of the TPS design rules as propounded by Spear and Bowen. The

next sections present the research objectives and describe the research approach adopted. The latter develops measures for the constructs with rationale. The results of the analysis suggest that the three TPS design rules, with some refinement, are transferable outside manufacturing, i.e. healthcare, and may be at least a partial answer to fixing its broken systems.

Literature Review

Research on Work Processes

Barley (1996) and Barley and Kunda (2001) contend that over the last few decades, organizational theorists have paid lesser attention to studies on work. Though they (Barley, 1990; Barley and Bechky, 1994; Barley, 1996) focus on studies of work, they note a serious dearth in research studies on work by others and they attribute this to the fact that organizational theorists since the 1960s have relegated “studies on work” to its sister discipline, the sociology of work and communications. As Barley and Kunda quip, “Organization studies have been less effective at understanding verbs than nouns. We tend to study organizations, not organizing” (2001: p. 88). In a subsequent study, Bailey and Barley (2005) note that Industrial Engineering, the nodal engineering discipline that studies work, has gradually shifted its focus from work-studies to more abstract quantitative approaches for financial reasons and also to glorify its image in the academic circles. Consequently, it became ill positioned to address issues related to work.

Despite Barley and Kunda’s cynicism there have been some attempts to understand work processes, though at a fairly abstract and conceptual level. Pentland

(1992) describes organizational performance in terms of four generic moves: assign, transfer, refer, and escalate in a software support organization, suggesting use of a lexicon on “moves” to express routines. Subsequently, Pentland (1995) toys with the idea of combining moves appropriately to create work processes. He uses the metaphor “grammar” to describe and theorize work processes, and suggests developing discrete sets of activities as “grammar” encapsulated in a lexicon, comparing the actual actions against the grammar and revising the grammar, if found violated. Later, Pentland (1999) also offers the idea of using narrative data in understanding a process or sequence of events that connect cause and effect. Malone et al., (1999) propose use of an on-line “process handbook” by collecting examples of best practices from different organizations to designing work processes. Mackenzie (2000) offers a conceptual understanding of processes as time-dependent sequences of events governed by a process framework comprised of (1) the elements used to describe the steps or stages in the process, (2) the relationship between every pair of these elements, and (3) the links to other processes. These conceptual studies, in general, have improved our understanding of work processes but seem too abstract to make them actionable in real world settings.

Leading scholars describe work in organizations in terms of “routines” (Nelson and Winter, 1982). Nelson and Winter describe routines as a “repetitive pattern of activity in an entire organization.” Since Nelson and Winter came up with the concept of routines more than twenty years ago, researchers have studied and researched its characteristics: as patterns of behavior, as recurrence of an activity, as collective phenomenon, as mindless execution of tasks vs. effortful accomplishments, and as a process embedded in an organization and situated in practice. They have also studied its

effects: to coordinate and control, to develop trust, to economize on organizational resources, to reduce uncertainty, to provide stability, and to store knowledge (see Becker, 2004 for an overview on the literature).

Despite extensive studies on routines and their pervasive nature in organizations, they have still been difficult to conceptualize (Feldman and Pentland, 2003) and study (Pentland and Rueter, 1994). They are riddled with ambiguities and their effects are less understood (Becker, 2004). Furthermore, if we try to understand how routines are constructed or if we want to imitate the same routine in a different setting to achieve a similar level of performance, we can't replicate it exactly or easily (O'Dell and Grayson, 1998; Pfeffer and Sutton, 1999; Winter and Szulanski, 2001; Szulanski and Winter, 2002) because we do not have satisfactory knowledge about its inner working. Nonetheless, with the rapidly changing global marketplace, and increased market demands, change of routines has become mandatory to meet those demands. And without a complete understanding of the inner working of routines, improvement is difficult.

One of the noteworthy contributions of the past research on routines has been the conceptualization of routines to explain organizational change (Feldman, 2000; Feldman 2003; Feldman and Pentland, 2003). Some scholars offer the concept of metaroutines (Adler et al., 1999) to explain organizational change. Metaroutines, they define, are standardized procedures for changing existing routines and for creating new routines. Adler and others, from their empirical work at New United Motor Manufacturing, Inc. (NUMMI), a Toyota-General Motors joint venture, note the usage of metaroutines by the workers to change routines thus remaining creative in work. At the same time, they maintain efficiency by following standardized work processes. The research findings of

Adler and others are corroborated by Spear and Bowen's (1999) work who, from their four-year field research, observe that Toyota and TPS driven plants are successful because they use three rules for designing organizational routines and a meta-routine (a fourth Rule for changing routines through problem solving) for improvement and adaptation. This paper concerns the first three TPS design rules that Toyota and TPS driven organizations use to create new routines or to improve old ones.

Spear and Bowen's Design Rules-in-Use

Spear and Bowen posit that Toyota designs production systems around three basic building blocks: activities, connections, and pathways. Each block is designed according to a rule, a so-called design Rule-in-Use. The building blocks can be construed as different types of routines for gaining maximum efficiency. The design rules provide guidance on how the three types of routines should be designed.

The first building block, an activity, is defined as work tasks that people or machines do to transform materials, information or energy. They argue that Toyota Motor Corporation or TPS driven organizations specify tasks to the minutest details leaving little room for confusion among the individuals executing it. In contrast, in a non-TPS driven organization, they find tasks not defined in sufficient detail, thus exposing the tasks to considerable variation during execution, affecting process outcome and product quality. Toyota specifies an activity in terms of four parameters: content, sequence, timing, and outcome. Content refers to the specific tasks within an activity. Sequence refers to the sequential order in executing the tasks. Timing refers to the time taken by

individual tasks, and outcome refers to the results of the task. Spear and Bowen define Rule 1 as:

Rule 1: All work shall be highly specified as to content, sequence, timing, and outcome.

The second building block, a connection, is the mechanism by which adjacent customers and suppliers transfer material, information, and energy. They find that Toyota emphasizes direct and clear interaction between the adjacent customer and supplier to communicate requests for goods and services and response to such requests. In contrast, in a non-TPS organization the requests for goods and services are not as direct or unambiguous like Toyota. Thus, Spear and Bowen define Rule 2 for connection as:

Rule 2: Every customer-supplier connection must be direct, and there must be an unambiguous yes-or-no way to send requests and receive responses.

The third building block, a pathway, is defined as a series of connected activities that create and deliver goods, services, and information. They observe that production lines in Toyota or TPS driven organizations are simple and direct. The product or service follows a designated path along its course from beginning to end. On the contrary, in non-TPS organizations, they observe that products often do not follow a specified path; rather, they move along a convoluted path depending on whichever resource is available to serve first. Thus Spear and Bowen define Rule 3 as:

Rule 3: The pathway for every product and service must be simple and direct.

Spear and Bowen's (1999) research posits some basic principles to understand the inner working of routines better. What makes their study stand apart from others is that the design rules capture in sufficient depth the specificity that is needed in describing the inner working of a routine. Yet, they are simple to understand and are actionable in real

world settings, suggesting that these principles are transferable not only across organizational boundaries but also across diverse sectors, thus alleviating the difficulties associated with transferring the best practices or routines to another setting. Moreover, the staff and the organization as a whole develop their own competency, capability, and independency to create their own routines using the design rules for gaining maximum efficiency and effectiveness instead of depending on others to transfer.

Research Objectives

Spear and Bowen's empirical work was in the manufacturing sector, i.e., in high volume production facilities. Interestingly, these design rules have not been applied much outside the non-manufacturing sector, such as healthcare, despite the fact that healthcare organizations are in serious crisis and need a model that could fix their broken systems. As was mentioned earlier, little documented research exists on the applicability of the TPS design rules outside the manufacturing arena. The studies by Thompson et al., (2003), Sobek and Jimmerson (2003), Jimmerson et al., (2005), and Spear (2005) are anecdotal accounts of the intervention process, and therefore, validity of the findings is yet to be established. Based on a thorough review of the literature this study appears to be the first research attempt to study the applicability of the TPS design rules in a non-manufacturing workplace.

The initial work at the research site suggests that in all failing processes one or more of these rules to design work was violated, resulting in errors and wasted time and resources. It was also noted that reconstructing the work processes with the design rules was easy and understandable to all actors who participated in the problem solving

exercise, which motivated further research work. I became interested in understanding why the TPS design rules can be important in constructing work processes in a healthcare setting; and in exploring to what extent, at present, the work practices conform to those rules and to what degree those rules can be implemented for making improvements. Based on the field investigations, three hypotheses were induced related to the design Rules-in-Use previously described.

H1: Increased activity specification is positively associated with better process outcome in a healthcare setting.

Industrial organizations such as Toyota Motor Corporation advocate use of standardized work procedures as a fundamental requirement towards achieving organizational goals (Ohno, 1988; Shingo, 1989; Spear and Bowen, 1999). Likewise, Porter and Tiesberg (2004) observe superior outcomes at lower costs with standardized work processes in healthcare. However, others have challenged this line of reasoning and argue that standardization could improve performance, but its long-term effectiveness is unclear (Hopp and Spearman, 2000) and could indeed stifle the creativity of the workers (Hopp and Spearman, 2000; Gilson et al., 2005). It seems there exists a constant tension between the two camps on the usefulness of standardized processes in organizations and seems unresolved, which leads me to the first hypothesis (H1).

H2: Increased connection clarity is positively associated with better process outcome in a healthcare setting.

Organizational processes encompass multiple interpersonal connections. These connections enable participants to communicate, share understanding, transfer information, and coordinate activities (Feldman & Rafaeli, 2002). I concur with Feldman

and Rafaeli's observation that connections are essential for organizational success. They, however, ignore the issue of good or bad connection, which is critical to the success of transferring right information and ensuring better understanding and coordination. Spear and Bowen (1999) argue that Toyota strives to make every connection direct and unambiguous, implying these are the qualities of a good connection. Spear and Bowen's definition of connection may be true in a manufacturing context but its suitability in a healthcare context is not known, as it is untested. Hence, I propose the second hypothesis (H2).

H3: Increased pathway simplification is positively associated with better process outcome in a healthcare setting.

Pathway refers to a series of connected activities that create/deliver goods and services. Spear and Bowen (1999) argue that in Toyota pathways for goods and services are simple and direct. In contrast, in a non-TPS organization, pathways for goods and services often follow a tortuous path to take advantage of variability pooling. Hopp and Spearman (2000) contend that variability pooling is good as it reduces overall variability in process times. It involves combining multiple sources of variability to reduce processing and waiting time and, consequently, cycle time in the system.

Though variability pooling may be an effective solution for the short term, it may hide inefficiencies in the system. For example, an efficient worker covers the inefficiencies of a poor worker, and therefore, problems of inefficiencies and bottlenecks in the system may never surface to get resolved on a long-term basis. Moreover, accountability and responsibility become poorly defined. In fact, with a simplified pathway, problems are likely to surface faster and are addressed faster, leading to better

outcomes. As there are conflicting views on what should be the nature of pathway of delivering goods and services, I formulate the third hypothesis (H3).

To test these three hypotheses, an empirical study was carried out in a hospital setting. The following section describes the research approach adopted in this study.

Research Approach

Because no empirical research exists on the application on TPS design rules in healthcare, a qualitative approach was first adopted. I spent a total of nine months over two extended stays at the project site in an attempt to understand the inner working of the work processes and also to examine the effects of the TPS intervention. Although the primary method of data collection was qualitative in nature, I had definite constructs in my mind, which I intended to measure during the study. So, I chose to induce three hypotheses for the study and attempted to test them qualitatively and quantitatively. Accordingly, the research approach could be best described as a blend of qualitative and quantitative techniques to understand an intervention (effect of TPS design rules) in a particular healthcare setting.

Background

The setting of this research was a mid-sized hospital, a 146-bed facility with 1,200 employees. The hospital's activities include obstetrics, pediatrics, rehabilitation, surgery, neonatal intensive care, nuclear medicine, emergency, cardiology, and general medical care. The Joint Commission on Accreditation of Healthcare Organization (JCAHO) and the Rehabilitation Accreditation Commission (CARF) accredit the facility.

The project started in May 2001, when the National Science Foundation offered a grant to two investigators, a professor at Montana State University and a registered nurse with thirty years of experience in trauma care, to go ahead with the project. It was a collaborative project between Montana State University (MSU) and the hospital.

In the first year of the project, the investigators introduced the Toyota Production System design rules to the staff members in the hospital. They coached staff members from different functional departments by teaching regular classes and provided hands-on training in process-related problem solving. In total, more than two hundred employees across the hospital were imparted training on TPS. In a subsequent move, one of the investigators developed training materials for the program. Later, they introduced the Value Stream Map (VSM), a visual tool that focuses on the total system and identifies the value added and non-value added activities. They also adapted the A3 report, a tool from Toyota Motor Corporation, modified it, and created a template on one side of an 11”×17” paper for simplicity and convenience (Sobek and Jimmerson, 2003). The A3 report captured the problem solving process.

At a later stage of the project, one investigator, with the assistance of an undergraduate student from Montana State University, carried out multiple problem solving exercises at the cardiology department and at the pharmacy department of the hospital using the design rules. Their studies indicate that one or more of the TPS design rules were defied in all the poorly performing work processes. Reconstructing those broken work processes with the TPS rules led to significant improvements in different process parameters. Reduced medication errors, reduced outstanding orders, and shorter

order-to-delivery times in the pharmacy were a few of the many improvements they realized from their initial efforts.

Data Collection

I stayed for nine months (worked forty hours a week), in the site and spent approximately 1600 hours observing work processes across functional specialties, coaching participants at every level, and assisting them in conducting problem solving.

The research comprised two stages of data collection. In the first stage (June-December 2003), I spent the first week on orientation and visited different departments in the hospital, introduced myself to the different staff, and later collected some first hand information about their work practices. In the following weeks, I spent time mingling with them in the cafeteria or hallway to build relationships, which turned out to be extremely fruitful in later stages. Those conversations gave me some glimpse and useful insight into the work practices of the hospital. As the principal investigators had already introduced the TPS design rules and trained the staff in problem solving, I immersed myself in actual problem solving sessions using action research with various departments such as Hospital Information Management, Emergency Room, Patient Financial Services, Transportation, and the Registration department. I also attended every meeting relevant to the research, discussed findings with the senior leaders of the hospital, and taught classes explaining the TPS design rules and the problem solving process. Occasionally, I met staff members in their offices to gather additional information pertaining to the problems being investigated. During all this time, different artifacts such as data sheets, minutes of meeting, and emails were also collected.

In the second stage (June-August 2004), I revisited the hospital and participated in additional problem solving sessions with new departments such as the Facilities department. Additionally, as part of my research effort, I formally selected and interviewed participants (purposive sampling) from various functional departments (Hospital Information Management, Registration, Rehab Nursing Unit, Heart Center, Patient Financial Services, Laboratory, Outpatient Therapy, Intensive Care Unit, Transportation Department, and Facilities) who were knowledgeable on TPS principles and had attempted to solve process-related problems using the rules. The informants represented various levels (director, manager, senior employee with some supervisory responsibility, and junior staff with no supervisory responsibility) in the organizational hierarchy of the hospital.

Each individual problem addressed by TPS design rules was considered a unit of analysis in this research. For ease of investigation, problems that were clear and well defined were selected for study. In total, eighteen problems were studied (see Table 1). To add rigor to the research, most of the problems were selected and undertaken before I arrived at the site or were conducted under the guidance of a TPS coach other than me.

Prior to the interview, an expert checked the questionnaire for validity. The questions were based on the research question posed in the study. Before each interview, interviewees were sent a letter describing the objectives of the research project. The semi-structured interview lasted for 90 minutes, although a few ran for as long as 120 minutes. The interviews took place in the informant's office, conference room, or even in the hospital's cafeteria. At each interview, I asked specific questions about "activity", "connection", and "pathway" along with a few open-ended questions to augment

understanding. In some cases, an informant was interviewed multiple times for further clarifications. Attempt was made to take extensive notes to capture details of the informant's answer. After the interview was over, I typed an interview report based on notes and my memory and gave it to the informants to check factual errors. In all the cases, the informants reviewed and approved the document within 48 hours. As the interviews were based on the problem they addressed using an A3 report, I collected the A3 report from each informant for triangulation. In most cases, to triangulate even further, different artifacts (secondary data) were collected: meeting minutes of the quality council, safety council, and Falls and Restraint committee; protocols; performance data sheets; and emails to ensure validity of the research findings. After returning to the work site, I maintained regular information exchange with many informants through emails to get additional data to fill gaps in my understanding. Attempts were also made to get feedback from most of the informants on outcomes on a monthly or quarterly basis for a year after the implementation of the improved process to assess the sustainability of the outcome. Scholars (Garsen 2002; Speroff & O'Connor, 2004) argue that if the trend in improvement is sustained beyond the normal fluctuations of time-series the success can certainly be attributed to the improvement process. In most of the cases, I collected data after a year to measure sustainability of the outcome. Finally, meticulous records of all documents for each informant and analysis process were preserved in computer files and binders for future reference.

Table 1. Informants and Descriptions of the Problems Studied

Informant	Type of problems addressed during problem solving
Informant 1	Names mismatch insurance card vs. hospital database
Informant 2	Lost charges on medical supplies used
Informant 3	Low productivity of therapists in rehab nursing unit
Informant 4	Bill denials by Medicare on certs/recerts
Informant 5	No. of outstanding bills in patient accounts dept.
Informant 6	Incorrect transcribing of stress tests in hospital information management department.
Informant 7	No. of complaints on late delivery of probes to emergency dept.
Informant 8	Incomplete documentation on restraints in the clinical departments
Informant 9	Low productivity of the transcriptionists in hospital information management department.
Informant 10	Incorrect IV medication drip rate calculation
Informant 11	Poor productivity of the therapists in medical surgical floor
Informant 12	Missing information on specimens from operating room to the laboratory
Informant 13	Misdirected specimens from the operating room to the laboratory
Informant 14	Specimens sent to laboratory from the operating room without orders
Informant 15	Delayed maintenance of equipments in the kitchen
Informant 16	Misdirected or no orders from the clinical departments to cardiology department for ECHO
Informant 17	Long patient transportation time from the floors to the diagnostic departments
Informant 18	Multiple modes of delivering X-Ray reports to the clinical departments causing confusion and wastage of stationary

Case Development

First, eighteen case reports were developed based on all the artifacts that were available: (1) the interview reports, (2) A3 problem solving reports, (3) minutes of meetings of safety council, quality council, and Fall and Restraint committee, (4) policies and procedures, and (5) emails. Each one was used as a check against the others. However, the primary document for building the case report was the interview report that I obtained from each informant.

The case report provided a comprehensive account of the problem I studied for the research. It also allowed me to become intimately familiar with each case. At the end of each report, I added my impression but kept it completely separate from the informant's story. Creating the case report was an iterative process as all sources of data were revisited multiple times to represent the reality as closely as possible. As a check on the adequacy of the case reports, an Industrial Engineering professor at Montana State University with significant experience in qualitative research reviewed each case and provided comment on clarity and thoroughness. After revising to the satisfaction of the reviewer, the case reports were entered in the Atlas Ti software indexed by case number and informant's name.

The case reports were then coded for activity, connection, and pathway using a pre-determined coding scheme developed for each construct. I focused exclusively on those activities, connections, and pathways that were addressed by the participants during the problem solving, and printed copies of the data pertaining to the before and after states. Each activity, connection, or pathway was read several times to understand the change in terms of the parameters for each design rule.

Quantification of Variables

For this study, three-independent variables – activity specification, connection clarity, and pathway simplification – and one dependent variable, i.e., the degree of change realized from each case as a part of the problem solving effort, were defined. The following sections describe the four variables and the quantification process.

Activity Specification. Based on Spear and Bowen's research, an activity is defined as work tasks that people or machines do to transform materials, information, and energy. Two primary codes were developed for activities: ACT-SB and ACT-SA referring to the level of activity specificity before and after the problem solving respectively.

According to Spear and Bowen, one of Toyota's design rules is that workplace activities shall be specified in terms of four parameters: content, sequence, timing, and outcome. I further argue that activities could be specified on a continuum using those four parameters. My intent was to leverage those parameters to measure change in activity specification.

To measure the change in specificity for those activities addressed during problem solving, the states of each parameter were compared before and after problem solving. For example, if the understanding of the "content" in an activity moved from the individual discretionary level (i.e. used own discretion to decide on what tasks to accomplish for an activity) to the group consensus level, or to a level covered by codified policies and procedures, and thus the tasks needed to be accomplished for an activity became more explicit and clear to all, it was interpreted as an increased activity specification for "content." In such case, "1" was assigned to that parameter because "1" was associated with any positive change and "0" for no change in activity specification in my quantitative scheme. This process was repeated for the three other parameters.

The scores of each parameter were then totaled to obtain a measure of change in activity specification. The minimum score attainable was "0" which meant no change in the level of specificity in any parameter, and the maximum score attainable was "4"

which indicated increased specification in the four parameters. Thus, any positive value suggested an increase in activity specification. A sample analysis of one case was offered to a reviewer for checking any interpretive errors. After he concurred, the process was repeated for other cases that dealt with activity specification during problem solving.

Connection Clarity. A “connection” is defined as the mechanism by which a supplier transfers materials, patients, services, and information to an adjacent customer. Two primary codes, CON-SB and CON-SA, referring to connectivity before and after problem solving respectively were developed. Through my action research in the hospital, I found that connections can be clarified by specifying five parameters:

- requester - person who requests a good or service;
- responder - person who responds to the request;
- method of transfer - mechanism by which responder receives request and/or goods or services are delivered to the requester;
- notification - requester alerted when the goods or services are delivered by the responder and/or the responder knowing the request has been made; and
- response time - time to meet such requests by the responder.

The change in connection clarity was measured in terms of the above parameters in a manner similar to activity specification. For example, if the understanding of “requester” moved from an individual discretionary level (i.e. anybody can request goods or services in place of a designated individual) to a group consensus level, or to a level covered by codified policies, and thus became amply clear to all on who should request, I

interpreted that as an increased connection clarity. In such case, I assigned “1” to that parameter because “1” was associated with positive change and “0” with no change in connection clarity. The process was repeated for the other four parameters.

The minimum obtainable score was “0” in case of no change in any parameter for connection clarity, and “5” which suggested change in all the five parameters. If a case addressed multiple “connection clarity” related problems, I computed the mean value for total scores of each parameter in that case.

A sample analysis of one case was offered to a reviewer for checking any interpretive errors. After he was satisfied, the process was repeated for cases that dealt with connection clarity issues during problem solving.

Pathway Simplification. Based on Spear and Bowen’s research, I define a pathway as a series of connected activities that create and deliver goods, services, or patients. Like activity and connection, the case data was coded as PATH-SB and PATH-SA denoting the statements related to pathway before and after problem solving, respectively. Extending Spear and Bowen’s characterization of a “simple” and “direct” pathway based on our action research, I define “pathway simplification” in terms of three parameters -- branches, loops, and delay:

- branched pathway - refers to the pathway where the supplier of goods or services could use two or more paths to connect with the adjacent customer in the process chain;
- looped pathway - refers to a sequence of steps that is repeated until a particular condition is met; and

- delay - refers to situations where goods and services do not proceed immediately to the next process step causing overall late delivery.

Pathway simplification is thus measured on a 0-3 scale using the three parameters.

Like “activity specification” and “connection clarity,” I followed a similar procedure to measure change in pathway simplification. I compared the before and after states of the pathway to measure the change in pathway simplification as a result of problem solving. For example, if I observed a simplification of multiple paths (individuals followed two or more paths to deliver goods or services based on their personal discretion) to a single path (path designated by a group of individuals to deliver goods or services) due to problem solving and thus became explicit to all, “1” was assigned to that parameter. In my quantification scheme, “1” was associated with positive change and “0” was associated with no change in pathway simplification. This exercise was repeated for loops and delays as well. The scores of each parameter were then summed up to obtain a measure of change in pathway simplification. The minimum score attainable was “0” which meant no change in pathway simplification and the maximum score attainable was “3” which indicated increased simplification in all of the three parameters.

A sample analysis was offered to a reviewer for checking any interpretive errors. Once he agreed, the process was repeated for other cases that dealt with pathway simplification issues during problem solving.

Outcome. Outcome (the dependent variable in this study) was defined as the change in the performance of the process due to problem solving. Outcome measures

varied from one case to another. These variations include the number of denials from Medicare, the amount of lost charges on medical supplies, the number of over-aged bills outstanding, restraint documentation rate and so on.

I compared the performance level before (baseline performance) and after problem solving to measure change in performance. Because the measures were different in each case, I computed them in terms of percent improvement to provide a common datum for comparison across cases. For example, if the lost charges on medical supplies on the Medical-Surgical Floor averaged \$300 per month before problem solving, and after problem solving averaged \$0 per month, the improvement gained would be 100 percent. The level of significance for the study was set at 0.10 due to the exploratory nature of the research (Garsen, 2002).

Results

In total, 18 cases were studied. Two cases were excluded from the final analysis because the participants in those cases were still implementing the actions when reviewed last. Therefore, no results were available for analysis. The participants in the remaining cases addressed either one, or two, or all of the three independent variables depending on the problems they studied. Table 2 displays the rule classification (independent variables), its associated parameters, and the percentage of cases addressing each parameter.

Table 2. Percent of Cases Addressing Design Rule Parameters

Rule classification	Sample size	Parameters	% of cases addressing
Activity specification	13	Outcome	69
		Content	100
		Sequence	85
		Timing	0
Connection clarity	14	Requester	22
		Responder	39
		Method of transfer	35
		Notification	43
		Response time	96
Pathway simplification	14	Branched	57
		Looped	93
		Delay	64

Qualitative Findings

The next stage of the analysis involved a qualitative cross-case analysis of the 16 cases. I categorized the magnitude of process outcome into three different categories: large change, medium change, and small change. The intent was to ascertain if a relationship might exist between the degree of change in activity specification, connection clarity, and pathway simplification (independent variables) individually with the magnitudes of change in outcome (response variable). Table 3 presents the results. The table demonstrates a pattern: a higher degree of change in activity specification is observed with large changes (68%-100%) in outcome. A higher-medium degree of change in connection clarity is observed with large changes in outcome. A higher degree of change in pathway simplification is associated with large changes in outcome. Likewise, medium changes in activity specification, medium-low changes in connection clarity, and medium-low changes in pathway simplification were observed with medium

changes (34%-67%) in outcome. In a similar vein, a mix of medium to low changes in activity specification, connection clarity, and pathway simplification are observed with low changes in outcome (0-33%).

Table 3. Degree of Change Measured in Design Rule Variables versus Percent Improvement in Performance

Magnitude of Change	Degree of change in Activity specification	Degree of change in connection clarity	Degree of change in pathway simplification
Large Change (68% - 100%)			
Informant 2	High	Low	High
Informant 3	Medium	Medium	Medium
Informant 5	High	Medium	High
Informant 6	High	Medium	High
Informant 7	Medium	High	High
Informant 10	High		
Informant 12	High	Medium	High
Informant 16	High	High	High
Informant 17	High	High	High
Informant 18	High	High	High
Medium Change (34% - 67%)			
Informant 4		Low	Low
Informant 8	Medium	Low	Low
Informant 13		Medium	Medium
Small change (0 - 33%)			
Informant 1	Medium		
Informant 9	Low	Low	Low
Informant 11		Medium	Low

Quantitative Findings

Table 4 presents the correlations among the predictor and outcome variables. The results indicate that the activity specification and pathway simplification are significantly correlated with the outcome. The connection clarity is positively correlated but moderate at ($r = 0.445$, $p = 0.08$). However, given the nature of qualitative data used in the analysis, such p values cannot be ignored. A strong positive correlation exists between connection clarity and pathway simplification suggesting collinearity. Specifically, connection is the interaction between two adjacent suppliers and customers in the pathway, and pathway is a series of connected activities. In essence, connection clarity is confounded within pathway simplification.

Table 4. Pearson Correlations of Design Rule Variables and Process Improvement Outcome

Variable	Activity specification	Connection clarity	Pathway simplification	Outcome
Activity specification	1			
Connection clarity	0.16	1		
Pathway simplification	0.38	0.83***	1	
Outcome	0.76***	0.44*	0.65***	1

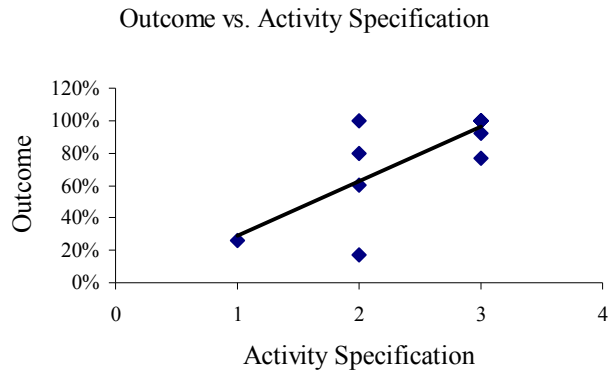
*** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$

To test the hypotheses relating outcome (dependent variable) to activity specification, connection clarity, and pathway simplification (independent variables), I conducted a multiple regression analysis on the 16 cases. In cases where less than three parameters

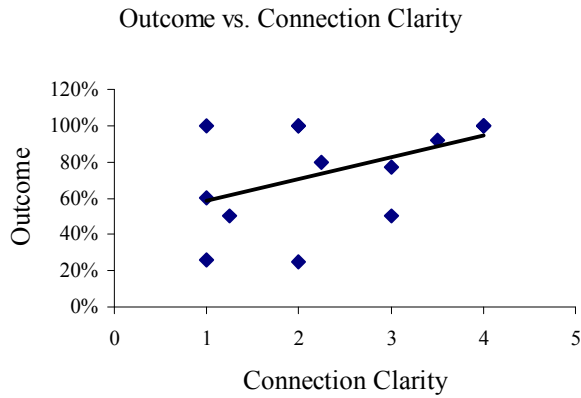
were addressed during problem solving, I assumed “no change” in those un-addressed parameters and used “0” for subsequent computation. Prior to running the regression analysis, linearity of each independent variable with respect to the outcome variable was checked by drawing the bivariate scatter plot (Figure 2). For each plot, some of the data points have the same scores and overlap. The plots indicate an upward trend suggesting that the independent and the dependent variables are positively related. The normality of the data was ascertained statistically for each construct and the variables conformed to normality assumptions of regression analysis. Using Minitab 14.0 software, I constructed three multiple linear regression models with outcome as the dependent variable and activity specification, connection linearity, and pathway simplification as independent variables. Since each model was significant as indicated by the F-ratios, I also checked for homoscedasticity by calculating the residuals from the predicted values and plotting them against the predicted values. The plots did not show any obvious pattern. The regression results are summarized in Table 5.

The first model includes the activity specification and connection clarity as the independent variables and outcome as the dependent variable. The activity specification is found to be a significant predictor of outcome, thus lending significant support to H1. The connection clarity also predicts outcome, though weakly supporting the H2. The overall model is significant. The first model explains 69% (R^2) of the variation in the outcome with an associated significance at $p < 0.01$.

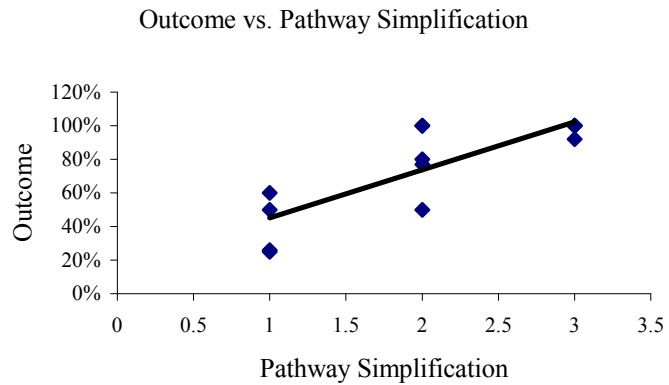
Figure 2. Scatter Plot of Design Rule Variables versus Percent Improvement



1a. Outcome vs. Activity Specification



1b. Outcome vs. Connection Clarity



1c. Outcome vs. Pathway Simplification

Table 5. Results of Regression Analysis on Design Rules

Variable	Model 1	Model 2	Model 3
Activity specification	0.19***	0.16***	0.16***
Connection clarity	0.07*		0.00
Pathway simplification		0.12**	0.12
R ²	0.69	0.73	0.73
Adjustment R ²	0.64	0.69	0.67
F-value	14.44***	17.89***	11.01***

***p < 0.01; **p < 0.05; * p < 0.10; N = 16

The second model displays activity specification and pathway simplification as the independent variables and outcome as the dependent variable. The activity specification is a significant predictor of outcome, thus H1 is supported. Pathway simplification is also a significant predictor, thus supporting H3. The overall model is significant and explains 73% of the variation in the outcome at $p < 0.01$.

The third model includes all the variables (independent and dependent). The activity specification is a significant predictor, thus supporting H1. The other two variables are insignificant predictors of outcome, most likely due to collinearity. The model explains 73% of the variation in outcome at $p < 0.01$. Though all the models are significant, the second model provides the best explanatory power for the variation in outcome, as indicated by the adjusted R² statistic.

Discussion

Extant literature on operations management claims lean manufacturing system or TPS as the best production system model devised to date to transform manufacturing organizations. However, little research exists on the application of the TPS design rules in the non-manufacturing sector such as healthcare. This research addresses that gap. This paper, I think, is the first research attempt to examine the effects of the rules to design work processes in a non-manufacturing environment and incorporates a blend of qualitative and quantitative approaches. Additionally, it extends and validates Spear and Bowen's (1999) work by providing evidence that Rules-in-Use are effective not just for manufacturing but also for non-manufacturing sectors such as healthcare.

This paper points to a number of interesting and potentially important findings that can advance theory and inform practice. The following paragraphs summarize and discuss the findings.

First, I examined the impact of increased activity specification on outcome and the empirical results (regression models 1, 2, and 3) provide evidence of strong positive association, thus supporting H1 (that increased activity specification leads to better outcome). Further investigation of the data (Table 3) revealed that higher degrees of change in activity specification were associated with higher degrees of improvement, which led to an interesting observation: TPS design rule 1 on activity specification provides better results when more of the design parameters are addressed in redesigning work. In simple terms, specifying 'content' is good but specifying 'content' and 'sequence' is even better in terms of process outcome.

While analyzing the activities that were addressed during problem solving, I noticed a general pattern in outcome, content, and sequence. The pattern suggests that most activities before the problem solving either lacked one or more of the design parameters or were ill defined. Further investigation indicated that in most of the work processes, the present actors followed the process they inherited from their predecessors without questioning its efficacy. As one informant commented on the existing surgery specimen collection and labeling procedure before problem solving, “The steps were touched upon but not clearly laid out step-by-step.” Likewise, when I questioned an informant about the existence of any protocol in H.I.M. for transcribing procedures, she said, “Not yet. Somewhat! It is not all written...It needs to be more monitored.”

Spear and Bowen (1999) suggest that all activities need to be specified in terms of content, sequence, timing, and outcome. They do not explicitly discuss the order of such specificity though one would be inclined to assume from their study that content needs to be addressed first, then sequence, then timing, and finally the outcome. The findings of this research suggest that the participants first decided on the desired outcome and then worked backwards to design their activities in terms of content and sequence to achieve the desired end. Such ordering of specification in designing activity seems to make sense because designing content or sequence is a futile exercise unless outcome is ascertained beforehand. Moreover, it established activity specification as a continuum (outcome→content→sequence→timing). This observation, in effect, refines Spear and Bowen’s (1999) model of specifying activities.

It is implied from Spear and Bowen’s work that in specifying an activity, one would first define content, next sequence, and then timing. Undoubtedly, a high level in

specificity is achieved when the tasks within an activity are timed. After all, timing of tasks is a critical aspect of superior performance. In a manufacturing set up, such specificity sounds logical and possible because processes are usually repetitive in nature and every task is very well defined. However, findings of this research suggest that for healthcare, increasing specification of activities seems to improve process performance even if timing is not done.

The results of the first regression model suggest that connection clarity moderately supports H2 (i.e., increased connection clarity leads to better process outcome). Further examination of the data revealed that high performing cases addressed more of the parameters in connection clarity compared to medium or low performing cases. In addition, the classification of “connection clarity” in terms of five distinct parameters (Requester, Responder, Method of Transfer, Notification, Response Time) is more effective in building better connections than the characterization (direct, send, and receive) provided by Spear and Bowen, thus refining their description of connection to suit the healthcare context.

The results of the second regression model indicate positive association between increased pathway simplification and outcome, thus lending support to H3 that increased pathway simplification leads to better process outcome. Spear and Bowen describe the ideal pathway as “simple” and “direct.” The term “pathway simplification” was defined in this research in terms of “branch,” “loops,” and “delay” because such characterization closely resembled the pathways observed, and it was much simpler for an individual to compare changes due to problem solving using those terms.

In the case of CMC, most of the paths to provide goods and services were exceedingly complex and often indescribable before the problem solving. The participants, while solving problems, experienced difficulties in drawing a diagram of the existing process, which suggests they were unable to comprehend it properly. One informant nicely summed up her observations while drawing the pathway for the current state:

I started with the actual current state drawing, which the RNs did not like it, as it was very complicated to understand [SIC]. Too confusing! They could not see any process. Too much variability! There was no control. There were no contacts between RN to RN. I had to simplify my drawing of the current state to make it understandable to the RNs.

The problem solving process facilitated cross functional interaction which enabled all the participants to have an in-depth and holistic understanding of the total path from beginning until end and how one department affected or was affected by others in the process chain. This understanding of the total path provided them with deep insights to develop an integrated process with minimum complexity. The results of the study seem to reinforce the general trend today in defining pathways in various processes in healthcare to improve outcome, coordination, and to reduce costs. The finding is also very encouraging and significant given the fact that other researchers, in the past, have voiced concerns over the lack of communication and integration across departments in healthcare settings (Shortell et al., 2000; Adler et al., 2003; Begun and Kaissi, 2004). The finding of the study is also in agreement with the argument of Roberts and Bea (2001) who argue that high reliability organizations continuously provide their employees with the bigger picture and attempt to get everyone to communicate with each other about how they fit into the bigger picture.

The second regression model provides the best explanation for the variation in the outcome. In other words, specifying activities and simplifying pathways will lead to improved results. However, simplification of the pathways was possible because many unclear connections within the pathway were addressed during problem solving. In fact, the correlations between pathway simplification and connection clarity were found to be highly significant ($r = 0.827$ at $p < 0.01$). Put another way, designing activities and developing clear connection through our characterization will essentially lead to simplified pathway and improved outcome.

This research study demonstrates at a deeper level why healthcare and possibly other organizations fail to perform effectively. At a broader level, experts claim that healthcare fails to deliver proper care due to a poor system (Kohn et al., 1999). Such understanding highlights the problem but does not explain poor performance. Spear and Bowen's model on Toyota's work practices enabled closer examination of work processes by deconstructing the process into activity, connection, and pathway and examining each one of them. At a micro-level analysis, the research revealed that the basic ingredients of designing work processes were missing, which likely would not have surfaced otherwise.

An issue that the informants persistently raised during the interviews concerned accountability in work. Most of them felt that accountability was generally missing in many cases, which led most actors in the process to accept poor performance without much upheaval. In many work processes, roles and responsibilities were not clear for the actors, and in many cases, responsibilities were overlapping. Given the nature of the work environment in healthcare, overlapping responsibilities seems plausible because patient

care is the primary concern and needs to be delivered without any delay. On the contrary, as Toyota argues, if a task is anybody's responsibility it is tantamount to nobody's responsibility. In fact, Spear's (2005) observation in other hospital sites supports our findings. One of the findings that emerged from the problem solving effort with TPS design rules is that the application of these rules clearly delineated the roles and responsibilities (inherently built into the first two Rules-in-Use) of all actors in the process, which ultimately made all actors responsible for their behavior and performance, and ensured greater consistency in their tasks. More than 50% of the informants felt their old policies and procedures were inadequate and revised them using the TPS design rules to incorporate well-defined responsibilities for strict conformity. Some informants during the interview expressed their desires to create policies and procedures for many work processes, which had not been written down before and had been carried out based on individual discretion. One informant mentioned, "The activities in the process were not clearly defined. The registration clerk never saw the insurance cards. It was not there in their job description." Consider a comment from another informant:

Although I don't always complete A3s they have helped me begin process improvement in other ways. For example, I have compiled different notebooks to centralize speech therapy information and have written protocols for procedures we do that haven't been written down before. These types of improvements have reduced run around and non-productive time. It greatly improved communication of typical procedures to staff who don't normally do them.

A third informant characterized TPS during the interview:

The beauty of TPS has been that it makes job description very important. It stresses correct policies and training of personnel. In order to ensure that all information is passed on to the next person, you have to have policies. Standardization makes a person sleep walk one's way through. It wakes you up if it is different. It alerts about a problem when it is different. Electronic media is so impersonal and standardized.

The results of this research have potential implications for broader organizational theory. Scholars (e.g. Lawrence and Lorsch, 1967 as cited in Scott, 2003) distinguish between mechanistic and organic organizations. They argue that bureaucratic or mechanistic organizations (industrial organizations such as Toyota), driven by formalized rules and procedures, are appropriate when the work environment is certain and stable. In contrast, organic organizations with few rules and procedures are suitable for an environment characterized by uncertainty and turbulence.

It is true that the environment in healthcare is uncertain to an extent. For example, technological advances are being made in many sectors of healthcare such as diagnostic procedures, computerized physician order entry systems, medication dispensing systems, laboratory procedures, admittance procedures and so on, which makes the healthcare environment uncertain. Galbraith (1977) suggests that "the greater the task uncertainty, the greater the amount of information that must be processed among decision makers during task execution in order to achieve a given level of performance." I also note turbulence in healthcare. For example, no two patients walking into a healthcare facility have similar complaints. By the same token, the number of patients visiting everyday is likely to be different.

A careful investigation of data on the nature of complaints of the patients over a certain period of time will possibly reveal a pattern. The caregivers may generally have a fairly good idea about the nature of complaints patients report everyday. Therefore, they are well aware of their remedies based on their past experience. Similarly, the laboratory personnel may be cognizant about what tests are requested on a routine basis and are therefore knowledgeable about the test procedures. I contend that most of these procedures are routine in nature even though they appear to be non-routine on the surface. My argument is that those procedures that are repetitive in nature can be designed and improved upon using four Rules-in-Use, which will enable employees to provide a consistent level of superior performance. Stated differently, TPS design rules provide a concrete mechanism to address stable, as well as uncertain and turbulent, environments organizations are faced with.

Limitation and Directions for Future Research

This research is the first empirical effort to test the applicability of the TPS rules in a non-manufacturing environment, i.e., healthcare. I hope the research will open up new vistas in the world of TPS research in the non-manufacturing environment. However, this study is not without limitations and, therefore, the results of the study need to be interpreted with caution and care because it was based on the experience of only one mid-sized healthcare organization. Therefore, the results cannot yet be generalized to other healthcare organizations. Researchers in the future should strive for a broader sample of organizations across healthcare to replicate and extend these results.

Even though experimental research using treatment and control groups help establish causality, such manipulation of the subjects was not possible in this study. However, a quasi-experimental design using replication logic suggested by some scholars Campbell et al. (1966) may help in establishing causality with real-life data.

Another limitation of this study is that I had been able to track sustainability of outcome over a period of one year (maximum) in most cases. However, there is always a possibility of regressing to old ways by the organizational members. Therefore, as Speroff and O'Connor (2004) suggest, ideally, one should study interventions over time to reinforce the conclusion that the change in outcome was indeed due to the intervention effect. Limitations aside, the empirical results of this research supported the hypotheses, which may be a good base for stimulating future empirical research.

Conclusion

Despite the limitations discussed above, this study provides several important contributions to the existing body of literature. Notably, applying TPS design rules in a non-manufacturing environment, i.e., healthcare, served to extend and validate Spear and Bowen's (1999) model. The results indicate that the reliable performance of many work processes is positively related with the design Rules-in-Use. Thus, increase in activity specification, connection clarity, and pathway simplification is associated with improved performance.

Spear and Bowen (1999) argue that Toyota strives to make every connection direct and unambiguous. In this research, I extend Spear and Bowen's characterization of connections to articulate five parameters - requestor, responder, method of transfer,

notification, and response time. Such a characterization is more actionable and helps in the design of clear, robust connections in a healthcare context. Similarly, I articulated three specific parameters for pathways – branched pathway, looped pathway, and delay – that result in, to use Spear and Bowen’s definition, direct and simplified pathways in a hospital setting. I also attempted to define activity specification, connection clarity, and pathway simplification on a continuum to measure change. Though such quantification is a crude measure of performance, nonetheless it provides an objective way of comparing the before and after states of a process due to problem solving.

While working on this research, I felt that understanding and attending to every detail in work design is critical for superior work performance. A lack of understanding of such details leaves enormous scope for variability among individuals in executing work and the ill effects of such variability are more pronounced in human intensive organizations such as healthcare. The TPS design rules with the necessary alterations as outlined above provide an actionable mechanism to deeply investigate and improve work processes in a healthcare context.

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CHAPTER 3

EFFECTIVE METAROUTINES FOR ORGANIZATIONAL
PROBLEM- SOLVING

The topic of how to deal with process-related problems and produce sustainable change continues to challenge organizational researchers. Scholars assert that organizations, when faced with a problem, should adopt short-term measures as a first step to tide over the immediate crisis, but as a second step should investigate the process critically and jointly to find and remove the root causes to prevent a recurrence (Hayes et al., 1988). Yet, Feigenbaum (1991) reports rarity in applying the second step, and today the trend persists (Tucker and Edmondson, 2002, 2003; Tucker et al., 2002). Organizations, therefore, continue to find sustainable change of work systems a significant challenge.

The organizational routines that result in short-term fixes to operational problems have been termed “first-order problem solving.” For example, a nurse detects a shortage of a medical supply in the supplies closet and enacts some routines – asks others, looks in other places, or borrows from another department – to prevent an interruption in providing care. If the nurse or the nursing team stops there, the immediate crisis is resolved, but the same scenario will likely recur because the root cause(s) to the problem have not been addressed. If, on the other hand, the nurse/nursing team investigates why the stock was depleted and implements countermeasures to prevent recurrence, the result would be a long-term solution to the problem (i.e., a sustainable change) that improves operational performance. Researchers have termed the organizational routines that

produce these higher levels of insight, and thus sustainable improvement, as “second-order problem solving.”

Improving healthcare work processes has received considerable attention in recent years. Healthcare is an important and vital sector of the economy, but one that continues to grapple with systemic issues (Tucker, 2004). To cite a few examples, healthcare organizations face the difficulty of providing the right quality of service to its customers, i.e., the patients. Individuals have difficulty in communicating and coordinating activities across departments as they lack common knowledge and values. They also confront the issue of delays in providing services to their customers. Dealing with some of these issues requires second-order problem solving. But research has found that most healthcare individuals are less inclined to engage in collaborative second-order problem solving (Tucker and Edmondson, 2003). This difficulty is not localized to healthcare; it seems to persist in many other sectors of the economy (Argyris, 1993). Therefore, how to promote second-order problem solving in the continuous improvement of organizational operations remains a topic of ongoing research.

I suggest that effective *metaroutines* can facilitate second-order problem solving to produce sustainable changes in organizations. According to Adler and his colleagues, a metaroutine is a standardized problem-solving procedure to improve existing routines or create new ones. They find that Toyota has been successful in the marketplace for decades because it continues to improve existing work routines, and that use of metaroutines is at the heart of such improvement (Adler et al., 1999). On a similar note, Tucker (2004) advocates the development of problem solving procedures to address work related failures. Nevertheless, the concept of metaroutines is still not well understood. In

an effort to examine the impact of metaroutines on organizational work processes, Sobek and Jimmerson (2003, 2004) adapted a metaroutine from Toyota to apply in healthcare and introduced second-order problem solving. The central purpose of this research was to investigate empirically whether this metaroutine, the A3 Process, produces sustainable change, if so, to explain its efficacy. To address this issue, the effects of the A3 Process implemented in diverse functional departments were systematically studied using a grounded theory approach.

In the next section, I review the literature on process-related problem solving and the role of two widely known quality initiatives: Total Quality management (TQM) and Six Sigma. Then, after presenting some background information and the research methodology, I present results from 18 cases that suggest adherence to the steps of the A3 Process significantly correlated with higher-order improvements. Next, I offer two models to explain, on one hand, why organizational members tend to adopt first-order problem solving when a metaroutine is not in place; and on the other hand, how the A3 Process produced the necessary motivation for second-order problem solving for a lasting resolution. I conclude by offering three characteristics of an effective metaroutine as implied by the models.

Literature Review

Many organizational procedures or routines exhibit abnormal variation or problems. From extensive field research in manufacturing enterprises, researchers observe that organizational members address process-related problems by two kinds of process control: reactive control and preventive control. Reactive control involves some

immediate measure (or work around) to bring the process back within its acceptable range when it strays outside due to some abnormal variation. In preventive control, effort is focused on pinpointing and eliminating the underlying sources of the abnormal variation within the process through deeper investigation of the causes and their effects. However, in most real world situations, members must implement some form of reactive control to tide over the immediate crisis of maintaining the production, before investigating deeply the real sources of the problem (Hayes et al., 1988).

Thus, reactive control often precedes preventive control because it helps people to accomplish their immediate objectives. But such improvements tend to be ephemeral in nature because they rarely prevent recurrence. As a consequence, sustainable process change fails to materialize unless subsequent deeper investigation takes place. The key to enduring process improvement hinges on challenging the assumptions of the existing processes and developing new ways to accomplish the work. This distinction between reactive control and preventive control is analogous to Repenning and Sterman's (2002) first-order improvement versus second-order improvement, Argyris and Schon's (1978) single-loop learning versus double-loop learning, and Tucker and Edmondson's (2003) first-order problem solving versus second-order problem solving. For convenience, we will use Tucker and Edmondson's terminology throughout this paper.

Problem Solving and Metaroutines

I argue that a metaroutine can be very useful for challenging prevailing conditions by developing and implementing newly shared understanding, which is at the heart of preventive control and sustainable change. A metaroutine is described as a standardized

problem solving procedure for changing existing routines and for creating new ones (Adler et al., 1999). However, for a metaroutine to promote second-order problem solving, it needs to capture certain elements: communication, shared investigation, and experimentation (Tucker and Edmondson, 2003). Adler et al.'s (1999) empirical study in NUMMI finds that the workers achieved high efficiency in their day-to-day work and yet were very creative in improving routines collaboratively using a six-step standardized problem solving procedure, i.e., a metaroutine. Though metaroutines may inhibit innovation by systematizing the creative process, Tyre et al. (1995) find from their field study in a manufacturing environment that organizational members achieve better quality and robust solutions using a systematic approach, compared to intuitive approaches.

Metaroutines have been around for at least several decades. In fact, Total Quality Management (TQM) and Six Sigma quality initiatives each embody a specific metaroutine. TQM in the management literature is viewed at three levels: a philosophy, a set of tools, and a metaroutine that integrates the tools with the philosophy. TQM philosophy, as espoused by the quality gurus such as W. Edward Deming, Joseph Juran, and Kaoru Ishikawa, suggests that the primary purpose of an organization is to remain in business by reducing variability in work processes and by producing products that satisfy its customers and at the same time promoting the satisfaction and growth of its members (Juran, 1969; Ishikawa, 1985; Deming, 1986 as cited in Hackman and Wageman, 1995). At the tool level, TQM is viewed as a collection of seven classical statistical process control tools (pareto chart, cause-and-effect diagram, histogram, control chart, scatter diagram, check sheets, and run charts) and seven management tools (affinity diagram, tree diagram, matrix diagram, matrix data-analysis diagram, process decision program

chart, and the arrow diagram). Connecting the philosophy with the tools is a systematic approach to solving process-related problems called the plan–do–check–act, or PDCA, cycle (Deming, 1986). PDCA can be seen as a metaroutine that governs the use of statistical tools in achieving the TQM philosophy.

Likewise, the primary philosophy of Six Sigma like TQM is to reduce variability in processes (Harry and Schroeder, 2000). The DMAIC (Define, Measure, Analyze, Improve, and Control) cycle, embedded in Six Sigma, is a structured problem solving methodology, patterned after the PDCA cycle that can also be seen as a metaroutine. Like PDCA, DMAIC governs the use of statistical process control tools and other advanced statistical tools such as hypothesis testing, multiple regression, design of experiments, and so forth to achieve the Six Sigma philosophy.

Extant research literature on TQM reports that, even though TQM has been in existence for many years now, in most cases, its success has been limited (Hackman and Wageman, 1995; Zbaracki, 1998; Keating et al., 1999; Rigby, 2001; Reppenning and Sterman, 2002). Some scholars report that TQM over the years has gradually shifted from scientific problem solving, the most distinctive feature of TQM, to rhetoric (Hackman and Wageman, 1995; Zbaracki, 1998). In his study of 69 TQM programs in five sectors (defense, government, healthcare, hospitality, and manufacturing), Zbaracki (1998) reports surprisingly limited use of statistical tools and little evidence that organizational members used the PDCA cycle in problem solving. In fact, PDCA fails to find a place in much of the literature on TQM that deals with its tools and techniques. This might explain why second-order problem solving and lasting change in organizations using TQM are rare. On a similar note, little empirical research on Six Sigma, other than the

“best practice” studies by consultants or practitioners (Linderman et al., 2003) exists, so our understanding of Six Sigma and the DMAIC metaroutine is limited.

Thus, TQM and Six Sigma are powerful quality initiatives but their effectiveness in effecting second-order problem solving appears to hinge upon their respective embedded metaroutines. The existing literature on TQM and Six Sigma suggests that the importance of the metaroutine as an effective medium of second-order problem solving still remains largely unclear to managers. The role of metaroutines in achieving enduring change also appears underemphasized in academic research. Therefore, although metaroutines seem important to lasting process improvement, much remains unknown about what characteristics of a metaroutine are important and how to make them effectual.

Metaroutines in Healthcare

The context for this paper is healthcare, a vital sector in the U.S. economy. United States healthcare spending is expected to reach \$3.4 trillion (18.4% of GDP) from \$1.8 trillion in 2004 (15.5% of GDP) in just a decade (Biotech Week, 2004). Despite its critical role in the U.S. economy and its impact on the lives of people, it lacks sound operating systems. Many experts say that the United States has the most expensive healthcare system in the world and its costs are rising (Berry et al., 2004; Bodenheimer, 2005). Even though costs are rising, service quality continues to remain unsatisfactory and uneven (Porter and Teisberg, 2004). A significant body of literature addresses numerous cases of medical errors and injuries due to poor service. A recent article even

reports that adults receive only 55% of the recommended care for their health conditions (McGlynn et al., 2003). In simple terms, healthcare is in crisis.

Like many other sectors, healthcare leaders did employ TQM to address the systemic issues. And similarly, the literature reports diminishing levels of scientific problem solving (Ovretviet, 1997, Blumenthal and Kilo, 1998; Shortell et al., 1998), and dominance of short-term approaches or work arounds to address problems (Tucker and Edmondson, 2002, 2003; Tucker et al., 2002). Compounding these findings is a lack of empirical research to examine its efficacy (Bigelow and Arndt, 1995, 2000; Ovretveit, 2002). However, Walley and Gowland's (2004) study is a notable exception. They find that the managers in one research site misinterpreted the key steps of the PDSA (Plan, Do, Study, Act – an adaptation of PDCA approach used in healthcare); for example, members assumed the causes of the problem without prior analysis and did not measure the performance of the implemented solutions.

The question that confronts us is how to design a metaroutine that would promote second-order problem solving and sustainable change in organizations. In an effort to answer that question I investigate the effectiveness of a metaroutine and offer some characteristics that drive such change. By doing so, this paper addresses a significant gap between research and practice on metaroutines. Even though this work focuses on one research site, a healthcare facility, I suggest that the model seems to have relevance for other organizations as well. I studied the intervention process in diverse functional departments of the hospital operations (clinical and non-clinical), finance, and support services, which has a similar functional set-up to many organizations. In addition, the healthcare sector, like most sectors, faces the challenge of “fighting fires” by using first-

order problem solving to keep the services running, yet needs to address the systemic issues using preventive control to remain competitive in a dynamic environment.

Background

From prior research, Sobek (2004) found that Toyota Motor Corporation, one of the most successful car manufacturing companies in the world, uses a structured problem solving methodology as a metaroutine to improve its internal work routines. The metaroutine, inspired by the PDCA approach, is a source of its competitiveness in the market place (personal communication). The metaroutine uses a tool, the A3 Report, which captures the key results of the major steps of the metaroutine on one side of size A3 paper, metric equivalent of 11”×17” (Sobek et al., 1998). Sobek and Jimmerson (2003, 2004) adapted Toyota’s problem solving methodology by articulating nine essential steps to apply in a mid-sized hospital. The nine steps of the A3 Process after a problem has been identified are:

1. Observing the current process;
2. Drawing a diagram to represent the current process;
3. Determining the root causes to the problem by asking “5 Whys”;
4. Developing the countermeasures based on the design rules to address the root causes to the problem;
5. Drawing a diagram of the envisioned process (target process) based on consensus with the affected parties;
6. Planning the implementation;
7. Discussing all of the above with the affected parties;

8. Implementing the actions planned; and
9. Collecting follow-up data on the outcome of the new process and comparing it against pre-specified targets.

Steps 1 through 7 refer to the “Plan,” step 8 refers to the “Do,” and step 9 refers to the “Check” stages of the PDCA cycle. The “Act” step is the creation of new organizational work routines using the design rules when they prove worthy in step 9. These nine steps provide an approximate order of solving problems. In fact, the steps could be iterative, as the problem solver may need to go back to previous steps in order to refine them. Additionally, reevaluation of the subsequent steps follows in light of the refinements.

In the initial stages of the collaborative effort, i.e., between May – September 2001, the principal investigators tried the tool and the metaroutine in the cardiology department of a mid-sized hospital and refined them based on their field experience. Later on, they developed a seven-week introductory training course materials and tested the refined metaroutine in the pharmacy department (Sobek and Jimmerson, 2003). Over the next 1.5 years, Jimmerson provided hands-on training to over 150 employees of the hospital on how to use the metaroutine and additionally wrote a workbook to accompany the training course materials developed earlier. Furthermore, she and others also experimented with the metaroutine at other hospital sites (Jimmerson et al., 2005).

In June 2003, I joined the team and spent six months at the site as a participant-observer and initially learned to use the problem solving methodology. I obtained first-hand understanding of how the employees in the hospital were addressing problems in the absence of a metaroutine. Using the metaroutine, I then facilitated some fourteen

problem-solving exercises and observed the change in behavior of individuals as they participated in those change efforts. While facilitating, I also trained “coaches” on how to use the metaroutine. All these field-based activities shaped my understanding for framing the research question to be investigated and the research methodology to be adopted.

Research Methodology

The work noted above provided preliminary evidence that the metaroutine seems effective in healthcare. However, I wanted more explanation for why it worked; but to my knowledge, no empirical research existed that examined its effectiveness. Thus, to generate novel and accurate insight about why the metaroutine is effective, a grounded theory approach was adopted (Strauss and Corbin, 1990, 1998; Cresswell, 1998).

Data Collection

In June 2004, I returned to the hospital site to collect data on my research intent and selected eighteen cases that involved addressing process related problems using the A3 Process. Cases were selected where employees had been trained in using the A3 Process and the A3 report, and where a process improvement effort was finished, or nearly so. They were picked from diverse functional departments such as Heart Center, Laboratory, Intensive Care Unit, Rehabilitation Unit, Registration, Hospital Information Management (H.I.M.), Transport, Quality Risk Management, Patient Financial Services, and Facilities. The majority of them were studied and resolved under the guidance of a coach other than me.

As part of the primary data collection, I conducted semi-structured interviews. The informants represented every level in the organizational hierarchy (directors, managers, registered nurses, therapists, technicians). The questionnaire asked participants to describe the process they used to address the problem in detail. Additional questions probed participants about what they thought was important about the metaroutine as a process improvement technique in their facility and why. The intent was to gain a deeper understanding of any step they thought essential to problem solving and the reasons thereof. For example, if an informant mentioned “observation” as a critical step, I sought to understand why s/he thought it to be critical. Similarly, if an informant claimed that s/he carried out an experiment, s/he was asked to explain why s/he felt it was important to conduct an experiment and what s/he learned from it.

Before conducting the interviews, an Industrial Engineering professor at Montana State University, with many years of experience in qualitative research methods, checked the list of interview questions for reliability. All informants were informed in advance about the intent of the interview. The interviews lasted between 60-90 minutes and took place in a location such as the informant’s office, a conference room, or the hospital’s cafeteria. In some cases, multiple interviews were conducted to complete the collection of data. During the interview, I took field notes by hand, and immediately thereafter I typed up an interview report based on the field notes and my memory and gave it to the informant to check for factual and interpretive errors. The informants returned the reviewed document within 48 hours.

Though the primary data were the interview notes from the lead problem-solvers, the A3 problem solving reports from each informant were also collected to triangulate the

findings of the interview. I also conducted informal interviews with other individuals who had some stake in the processes studied. To triangulate even further, I collected a wide range of other artifacts such as electronic mails that were exchanged between problem solvers during problem solving, and meeting minutes of Quality Council and Safety Council. Finally, I maintained contact with informants by email or phone for 12 months following the interview to obtain follow-up quantitative data on process performance and to clarify questions that arose in case development.

Analysis Approach

The data were analyzed at two levels: (1) a first-order cross-case comparison and (2) an in-depth analysis using a grounded theory approach. The objectives behind first-order analysis were to ascertain how well participants adhered to the A3 Process to ensure its effectiveness. The A3 report and interview notes were carefully reviewed to make an objective assessment as to which steps of the metaroutine were followed. If a step was executed as trained, I construed that as “completed.” If the participants did not skip the step but failed to follow it as per the instructions provided during training, or partially completed it when reviewed last, I labeled that step “partially completed.” Any step in the metaroutine that was skipped was considered “not completed.”

In some cases, steps in the back end of the metaroutine (e.g., discuss, execute, follow-up) were not completed when I interviewed the participants. In those situations, the informants were once again contacted by telephone or email to ascertain the status of those steps. A comparison chart was then prepared (Table 6) to summarize the findings.

Table 6. Summary of the Metaroutine Steps Followed by the Participants

	Observe	Draw current process	Analyze root cause	Develop c/measures	Draw target process	Plan implementation	Discuss	Execute	Follow-up	The A3 Process followed	% Improvement
Case 2	●	●	●	●	●	●	●	●	●	Y	100%
Case 5	●	●	●	●	●	●	●	●	●	Y	100%
Case 6	●	●	●	●	●	●	●	●	●	Y	100%
Case 7	●	●	●	●	●	●	●	●	●	Y	100%
Case 10	●	●	●	●	●	●	●	●	●	Y	100%
Case 16	●	●	●	●	●	●	●	●	●	Y	100%
Case 18	●	●	●	●	●	●	●	●	●	Y	100%
Case 17	●	●	●	●	●	●	●	●	●	Y	92%
Case 3	●	●	●	●	●	●	●	●	●	Y	80%
Case 12	●	●	●	●	●	●	●	●	●	Y	77%
Case 8	●	⊙	●	●	⊙	●	●	●	●	N	60%
Case 4	●	●	⊙	●	●	●	●	●	●	N	50%
Case 13	●	●	●	●	●	●	●	⊙	●	N	50%
Case 9	●	●	●	●	●	●	⊙	⊙	●	N	26%
Case 11	●	●	●	●	●	●	⊙	●	●	N	25%
Case 1	●	●	●	●	●	●	⊙	●	●	N	17%
Case 14	●	●	●	●	●	●	●	○	○	N	0
Case 15	○	⊙	⊙	●	⊙	●	⊙	○	○	N	0

Legend: ● Step completed, ⊙ Step partially completed, ○ Step not completed

In order to explain the results of the first-order analysis, a deeper investigation was carried out using a grounded theory approach (Strauss and Corbin, 1990, 1998; Cresswell, 1998). Though the interview report from each informant was the primary source of data, all of the artifacts related to a case were considered to get a comprehensive picture of what the problem was and how it was resolved using the metaroutine. Thus, all documents related to a problem were linked together and entered into Atlas Ti software for coding.

First, all the artifacts (interview reports, emails, meeting minutes) were read several times for salient categories of information related to problem solving and were open coded. After completing all eighteen cases, the data were revisited to look for additional codes, until no new insight was found. Some of these codes were then grouped into a higher order category due to similarity. Next, I divided the categories derived from open coding into “Without A3 Process” and “With A3 Process” groupings. I performed axial coding on the “Without A3 Process” categories to try to understand the relationships among categories to explain what inhibited second-order problem solving in the research site and developed a model. Likewise, I did similar coding on the “With A3 Process” categories to explain why the A3 Process prompted second-order problem solving. From the axial coding, a second model was developed to explain the phenomenon of instituting second-order problem solving. The Industrial Engineering professor examined the artifacts and documents against the analysis to check any interpretive errors. The resultant models were then tested against the empirical data (interview reports) to check their validity.

Results

The results of the first-order analysis indicate that ten of the eighteen cases studied followed all the steps of the metaroutine and the magnitude of improvement ranged from 77% to 100% (see Table 6). In contrast, those that skipped one or more steps realized improvements that ranged between 17% and 60%. These results seem to indicate that adherence to all the steps of the A3 Process significantly correlated with higher order improvement, and that sacrificing even one of the steps resulted in a significant decrease in its effectiveness.

The grounded theory analysis of the data from the 18 problem solving efforts resulted in two contrasting models. The following sections present the two models in the context of an actual case. For each model, I first describe a case of labeling specimens collected from the patient in the operating room (OR), and transporting the specimens to the hospital's laboratory for diagnosis and testing. I then critique the case to elicit the key features of the model.

Problem-Solving Without an Effective Metaroutine

The first case description illustrates typical problem-solving routines when an effective metaroutine for problem solving is not enacted.

The physicians in the OR collect samples (blood, bodily fluids, human tissue) from patients for various diagnostic tests. They handed specimens over to the OR circulator, who was responsible for recording information, dispatching specimens, and managing equipment in the OR. Usually, the physician verbally provided all pertinent information (name of the patient, medical record #, body site, body side, date, time, and sample #) to the circulator who labeled the specimens. The circulator then handed the labeled specimens to a transporter, an OR person, for transporting to the

laboratory. As the OR was located on a different floor, the OR personnel transported specimens by various modes: hand carried, sent through pneumatic tube system, or transported by elevator.

However, there were delays in transporting the specimens. Microbiology and Clinical laboratory specimens were sometimes placed in the elevator, which was not always checked by the laboratory staff because they never expected to receive the specimens that way. Similarly, certain types of specimens such as "STAT" were not always sent by hand which caused delays in transport and immediate attention by the laboratory technicians. When the specimens were sent by an unacceptable mode, the laboratory personnel would bring this issue to the attention of the surgery department by sending them an internal occurrence report or reporting to the director of laboratory. The superiors of the two departments discussed at their levels to resolve the issue. But the problem was not resolved as the transporters continued to transport specimens by various modes.

There were problems with the labeling of specimens as well. The information provided to the laboratory was occasionally incomplete and/or incorrect. The laboratory personnel expediently attempted to resolve such problems by making multiple phone calls to obtain the information about the specimens. However, the problems were not eliminated and laboratory personnel continued to face similar problems at regular intervals.

This case provides strong evidence of first-order problem solving and a lack of second-order problem solving. Both problems recurred at sufficiently high frequency to be a perennial source of frustration. Interestingly, I also observed a behavior that seems to resemble an individualistic behavioral pattern. The individualistic behavioral pattern is characterized by three elements: unclear work expectation, limited communication, and inadequate accountability.

First, each individual with the same job function completed tasks differently, suggesting the work expectation was unclear to many individuals. For example, STAT specimens were sometimes sent by modes other than hand, which delayed immediate action by the lab personnel. Analogously, specimens were sent to the Microbiology

department by elevator, which was unacceptable to the lab personnel. Thus, every transporter tends to have his or her own preference of transporting specimens depending on his or her convenience and understanding, often oblivious to the implications of such transporting.

Unclear work expectations were common across the sample of cases. A manager of the transportation department described how the members from the diagnostic department requested patients from the clinical floors.

There was no written information about a patient to be transported: the transporter only knew a patient was needed and no record of where the patient was to go. One staff person from the diagnostic department called the transporter, another the floors, and another wrote it on a board somewhere and was checked when a transporter got there. A great deal of time was wasted on patient search and rescue (just patient name, no room number, bed number, or floor or area).

In this case, the requester from the diagnostic department did not have any clear understanding of how to place requests for transporting a patient. Therefore, every requestor had his or her own way of placing requests, which created considerable confusion for the clinical departments and the transporter.

Second, it seems that the individuals communicated little within the department to successfully accomplish a task, which further reinforced their individualistic behavior. One individual mentioned that the transporter did not always verify with others in the OR to make sure that the information on the specimen labels was in order or that the transportation mode was right before taking or sending them to the laboratory. Another informant mentioned that the OR circulator did not always verify from the physician on the exact specimen details before handing the specimen to the transporter.

To cite another example from a different case, a speech language pathologist who examined the issue of inconsistent group meal therapy treatment explained that the therapy treatment differed from one therapist to another due to a lack of proper communication between the person performing the therapy and the primary therapist, who determined the therapy goals upfront. Consequently, patient care was not satisfactory and the productivity of the therapists suffered.

An absence of communication across departmental boundaries was also a common trend. When lab specimens were brought by hand, the delivery did not always result in direct face-to-face interaction as the specimens were brought to the lab without prior intimation and left on the counter. Hence, there was a lack of communication between the two departments to ensure that the specimens arrived with the right information. To cite a second example from a different case:

The diagnostic department and the nursing stations (clinical floors) never communicated as to the expected patient transport times or procedure times. The patient's nurse often did not even know the patient was going to a procedure and so the patient's medical needs were not always met for the procedure, i.e. IV change, medicines, etc.

These examples suggest that there was a general lack of communication among the members within or across departments in accomplishing work on a day-to-day basis.

Third, the inconsistent level of task performance and limited communication within and across functional departments seemed to be exacerbated by inadequate accountability. For instance, even though certain specimens that needed immediate transport by hand were delivered by other modes, resulting in delays in its transporting, testing, and reporting, there were few consequences for such behavior and the processes continued for years. On a similar note, the hospital leadership team did not seem to hold

OR staff accountable, even when important information on specimen labels were often missed, which ultimately caused delays in testing and reporting, thereby potentially compromising patient care.

In sum, different individuals with the same job function executed the same task differently. This unclear work expectation was further reinforced because they communicated little with others to clarify work expectation. Unclear work expectation and limited communication were further exacerbated by inadequate accountability. Their superiors did not always question them for unsatisfactory performance, which in turn did not place a demand on an individual to clarify work expectation and produce consistent and superior performance. Thus, the interaction of these three dynamics – unclear work expectation, limited communication, and inadequate accountability – produced highly individualistic behavior.

In addition to the individualistic behavior, I observed a superficial understanding of work, also manifested in three elements. First, in many cases individuals inherited functional knowledge from their predecessors orally without questioning their validity. There was no mechanism for an individual to ensure that whatever tasks s/he did would lead to a satisfactory process performance. In addition, a history of executing a process the same way over an extended period prevented them from challenging its legitimacy. A nurse who examined the issue of lost charges on medical supplies in one of the clinical departments noted, “No policy in place. Nobody questioned. The process has continued this way for years.” Similarly, the transport manager, when asked how the patient request process evolved over the years remarked, “It is anybody’s guess. It was just an inherited

process that evolved differently in each department. All anybody knew was to page a transporter and when they arrived they told them what was to be done.”

Second, members did not have a sound knowledge of the work practices within the department because they lacked shared understanding of how those work practices needed to be successfully accomplished each day. To illustrate, the members in the OR did not effectively communicate with other members about the specimen labeling and its transporting. Neither did they have any well-defined policies, even for the routine tasks such as specimen labeling, so that every OR circulator could gain a common understanding of what successful specimen labeling entails. A physician mentioned, “The steps [specimen labeling] were touched upon but not clearly laid out step-by-step.” The existing work description was not very explicit on the information that was needed on the labels prior to dispatch. For similar reasons, the transporters did not have adequate shared understanding of similar routine tasks regarding how different types of specimens collected in OR should be transported to the lab.

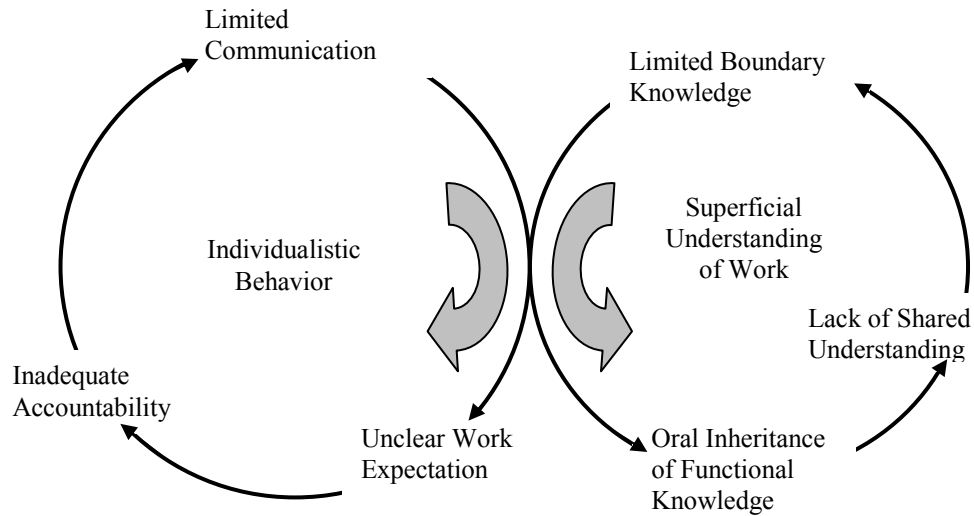
Third, poor understanding of the routine processes made working across functional boundaries even more challenging because the members in one department did not understand what information they needed to provide for smooth execution of work in the other department. As a result, they could not attune their internal processes accordingly for smooth execution across boundary lines. For instance, the OR circulator had some understanding of the activities in the lab but she did not always provide all the necessary information to the laboratory personnel. A supervisor in the laboratory expressed his reaction to this lack of understanding of work across functional boundaries as follows:

Not all specimens that come from OR are just a “SPECIMEN.” The specimen may require clinical lab testing, (i.e. cell count), microbiology cultures, or a pathologist’s examination. The OR staff need to be aware of what these specimens are and what area of the laboratory they are to be sent for what type of testing.

Individuals continually cycled through the process of oral inheritance of functional knowledge from his or her predecessors without validation. Such inheritance in the absence of an appropriate validation mechanism precipitated lack of shared understanding within a department and limited understanding of work at the functional boundaries. Absence of boundary knowledge reinforced the individual’s desire to continually acquire new functional knowledge, again without validation, commencing another cycle of superficial understanding.

In sum, the general pattern that emerges from the data is that problem solvers did not get beyond first-order problem solving because of limited understanding of the work processes, combined with individualistic behavior. Unclear work expectation, limited communication, and inadequate accountability fostered an environment of individualistic behavior, which resulted in a lack of shared understanding within the department and limited knowledge of work at the boundary. Inversely, absence of shared understanding and limited boundary knowledge did not place any demand on the members to challenge the assumptions of the existing processes to clarify work expectations, thus reinforcing individualistic behavior. Furthermore, oral inheritance of functional knowledge supported inadequate accountability in work because there were no consequences for poor performance. These cycles, illustrated in Figure 3, interacted (tightly interwoven) to discourage second-order problem solving.

Figure 3. Model of Problem-Solving Behavior Without a Metaroutine



The lab specimen example illustrates this dynamic. Due to the existence of individualistic behavior and superficial understanding, members from the laboratory and operating room did not seem to have had any motivation to engage in second-order problem solving efforts. Hence, they could not objectively understand the current specimen labeling and transportation processes, and how they impeded effective performance at the boundary. When the processes failed to perform satisfactorily, the actors tended to enact ad hoc approaches (e.g., laboratory personnel communicated with the OR personnel for additional information or submitted an internal occurrence report to the OR). These first-order problem-solving strategies resolved the immediate issues and allowed the members to continue with their daily work routines, but were not very effective in the long run because the problems kept resurfacing at regular intervals and were a continuous source of concern and frustration for the laboratory personnel. There

was no endeavor to jointly understand the underlying causes to the problems they encountered on a daily basis or to eliminate them. This pattern of first-order problem solving existed across all the cases I studied, and helps explain why second-order problem solving was rare and why enduring change was difficult to achieve.

Metaroutine Enabled Problem-Solving

With the introduction of the A3 Process in the hospital site, some of the individuals from the laboratory and OR underwent training in using it. The training was the first step in the behavioral transformation process as they became very interested in addressing those problems (specimen labeling and transporting) that had confronted them for years. A team was formed under the tutelage of a coach, an employee from the Quality Risk Management department. The other participating members were from OR, laboratories, information system, and education.

The first step the problem solvers adopted was to gain a detailed understanding of the current specimen labeling and transporting process through first-hand observation. One of the problem solving team members obtained permission from the OR leadership team to interview the OR personnel and observe the proceedings. She spent 10 hours talking with OR staff (circulators, secretaries, surgery techs, nurses, and administrative personnel) and another 6 hours observing surgeries. While she observed in the OR, others observed specimen transport and specimen labeling in the lab as specimens arrived.

After observing the proceedings in the OR, she drew a diagram illustrating the current specimen labeling and transporting process. She then walked the other participating members through the drawing. As she described the current process, members from the group provided additional information, which made the current process look even more cumbersome. The group saw the problems associated with specimen labeling and transport, and identified lack of clear specification of the specimen labeling and transporting process as the root causes. The team met several times to discuss these issues. Based on consensus, the problem solving team devised a new labeling system (secondary label) as a countermeasure that

captured 100% accurate information in the OR prior to transporting the specimens to the laboratory. Consequently, they developed a new process targeted at meeting this goal and drew it on the A3 report.

As part of the implementation plan, the team planned on printing the secondary label and implementing it immediately. One of the participating members, a physician, became responsible for coordinating with other physicians in the OR. The other participating members from OR and Lab discussed the problems and the new labeling system with their colleagues in their respective departments.

The new process was implemented and follow-up data was collected to ascertain its efficacy. Initially, the team was able to achieve significant success with the new process, as there was a marked reduction of missing information on specimen labels. But a month later, a similar experiment discovered some slippages with the new processes, which caused concern among the team members. The initiator of the problem solving effort found that though the new process was operationally feasible, more control and training was needed at the operational level to make it part of habit for its ultimate success. She shared the data with the team members and all other staff in the OR and the laboratory using email and warned about the consequences of not complying with the new process and suggested stricter control before sending specimens to the laboratory. In fact, she proposed halting transport of specimens to the laboratory until the secondary label was completed and placed on the specimens in the OR. Six months later another set of follow-up data was collected to measure the success of the new process and the results were astonishing. The success rate was close to 90% in most of the parameters studied. Observing the latest results, the team was certain that the new process was capable of providing accurate, timely, cost-effective, and safe medical care and so they developed new policies and procedures for labeling laboratory specimens and added them to the Administrative Policy and Procedure Manual.

In order to address the transportation problem, the problem solving team as a countermeasure agreed upon stopping any transport of specimens by elevator. The laboratory personnel carried out an informal experiment to check whether sending specimens by elevator was discontinued or not. They kept observing the OR personnel on how they transported specimens over an extended period of time. The results were very satisfactory because sending specimens by elevator was completely discontinued. The new policies on how to transport specimens during routine operation hours and after hours were also developed.

Though all the steps of the A3 Process were followed to successfully accomplish the problem-solving effort, I observed four steps, in particular, that appeared to have played a dominant role in switching the organizational members from a first-order problem solving to a second-order problem solving mindset. These steps were observing the current process, hand sketching the current state on the A3 report, discussing with other stakeholders, and conducting follow-up studies.

First-hand observation of the specimen labeling process and its disposition in the OR seems to have provided a detailed understanding of the problem. In this case, the observer talked to the OR staff prior to observing, and therefore, observation was a mechanism to validate against their statements. Likewise, what the observer thought beforehand about a process was not necessarily the reality. Therefore, observation provided a validation against her current understanding of how the specimen labeling and transporting worked in reality and how it impacted the working of the laboratory. In addition, observation provided some additional new knowledge to the observer about the work practices within the OR that contributed to wrong labeling. For example, the specimen labels of the previous patient were not always removed from the OR which contributed to errors in labeling. Similarly, multiple specimens were not clearly differentiated. A pathology form lists specimens as A, B, C, etc., while the physician identified specimens as 1, 2, 3, etc. Furthermore, collection of objective facts through direct observation motivated the behavioral change process at the individual level. The findings were so compelling that they motivated the observer to be proactive in seeking a solution collaboratively rather than being passive. The observer remarked on her observational experience:

It [observation] was very educational. I learned a whole lot. I went up to OR and watched several surgeries and just made sure what they [circulators] told me matched with what they were doing. I even questioned people from Pre-op to find what they really did. I talked to Pathology to get their experience. It was very interesting and was a major learning experience. It is so hard to make anything better without others' cooperation.

In an effort to seek a collaborative solution to the problem, the observer decided to explicate her tacit understanding to the other participating members. By getting the other stakeholders involved, the observer not only mitigated their possible resistance to any change, but also stimulated them to contribute to a more effective change process. When the observer discussed the observations she made in the OR with the other stakeholders and walked them through the iconic representation of the current state on the A3 Report, they, too, contrasted their conceptions with the observed data and/or confronted misconceptions, and integrated knowledge from multiple sources. They realized that the existing work practices in OR and Lab were incapable of achieving the organizational goals. Therefore, they assumed active roles and collaboratively identified the sources of the problem, and created new-shared knowledge to address it. In fact, they created a new secondary labeling system, which captured all the relevant information on specimens prior to transporting. They also decided to discontinue the elevator mode of transporting because it was not desirable and delayed the testing and reporting process.

This joint validation and collaborative act of individuals during the A3 Process was a common trend that I observed. In another case, an informant who studied the problem of wrong transcribing of stress tests in Hospital Information Management department nicely summed up a similar reaction when she drew the current state diagram.

The drawing of the current state of affairs was the most impressive. I observed each step of how the current process was being done. I knew it was a mess. Drawing out the current state on paper was an eye opener. Not just for me, but for all departments involved. We were all shocked at how bad our process was and how it screwed everything up. Once, it was drawn out, it was easy to see where things could be changed.

The collaborative understanding appears to have provided the necessary groundwork for the members to verify their newly developed process objectively and jointly using a small-scale experiment to see whether this process worked or faltered. Indeed, the team observed some glitches in the initial stages of the implementation in the secondary labeling system and had to make minor adjustments in the new process to make it fully functional. The lesson learned is that real learning occurs only when new knowledge is put to practice.

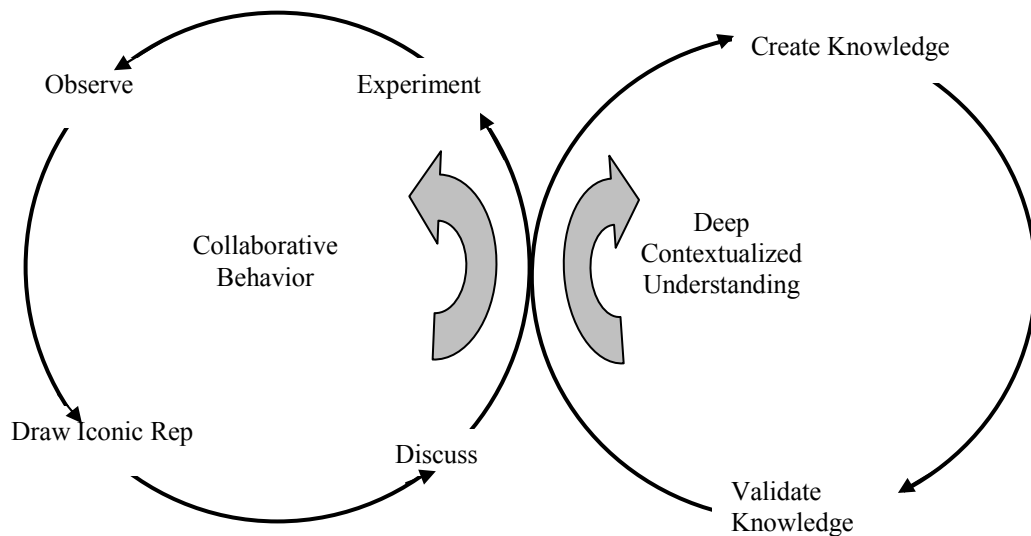
An informant from a different case, who studied the issue of missing orders for the diagnostic tests, required on specimens (the project failed to deliver any positive results), recounted his experience on how such real learning was missed when experimentation was skipped in their A3 problem solving effort.

I think experimentation is critical, so that a bad process is not implemented and the whole process is thrown out of whack. That happened in our work with one of the clinical departments, who seemed to develop every idea without carefully looking at the ramifications or experimenting to see what the results might be...

In summary, the generalized conclusion I make from examining the successful cases is that observing, drawing an iconic sketch, discussing with other stakeholders, and experimenting appear instrumental in transforming the behavior of individuals from an individualistic and passive, to a collaborative and active, mindset. These activities, in

turn, influenced either knowledge validation or knowledge creation, or both, and led to a deeper contextualized understanding of work. Observation and iconic representation caused individuals to validate their current understanding of work processes and helped to gain new knowledge. Discussions also aided knowledge validation through shared understanding with others involved in the process, and in many cases, fostered new knowledge creation in many cases. Experimentation validated the new knowledge just created. Challenging assumptions, preconceptions, and misconceptions seemed central to deep understanding of work, and resultantly in stimulating second-order problem solving, because preconceptions and misconceptions hid the root causes from surfacing. Observation, drawing, discussions, and experimentation actually peeled the surface to uncover the underlying causes. In short, adopting the A3 Process as a metaroutine changed the behavior and the cognitive abilities of individuals as shown in Figure 4. These two cycles interacted together to promote second-order problem solving.

Figure 4. Model of Second-Order Problem Solving Using the A3 Process



Characteristics of an Effective Metaroutine

The lesson learned from the comparative case example presented in this paper, and from other similar efforts in the hospital site, is that an effective metaroutine for continually improving work processes must embody three essential characteristics. The first characteristic is validating contextual knowledge at the individual level, i.e., crosschecking the existing understanding against the reality and altering the former, if necessary. Without such accurate understanding, problem resolution becomes biased, opinionated, and sub-optimal. The second characteristic is validating knowledge at the group level when individuals discuss and validate their tacit understanding with that of individuals from other functional departments. Validation not only gives the individual(s) the confidence that his or her understanding of the current process is sound, it also aids in the creation of new collective common knowledge. This new explicit knowledge then becomes readily deployable. The third characteristic of an effective metaroutine is joint validation of new knowledge through its implementation. If the consequences are positive, they buttress the individuals' confidence in the worthiness of the new knowledge. If there are negative consequences, the individuals have the opportunity to alter the new knowledge.

The above three characteristics seem to be in agreement with the prescription of some scholars who posit that communication, shared investigation, and experimentation are key ingredients to promote second-order problem solving (Tucker and Edmondson, 2003). These scholars imply that second-order problem solving necessitates conscious and explicit inquiry to address a problem. This research offers something deeper that supplements their work. At the heart of second-order problem solving is constant

knowledge validation, which provides the necessary fluidity to knowledge absorption and its dissemination at the individual and collective levels. An effective metaroutine is one conduit to achieve that validation systematically.

TQM in Practice

The model depicted in Figure 4 may also help explain why TQM programs often fail to produce second-order problem solving and deliver satisfactory results. In most of the cases reported in the literature, the managers or the senior staff handled problem-solving efforts, and hence, problem solving seemed divorced from the actual problem site and became de-contextualized. Objectively validating existing knowledge was not apparent in those efforts; for example, the problem solvers (senior staff in the organization) in one study assumed the source of the problem without any prior research (Walley and Gowland, 2004). Therefore, there was no individual validation of the current process by the problem solver(s) before embarking on the subsequent steps.

Second-order problem solving requires collective validation of existing knowledge, and a boundary object seems to facilitate such validation process. Boundary objects are tangible artifacts used by organizational members to facilitate communication back and forth among organizational members from different functional expertise to solve problems (Star and Griesemer, 1989; Carlile, 2002). A typical example of a boundary object in a healthcare setting is a medical chart used by physicians and other caregivers to treat a patient. By using the information provided in the chart, different caregivers can validate their tacit understanding about the health condition of the patient, discuss, and plan on their subsequent interventions to achieve patient care goals.

In the case of TQM, many researchers document limited use of TQM tools in many TQM programs (Kano, 1993; Hackman and Wageman, 1995; Zbaracki, 1998; Rigby, 2001). Zbaracki observes from his field study that one of the primary reasons members were reluctant to use the tools was because the members found the tools cognitively difficult to understand. As a result, the frequency of the usage declined as the tools became more technical. The problem was more acute with employees from service sectors such as hospitals and hotels. Similarly, Kano in his field study finds that members did not take any action even when the control charts showed out of control situations. These findings seem to suggest that the tools were not very effective as boundary objects, as the organizational members faced roadblocks in validating their tacit understanding using them, discussing with others, and taking appropriate actions in their respective departments to resolve the problem.

Experimentation enhances second-order problem solving by validating newly created shared knowledge. Though experimentation is advocated in TQM, scholars report that users often abandon it (Hackman and Wageman, 1995; Ovretveit, 1997) or do not use it rigorously (Walley and Gowland, 2004). One explanation for this disregard for experimentation is the superficial understanding of the problem solvers – the managers. Because they did not always validate their current understanding by objective means upfront, they lacked deep contextualized understanding of work and how it impacted performance. Therefore, there was no individual-felt compulsion to test whether the new knowledge faltered or not.

Thus, it appears that in most failed cases in TQM programs, the problem solvers did not address the problem with objective approaches such as observing the current

process and mapping it, discussing with others, and experimenting. As a result, the members failed to validate their existing knowledge and create new knowledge for an enduring change.

Conclusion

Even though the topic of how to achieve lasting change in an organization when confronted with process-related problems has received a great deal of attention in the literature, it remains largely inconclusive. Scholars observe that problem solvers resort to first-order problem solving and rarely undertake the next step, that is, second-order problem solving, to prevent recurrence. I argue that a properly designed and deployed metaroutine may be an effective mechanism to foster second-order problem solving. But the effectiveness of metaroutines in improving work processes is not well understood.

This empirical research makes several contributions to the existing body of knowledge on second-order problem solving. I presented the empirical findings and a model to explain why in the absence of a metaroutine first-order problem solving was much more common than second-order problem solving. Subsequently, I noted that second-order problem solving is indeed possible, and demonstrated how the A3 Process became instrumental in transforming the behavior and cognitive processes of individuals jointly. I then presented a model that characterizes the metaroutine and also highlighted three characteristics that are indispensable to achieving second-order problem solving and sustainable change.

Although additional work should be conducted to confirm these findings in other contexts, I suggest that the findings of this research still remain important. The empirical

data suggests that problem solvers rarely got to the root cause of the problem due to inadequate shared understanding of the work, coupled with individualistic behavior. Hence, they did not expend sufficient effort to engage in second-order problem solving. The research data shows that a metaroutine such as the A3 Process can be very effective for organizational members to collectively validate existing knowledge through shared understanding, identify and deal with the problems at their sources, and to create new knowledge to address them for a sustainable change.

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CHAPTER 4

TEST OF A BOUNDARY OBJECT FOR PROCESS IMPROVEMENT

One of the primary ways organizations respond to dynamic environments is by solving internal problems related to developing a new product, introducing a new technology, improving work processes. Often such problem solving entails interacting with individuals from different functional departments. A significant body of literature acknowledges that problem solving involving many departments is challenging and difficult because knowledge, which is central to effective problem solving, seems to travel with greater difficulty across departments than within departments (Szulanski, 1996; Brown and Duguid, 1998; Pfeffer and Sutton, 1999; Carlile, 2002; Soo et al., 2002; Leonard-Barton, 1995 as cited in Carlile, 2004).

Many scholars are convinced that use of boundary objects (BO) seems to be one possible approach to facilitate such inter-departmental problem solving (Henderson, 1991; Brown and Duguid, 1998; Carlile, 2002). BOs are physical but flexible artifacts that provide a common language and promote shared understanding about a problem or a situation among a group of individuals to reach a mutually satisfactory resolution. For example, a medical chart in a hospital is a physical artifact usually presented in a standardized format that serves as a BO. Physicians from different functional disciplines read the chart, record information, and discuss among themselves the best possible treatment for the patient.

Most of the existing empirical research examines the use of BOs in problem solving contexts such as new product design and development (Henderson, 1991, 1995;

Carlile, 2002, 2004; Bechky, 2003). Such examination makes logical sense because new product development is a multi-disciplinary exercise; therefore, effective participation by everyone is required to make a new product succeed in the market place. However, based on the review of the literature, little is known about the use of BOs in process improvement activities, even though process improvement is often a multi-disciplinary exercise.

This research builds on prior work on boundary objects, which suggests that effective BO's exhibit certain key characteristics. Action research involving the A3 Report, a problem-solving tool adapted from Toyota, suggests that it embodies those characteristics. It also seems to display an additional characteristic, not discussed in the literature, which may be relevant in the process improvement context. Using quantitative research (field-based survey), I tested the predictive abilities of those characteristics to explain the efficacy of the A3 Report as a BO in process improvement.

In the next section, I provide some background information that motivated this research. Next, I present the literature review on the application of BOs in different problem solving environments and the hypotheses for the different characteristics to be tested. I then discuss the research methodology followed by the findings. Subsequently, I discuss the implications of the results, and conclude the chapter with some final comments.

Background

To better understand the efficacy of BOs in an inter-disciplinary work environment, Sobek and Jimmerson (2004) adapted the A3 Problem Solving Report, or

succinctly the A3 Report, from Toyota Motor Corporation. The report is so named because it is encapsulated on one side of A3 size paper (metric equivalent of 11"×17"). The A3 Report template (Figure 5) guides the problem solver to follow the prescribed steps of the A3 Process and document them. The left-hand side of the report involves “problem investigation” and the right-hand side involves “problem resolution” (Sobek and Jimmerson 2004; Jimmerson et al., 2005). The outline of the template is as follows:

1. Theme: Description of the problem being investigated.
2. Background: Information essential to understanding the problem and its importance.
3. Current Condition: A hand drawn pictorial representation of the current process using iconic symbols. The pictorial representation is based on the first-hand observation of the problem associated with the current process. Alongside the diagram, problems are highlighted using storm clouds, and the magnitudes of the problems are quantified.
4. Cause Analysis: Results of the structured analysis to ascertain the root causes for the problems outlined in the storm clouds of the current condition.
5. Target Condition: A hand drawn pictorial representation of the envisaged new process using iconic symbols based on the understanding of the current state, the root causes, and the countermeasures to address the root causes.
6. Implementation Plan: The actions necessary to accomplish the target condition, the person responsible for each action, a target date for completing each action, and the likely outcome.

7. Follow-up: How and when the new process will be measured for improvement.

Reasonable targets are established beforehand and the results of the new process are measured against the specified targets to assess the magnitude of the improvement.

The setting of this research was a mid-sized hospital. The project was a collaborative undertaking between Montana State University and the hospital. Sobek and Jimmerson, in the initial stages, trained the individuals from various functional departments in the hospital to use the A3 Report. Subsequently, they tested the tool in the cardiology department and later in the pharmacy department. As time progressed many individuals in the hospital were trained and became interested in using it, and the process improvement efforts propagated hospital-wide.

At a later stage, I joined the hospital as an action researcher and spent six months participating in multiple process improvement related problem solving exercises using the A3 Report. The problems addressed were strategically important to the leadership of the hospital. Members from patient financial services, hospital information management, registration, and emergency departments participated in such problem solving efforts. As I coached the individuals, I observed limited knowledge of the members beyond their own functional departments and that they had little understanding of how their performance impacted other departments. The departments did not seem to work towards a common purpose and so organizational goals were often not met. For example, financial goals of the organizations were sacrificed at the expense of patient care goals.

Figure 5: Template of A3 Report (Source: Jimmerson et al., 2005)

<div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> THEME: "What are we trying to do?" </div> <div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> Background <ul style="list-style-type: none"> Background of the problem Importance of the problem; how it impacts company's goals or values </div> <div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> Current Condition <ul style="list-style-type: none"> Diagram of how the current process works. Key problem(s) noted Quantified measures of the extent of the problem(s) </div> <div style="border: 1px solid black; padding: 5px;"> Cause Analysis <ul style="list-style-type: none"> Key problem(s), and most likely root cause(s) <ul style="list-style-type: none"> Why? <li style="margin-left: 20px;">Why? <li style="margin-left: 40px;">Why? <li style="margin-left: 60px;">Why? <li style="margin-left: 80px;">Why? </div>	<div style="text-align: right; margin-bottom: 20px;"> To: _____ By: _____ Date: _____ </div> <div style="border: 1px solid black; padding: 5px; margin-bottom: 20px;"> Target Condition <ul style="list-style-type: none"> Diagram of how proposed process will work Specific countermeasures noted Measurable targets (quantity, time) </div> <div style="border: 1px solid black; padding: 5px; margin-bottom: 20px;"> Implementation Plan <table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th style="width: 25%;">What?</th> <th style="width: 25%;">Who?</th> <th style="width: 25%;">When?</th> <th style="width: 25%;">Where?</th> </tr> </thead> <tbody> <tr> <td style="text-align: left;">Actions to be taken</td> <td style="text-align: left;">Responsible person</td> <td style="text-align: left;">Times, Dates</td> <td></td> </tr> </tbody> </table> </div> <div style="border: 1px solid black; padding: 5px; margin-bottom: 20px;"> Cost: _____ </div> <div style="border: 1px solid black; padding: 5px;"> Follow-Up <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 50%;">Plan</th> <th style="width: 50%;">Actual Results</th> </tr> </thead> <tbody> <tr> <td style="vertical-align: top;"> <ul style="list-style-type: none"> How will you check the effects? When will you check them? </td> <td style="vertical-align: top;"> <ul style="list-style-type: none"> In red ink/pencil. Date check done. Results, compare to predicted. </td> </tr> </tbody> </table> </div>	What?	Who?	When?	Where?	Actions to be taken	Responsible person	Times, Dates		Plan	Actual Results	<ul style="list-style-type: none"> How will you check the effects? When will you check them? 	<ul style="list-style-type: none"> In red ink/pencil. Date check done. Results, compare to predicted.
What?	Who?	When?	Where?										
Actions to be taken	Responsible person	Times, Dates											
Plan	Actual Results												
<ul style="list-style-type: none"> How will you check the effects? When will you check them? 	<ul style="list-style-type: none"> In red ink/pencil. Date check done. Results, compare to predicted. 												

Most processes were fraught with errors, rework, and wastes. While participating in the problem solving, I observed that the A3 Report not only provided a common language but also facilitated shared understanding among the individuals from these disparate departments. Individuals were able to discuss their differences, their interdependencies, and how lack of contextualized understanding inhibited satisfactory process performance. They negotiated agreed upon solutions to resolve the problems. The agreed upon solution motivated them to alter their pre-existing understanding (domain-specific knowledge) – some old knowledge was relinquished and some new knowledge was embraced to honor the collective solution. As they implemented the new process they were able to see the improved results, which further solidified their new knowledge. These field-based problem-solving efforts shaped my understanding of A3 Report as a potential BO in process improvement activities.

Literature Review

The concept of BOs can be traced to the work of Star and Griesemer (1989). They use the example of a dead bird and demonstrate how individuals from different thought worlds use the same object for different purposes. The same dead bird had different meaning to the amateur bird watcher and the professional scientist. Using the bird, the scientist shaped his research goals and the amateur bird watcher planned to preserve the bird as a collection in the museum. Accordingly, they coordinated their activities to meet their individual goals.

Following Star and Griesemer's work, a number of researchers became interested in the concept and use of BOs in inter-departmental problem solving. For example, Berg

and Bowker's (1997) work finds a medical record to have been an effective BO among different caregivers for planning interventions, coordination, and interaction in a healthcare setting. The same medical record became useful to the insurance companies, researchers, and government bodies for different purposes. Pawlowski and Robey's (2004) study in a manufacturing setting report the use of shared information systems as BOs in integrating knowledge across functional departments and in resolving organizational conflicts. Yakura (2002) investigates the role of a Gantt chart (visual artifact to represent a project timeline) as a temporal BO between an information technology (IT) consultant and its client, a public utility company, in managing the progress of an IT project. The Gantt chart became an effective temporal BO in interpretation and negotiation between the IT consultant and its client. Patel and her colleagues (2002) argue that properly designed pharmaceutical labels can act as effective BOs and can avoid biases and errors in interpretation between the prescribers and the ultimate users of the medicine.

Thus, BOs have been deployed in multiple problem solving contexts, but the context where BOs have been most studied in the past decade or so is new product design and development. Henderson (1991) contrasts the efficacy of two different BOs in the same organizational setting. She notes that hand sketches facilitated knowledge integration between designers and the shop floor personnel in designing a new turbine engine package. The designer hand sketched the product and sought input from the shop floor personnel. Based on the input received, s/he modified the drawing. Thus, sketches provoked individual thinking and captured new knowledge, which resulted in collective new knowledge. The development of similar collective knowledge was impaired when

CAD-CAM drawings were used. CAD-CAM appeared so strongly structured in common use because of its interlocking devices with other computer databases that it lost its flexibility to change and became less effective for knowledge integration.

In a related study, Carlile (2002) investigates the role of different BOs in the development of new safety valves for a manufacturing firm. In particular, he observes that the assembly drawing became an effective BO for three reasons. First, it provided a common language for the stakeholders – the manufacturing engineering department and the design department. Second, it offered a concrete means to represent the work context and the associated concerns of the stakeholders. Finally, it provided a platform for knowledge transformation. As a consequence, the stakeholders were able to see the differences (domain-specific knowledge of each other) and the interdependencies, and how they affected the new product development process. This exchange of knowledge propelled them to reach an agreement, which necessitated them to jointly transform their domain-specific knowledge. Such joint knowledge transformation was not previously possible because the old assembly drawing reflected the concerns and the work contexts of the manufacturing department and not the concerns and the work context of the design department, and therefore, had limited impact on product development efforts. Interestingly in Carlile's research both the design department and manufacturing department personnel had similar levels of training and expertise to understand drawings. Hence, the drawing became the common language for conversation to solve problems. However, when the training of individuals of different departments is different, drawings could become a roadblock in problem solving, as I observe in another study, i.e., in Bechky's (2003) work.

Bechky, from her empirical research in a semiconductor equipment manufacturing company, finds tangible BOs, such as prototypes, to be more effective than drawings in creating common ground between two departments (design and assembly) because such objects invoke the necessary elements of work context. In fact, quite contrary to the general notion that engineering drawing is the best communication medium for cross-departmental knowledge interchange, Bechky reports that the assemblers found it too abstract to associate with their physical conceptualization of the product. The assemblers readily understood the machine in terms of the physical parts and their spatial relationship and not in terms of the conceptual language of the drawing, while the engineers only understood the product in the language of drawings. Thus, the engineering drawings failed to develop a common understanding to facilitate a meaningful conversation between the designer and the assembler toward solving problems in the new prototype development. Consequently, the designers used the prototype to tap into the domain-specific knowledge of the assemblers to facilitate knowledge integration to solve problems.

What appears from these studies is that an appropriate BO in one setting can become a boundary roadblock in another setting, even when the problem solving contexts are very similar, i.e., producing a new product. Nonetheless, several important characteristics of an effective BO emerge from the review of the existing literature. First, it needs to accommodate the work context and be objective to represent the concerns of all stakeholders for meaningful participation (Carlile, 2002). Second, it should be loosely structured to promote individual creativity and communication for solving problems (Henderson, 1991). Finally, it should facilitate integration of different knowledge of

individuals to develop a new collective knowledge to solve problems (Henderson, 1991; Carlile, 2002; Bechky, 2003). However, such characteristics emerged from qualitative research in addressing a specific problem type in a particular organizational setting. Therefore, it is unclear if some of the characteristics are indeed relevant in multiple problem solving contexts.

Boundary Objects in Process Improvement

Process improvement is as important as developing a new product, and requires participation from diverse functional departments to make a process work successfully. Experts posit that the dynamic core competency of a firm depends on process related improvements that require close inter-relationships among key personnel in various functions (Lei et al., 1996). In this respect, others have shown how Japanese companies such as Honda (MacDuffie, 1997) and Toyota (Adler et al, 1999; Spear and Bowen, 1999) have relentlessly pursued the path of corporate-wide process improvement continuously to ascend in the competitive car market. In fact, these high performing companies have always encouraged inter-departmental problem solving to share skills with each other to develop new products and processes. Furthermore, process improvement leads to the creation of new routines, which promotes acquisition of new knowledge and skills by organizational members, and helps develop and refine core competencies, not easily imitable by competitors (Dosi, 1988; Lei et al., 1996). Some argue that continuous innovation in routines is needed for the creation of new skills for developing future products and process technologies (Leonard-Barton, 1992; Henderson

and Clark, 1990). In sum, process improvement is critical to maintaining a competitive advantage in the turbulent and chaotic market place.

Even though process improvement is important, little empirical research exists on the use of BOs in process improvement related problem solving compared to the research in new product design and development. One possible explanation for why new product development is a favorite research context is that products being developed are tangible objects, thus the BOs used in such development-related problem solving typically map closely to the envisioned physical artifact. Therefore, problems are defined and the tools used to solve such problems are well defined. For example, an engineering drawing is a two-dimensional pictorial representation of the actual physical product and organizational members are able to conceptually connect the drawing with the intended new product readily. Similarly, a prototype is almost an exact replica of the intended new product to be manufactured. Consequently, problem solving revolves around a tangible object. By seeing the product, members are able to invoke the necessary work context with ease and are able to discuss their specialized knowledge, their interdependencies, and work on a mutually agreeable solution. Therefore, such settings provide an ideal context to the researchers to investigate their research goals.

In contrast, the task of using a BO for improving a process seems difficult because processes are not as tangible as a physical product. Unlike a physical product, a work process is difficult to represent by a BO. The traditional process maps comprising ellipses, diamonds, and rectangles are often used to represent a process, but they do not exactly map onto the real process closely, and therefore, members do not seem to connect to the work context easily to participate in a meaningful discussion. Henderson's (1998)

study in a call center for a copy machine manufacturer is an example that contrasts this difficulty under the two environments: new product development versus process improvement. The design engineers, while developing a new machine, sketched its parts on scrap paper or in the margins of the drawings and the discussions among the members ensued. In contrast, process reengineers used pre-defined computerized templates for process improvement, which were somewhat inflexible, high-level abstractions of the process, and thus became dysfunctional as BOs (Henderson, 1998). Nevertheless, in a manufacturing setting, organizational members, irrespective of their skills and training, seem to have one common thread, i.e., producing a tangible product using a well-defined process, which is the starting point in any inter-departmental problem solving. This makes the problem-solving task for all individuals easier. Such a common thread does not necessarily apply in non-manufacturing organizational settings such as healthcare.

Boundary Objects in Healthcare

Our understanding of a BO as a process improvement tool becomes even fuzzier in healthcare. Unlike manufacturing, healthcare services are intangible. In addition, most processes are electronically or manually driven and so are not easily observable. Hence, it is difficult to define a process in concrete terms in a healthcare context. Furthermore, healthcare individuals have conflicting goals (patient care versus non-patient care), and therefore, lack the necessary common thread as a starting point to solve a problem. Therefore, collaboration across functional disciplines seems difficult and challenging and the need for BOs becomes more pronounced to bridge the differences.

Hypotheses

To investigate the efficacy of BO in process improvement, the A3 Report was enacted as a tool in various functional departments and produced satisfactory results. In fact, it seemed to possess the same key characteristics as enumerated by scholars in the literature on BO – providing objectivity, facilitating knowledge integrability, fostering creativity, and assisting communicability. My action research in the research site suggested an additional characteristic – simplicity in use – not discussed in the literature, which may be relevant to the effectiveness of BO in process improvement context. I observed that many employees at the research site did not have a college level education, yet their participation was essential for successful process improvement. Therefore, a complex tool would have impeded effective participation by those individuals. From a BO perspective, the A3 Report is a simple tool to understand and write.

I measured the efficacy of the A3 Report as a BO in two dimensions. First, it can be described as effective only when the organizational members prefer to use it again. Second, it is said to be effective when its repeated use results in superior process outcomes. In an effort to answer the two questions of what characteristics of the A3 Report motivate repeat usage, and as a second step, what characteristics are reported to be essential for superior process outcomes, I framed the following hypotheses.

Hypotheses: *The following characteristics of the A3 Report will be positively associated with tool usage (H1) and process improvement (H2):*

- a. *Objectivity*
- b. *Knowledge integrability*
- c. *Communicability*

d. Creativity

e. Simplicity

The five characteristics (a-e) will be described later.

Research Methodology

To test the hypotheses, a field survey was conducted in the same hospital as described in the background section. The target respondents for this study were individuals who had direct experience in writing the A3 Report, or were involved in problem solving using the report. I initially made a list of prospective respondents based on the information I received from the individuals who provided training to others on TPS design rules, the A3 Process, and the A3 Report. Subsequently, I sent an email to all employees in the hospital to make sure no individual with such report writing experience was left out of the survey. While doing this exercise I also observed that a significant number of individuals with A3 Report writing experience had left the organization. Therefore, they could not be contacted. In total, 60 respondents were identified for the study. These individuals represented every level (directors, managers, supervisors, and front line staff) in the organizational hierarchy.

Data Collection

A detailed survey instrument was used, which contained close-ended questions on the predictor and the criterion variables. In designing the instrument, I followed the guidelines of some scholars (Aiman-Smith & Markham 2004; Alreck & Settle, 2004). Prior to conducting the survey, an expert checked for the content validity of the instrument. A number of experts from the hospital also checked the questionnaire for the

face validity. In order to counteract response bias, some of the questions were reverse worded. For every predictor variable I used at least three items as measures. The survey instrument was kept short to maximize the rate of response without diluting the survey objectives and was coded for faster post-survey analysis. Because of the subjective nature of the data (measuring perceptions of the respondents), the level of significance was set at 0.10.

Prior to conducting the final survey, I conducted a pilot survey (N=6) to check any ambiguities in the questionnaire. I had to content myself with a small sample for the pilot study due to the size of the respondent pool. I looked at the response pattern of those few individuals and also checked for any missing data. No abnormal responses were observed to suggest that ambiguity in the questions existed. I calculated the Cronbach's alpha for each variable and it varied between 0.6 and 0.9. Two variables had Cronbach's alpha between 0.6 and 0.7, which is acceptable for new scales (Robinson et al., 1991). I also ensured that correlation was less than 0.65 to measure discriminant validity, i.e., the predictor variables were indeed different (Aiman-Smith and Markham, 2004).

The survey instrument was sent with a cover letter to 60 individuals in the hospital. The cover letter guaranteed that their responses would be kept confidential. We received 56 responses indicating a response rate of 93%. The respondents included 11 males and 42 females and the remaining 3 respondents did not disclose their sex. Individuals held a master's degree (N = 10), a bachelor's degree (N = 18), an associate degree (N = 10), a high school education (N = 16), or other degrees (N = 2). A significant number of respondents represented the clinical department (N = 31), or represented fiscal and administration (N = 15), or represented ancillary and support (N = 10). Most of the

respondents worked full time (N = 46) though there was some who worked part time as well (N = 10).

Criterion Variables

I measured the “A3 Report usage” in terms of how many A3 Reports a respondent completed in the last year since I administered the survey. This measure was an objective account of the actual usage of the tool and the effectiveness of the A3 Report. In many cases, respondents wrote multiple A3 Reports, suggesting that they found it beneficial to improve their work despite tight work schedules.

“Process improvement” (PI) is defined as the improvement in various process parameters (productivity, wasted time, number of errors, costs, patient care) as a result of problem solving, as reported by the respondents. This construct is a measure of the effectiveness of the A3 Report. I constructed six items to measure this construct based on the different process parameters used by the organization. I used a 3-point Likert scale fixed from 1 = worse to 3 = better. I also used a seventh item using a 5-point Likert Scale anchored at 1 = strongly disagree and 5 = strongly agree for the construct (Cronbach alpha = 0.87). I added up the scores for seven items and averaged to get a composite score for the scale. See the appendix for the items used in the scale.

Predictor Variables

There were five predictor variables of interest: objectivity, knowledge integrability, communicability, creativity, and simplicity. However, as the correlation between communicability and knowledge integrability was high ($r = 0.76$, $p < 0.05$) and appeared collinear, I did not use them together in the same regression model. The actual

measures for each of the variables can be found in the appendix. Except where noted, a five-point Likert scale, was used for each measure, with 1 = strongly disagree to 5 = strongly agree.

“Objectivity” of the A3 Report is defined as approaching and solving a problem using the A3 Report based on field data, and not guided by the personal opinions of participating individuals. A three-item scale was developed to measure the objectivity of the A3 Report, guided by the extant literature (Carlile, 2002) and my field experience (Cronbach alpha = 0.66).

“Knowledge integrability” of the A3 Report is defined as its ability to stimulate concerns and identify dependencies among the organizational members to develop a shared understanding of how the new process should work to meet the organizational goals. A six-item scale was used to measure knowledge integration. The Likert scale was developed based on my review of the literature and field experience (Cronbach alpha = 0.89).

“Communicability” of the A3 Report is defined as the degree to which it facilitates interactive discussions among the organizational members to resolve a problem. A three-item scale was constructed to measure the communicability of the A3 Report, guided by the extant literature (Henderson, 1991, 1995; Carlile, 2002) and my field experience (Cronbach alpha = 0.59).

“Creativity” of the A3 Report is defined as its ability to invoke innovative ideas from individuals during construction of the current state and the target state diagrams. I developed a five-item scale to measure creativity of the A3 Report, guided by the extant literature (Henderson, 1991). The Cronbach alpha was 0.70.

“Simplicity” of the A3 Report is defined as ease of interpretability and usability by all individuals, irrespective of their educational levels. I developed a three-item scale to measure simplicity based on our field understanding. The response for the second item was coded using a 5-point Likert Scale (0-2 hours = 1, 9-10 hours = 5) during analysis. The Cronbach alpha was 0.75.

Control Variable

“Following the A3 Process” equates to executing certain key steps (observing, experimenting) in the problem solving process that are critical to effective problem solving. This was done to investigate the potential effect this factor may have on the relationship between the predictor and criterion variables in process improvement. I used four items using a Likert Scale to measure the A3 process as a control variable anchored at 1 = strongly disagree to 5 = strongly agree (Cronbach alpha = 0.70).

Analysis Approach

As the intent was to identify what characteristics of the A3 Report predicted its effectiveness, a multiple regression analysis approach was adopted. First I checked for any missing data in the responses and no missing data were observed. However, seven respondents could not implement the new process, or the new process implementation was in progress when the survey was conducted. As a result, they lacked any results on process improvement. Those cases were deleted from the dataset. The data was checked for outliers (data that do not fit with the rest of the data) by checking values of the criterion variable (number of A3 Reports written) that were 3 standard deviations above or below the group mean, as well as by visual inspection. Two such cases from the

criterion variable were deleted from further analysis. As the predictor variables were on the Likert Scale, no outliers were observed. In total, nine cases were excluded from the dataset, resulting in 47 data points for subsequent analysis. I then averaged all the items—positively worded and reversed negatively worded questions—together as a measure for each predictor variable.

For each of the two criterion variables, multiple regression analysis was performed to test the hypotheses. Before conducting the regression analysis, I checked the normality assumptions of each predictor variable by drawing the normal probability plot. Because I found some non-normality, I used a square root transformation with one of the criterion variables (number of A3 Reports) and a natural log transformation for two predictor variables (objectivity and knowledge integrability) and the control variable to induce more normality in the data. I redrew the plot again to ensure normality. The rest of the variables were approximately normal. Prior to conducting the regression analysis, I checked the linearity of each predictor variable with respect to the criterion variables by drawing bivariate scatter plots of the predictor variable versus the transformed criterion variables (number of A3 Reports), and also for the other criterion variable (Process Improvement). The plots were approximately linear. Using SPSS software, four multiple linear regression models were constructed. After creating each model, the homoscedasticity of the residuals were also checked.

Results

Table 7 presents the means, standard deviations, and the bivariate correlations for the predictor, criterion, and control variables. All correlations between predictor variables

are well below 0.75, the level generally accepted as problematic (Masson and Perreault, 1991; Pelled et al., 1999). As a cross check, I also computed the variance inflation factor (VIF) scores to check multicollinearity. All scores were well below the standard benchmark score of 10 (Cohen et al., 2003). As evidenced from Table 7, all predictor variables (except creativity) are positively correlated with the criterion variables, A3 Report usage, and process improvement. In particular, objectivity is significantly correlated ($r = 0.40$, $p < 0.01$) with A3 Report usage. Similarly, knowledge integrability ($r = 0.42$, $p < 0.01$) and communicability ($r = 0.45$, $p < 0.01$) are significantly correlated with process improvement. Simplicity and the A3 Process (control variable) are also somewhat correlated ($r = 0.25$, $p < 0.10$) with process improvement.

As I was interested in finding whether the perception of the individuals in the clinical and non-clinical departments (fiscal, administration, and ancillary departments were combined) differed with respect to the three main characteristics that attributed to the effectiveness of the A3 Report, I conducted Two-Sample t-tests for each predictor variable. The results imply no difference in the means, which indicates that the individuals in the clinical and non-clinical departments perceived the different characteristics of the A3 Report in similar ways.

Table 8 presents the results of the multiple regression analysis. Model 1 is the regression of the predictor variables (excluding communicability) against the criterion variable, A3 Report usage. The control variable is not included in the regression because its effects are only realized during problem solving and not during the decision process of

Table 7. Means, Standard Deviations, and Correlations among Boundary Object Study Variables

	Mean	Std Dev.	1	2	3	4	5	6	7	8
1. A3 report ^a	1.18	0.64	1							
2. Process improvement	2.90	0.33	0.29*	1						
3. Objectivity ^b	1.41	0.19	0.40**	0.23	1					
4. Knowledge integrability ^b	1.49	0.14	0.13	0.42**	0.30*	1				
5. Communicability	4.21	0.82	0.19	0.45**	0.51**	0.76**	1			
6. Creativity	4.46	0.50	0.05	0.22	0.42**	0.50**	0.50**	1		
7. Simplicity	4.19	0.65	0.16	0.25†	0.33*	0.37*	0.37*	0.16	1	
8. A3 process ^b	1.39	0.20	0.31*	0.25†	0.21	0.40**	0.48**	0.25†	0.13	1

Notes: N = 47

^a Square root transformed

^b Natural log transformed

** p < 0.01; * p < 0.05; † p < 0.10

whether or not to use the A3 Report. The results indicate that objectivity of the A3 Report is a very strong predictor of its usage ($p < 0.01$), thus supporting **H1a** that objectivity of the A3 Report is positively associated with its repeat usage. The overall model is significant (F-value = 2.31, $p < 0.1$) and explains 18 percent of the variance (R-squared value) in the criterion variable. The other predictor variables do not show a statistically significant relationship with the criterion variable ($p > 0.1$). The plot of residuals against the predicted values shows no pattern.

Model 2 is the regression of the predictor variables (excluding knowledge integrability) against A3 Report usage. Objectivity is again a strong predictor ($p < 0.05$), thus supporting hypothesis **H1a**. As can be seen, the model is significant (F-value = 2.25, $p < 0.10$) and explains 18 percent (R-squared value) of the variance in the criterion variable at $p < 0.10$. The other predictor variables do not reliably predict the criterion variable ($p > 0.1$). The plot of residuals against the predicted values is structure-less.

Model 3 is the regression of the predictor variables (excluding communicability) against the criterion variable, process improvement. The model suggests that statistically, knowledge integrability is a moderate predictor of process improvement ($p < 0.10$), thus supporting **H2b**. The other predictor variables fail to predict the criterion variable ($p > 0.1$). The overall model is significant (F-value = 2.06, $p < 0.10$) and explains 20 percent of the variance (R-squared value) in the criterion variable. The plot of residuals against the predicted values shows slight deviation from a structure-less pattern.

Model 4 is the regression of the predictor variables (excluding knowledge integrability) on process improvement. As can be seen from the data, communicability is a strong predictor of process improvement ($p < 0.05$), thus supporting hypothesis **H2c**.

The remaining predictor variables fail to predict the criterion variable statistically. The overall model is significant (F-value = 2.22, $p < 0.1$) and explains 21 percent of the variance in the criterion variable. The plot of residuals against the predicted values appears randomly scattered.

Table 8. Results of Regression Analysis of Boundary Object Study Variables

Variables	Model 1 (A3 Report usage)	Model 2 (A3 Report usage)	Model 3 (Process improvement)	Model 4 (Process improvement)
A3 Process			0.15	0.08
Objectivity	1.43***	1.41**	0.15	-0.03
Knowledge Integrability	0.39		0.80*	
Communicability		0.03		0.16**
Creativity	-0.22	-0.19	-0.02	0.00
Simplicity	0.01	0.03	0.05	0.05
R-squared	0.18	0.18	0.20	0.21
Adj. R-squared	0.10	0.10	0.10	0.12
F-value	2.31*	2.25*	2.06*	2.22*

Notes: N = 47

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$

Discussion

The purpose of this field-based study was to identify the characteristics that predict the effectiveness of the A3 Report as a BO in process improvement. I measured its effectiveness in terms of two dimensions – its repeat usage and improved results as a result of process improvement. Consistent with predictions, the results provide significant support for the hypotheses **H1a**. The finding implies that organizational members

perceive the objectivity of the A3 Report as a likely factor in their decision to use it again. Indeed, individuals from both clinical and non-clinical departments perceive the A3 Report to be an objective tool in cross-departmental problem solving. It is a data driven tool and the iconic representation of the current state on the A3 Report mirrors the actual state of current affairs. Thus, there is little apprehension in the minds of the problem solvers about the real problems and their impact on the system. Our finding of objectiveness of a BO in cross-departmental problem solving is in agreement with the existing research literature on BOs in other problem solving contexts. For instance, Carlile's (2002) research states that only when the updated assembly drawing reflected the concerns of all stakeholders (manufacturing engineering and design), did it become an effective BO for negotiation in new product development.

The finding that the A3 Report seems to promote knowledge integrability to improve process outcome is well founded, thus supporting the hypothesis **H2b**. The result implies that organizational members perceive that the A3 Report facilitates knowledge integration among the organizational members during process improvement. This finding seems to be consistent with the findings of other scholars (Carlile, 2002; Bechky, 2003) who find similar results of knowledge integration using other BOs (assembly drawing, prototypes) in new product development contexts.

The results also offer evidence that communicability is an important characteristic of an A3 Report during process improvement, thus statistically supporting the hypothesis **H2c**. In fact, the iconic representation of the current state on the A3 Report stimulates conversation among the organizational members about the difficulties associated with the current state, which in turn leads to development of the target state for better process

outcomes. This finding seems congruent with the findings of other researchers who indicate that effective BOs facilitate communication and knowledge interchange in cross-departmental problem solving (Henderson 1991, 1998; Carlile 2002).

Contrary to my arguments, the effect of creativity on repeat A3 Report usage and on process improvement is not statistically supported. One possible explanation for this result is that creativity is statistically related to objectivity ($r = 0.42$, $p < 0.01$), knowledge integrability ($r = 0.50$, $p < 0.01$), and communicability ($r = 0.50$, $p < 0.01$), which suggests that the effect of creativity is confounded in the other three predictor variables, resulting in a situation of statistical suppression of its actual predictive power. A second explanation may be that creativity is analogous to a “double-edged sword.” It is important that individuals generate new insights to solve problems. The downside is that unless those insights are integrated into a new collective knowledge, they have little impact on process improvement. Thus, it appears from our results that creativity and knowledge integrability may be inexorably intertwined during the problem solving process.

Contrary to my expectations, I find little statistical support that simplicity of the A3 Report is positively associated with its repeat usage or in process improvement. There may be multiple explanations for this limited support. From informal talks with the individuals in the facility, I discovered that the A3 Report overtly appears to intimidate people by its appearance, but as one dives into it and uses it s/he finds it simple. One individual nicely summed up the above argument; “The A3 [report] is a good tool. It is complicating at first and I can see people not wanting to use it because it is intimidating. I was confused when I actually sat down to put it on paper. It seems so easy when

someone tells you how to do it and how it works.” Another possible reason for its apparent complication is that it often involves expending some time and effort beyond the daily work schedule to engage in any objective problem solving.

I included the A3 Process as a control variable in our regression analysis. This variable individually showed significant relationship (F-value = 3.00, $p < 0.10$) when regressed against the criterion variable, process improvement. But, when it was considered with other predictor variables, the pattern of the regression results did not change. However, it slightly weakened the significance level of some of the predictor variables due to its significant correlation with them.

In sum, four out of 10 sub-hypotheses were found to be significant. However, taken together, three out of the five hypothesized characteristics of the A3 Report emerge to predict its effectiveness as a BO. First, the results imply that the organizational members find objectivity of the A3 Report to be a strong determinant for its repeat usage in process improvement efforts. Second, knowledge integrability and communicability seem to be the determinant characteristics of process improvement.

Although the primary thrust in this research study was in investigating the additive effects of the main predictor variables on the criterion variables, we also investigated the joint effects of the predictor variables, or the two-way interactions, on the criterion variable over and above the individual additive effects. I found the two-way interactions by the cross product of two predictor variables. Since I had four main predictor variables in each model, I examined the effect of six two-way interactions. I regressed the four main predictor variables, six two-way interaction variables, and the control variable over the criterion variable using the centered predictor approach

suggested by Cohen et al., (2003) for regression analysis containing interactions. The overall model is insignificant ($F = 0.98$, $p > 0.1$) and the R^2 value is 0.24. The four main predictors, as well as the six interaction variables, are statistically insignificant.

Even though this study presents some interesting results, it is not without limitations, and therefore, suggests some areas for follow-up research. First, it is important to note that the results reflect the findings in one organization – specifically, a mid-sized hospital. Since specific characteristics of the site could influence the findings, it is difficult to generalize them. Therefore, results of this study should be interpreted with care. A second limitation of this study is the small number of respondents. A larger respondent size would have given more statistical power to our results. A third limitation of this study is that the design is cross-sectional. Therefore, causal relationships cannot be established among the study variables. Finally, the fourth limitation is the threat of common method variance because all variables or constructs were measured using the same survey instrument.

Future empirical research should extend this work by focusing on the use of the A3 Report in multiple organizational settings (manufacturing and non-manufacturing) to validate the characteristics of a BO discussed in this paper in order to generalize the results. Furthermore, such studies should be replicated at multiple points in time. I hope future research will also attempt to address any other relevant characteristics of a BO not addressed in our research that would enhance the understanding of the A3 Report as a potential BO in cross-departmental problem solving.

Conclusion

Despite these limitations, the results of this study have potentially important implications for the academic literature and real world practice. Most studies have examined the role of BOs in different problem-solving contexts qualitatively. Furthermore, most of the attention has been focused on new product development and very little on process improvement. I argue that process improvement is critical to remain competitive and viable in today's dynamic environment. From that perspective, this research addresses a significant gap in empirical research on BOs. I examined the A3 Report's characteristics as a BO in process improvement using a field-based survey, and in the process I validated and strengthened the findings of the earlier studies.

From the viewpoint of real world practice, the findings are noteworthy. Even though this empirical research is focused in one organizational setting in healthcare, the challenge of integrating knowledge across functional departments is not just limited to healthcare but seems to apply to all organizations, as found by numerous scholars (Brown and Duguid, 1998; Carlile, 2002; Soo et al., 2002). The A3 Report appears to be an objective tool that promotes communication and integrates the specialized knowledge of individuals from different functional departments to work toward a common purpose in improving organizational work processes. Finally, I conclude with the fervent hope that the A3 Report has the potential to emerge as an effective BO in many other work settings that need process improvement.

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CHAPTER 5

DISSERTATION CONCLUSIONS

This study is the first empirical research to examine the application of TPS in a healthcare context. It is inarguably relevant because the healthcare sector is in crisis and demands attention and investigation into its work practices. Since the primary goal of this research was to offer assistance with improving systemic issues, I formulated three specific research objectives related to the rules to design work, the A3 Process, and the A3 Report.

The first objective of this research was to test the applicability of the design rules outside manufacturing, more specifically, healthcare, and refine the rules in light of their applicability. As no empirical research existed on the application of TPS design rules, I adopted a qualitative approach to collect the data and relied on a combination of qualitative and quantitative methods to analyze the data.

Several of the findings for this part of the research work are noteworthy. In every failing process, one or more of the design rules were missing. Thus, increase in activity specification, connection clarity, or pathway simplification is associated with better process outcomes. The results suggest that activity specification and pathway simplification are the two main predictors of outcomes. However, simplification of the pathway was possible because many unclear connections were addressed during problem solving. Therefore, designing activities and clear connections lead to a simplified pathway and seem to be a better approach to design work. Additionally, the results of the qualitative analysis show that a higher degree of change in activity specification,

connection clarity, and pathway simplification correlates with a higher degree of improvement.

The findings seem important because organizational scholars argue that rules and procedures are appropriate for stable environment and organic form of work is suitable for unstable environments such as healthcare. This research suggests that rules are suitable for healthcare as well because the rules not only provided consistency in performance by different individuals in the hospital, they also provided necessary flexibility to change. Thus, the rules offer a datum or baseline performance against which improvements can be compared and the organizational work procedures can be changed accordingly to react to the dynamic environment in a hospital setting. Without such established standards, improvement efforts tend to be futile.

The second objective of this research was to investigate whether the efficacy of the A3 Process, a metaroutine, could sustain improvement in work processes using the design rules, and, if so, to provide an explanation for its efficacy. As no empirical research existed on the application of the A3 Process, I adopted a qualitative approach (grounded theory) to analyze the data.

The result reveals that those who followed all the steps of the A3 Process realized higher order improvements than those who did not. The finding thus implies that following all the steps correlated with higher order improvements, and conversely that leaving out even one step diminishes the power of the metaroutine dramatically. This finding is in agreement with the findings of other researchers who show that systematic problem solving approaches lead to superior results (Tyre et al., 1995).

Second, in order to explain the results of the case comparison, a deeper

investigation was conducted using a grounded theory approach. The case reports were first open coded and then coded axially. Based on the axial coding, two conceptual models were developed. The first model explained the problem solving behavior and cognitive processes of the individuals in the absence of a metaroutine, and how these two elements inhibited second-order problem solving. The second model explained how the A3 Process facilitated second-order problem solving.

The findings indicate that at the heart of second-order problem solving is the constant iterative process of knowledge validation and new knowledge creation. These two processes provide the necessary impetus to the individuals to seek a collaborative solution to a problem, thus promoting second-order problem solving and sustainable change. Therefore, direct observation of work processes and their iconic representation, discussion with all stakeholders [of what?], and experimentation provide the means to achieve the knowledge validation, knowledge creation, or both.

The findings of this part of the research seem cogent and powerful because many scholars report that when individuals are faced with problems, they predominantly resort to first-order problem solving and rarely pursue the next step, i.e., second-order problem solving (Tucker and Edmondson, 2003; Tucker et al., 2002; Feigenbaum, 1991). As a result, problems recur at regular intervals and are a constant source of frustration and agony for the individuals. The problem is further exacerbated, because as some scholars argue, there is very little empirical research that exists on the effectiveness of the metaroutine embedded in TQM (Bigelow and Arndt, 1995, 2000; Ovretveit, 2002), or how to make quality improvement methods effective (Ovretveit, 2002).

The third objective of this research was to investigate which characteristics of an

A3 Report made it an effective BO in process improvement. Even though there has been considerable empirical substantiation (qualitative) on the role of BOs in the new product development context, little was known about their role in process improvement. This research gained importance because some argue that a BO in one problem-solving context may falter in another problem solving environment (Carlile, 2002). Furthermore, in most empirical studies, the researchers examined the role, or effectiveness, of a BO in one specific problem-solving context in a particular organizational setting. As a consequence, there was considerable confusion about what makes a BO effective in a multi-disciplinary problem-solving environment.

In order to alleviate that confusion, a quantitative research methodology was deployed. Based on the literature review and my action research, the characteristics of an effective BO were developed. A survey instrument was created to measure the characteristics and identify which were significant predictors of the A3 Report as a BO.

The results of the survey analysis suggest that three characteristics – objectivity, communicability, and knowledge integrability – are the main predictors of an A3 Report's effectiveness. Organizational members who perceived the objectivity of the A3 Report as high are the ones who decided to use the A3 Report again. Similarly, the data indicate that the organizational members who perceived the communicability and knowledge integrating abilities of the A3 Report as high were more likely to report positively on its effectiveness during problem solving.

Systemic View of Quality Improvement Program

Taken together, the three pieces of this study suggest that the rules to design work, the metaroutines, and the BOs are important ingredients of any quality improvement or process improvement program. Metaroutines provide a systematic problem solving approach to improve any existing routines. The metaroutines employ root cause analysis and the rules to design work processes come into play when the root causes are addressed. But improving processes is an interdisciplinary problem solving activity, and consequently, BOs play a pivotal role in assembling individuals from different disciplines together to solve the problem. Thus, these three elements need to be mutually reinforcing each other to produce any meaningful improvement in work processes (please refer to Figure 1, page 10).

An examination of the typical TQM programs from this system perspective reveals interesting insights. First, the existing TQM literature does not seem to suggest rules or guidelines to design work when using TQM intervention even though they seem very pertinent to the problem solving process. The general theme of TQM, as espoused by foremost quality gurus (Walter A. Shewart, W. Edward Deming) has been focused on reducing variability from work processes. They argue that all processes exhibit variation, and that reducing variability simultaneously reduces cost and improve quality. By using the statistical process control tools, the root causes are determined, but it is not always clear to the problem solvers how to construct the work processes to address those root causes and reduce variability.

Second, the existing literature on past TQM programs reports that the PDCA metaroutine has not been used to its full potential (Walley and Gowland, 2004). Several scholars have noted the attenuated role of scientific problem solving in TQM programs (Hackman and Wageman, 1995; Ovretveit, 1997). Kano (1993) reports that many individuals have faced difficulties in applying PDCA to their jobs PDCA may be too philosophical and abstract to be directly actionable. A more specific and contextualized metaroutine may be required to effectively implement the PDCA concept.

Finally, TQM literature espouses seven basic statistical process control tools (pareto chart, control chart, fish bone chart, histogram, check sheets, run chart, flow chart) in process improvement using PDCA. However, the literature on TQM programs suggests that statistical process control tools have found limited acceptance in the industrial world (Hackman and Wageman, 1995; Zbaracki, 1998), implying that these tools did not appear to have been effective BOs in cross-departmental problem solving. In addition, past research notes that as the tools became more technical, their usage further diminished. This problem of limited usage of these tools was found more acute in the service sector than in the manufacturing sector.

In sum, one possible explanation into why most TQM programs found limited success is that the three elements of organizational improvement programs (rules to design work, metaroutines, boundary objects) were either inadequate or ineffective during the intervention process. Therefore, the beneficial aspect of this framework is that it can guide individuals with reasonable authority in organizations to evaluate their existing quality improvement programs in light of these three ingredients and take appropriate corrective measures to make them more effectual. In the absence of a quality

improvement program, the ingredients can be used to guide the development of new programs.

The findings of this research, therefore, propose a new theory of organizational work process improvement. The proposed theory is that in order to improve work procedures, organizations need collaborative adoption of rules, metaroutines, and BOs in their quality improvement programs or systems. The proposed theory, however, needs further empirical substantiation, but the findings of this research seem to point in that direction.

Limitations

The present research study has several limitations that need to be recognized. First, the research was conducted in one organizational setting, and therefore, the generalizability of all the findings is difficult to ascertain. More research studies are needed in other hospitals and clinics and in other non-manufacturing sectors of the economy such as banking, insurance, hospitality, and so forth to externally validate the findings of this research.

The study design used to test the TPS design rules in addressing Research Question 1 did not have a control group. Comparing the results of the intervention and the control groups would have given more credibility to the results. In addition, future work should also focus on measuring the performance of the processes using statistical process control tools (a control chart for example) over a prolonged period to measure the stability in the process. The performance of the process within statistical limits over an extended period would lend support to the conclusion that the intervention was

responsible for the improvement. However, in such studies, care should also be taken to disentangle the effects of the exogenous and endogenous factors because they can seriously obscure the relationship between the intervention and the outcome.

Third, only one metric was used in each case to measure the effect of the TPS design rules. However, future work should focus on using multiple measures for measuring the effect of the TPS intervention, such as increased employee satisfaction, increased employee knowledge, or other measures that seem appropriate. Using such multiple measures will make the results robust against interpretive errors.

Further, this study has focused on applying TPS design rules to areas outside the direct patient/clinician interface. Future research should also investigate the possibility of applying the rules in clinical care to reduce errors and costs. In fact, some scholars argue that performing clinical procedures repeatedly over a long period results in lower mortality and reduced costs (Porter and Teisberg, 2004). Thus, it appears that standardization of the clinical work procedures results in productivity gains and better patient care. I believe the TPS design rules, with the necessary modifications suggested in this research, can be important complements to that exercise.

The possibility of bias, especially in answering Research Question 2, could not be eliminated. Since little empirical research existed on the application of the A3 Process, a qualitative study design was adopted. Despite all efforts made to reduce bias, the potential for some bias in this type of qualitative research still remains. Therefore, future work is required to investigate the efficacy of the A3 Process quantitatively in multiple organizational settings to triangulate and generalize the findings of this research.

Another shortcoming of this research is the small respondent size for the survey analysis used in addressing Research Question 3. The primary reason for this is that the research took place in one site. A larger respondent size, representing multiple organizations, would have given more statistical power to the survey data and results. Additionally, the survey was cross sectional, that is, the survey asked questions at one point in time. Therefore, establishing definitive causal relationships among the study variables was not possible. The results would have had more validity if the survey was replicated at multiple points in time (longitudinal survey design). Therefore, future research will have to study with a larger sample, and in multiple research sites, to assess the degree to which the results of this research apply in other contexts.

Finally, the system of organizational work process improvement is based on the study conducted in one firm. Therefore, future work is needed to replicate this perspective in other organizations (manufacturing and non-manufacturing). Literature suggests that many organizations import best practices or routines from other organizations to boost their performance. But the literature also indicates that the transferring of best practices is fraught with dangers and often ends up in incomplete transfer, inaccurate transfer, and sometimes even failures (O'Dell and Grayson, 1998; Szulanski and Winter, 2002; Berta and Baker, 2004) because the necessary details on how such routines were constructed is not available to the recipient. To surmount these difficulties, a better approach will be to develop new routines internally, or modify existing routines, using the systems approach proposed in this research.

Future Directions

It will be very interesting to investigate the effect of this concept when its transported to new emerging sectors such as virtual organizations (software organizations, online businesses) where the entire operation is fast changing, conducted on the digital space, the work environment is completely virtual, and the functional boundaries are blurred. The questions are: does this perspective really apply in such unstable sectors? What rules of designing work will be appropriate in such environments? How do you improve work processes using metaroutines in such environments when the work is continuously changing and not even observable? What will the structure of a boundary object be in such environments? Will it remain flexible enough to inscribe the ideas and differences of different individuals? These are some of the many pertinent questions that will soon emerge and need to be investigated in far greater detail as more and more virtual organizations are dotting the corporate landscape. In fact, many service-oriented organizations like banks, insurance companies, and educational institutions are gradually becoming virtual and paperless, and much of the work in those sectors seems to be getting more and more invisible.

Future research should also explore the possibility of using the three ingredients of the suggested quality improvement program to evaluate existing quality programs. A rating scale could be developed for each ingredient for such purposes. Then statistical analysis could be conducted to evaluate which programs are superior. Ultimately, a relationship could be established between the degree of conformance to the framework and the outcome achieved.

This work opens up new vistas for research in the area of management engineering. Management engineers in an organization are typically asked to participate in improvement projects that will enable them to improve the utilization of human, financial, and physical resources. Given that there are multiple ways of designing work (TPS design rules being just one example), multiple metaroutines (A3 Process being just one of the many metaroutines), and multiple boundary objects (A3 Report being just one example), organizational leaders are surfeited and confused with too many options. Therefore, research could be conducted to evaluate which combination of the three ingredients can best achieve the goals of the organization. This would enable organizational leaders to determine a specific solution that will best serve their needs.

I wrap up this dissertation with one final thought. Many healthcare givers consider activities related to direct patient/care interface to be their primary responsibility. They are less inclined to consider other activities important and usually pay less attention to them. The findings of this research seem to contradict this viewpoint. The research observed that all the activities that support the direct patient/clinician interface are very important and critical toward delivering the best patient care. An example of poor patient care would be if the patient is transported late from the clinical department to the procedure department, which results in delayed procedure or even cancellation of the procedure. Likewise, if the reports from the laboratory or the radiology department are delayed, the physician may be unable to deliver the next treatment, resulting in poor patient care. Therefore, every activity – clinical or non-clinical – assumes similar importance toward satisfying the patient. I hope the reader will

harbor this opinion after reading this dissertation, as I do after doing this research, and will be inspired to extend this work further.

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APPENDIX A:

BOUNDARY OBJECT VARIABLES – MEASURES AND RELIABILITY
COEFFICIENTS

Variables	Measures	Alpha
Process Improvement	<ol style="list-style-type: none"> 1. I observed positive results within a few weeks of implementing the target state 2. The change in performance after implementation of the A3 Report: <ol style="list-style-type: none"> a) Staff productivity b) Wasted time c) No. of errors d) Labor costs e) Material costs f) Patient care 	0.87
Objectivity	<ol style="list-style-type: none"> 1. The steps followed in the A3 Report are dependent on personal opinion 2. The steps followed in the A3 Report are based on unbiased data 3. Different individuals with different background will reach similar conclusions by using the steps of the A3 Report 	0.66
Knowledge Integrability	<ol style="list-style-type: none"> 1. The A3 Report rarely helped me share problems, mistakes, or concerns about current work processes with other functional departments and reconcile our differences 2. By drawing the current state on the A3 Report everyone had a better understanding of the work processes that spans across many departments 3. A3 Report helped me and others participating in the project to visualize the problem in all its dimensions 4. By using the A3 Report, we developed solutions that involved how the work processes of various departments would be linked together to achieve organizational goals 5. By writing the A3 Report I have a deeper understanding of the work processes and why we do it that way 6. By being involved in the A3 Report, I became more knowledgeable of the work processes of other departments as well 	0.89
Communicability	<ol style="list-style-type: none"> 1. A3 Report facilitates quick and easy communication with others 2. The pictures (current state and target state) encouraged communication among different members of the A3 team 3. A3 Report became a common ground for conversation among different members of the A3 team 	0.59
Creativity	<ol style="list-style-type: none"> 1. By using pencil and paper in writing the A3 Report, I was involved in free exploration of ideas 2. I drew and redrew sketches of the current state multiple times with a pencil to ensure that my mental imagination truly represented the actual current state 3. While drawing the target state with a pencil I was 	0.70

	involved in creative and conceptual thinking about how to improve existing work processes	
	4. Writing A3 Reports by hand encouraged me to be aware of the bigger picture	
	5. The A3 Report written by pencil can be easily passed around to other participants to draw out ideas	
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Simplicity	1. Writing the A3 Report requires a high level of skill and education	0.75
	2. It took me ---- hours to write the A3 Report	
	3. We spent a lot of money to effect the change as suggested in my A3	
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A3 Process	1. Observing current state was important for my study	0.70
	2. I designed the target state based on three design (specifying activities, creating direct connection, and simplifying pathways) rules of TPS	
	3. I carried out a test for my A3 Report	
	4. I and others have been able to verify our understanding of the improved process by devising a test and comparing the actual results with the predicted results	
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