This is to certify that the
dissertation entitled

LEARNING MECHANISMS IN PROCESS IMPROVEMENT INITIATIVES

presented by

JOHN DAVID HANSON

has been accepted towards fulfillment
of the requirements for the

Ph.D. degree in Business Adminstration

Major Professor's Signature

12-14-05

Date

LEARNING MECHANISMS IN PROCESS IMPROVEMENT INITIATIVES

By

John David Hanson

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Marketing and Supply Chain Management

2006

ABSTRACT

LEARNING MECHANISMS IN PROCESS IMPROVEMENT INITIATIVES

By

John David Hanson

This study is concerned with the process by which organizational knowledge is created. Knowledge is widely-acknowledged to be important as a resource or competence of an organization, and this importance is seen to be increasing with time. One result of this is a diverse and complex literature on Knowledge Management that deals with activities such as production, absorption, memorization, sharing and transferring of knowledge. While these activities are relevant to knowledge at an individual level, they are less meaningful in the context of organizational knowledge – that is, knowledge that is uniquely a property of the organization as opposed to its membership.

This study finds that organizational knowledge is a unique combination of two distinct elements and as such is not a thing that can be transferred. Instead, there is a need to focus on the process of creation of knowledge. Existing literature has been primarily content-based and fails to provide explanation of the mechanisms involved. There have been repeated observations that the process aspect is poorly understood and in need of further research.

This study seeks to provide explanation of the mechanisms of knowledge creation by taking a process view. To do so, a case study approach was taken, drawing data from three short-cycle process improvement initiatives (Kaizen

events

in an ex

conside

differen

process

The stu

knowle

learning

- C

  r

- T

  a

- *L*

  ir

- L

  th

Some in

discuss

culture

events). The analysis is both inductive and qualitative to support theory-building in an exploratory context. Deriving insight from the inductive approach requires considering the full range of evidence. To ensure a comprehensive view, three different perspectives were used, corresponding to the central entities in the process: knowledge itself, the individuals involved and the organization.

The study provides a grounded framework for understanding and explaining the knowledge creation process. The result is a prototypical theory of organizational learning that is elaborated by four propositions:

- Organizational knowledge is a 2-part construct consisting of performance routines coupled with an underlying logic of action.
- The logic of action underlying a performance routine must be understood as an element of the culture of the organization.
- Learning, as in modifications to organizational knowledge, takes place independently in the two components, and by different mechanisms.
- Learning takes place through the actions of individuals who must reconcile their paradigmatic and narrative views of the situation.

Some implications of these findings and directions for future research are discussed with particular attention being directed to the role of organizational culture and values.

Writing

yet a mo

contribu

this opp

been ins

I would

chairper

better do

to Brian

shown b

Finally, a

Hanson,

support

ACKNOWLEDGEMENTS

Writing the doctoral dissertation often seems to be the world's loneliest endeavor, yet a moment's reflection reveals that there are many people who have contributed directly or indirectly to the completion of the task. I would like to take this opportunity to acknowledge the efforts of those whose contributions have been instrumental to the realization of my goals.

I would like to thank my entire committee, but special thanks are reserved for the chairperson, Steven Melnyk, whose constant critiques have made this a much better document than it would otherwise have been. Special thanks are also due to Brian Pentland who has been a constant source of encouragement, and as shown by the reference list, a source of intellectual inspiration as well.

Finally, a special place in these acknowledgements is reserved for Patricia Hanson, my wife and companion of twenty-five years, without whose unswerving support this entire venture would not have been possible, or even worth doing.

TABLE OF CONTENTS

Chap

Chapt

Table

Table

Table

Table

LIST OF TABLES

LIST OF FIGURES

The Im

This re

their op

knowle

Few wo

is also

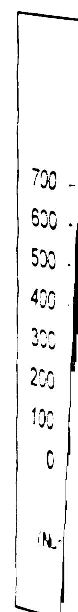
the eco

increas

Mukhe

popular

growth



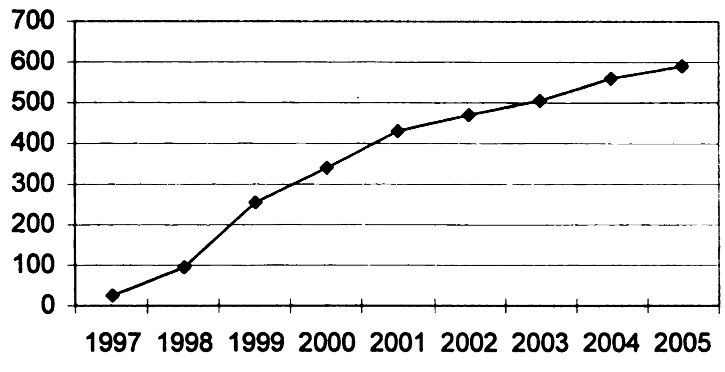
CHAPTER ONE: INTRODUCTION

The Importance of Knowledge:

This research addresses the question of how organizations create knowledge in their operations. In that context it is appropriate to begin by establishing that knowledge is important, and to suggest why it is of interest to study its creation.

Few would challenge the premise that knowledge is important to the firm. There is also a corresponding belief that the importance of knowledge to the firm and to the economy at large is increasing with time, attributable primarily to the increasing technical complexity of our world (Drucker, 1993; Bettis & Hitt, 1995; Mukherjee, Lapre & Wassenhove, 1998). This belief can be seen in the popularization of the term "Knowledge Management" and the year-by-year growth in the number of articles published in that area (Figure 1).

Figure 1: Articles on Knowledge Management



(Number of refereed journal articles in the Proquest database containing the term "Know ledge Management" in the title or abstract.)

The re

not ne

attenti

View c

fundar

source

the fev

reasor

Centra

source

statem

Leonar

1994; N

Zander

Nahapi

As note

generat

either c

its sim

and he

above

the la

be rea

The recognition that knowledge constitutes an important resource of the firm is not new (it can be seen clearly in Penrose, 1959 for example), but increased attention to this fact has coincided with the emergence of the *Resource-Based View* of the firm (RBV) in the field of strategy. Arguing the economic fundamentals of the RBV, Williamson (1981) makes the case that knowledge is a source of economic rent. The basis for this argument is that knowledge is one of the few resources whose use incurs no opportunity cost. Extending this reasoning, Grant (1996) proposed the Knowledge-Based View (KBV) of the firm. Central to this view is the argument that knowledge is a firm's primary, if not only, source of sustainable competitive advantage. Many researchers have made statements to this effect (Prahalad & Hamel, 1990; Barney, 1991; Nelson, 1991; Leonard-Barton, 1992; Cyert, Kumar & Williams, 1993; Henderson & Cockburn, 1994; Nonaka, 1994; Bates & Flynn, 1995; Nonaka & Takeuchi, 1995; Kogut & Zander, 1996; Miller, 1996; Spender, 1996a; Davenport & Prusak, 1998; Nahapiet & Ghoshal, 1998).

As noted above, the economic foundation of the KBV is that knowledge can generate rents because its use incurs no opportunity cost. This can be true for either of two reasons; the use of knowledge in one application may not preclude its simultaneous use in another, or the knowledge may be difficult to replicate and hence have no market value as an item of trade. The arguments cited above for the role of knowledge in creating competitive advantage hinge more on the latter point than the former. To the extent that the knowledge of a firm cannot be readily copied, it represents a source of *sustainable* competitive advantage.

Th

reu

Fro

of k

ma

firm

ass

Sta

at:

book

value

conse

that m

create

consis

genera

We hav

Manag

critica

growt

a broa

Cohe

memo

The ideal situation for a firm would be to have knowledge that was readily reusable within the firm, but impossible to copy externally.

From a managerial perspective, it is of interest to assess the relative magnitude of knowledge as one of the resources of a firm. A simple check on this magnitude can be made by examining the price-to-book ratio of publicly-traded firms as a proxy for the ratio of their total worth to the value of their tangible assets. This ratio fluctuates somewhat, but on August 4, 2005, the Morgan Stanley Capital International (MSCI) US Broad Market Index (statistics available at: http://flagship4.vanguard.com/VGApp/hnw/FundsHoldings?FundId=0085&FundIntExt=INT) had a price-to-book ratio of 2.7:1, suggesting that tangible assets make up less than 40% of the value of a typical firm. Admittedly, the accounting system tends to be conservative in its valuation of assets, and there are things other than knowledge that make up the missing 60%, such as brand names and *de facto* monopolies created by historical accident or legislative action. Nonetheless, this result is consistent with the above citations which argue that the principal value-generating resource of a firm is its aggregate store of knowledge.

We have previously noted the rapid growth in the literature on *Knowledge Management* which is consistent with the both the view that knowledge is a critical resource of the firm and that its importance is growing with time. This growth was explicitly forecasted by Drucker (1993). Knowledge management is a broad term lacking a universal definition, but was described by Amin and Cohendet (2000) as consisting of the activities of *production*, *absorption*, *memorization*, *sharing* and *transferring* of knowledge. It should be apparent by this point that, if we are to make much progress beyond sweeping generalizations, we will have to be much more precise about what we mean by knowledge. Wacker (2004) noted that common language or "dictionary" definitions are rarely useful for research because they are insufficiently precise. This is very much the case in this research, and we will develop more precise definitions in Chapter Two. What we must establish at this point however, is the distinction between *organizational knowledge* and all other forms that we encounter.

Knowledge versus Organizational Knowledge:

A key issue of concern in the strategy literature is the *appropriability* of rents (Collis & Montgomery, 1998). In the context of knowledge, it becomes an important distinction whether knowledge is uniquely a property of the organization (which would then capture the rents), or a property of the individuals who happen to make up the organization at the time (and who would capture at least a portion of the rents through above-normal salaries). In the work that follows, the term *organizational knowledge* will be used to mean a form of knowledge that is uniquely a property of the firm; something that the firm can claim as its own and is robust against disturbances such as employee turnover. In the framing of the research question it is *organizational knowledge* that will be central to the research.

Focus on Routines:

Having established our interest in organizational forms of knowledge, we turn our attention to the subject of *routines*. We do so because many researchers have conclu

organi

2002)

as org

Simon

existe

refer t

opera

(1958

were

Since

organi

and P

action

Bacda

of an

resista

organ

declar

(199

prope

Chap

(pote

concluded that routines are the means by which knowledge is embedded in an organization (Levitt & March, 1988; Cohen, 1991; Amundson, 1998; Orlikowski, 2002). While no single researcher can claim priority on the concept of routines as organizational knowledge, the idea is clearly present in the work of March and Simon (1958) who observed that what we are calling organizational knowledge existed in the form of *performance programs,* which we now more commonly refer to as *routines*. These routines are fundamental to production and operations management. While drawing attention to routines, March and Simon (1958) did not describe how they were encoded in organizations or how they were created.

Since then, progress has been made in understanding the anatomy of organizational knowledge in the form of routines. Pentland and Rueter (1994) and Pentland (1995a) characterized routines as consisting of a *grammar* of actions that could be used to define a range of effective behavior. Cohen and Bacdayan (1994) characterized routines as representing the *procedural memory* of an organization, arguing that their inherently tacit nature made them highly resistant to change and that they therefore represented a source of stability in organizations. Note that in making the distinction between procedural and declarative memory, Cohen and Bacdayan (1994), like Cohen and Levinthal (1990), are drawing an analogy between the psychology of individuals and the properties of an organization. The validity of this approach will be considered in Chapter Two. Leonard-Barton (1992) also characterized routines as sources of (potentially unwanted) stability by equating core capabilities with "core rigidities."

Feldr

poter

chan

rout

two v

by p

some

perfo

aspe

they

know

are cr

__The F__

The p

from t

devote

'The s

directe

limited

1996

While

orga

the is

Feldman (2000) countered this view by suggesting that routines could include the potential for variation and selection, and therefore evolutionary, incremental change. More recently, Feldman and Pentland (2003) have decomposed routines into "ostensive" and "performative" aspects. This somewhat bridges the two views (routines as sources of stability versus routines as agents of change) by pointing out that the visible aspects of a routine are but a manifestation of some underlying rationale. A great deal of change may be possible in the performative aspects of a routine without challenging the stability of the ostensive aspect. While it is not fair to claim that these concepts are universally accepted, they do go a long way towards describing the anatomy of organizational knowledge. What remains relatively unstudied is the question of how routines are created or changed.

The Research Question:

The preceding comment is motivated at least in part by the following quotation from the introduction to a 1996 special issue of *Strategic Management Journal* devoted to "Knowledge and the Firm":

"The surge of interest into organizational capabilities and competences has directed attention to organizationally embedded knowledge, but has made only limited progress in understanding its anatomy and creation." (Spender & Grant, 1996)

While progress has been made since then on understanding the anatomy of organizational knowledge (described above, and in more detail in Chapter Two), the issue of its creation remains poorly understood. This shortcoming with respe

to be

disco

some

simp

that e

augm

by St

prese

resea

their

<u>Posit</u>

The o

of proc

resear

proces

Clark,

1998).

Manag

stocks

The d

was

and

respect to the understanding of the creation of organizational knowledge proved to be particularly salient within the scope of this research. It was ultimately discovered that every instantiation of organizational knowledge was unique in some respects and could be seen as an instance of the creation process and not simply an application. This point was anticipated by Hayek (1945) who noted that every circumstance was specific and that generalizations must be augmented with something else to be useful. A similar conclusion was reached by Starbuck (1992) who stated that "the distinction between creating, applying or preserving knowledge is very hard to make or defend." This leads us to the research question, broadly stated: "**How do organizations create knowledge in their operations?**"

<u>Positioning of the Research Question:</u>

The operative word in this question is "how." This positions the question as one of *process* as opposed to *content*; a critical point of distinction between this research and much that has gone before. A shortage of research into the *process* of organizational learning has been noted by many researchers (Adler & Clark, 1991; Miller, 1996; Amundson, 1998; Hatch & Mowery, 1998; Meredith, 1998). Fahey and Prusak (1998) offer the suggestion that Knowledge Management should be thought about in terms of flows of knowledge rather than stocks of knowledge; also a clear call for attention to the underlying process.

The distinction between process and content points of view in strategy research was discussed by Huff and Reger (1987), who made a number of observations and recommendations specific to process research. A key observation was that ther

and

thei

from

Anot

reco

is un

resea

a lack

of a s

organ

literatu

study

for que

Huberr

Focus

The res

operat

interpre

resear

Martin

proces

there were divides between those who study firms and those who study people and between those who study economics and those who study behavior. One of their major recommendations was to bridge these divides by importing concepts from other fields such as organizational behavior and psychology.

Another recommendation was to vary the use of research methods, a recommendation consistent with the observation that process-oriented research is underrepresented in the literature. As noted by Meredith (1998), different research methods lend themselves to different types of question. Consequently, a lack of attention to process-related questions is consistent with his observation of a shortage of case study and field research. By focusing on the *process* of organizational learning (the "how"), this study is a departure from much of the literature and must make use of different research methods. Specifically, a case study approach, using direct observation and qualitative analysis is appropriate for questions of "how," particularly when there is a lack of existing theory (Miles & Huberman, 1994; Yin, 1994; Meredith, 1998).

Focus of the Research Question:

The research question; "How do organizations create knowledge in their operations?" is a broad one that can be approached from many directions and interpreted in many ways. At the outset it must be acknowledged that this research is undertaken and described with a *Managerial Interest* as defined by Martin (2002, p. 169). What this means is that the research focuses on processes that are of interest to managers because the desired outcome is a perf

impr

A fu

Ope

and

base

unde

is tha

other

a gap

be de

Finally,

as *opp*

differen

(1998).

theory t

Spende

concept

Importa

The for

organiz

creatio

poorly

performance improvement as defined by typical measures of productivity improvement or cost reduction.

A further narrowing of the focus of the research is that it is research in Operations Management. This is fully consistent with the managerial interest and is motivated by two factors. One is that there are particular knowledge-based problems in Operations Management that could benefit from a better understanding of process. These will be described in the next section. The other is that Operations Management has been relatively slow to adopt concepts from other branches of management (Huff & Reger, 1987; Amundson, 1998), leaving a gap that this research addresses in formulating the research protocol. This will be developed further in Chapter Two.

Finally, the focus of this research is on theory-building, meaning theory creation as opposed to theory-testing. This distinction is noted in part because of the different treatments of the term *theory-building* by Hunt (1991) and by Wacker (1998). This focus follows from the conclusion that there is a lack of existing theory that is sufficiently explanatory, and is consistent with the contention of Spender (1996b) that organizational knowledge, learning and memory are "three concepts in search of a theory."

Importance of the Research Question:

The foregoing has attempted to show the importance of knowledge and of organizational knowledge in particular. It has also argued that the process of creation of organizational knowledge (equivalently: *organizational learning*) is poorly understood. It remains to be argued that an improved understanding of the p

for p

The

Rec

betw

ratio

betw

argu

Tobi

a sig

than

This

the c

mana

must

know

neces

as "o

The

wou

bet

bee

act

the process will be of value, although this is clearly the rationale behind the calls for process-focused research.

The Manager's Problem:

Recall the Price-to-Book ratio of 2.7 cited above. The existence of a gap between market and book values highlights an important problem. Price-to-book ratio is the best proxy we have for Tobin's Q, which is defined as the ratio between the market value of a firm's assets and their replacement cost. Tobin argued that this ratio should, on average, be unity (Brainard & Tobin, 1968; Tobin, 1969). Unless Tobin was seriously mistaken, corporations are made up of a significant percentage of assets that we simply do not know how to value, other than through an auction process.

This is a well-known problem that is unlikely to be resolved, in part because of the conflicting demands on the accounting system. The problem for the managers of these corporations is that they are entrusted with a major asset, and must manage it appropriately. They must maximize the returns from the knowledge assets that they have and must acquire or replenish these assets as necessary. In fact, Drucker (1993) offers the "right definition of a manager" (*sic*) as "one who is responsible for the application and performance of knowledge." The problem is this: knowledge assets *per se* are not measurable (or there would not be the gap between market and book values), yet many managers believe that "if you can't measure it, you can't manage it." (This statement has been attributed to many writers but often, wrongly, to Deming, 1986, who was actually making the counter-argument, describing the above problem.)

The resu

depend

(Austin.

proxy m

that it n

of tear

high-sp

Anothe

sales f

includ

Corpo

the lev

measu

this re

DeCar

are pr

impro

poter

The

The

stra

("w

ma

The result is that managers and practitioners in Operations Management must depend on proxies for knowledge. Proxies are problematic for several reasons (Austin, 1996). The principal problems are that an increase in the value of a proxy measure does not guarantee an improvement in the true objective, and that it may also lead to unwanted effects. An example cited by Austin is the use of tear strength of paper as a proxy for the propensity of the paper to break in a high-speed printing press.

Another example of a proxy (for innovativeness) might be the percentage of sales from products introduced in the last five years (used by many companies, including the subject of this research; a more public example being Emerson Corporation in their 2004 Annual Report, p. 6). A manager seeking proxies for the level of knowledge might consider the training level of the staff (this was a measure used in one of the divisions of the corporation that was the subject of this research), or the number of patents awarded (Spender & Grant, 1996; DeCarolis & Deeds, 1999), or R&D spending (Bettis & Hitt, 1995). All of these are proxies for content with obvious potential for unintended results. An improved understanding of the *process* of organizational learning has the potential to reduce managers' dependence on proxies for *content*.

The Researcher's Problem:

The problems faced by researchers are related but slightly different. At the strategic level, researchers are interested in issues such as firm heterogeneity ("why do firms differ in the value of their knowledge assets?") and the role of management in creating that heterogeneity (e.g.: Nelson, 1991; Conner &

Pra

bett

use

man

as in

1985

At a

firms

Mana

(e.g.

1995

a con

adop

This i

is sim

firms

lack o

resu

they

<u>The</u>

The

is

Prahalad, 1996). There is a general premise that better management leads to better performance (otherwise we should close all business schools), but lacking useful measures of assets, and hence return on assets, researchers, like managers, are forced to rely on "noisy" proxies such as share price appreciation as indicators of managerial performance (Dess & Robinson, 1984; Hitt & Ireland, 1985).

At a more operational level, there is considerable interest in the question of why firms differ in their ability to effectively implement concepts such as Total Quality Management (TQM). The research in this area has been primarily content based (e.g. Ferdows & De Meyer, 1990; Flynn, Schroeder & Sakakibara, 1995; Powell, 1995; Sakakibara, Flynn, Schroeder & Morris, 1997; Flynn & Flynn, 2004). From a content perspective, the differences in results represent a puzzle because firms adopting (for example) a TQM methodology are homogeneous in this respect.

This is not to imply that these researchers are unaware of the role of process; it is simply a reflection of the fact that researchers are generally obliged to study firms from the outside, where issues of process are not readily visible. It is the lack of visibility into process issues that this study seeks to rectify. While the results should be of primary interest to researchers in this field, it is expected that they will also be of value to managers and practitioners alike.

The Research Approach:

The foregoing has set out to establish that the process of organizational learning is not well understood. That being the case, there is no established theory that this

buil

Foll

offe

cen

indu

and

grou

obs

und

stat

key

desi

Rese

The f

resea

This s

recon

are w

not

com

(199

phe

this research seeks to confirm or justify. Rather, this research is aimed at theory building, operating in the *context of discovery* as described by Hunt (1991).

Following further with Hunt's typology of research, purposive theory building offers the researcher the choice of *inductive* or *deductive* methods. Lacking any central law or hypothesis that is presumed to apply, this research adopts an inductive approach, comprised of the steps of *observing, recording, classifying* and *generalizing*. This procedure is closely analogous the development of *grounded theory* (Glaser & Strauss, 1967), in which theory is developed from observation only. In this mode, the researcher enters the field with "no theory under consideration and no hypotheses to test" (Eisenhardt, 1989). This ideal state creates certain problems which will be dealt with in Chapter Three, but the key point is that the choice of approach has a major influence on the research design.

Research Design:

The first step in the inductive process of theory building is *observation*, so the research design must be one that provides sufficient opportunity for observation. This strongly suggests a case study approach, consistent with the recommendation of Yin (1994) and Meredith (1998) who state that case studies are well-suited to research questions of the "how and why" variety. Where it is not the cases themselves that are of interest, but rather some underlying commonality, the preference is for *instrumental* cases as defined by Stake (1994). Instrumental means that the cases are simply vehicles for studying some phenomena; the cases themselves are not unusual in any way, nor should they *be.*

imp

Mor

be u

Cas

met

direc

moti

prec

adm

a *pro*

partic

mode

bridg

This c

would

watch

by Ba

exch

latte

nece

Wh

wor

be. Ultimately, three cases were used, consisting of short-cycle process improvement projects of the type known as Kaizen events (Melnyk, Calantone, Montabon & Smith, 1998). The issues of actual case selection and the criteria to be used will be discussed in Chapter Three.

Case study is not in itself a method (Stake, 1994); it still remains to select the method for collecting data. For this research, the choice was made to employ direct observation as opposed to surveys or interviews with informants. This was motivated by two factors: a) the grounded nature of the research, which precluded the assumption of specific constructs and propositions, and b) the admonition (paraphrasing Melnyk & Stewart, 2000) that one "cannot understand a process by having participants discuss what they think is going on." In particular, it was decided to employ a participant-observer model. This is a model often employed in ethnographic research (Martin, 2002, pp 48, 210) which bridges the "insider" and "outsider" views of an organization.

This choice was based on the premise that interaction with the participants would: a) result in greater insight and b) cause them to lose the sense of being watched, and therefore behave more normally. The former point was addressed by Bartel and Garud (2003) when they stated that "to see and understand (the exchanges that take place), the researcher must become semi-native." The latter point was actually validated in one of the case studies when it was necessary for the project team to collect time-study information on a process. When the team members observed the production workers in a passive way, the workers performed in a stylized fashion, showing great energy but omitting key step

wor

pros

Qua

Hav

ana

wide

stre

anal

That

patte

The

resul

refers

resea

proble

valida

resea

extra

their

steps. It was only when the team started discussing the process with the workers in a more engaged and informal way that a true picture of the work process started to emerge.

Qualitative Data Analysis:

Having defined the research approach to this stage, it was evident that the analysis of data would have to be qualitative in nature. The need to consider a wide range of possible explanations for the observations is actually one of the strengths of qualitative analysis (Miles & Huberman, 1994). The exact process of analysis is what Kaplan (1964) and Hunt (1991) describe as *pattern matching*. That is, the recorded observations are scrutinized for repeating themes and patterns of potential interest.

The human brain is good at seeing patterns in data – perhaps too good. As a result, this method suffers from problems with the criterion that Hunt (1991) refers to as *intersubjective confirmability*. Simply stated, this means that two researchers may not extract the same patterns from a common data set. This problem disappears with time as a field converges on an accepted set of validated constructs, but is unavoidable at the exploratory stage where this research is positioned. To mitigate this potential threat to validity, the themes extracted were reviewed with a panel of experts to determine consistency with their experience.

Re

It v

ob:

the

is a

uni

con

thro

(199

Two

The

the u

rese

mea

not.

not o

Seco

The

addre

persp

learn

knov

dis

Research Protocol:

It was stated above that the inductive method of theory-building begins with observations, but the question is: observations of what? If one starts with "no theory under consideration and no hypotheses to test" (Eisenhardt, 1989), there is a great danger of recording too much of what ultimately proves to be uninteresting at the expense of that which, retrospectively, is interesting. A compromise to the ideal of grounded theory is required and this is ideally done through the development of a sound research protocol as elaborated by Ellram (1996). Development of this protocol is one of the central purposes of Chapter Two.

The research protocol for this study consists of an event checklist (Ellram, 1996), the usage of which was twofold. Prior to case observations it is a tool for the researcher to become sensitized as to what to look for. *Post facto*, it provides a means of classifying data as representing an instance of some phenomenon, or not. To fulfill these roles, the protocol requires two characteristics. First, it must not only specify what is to be looked for, but also how it might be recognized. Second, it must cast as broad a net as is feasible.

The latter task is the more difficult and, as will be seen in Chapter Two, it is addressed by examining the issue of organizational learning from three perspectives. These perspectives correspond to the identifiable entities in the learning process: the individual(s) involved, the organization being studied, and knowledge itself as a distinct entity. Interestingly, these perspectives draw upon distinct literatures with very little overlap. If one accepts the proposition that the

pro

cas

exp

imp

rec

con

Sur

This

know

grow

we w

cont

of its

It is a

numb

unde

outco

outco

fail t

this

The

org

res

process of organizational learning is not well understood, then it must be the case that none of these streams of literature has, by itself, provided a satisfactory explanation. Combining the different perspectives in a single protocol not only improves the breadth of the observations, it also responds to the recommendation of Huff and Reger (1987) and Amundson (1998) to integrate concepts from other fields.

Summary:

This introduction has sought to establish a number of points, firstly that knowledge is important to an organization or firm and that this importance is growing. Appropriable knowledge is particularly important and this defines what we will refer to as organizational knowledge. Secondly, while the nature and content of organizational knowledge are at least partially understood, the process of its creation, organizational learning, is much less well understood.

It is argued that a better understanding of organizational learning will address a number of problems for researchers and practitioners. In particular, an improved understanding of the process variables may allow a reduction in dependence on outcome measures that are but proxies for learning. While models based on outcome measures (such as a learning curve) may have predictive value, they fail the test of explanation (Schmenner & Swink, 1998). It is the ultimate goal of this research to supplement them with more explanatory process models.

The central research question addressed by this research is: "How do organizations create knowledge in their operations?" The approach taken by the research to answer this question is inductive theory-building. A logical conse

case s

this ap

protoc

The b

Chapt

protoc

These

organi

of the

Chapte

methoc

Chapte

three ca

summa

propos

Chapte

particu

that ca

are dis

consequence of this approach is the use of a participant-observer model in a case study setting, with qualitative analysis of data. Potential threats to validity in this approach are addressed by the development of broadly-based research protocol and the use of an expert panel for validation of specific findings.

The balance of this report is organizes as follows:

Chapter Two is primarily devoted to development of a research framework and protocol based on a reading of the literature from three different perspectives. These perspectives correspond to the individuals involved in the process, the organization in which it takes place, and the knowledge that is created as a result of the organizational learning process.

Chapter Three describes in more detail the development of the research methodology, including the research protocol and the case selection criteria.

Chapter Four contains the summaries and analysis of the data recorded from the three case studies and from the discussions with the expert panel. These summaries are integrated, following the research protocol and a set of propositions are derived.

Chapter Five discusses the significance and implications of the propositions. In particular, the implications are starting points for the development of hypotheses that can be tested in other settings. Limitations with respect to generalizability are discussed and suggestions for additional research are presented.

Introd

In intr

knowl

creat

this s

positi

This c

objec

learni

objec

might

obser

that a

proce

throu

The fi

togeth

ways.

the in

a ne

inte

de

CHAPTER TWO: REVIEW OF RELEVANT LITERATURE:

Introduction:

In introducing the research question, Chapter One sought to establish that knowledge is important to the firm, and that understanding the process of its creation should be of interest to both researchers and practitioners. In so doing, this study was positioned as one focusing on process as opposed to content; a positioning that sets the requirements for this chapter.

This chapter is devoted to a reading of the literature, and has three specific objectives. The first is to establish definitions of organizational knowledge and learning that are consistent with and grounded in the literature. The second objective is to cast a broad net to identify a list of key concepts or constructs that might be expected to be relevant to the research question and fruitful as areas of observation. The third objective is to identify and survey the streams of literature that are constrained by the limited understanding of the organizational learning process. It is these streams of literature that this research proposes to extend through improved insight into the process.

The first objective falls naturally out of the second, so these will be treated together. The concepts that are identified from the literature will be used in two ways, consistent with the *inductive* approach to theory-building (Hunt, 1991). In the inductive approach, one ideally begins with observations. However, there is a need to establish certain screens for deciding what observations will be of interest and which will not. Therefore, one use of the concepts will be the development of a *research protocol*. In this instance the protocol will take the f

i

d

c

c

fr

pr

Th

re'e

lite

the

of th

inste

How

requ

Proc

In the

conte

impo

base

revie

und

form of an event *checklist* (Ellram, 1996) that will ensure that the questions of interest are investigated uniformly in all cases. The second use will be the development of a research framework. The concepts represent potential constructs to be used in theory-building and are the basis for the process of *classification* in inductive theory-building (Hunt, 1991). As elements of a framework, they define the range of relationships that can be expressed as propositions of a tentative theory.

This chapter will be organized in two main parts. The first part will identify the relevant concepts and definitions. The second will identify those streams of literature that are intended to be enhanced by this research. It will be noted that there was considerable reference to the literature in establishing the importance of the research question in Chapter One. That work will not be repeated here; instead, this chapter will be focused on the three purposes described above. However, before proceeding with those tasks there is an additional point requiring elaboration.

Process versus Content: Lessons from the Literature:

In the introduction, this study was positioned as one of *process* as opposed to *content*. A number of references were cited to make the case that this is an important difference with implications for the research design and that process-based research was lacking. A recurring theme that will be seen in this literature review, particularly in Part II, is the call for more research, or at least better understanding, of the *process* of organizational learning.

W
pr
pr
the
pro
(Ha
ma
this
obje
and
conc
Som
MacD
organ
of the
of the
were p
Roos,
and Sc
do not
conte
orien

With that in mind, the literature was examined for lessons learned with respect to process-oriented research. The immediate conclusion was that there is very little process-oriented research. The great majority of research that even addresses the issue of process in organizational learning is, in essence, attempting to infer process by examining outcomes. Unfortunately, in the presence of *equifinality* (Hambrick, 1984), the results of such inference will be indeterminate. The majority of the works cited in Part II of this chapter could be cited as examples of this approach. A noteworthy example is Adler & Clark (1991), cited not as an object of criticism, but as an instance of an explicit recognition of this problem and a recommendation to pursue process-based research. The overriding conclusion is that to understand process, one must observe process.

Some good examples of good process research were noted, specifically MacDuffie (1997) and Sinclair, Klepper and Cohen (2000) with respect to organizational learning in Operations. In the general context of Operations, one of the most comprehensive pieces of process research ever undertaken was that of the International Motor Vehicle Program at MIT (IMVP), the results of which were presented in *"The Machine That Changed the World"* (Womack, Jones & Roos, 1991). Other good examples are Ward, Liker, Cristiano and Sobek (1995) and Spear and Bowen (1999). In looking at these examples, we note that they do not generate much new theory in spite of the richness and usefulness of their content. As a result, they tend to be published as books or in more practitioner-oriented journals, and with the exception of Womack, do not get cited very often.

The

rese

dura

invo

Eve

buil

cont

all o

are *r*

Havi

learn

the *fo*

achiev

a close

Operat

descri*b*

There are lessons here about the difficulty of doing good process oriented research. Specifically, it is difficult to do studies of sufficient depth, breadth and duration to progress beyond single-sample anecdotes. Note that the IMVP study involved 55 researchers, took five years and cost $5M (in 1980's dollars).

Even with those resources to address the problems of breadth and duration, building theory is a challenge because of the problem of establishing adequate controls. Organizations are open systems and it is rarely possible to be sure that all of the relevant factors have been observed. Unless the subjects of the study are naturally bounded in some way this will always remain as a question.

Having taken up the challenge of observing the process of organizational learning, these lessons have to be taken into account if the research is to allow the formation of even tentative theory. In particular the critical issues are to achieve a degree of repeatability in the research setting while also approximating a closed system. In effect, what is needed is a virtual laboratory, set in the Operations world. These issues will be addressed in the research design, described in Chapter Three.

PA

A c

tha

fon

anc

the

sem

As v

takin

viewe

resul

impro

identif

-
-
-

is

th

c

t

Interes

non-o

branc

PART I: DEVELOPMENT OF CONCEPTS AND CONSTRUCTS:

A disadvantage of a process point of view relative to a content-based analysis is that it requires more data. Consideration must be given to all of the factors that form the mechanism of interest. In seeking to develop a list of relevant concepts and constructs with which to populate a research framework we are faced with the challenge of casting a sufficiently broad net while maintaining some semblance of coherence and order.

As was suggested in the introduction, this study will attempt to do just that by taking a subject-object view of the process. In other words, the process will be viewed from the perspective of the principal agents and/or objects involved. This results in three major perspectives from which to observe and interpret a process improvement step. For each of these points of view, relevant constructs can be identified from the literature. These points of view are:

- The knowledge that is created, used or transformed in the process.
- The individual person(s) involved in the process.
- The organization within which the process occurs. The organization view is two-fold: as an economic entity, it provides the purpose, and therefore the definition of process improvement. The organization also defines a culture or institution within which the individual(s) operate and learning takes place.

Interestingly, each of these points of view is supported by distinct and largely non-overlapping fields of literature. Specifically, these fields are the various branches of epistemology, psychology and organization theory, respectively.

Sur

scop

only

inter

conc

indivi

intere

the inc

connec

With *th*

constru

to a pro

literatur

Epistem

Definitio

We begir

with an in

is it simp

(1995) n

the para

indepen

points o

has pro

Surveying any of these fields would be a vast undertaking in its own right, but the scope of the problem can be substantially reduced by noting that we are really only interested in the intersections of these areas. For example, we are interested in the psychology of the individual, but only to the extent that it concerns the processing and absorption of knowledge or the interaction of the individual with the organization. On the subject of knowledge itself, the prime interest is in knowledge in an organizational context. Knowledge in the context of the individual may be of interest to the extent that it has an identifiable connection to organizational knowledge.

With the field narrowed in this way, the following is a search for the relevant constructs that can be used to develop a research framework that will in turn lead to a protocol or event checklist. An important additional goal is to derive from the literature appropriate definitions of organizational knowledge and learning.

Epistemology:

Definitions of Knowledge:

We begin with the study of knowledge itself, or *epistemology*, and are confronted with an immediate problem. Does knowledge have an independent existence or is it simply a descriptive property of some other entity? Nonaka and Takeuchi (1995) note that Western philosophy has been dominated by the *Cartesian Split*, the paradigm of Descartes in which knowledge, and by extension truth, are independent absolutes which can be discovered and proved. Polanyi (1958) points out that this assumption underpins the scientific method as we know it and has proven to be useful and effective in that context. However, he ultimately conc

uniqu

justifi

is the

perso

This p

Amin

memo

the *ter*

indepe

but the

that Ne

deal *by*

persona

not the g

as a warn

as a *thing*

important

To addres

and *typo*

observat

starting w

concludes that this view is false and that knowledge is, in the final analysis, unique to the knower. In this he falls back on a definition of knowledge as *justified belief*, a definition that Nonaka and Takeuchi (1995) attribute to Plato. It is the role of belief and the context of justification that makes this an individual or personal form of knowledge.

This presents a difficulty for Knowledge Management as a field (described by Amin & Cohendet, 2000 as consisting of the activities of *production*, *absorption*, *memorization*, *sharing* and *transferring* of knowledge). These terms, and even the term *Knowledge Management* itself, imply a *reified* view of knowledge as an independent entity. This clearly conflicts with the conclusion of Polanyi (1958), but the distinction may not be significant in practice. For example, we all know that Newton's laws of motion are not quite right, but we have achieved a great deal by accepting them as correct. In a relatively homogeneous society, the personal nature of knowledge may not be particularly visible or important. It is not the goal of this study to take sides in this debate, but the discussion serves as a warning that words can create a trap. If we speak too freely of knowledge as a thing to be managed (stored, retrieved, applied, etc.), we may fail to see important issues.

To address issues of knowledge in this research, we need suitable definitions and typologies of knowledge so that we can classify and organize our observations. Many definitions of knowledge exist with respect to an individual, starting with "justified belief" as discussed above. Another example would be

th

po

Ho

anc

app

orga

leave

(199

ascrib

Teece

organi

assemb

Knowle

form of

property

To arrive

Pentland

specifica

This scho

writings (

the idea

situation

situated

"the subjective meaning of the known to the knower" (offered as one of many possible definitions by Machlup, 1980).

However, our interest is primarily in knowledge as a property of an organization, and it is not clear that definitions centered on individuals are relevant when applied to organizations. Cyert and March (1963) first proposed that an organization could learn independently from its individual members but did not leave us with a comprehensive definition of organizational knowledge. Grant (1996), in proposing the Knowledge-Based View of the firm, avoided the issue by ascribing knowledge purely to the individuals comprising the organization. Teece, Pisano and Shuen (1997) also avoided the issue by arguing that what the organization possesses is the complementarity of the knowledge of individuals assembled within the organization. Nonetheless, the term *Organizational Knowledge* is very much part of our vocabulary and many feel that it is a distinct form of knowledge. Specifically, Hedberg (1981) describes it as being a "robust property" of an organization.

To arrive at a useful definition of organizational knowledge, we follow the lead of Pentland (1992), who drew on the philosophy of American pragmatism, and specifically the work of George Herbert Mead, William James and John Dewey. This school also rejects the Cartesian view of knowledge and it is from their writings (specifically Dewey, 1916 and Dewey & Bentley, 1949) that we derive the idea that knowledge is *situated*, that is to say: defined only relative to a situation. Accordingly, we adopt the definition of organizational knowledge as *situated performance,* which means the ability to deliver a satisfactory pe

de

ge

im

co

se

Ma

bee

the

sam

Sab

Onc

perfo

woul

eleme

Schön

definit

of situa

Even t

above

enter

defir

neec

performance in a defined set of circumstances. This is a functional rather than a descriptive definition, but is made manageable by the fact that organizations generally have a defined purpose that defines the situation. Note that there are important parallels between this formulation of knowledge and the treatment of cognition in the psychology of individuals, which will be addressed in the next section.

Many equivalent definitions or statements about organizational knowledge have been made. Amin and Cohendet (2000) speak of the firm as *"a social institution, the main characteristic of which is to know well how to do certain things."* In the same vein, Orlikowski (2002) equates knowledge with *"effective action"* as do Sabherwal and Becerra-Fernandez (2003).

Once we accept the definition of organizational knowledge as situated performance we can derive a working definition of *organizational learning* which would be: *an increase in situated performance*. This definition lacks a certain element of volition, so it will be supplemented by one proposed by Argyris and Schön (1978): *the detection and correction of error*. Equivalence of the definitions can be established by regarding "error" to be any unsatisfactory level of situated performance.

Even though our primary interest is in organizational knowledge as defined above, it is clear that knowledge as a property of individual persons may also enter into the research question. As noted above, there is a vast range of definitions that can be applied to individual knowledge, but there is no particular need for us to be too precise in defining that term. As long as our focus is re

kn

th

pu

kno

Typ

The

1991

(proc

expla

of kno

Many

shape

One of

tacit ve

someth

Given th

not clea

Typolo

we wa

comm

venue

codifi

restricted to the activities of individuals that have an impact on organizational knowledge as defined, we need not be concerned about whether the content of these activities meets a specific definition of knowledge. For classification purposes, multiple forms of individual knowledge can coexist with organizational knowledge.

Typologies of Knowledge:

The second step, after observation, in the inductive process of discovery (Hunt, 1991) is classification. While we are primarily interested in classifying the actions (processes) that lead to changes in organizational knowledge, the task of explanation is simplified by the ability to distinguish between the different aspects of knowledge.

Many typologies of knowledge have been put forward, their dimensions being shaped by whether one subscribes to the reified or situated views of knowledge. One of the most enduring is that of Polanyi (1958) who introduced the concept of *tacit* versus *explicit* knowledge. In his meaning of the term, tacit knowledge is something unique to the knower, which by its very nature, *cannot* be articulated. Given that this usually implies some sort of motor skills or neural learning, it is not clear that there is an organizational analog of this concept.

Typologies of knowledge that are specific to an individual are problematic when we want to speak about an organization. In an organizational context, it is more common to adopt a reified view and classify knowledge according to its form or venue. Winter (1987 p. 170) offers such a typology based on forms of codification in which one of the categories is tacit knowledge, by which he simply mea

how

diffe

orga

to a

The

the i

setti

by c

of kn

conv

know

more

are nc

tacit k

be art

that *ina*

Episten

an orga

indepe

memc

corres

appro

means "not codified," or resident only in communal memory. This is similar to how Walsh (1995) describes knowledge in an organization as being deposited in different "bins." Using this view of knowledge, it would make sense to analyze organizational learning by observing the flow of identifiable pieces of knowledge to and from various bins.

The classification of knowledge as being either tacit or explicit does depend on the individual(s) involved, but the concept can be used in an organizational setting. Nonaka (1994) attempts to do so in a theory that knowledge is created by *conversions*, specifically conversions between or within tacit or explicit types of knowledge. Using this view, learning would be described in terms of the conversions that take place. While Nonaka (1994) aligns his definition of tacit knowledge with that of Polanyi (1958), Tsoukas (2003) counters that the usage is more akin to that of Winter (1987), and as a result, the transformations involved are not truly different in kind. In developing the research protocol, we will discuss tacit knowledge, and will use a compromise definition: knowledge which cannot be articulated by the person involved. We will not attempt to distinguish whether that inability is a function of the person or the nature of the knowledge.

Epistemology thus gives us two fundamental ways to characterize knowledge in an organizational context, but both depend on a reified view of knowledge as an independent entity. One is classification by location (written records, individual memory, etc.). In such a typology, the specific "bins" would be chosen to correspond to the environment in which activities take place. The alternate approach is classification by type, where the state of knowledge changes through con

tacit

the

posit

As na

purpo

reified

parag

corres

be disc

circums

<u>Psycho</u>

<u>Cognitio</u>

The rea

question

organiza

psycholo

is a broa

reasonin

a relativ

from its

conversions (tacit to explicit, explicit to explicit, etc.). An expanded definition of tacit is used here to ensure relevance in the organizational setting. As noted in the Definitions section, individual and organizational knowledge can both be positioned within these typologies.

As noted above, we have adopted a *situated* definition of knowledge for the purposes of this study, but have also acknowledged the potential usefulness of a reified view for practical observations. This is the basis of the preceding paragraph. However, if these typologies are found to be not useful, there is no corresponding typology of situated knowledge. In that case, knowledge can only be discussed as a property of the individual or the organization in a specific circumstance. These entities are the subjects of the following sections.

Psychology:

Cognition:

The reader will have noted from the section on epistemology that is an open question as to whether knowledge is an identifiable independent entity in the organizational learning process. This uncertainty has an exact counterpart in the psychology of the individual; specifically in the functioning of *cognition*. Cognition is a broad concept, defined by DeFillippi and Ornstein (2003) as "thinking, reasoning and memory." As with knowledge, the question is whether cognition is a relatively independent property of the individual or whether it is inseparable from its environment or situation.

The

that

impo

was

signs

to th

Lyles

(1991

scienc

led to

by Pyl

Organ

theoris

environ

sense;

in this d

operate

the orga

pragma

and De

– only

adapta

occurs

The proponents of the former view coined the term *cognitive science* and argue that human cognition should be understood primarily in terms of (admittedly imperfect) mathematical processing. A telling quotation is that "the computer was made in the image of the human" (Simon & Kaplan, 1989). In 1991, a significant amount of published work in organizational learning could be assigned to the pure cognitive or "neo-rationalist" school (term used by Easterby-Smith & Lyles, 2003). Examples include: Epple, Argote and Devadas (1991), Huber (1991), March (1991), Simon (1991). Since then, the attention of cognitive science has somewhat turned away from organizational learning and has instead led to important advances in artificial intelligence and expert systems as signaled by Pylyshyn (1984).

Organizational learning has become much more the province of the *practice-theorists*, who argue that learning is situated in and inseparable from its environment. In other words, a person does not "know" something in an absolute sense; they only "know" it in the context of their environment. The environment in this discussion is generally taken to be the culture in which the individual operates. We will have more to say later about culture from the point of view of the organization. This view has its origins in the same school of American pragmatism that gave us *situated performance*, specifically Dewey (1916; 1933) and Dewey and Bentley (1949), who argued that there is no absolute knowledge – only that which is rooted in experience. As a result, learning is *situated*, "an adaptation of a person or group to features of the situation in which learning occurs" (Rosch & Lloyd, 1978).

More r

to the i

organi

commu

Examp

Balzan

(1989)

Lave a

Wenge

In mak

Hutchi

(1989)

image

the ind

fundam

The ab

the imp

whethe

individ

(1991;

to arg

beha

the in

More recent years have seen a great increase in the amount of research devoted to the impact of culture on cognition and its corresponding impact on organizational learning. Much of this literature has been based on the concept of *communities of practice* as the specific culture in which this takes place. Examples of research in this stream are: Shaw and Alley (1985), McCabe and Balzano (1986), Suchman (1987), Lave (1988), Brown, Collins and Duguid (1989), Greeno (1989), Orr (1990), Rogoff (1990), Brown and Duguid (1991), Lave and Wenger (1991), Cook and Yanow (1993), Nicolini and Meznar (1995), Wenger (1998), Bartel and Garud (2003).

In making the case for situated cognition (and against cognitive science) Hutchins (1995) counters the above-cited quotation from Simon and Kaplan (1989) by saying that "cognitive science has tried to remake the human in the image of the computer." He goes on to argue (p. 354) that "the understanding of the individual that has developed without consideration of the cultural process is fundamentally flawed."

The above discussion has related to the role of cognition in the individual, and the impact of the culture or organization in influencing it. An open question is whether organizations can be said to exhibit the same cognitive properties as individuals. Some researchers argue that this analogy can be made. Cohen (1991) and Cohen and Bacdayan (1994), for example, cite numerous examples to argue that organizations and individuals exhibit very similar modes of behavior, at least on the surface. The role of cognition has been extended from the individual to small groups by many researchers (see Walsh, 1995 for a discu

unde

exten

clear

where

this a

Learn

As ind

one ta

select

that kr

contra

is a los

approa

Argote

On the

knowle

situatio

effectiv

some f

situate

the ne

(1981,

discussion of this literature – and its limitations) and to organizations as whole under the term *Absorptive Capacity* (Cohen & Levinthal, 1990). While these extensions appear to be justified on the basis of their outcome measures, it is not clear that the underlying mechanisms support this. For process-based research where it is the mechanisms that are being studied, it is not necessary to make this assumption in advance.

Learning and Unlearning:

As individuals and organizations learn, so can they forget ("unlearn"). The view one takes of this mechanism is highly dependent on the view of cognition that is selected. In the pure cognitive view (cognitive science), one must take a position that knowledge is good and that it is cumulative – more is better. Things that contradict each other cannot both be knowledge. This being the case, forgetting is a loss of knowledge and, by extension, a loss of performance. This is the approach taken by Argote, Beckman and Epple (1990), Argote and Epple (1990), Argote (1999) in modeling a forgetting process.

On the other hand, situated cognition or practice theory suggests that what is knowledge at one moment may cease to be in the next as the perception of the situation changes. To the extent that neither individuals nor organizations can effectively reconcile mutually contradictory paradigms, this view suggests that some form of unlearning may be a necessary prerequisite for an increase in situated knowledge as we have defined it. A number of researchers have noted the need for unlearning: Duncan and Weiss (1979), Weick (1979), Hedberg (1981), Lyles (1988), Lyles and Schwenk (1992), Schein (1993), Bettis and

Pra

res

var

ren

res

knc

<u>Info</u>

Sinc

proc

degr

rese

proc

thoug

while

He ch

story'

Lapre

proces

disting

Briefly

experie

is data

Prahalad (1995), Pentland (1995), Bettis and Wong (2003). Many of those researchers have also noted the difficulty of unlearning and have offered a variety of explanations as to why that should be so. These findings serve as a reminder that the process of creating knowledge that is the subject of our research question may equally involve activities that destroy or displace knowledge.

Information Processing:

Since transformations or flows of knowledge will depend on information processing by individuals, the role of processing must be understood. To a large degree, this dovetails with the discussion of cognition but there is additional research that sheds some light on the underlying processes. With respect to processing of information, Bruner (1986, p. 11) describes "two modes of thought," which he categorizes as *narrative* and *paradigmatic*. He argues that while both modes can be present, neither is ultimately reconcilable with the other. He characterizes the difference between them as the difference between a "good story" and a "logical argument," respectively. Walsh (1995) and Mukherjee, Lapre and Wassenhove (1998) make similar arguments about dual modes of processing, but with somewhat more descriptive terminology. Walsh distinguishes between top-down and bottom-up processing of information, Briefly, in the top-down mode, data are interpreted on the basis of prior experience and knowledge structure (justified beliefs), while the bottom-up mode is data-driven and analytical in nature.

In lig

proc

woul

(199

pract

ques

lives'

narra

proce

given

conte

the us

deten

conta

Both

the kn

relatio

indivic

Small

There

individ

behav

eman

In light of the above discussion on situated learning, the narrative role of processing is expected to play an important role, for it is in this mode that we would expect to see the cultural context of learning being transmitted. Wenger (1998) suggested that narratives were the means by which communities of practice shared their knowledge. Bartel and Garud (2003) asked a similar question to ours: "how do actors create and apply knowledge in their daily work lives?" Although they do not answer the question directly, they suggest that narratives are an important vehicle by which this occurs. They suggest a process of *abduction* by which individuals can extract multiple lessons from a given narrative, based on the nuances of context. It is this transmission of context that distinguishes narrative processing from paradigmatic. As implied by the use of the term abduction, the extraction of lessons from a narrative is not deterministic, but rather, situational. As a consequence, a "good" narrative must contain some "evaluational reference" (Pentland, 1999).

Both narrative and paradigmatic modes of processing are potentially important in the knowledge creation process, but their relative importance and their relationship to each other are matters of interest when considering the roles of individuals in the organizational learning process.

<u>Small Group Dynamics:</u>

There is one additional point we wish to cover with respect to the role of the individual in our research setting. The above discussion has signaled that the behavior of individuals is expected to be influenced by the surrounding culture – emanating from either the organization as a whole, or perhaps from some com

rese

invol

norm

The

their

not th

study

Our r

kind i

None

perfor

of var

group

Littlep

Littlep

group

Neale,

Hunt, C

interes

proces

group

inform

community of practice within it. There is an additional level of interaction in our research settings, and that is the interpersonal dynamics of the individuals involved in the cases being studied. While these may reflect broader cultural norms, there may be other dynamics at work.

The internal dynamics of small groups have been much studied with respect to their *effectiveness*. The focus on effectiveness suggests a content focus that is not the primary interest of the present research. The research question in this study concerns itself with *what* these groups do, not how effectively they do it. Our null hypothesis is that the groups in question will be representative of their kind in terms of their activities and effectiveness.

Nonetheless, it is useful to be aware of the key determinants of group performance as reported in the literature as a way to recognize potential sources of variance in the research settings. Some commonly studied parameters are: group size (Cummings, Huber & Arendt, 1974; Yetton & Bottger, 1983; Littlepage, 1991; Hwang & Guynes, 1994), task type (Kabanoff & O'Brien, 1979; Littlepage, 1991; Straus & McGrath, 1994) and power relationships within the group based on status or recognized expertise (Gruenfeld, Mannix, Williams & Neale, 1996; Franz & Larson, 2002; Okhuysen & Eisenhardt, 2002; Thomas-Hunt, Ogden & Neale, 2003). Some observations about group dynamics are interesting as they relate directly to the issues of knowledge and knowledge processing. Stasser and Titus (1987) noted that the greater the degree to which groups shared a common base of knowledge, the less unique or divergent information was brought forward. Several explanations for this phenomenon are poss

comp

conte

Welc

detai

narra

(198

solvir

woulc

proce

The F

Most f

resilie

48). V

reflect.

sharec

and sta

as som

juxtap

cited

expla

states

of kn

possible, but the point of interest for the present research is that group composition has the potential to change the process of learning as well as the content.

Weldon and Bellinger (1997) found that groups collectively remembered random details better than did individual members, but the reverse was true for organized narratives. This echoes the "two modes of thought" concept attributed to Bruner (1986) above and suggests that groups may engage in more bottom-up problem solving, but that individuals might prefer top-down or narrative approaches. This would be another example of how group composition or size might affect the process of learning.

<u>The Firm as a Cultural and Institutional Entity:</u>

Most firms are examples of institutions in the sense that they have a certain resilience or stability, and an ability to perpetuate themselves (Scott, 2001; p. 48). When viewed from a cultural/cognitive perspective (Scott, 2001; p. 52), the reflective indicators of an institution are the presence of *common beliefs* and *shared logics of action*. The latter term is more relevant to an operations setting, and stands as something that can be a component of organizational knowledge as something that is uniquely a property of the organization. Note however the juxtaposition of *common beliefs* as an indicator of culture with the previously cited definition of knowledge as *justified belief,* suggesting a cultural origin or explanation for organizational knowledge. In a similar vein, Martin (2002, p. 36) states that culture can supply the underlying "why" rationale that is the foundation of knowledge.

A sh

shar

he i

that

indiv

exis

cultu

to ce

In th

mea

term

of di

In sh

socio

defin

we o

ration

work

group

enforc

cultur

Denis

Muk

A short digression is required at this point with respect to the use of the word *shared*. When Scott (2001) used the term *shared logic*, it was not obvious that he intended it to mean *universally agreed upon*. A more useful interpretation is that behavior was broadly influenced by the logic, regardless of whether individual members understood it, agreed with it, or were even aware of its existence. Martin (2002) noted a similar problem in defining what it is about a culture that is *shared*. She concluded that even members who violently objected to certain elements of a culture were still, in the end, defined and influenced by it. In the work that follows, we will use the term *shared* broadly, without intending it mean anything beyond having some distributed influence over a group. A better term might be *dominant logic* as proposed by Prahalad and Bettis (1986). (End of digression.)

In sharp contrast to the Cartesian view of knowledge, a stream of research in sociology (Berger & Luckmann, 1966; Gurvitch, 1971; Holzner & Marx, 1979) defines knowledge as a sociological construct, a product of the culture in which we operate. This is consistent with Martin's view of how culture supplies the rationale that underpins knowledge. We can see practical evidence of this in the work of Stasser and Titus (1987) and Brown and Duguid (1991) who show that group dynamics within a community tend to suppress dissenting views and enforce a commonality of what is accepted as knowledge. Suggestions of the cultural component of knowledge in organizations can also be seen in the work of Denison and Mishra (1995), Miller (1996), Davenport and Prusak (1998), Mukherjee, Lapre et al. (1998), Alavi and Leidner (2001). Implicit in a cultural

vie
kn
me
ac
Th
int
dis
cu
wil
to
cer
of t
nar
The
Cha
obs

One
orga
opin
embe
in mo
there

view of knowledge is the idea that learning, in the sense of a change in knowledge state, must at some level require a change of culture. While mechanisms of culture change are poorly understood, it is generally acknowledged to be a difficult thing to bring about (Martin, 2002, p. 347).

The introduction of a cultural dimension raises issues of methodology and interpretation, summarized by the *etic/emic* divide (Martin, 2002, p. 36). The distinction in this divide is that the researcher's point of view is either within the culture, or outside of it. Each point of view will fail to see things that the other will. Most typically, the etic (outside) view will fail to see the significance attached to various symbols or actions, while the emic (insider) view will fail to see that certain taken-for-granted truths are not universal. In addressing the shortcomings of the etic view, Bartel and Garud (2003) note that: "to see and understand narratives, the researcher must become *semi-native*" (emphasis in the original). The methodological issues raised by this distinction will be discussed in the Chapter Three, but the result is the selection of a participant-observer model of observation (Martin, 2002 pp 48, 210) as a way to bridge that gap.

One of the objectives of this discussion has been a well-grounded definition of organizational knowledge. In Chapter One it was shown that there is a body of opinion that holds that whatever organizational knowledge is, it can be found embedded in an organization in the form of routines. Routines will be discussed in more detail below, under the heading of the firm as an economic entity, but there are cultural aspects of the firm that apply to routines as well.

In t

Pe

sep

asp

ost

"sh

abo

wha

wha

Sco

for c

term

"take

orga

Cons

sugg

beyo

institu

"domi

2003)

To su

impor

such

In their research on organizational routines Feldman and Pentland (2005) and Pentland and Feldman (2005) found that, to be understood, routines must be separated into their *performative* and *ostensive* components. The performative aspect is the familiar, observable operation of the routine in practice. The ostensive portion on the other hand, is the underlying rationale, equivalent to the "shared logic of action" as it is described by Scott (2001) (and subject to the above note about the usage of *shared*). Recognition of this ostensive aspect is what permits the observer to understand otherwise unpredictable variations in what seems to be tightly-defined process.

Scott (2001) notes that in the cultural/cognitive view of the institution, the basis for compliance with the logic of action (equivalently: the ostensive component as termed by Pentland & Feldman, 2005) may be a *"shared understanding"* or *"taken-for-grantedness"* (p. 52). This strongly suggests that routines and organizational knowledge in general will have an important cultural component. Consistent with the above discussion on the limitations of the emic view, this also suggests that a shared logic that is based on taken-for-grantedness may be beyond the reach of question or debate. This may be one of the reasons that institutions are "resilient" as noted by Denison and Mishra (1995), or that "dominant logics are extraordinarily resistant to unlearning" (Bettis & Wong, 2003).

To summarize the above discussion: an underlying rationale or shared logic is an important, and possibly necessary, component of organizational knowledge. As such, a shared logic becomes an important concept in the development of a thec

logi

cha

cha

The

The

the

with

orga

knov

The

strat

consi

econ

trans

Rugm

could

Simor

some

progr

now

rout

theoretical framework for the study of organizational learning. Such a shared logic is potentially an indicator of a culture or institution. If learning involves changes to the logic, the cultural and institutional forces that protect it from challenges must also be understood.

The Firm as an Economic Entity:

The preceding sections have examined the role of knowledge, its interaction with the cognitive functioning of the individual, and the interaction of the individual with the culture of an organization. In this section we close the loop from the organization (now seen primarily as an economic entity – typically a firm) back to knowledge.

The firm as a unit of analysis is central to the literatures of economics and strategy. From the beginning, knowledge, or know-how of some sort has been considered as an important property of the firm. The strategy literature, rooted in economics, has sought to explain the boundaries of the firm on the basis of transaction and coordination costs (Coase, 1937). Penrose (1959) (discussed in Rugman & Verbeke, 2002) argued that through the process of learning, firms could reduce their coordination costs and expand those boundaries. March and Simon (1958) recognized that this knowledge described by Penrose (1959) was something specific to a firm, and introduced the concept of *performance programs* as the form in which it was embedded in the firm. These are what we now more commonly refer to as routines. Nelson and Winter (1982) connected routines with transaction cost economics to suggest that routines were the me

inte

This

Bas

part

unic

indiv

fore

or no

gene

If this

firm i

Barn

1993

Nona

Dave

is so

of the

but of

declin

RBV

albeit

mechanisms by which an organization could efficiently manage transactions internally and hence grow.

This notion of firm-specific resources is critical to the emergence of the Resource Based View (RBV) of the firm in the strategy literature. Knowledge is of particular importance to this view, at least in its economic aspects, because it is a unique class of asset. It is imperfectly tradable (Williamson, 1981), and indivisible in the sense that using it for one purpose does not require the firm to forego its use for another (Teece, 1980). Thus, the use of knowledge incurs little or no opportunity cost, making it one of the few, if not the only resource that can generate true rents (Mahoney & Pandian, 1992).

If this is true, it is logical to argue that knowledge is the most important asset of a firm in terms of creating competitive advantage (Prahalad & Hamel, 1990; Barney, 1991; Nelson, 1991; Leonard-Barton, 1992; Cyert, Kumar & Williams, 1993; Henderson & Cockburn, 1994; Nonaka, 1994; Bates & Flynn, 1995; Nonaka & Takeuchi, 1995; Kogut & Zander, 1996; Miller, 1996; Spender, 1996; Davenport & Prusak, 1998; Nahapiet & Ghoshal, 1998). The role of knowledge is so central to strategy, that Grant (1996) proposed the Knowledge-Based View of the firm (KBV) but in doing so treated knowledge not as a property of the firm but of the individuals comprising the firm. At the same time, he expressly declined to offer any specific definition of knowledge, so in keeping with most RBV literature, knowledge as a resource remains a highly abstract concept, albeit a vital one.

Rou

rout

leas

solic

rout

mac

exp

sele

Mor

have

two

perfo

routi

unob

unde

perfo

obser

organ

deter

Likew

com

orga

poin

Routines were mentioned above, with little elaboration. The concept of the routine is generally attributed to March and Simon (1958), but can be traced at least to Barnard (1938). Although many researchers have done a great deal to solidify the concept of the routine, there has been relatively little said about what routines consist of and how they are created or changed. Progress has been made on the anatomy of routines by Feldman and Pentland (2003) who expanded the basic concept of routines to include the potential for variation and selection, and therefore evolutionary, incremental change.

More recently, Feldman and Pentland (2005) and Pentland and Feldman (2005) have argued that to be understood, routines must be considered as consisting of two layers; the *ostensive* and the *performative* (plus associated *artifacts*). The performative layer is the observable sequence of actions that constitute the routine as it is practiced in the moment. The ostensive part is the relatively unobservable underlying purpose or intent of the routine. The need to understand the ostensive layer was motivated by their observation that the performative layer tended to vary spontaneously and unpredictably (to an outside observer) in response to changing conditions. If the routine is the embodiment of organizational knowledge, the ostensive part is at least as important a determinant of situated performance as the performative part.

Likewise, if performative and ostensive components are both essential components of organizational knowledge, then beyond some point, organizational learning must involve changes to both parts. This is precisely the point made by Argyris and Schön (1978) when they coined the term *"double loop* *lea*

co

"the

the

Wh

repr

cult

perf

strea

emp

powe

Schr

hint s

Using

statin

orche

Summ

The p

constr

To en

was e

elem

learning" to describe the case where the ostensive part is examined and re-considered. They did not use the term ostensive; instead they spoke of the "theory in use" that provided the belief that a certain set of actions would result in the desired outcome.

Whether we speak of *ostensive* aspect or *theory in use*, it is clear that these represent the same thing as *a shared logic of action* (Scott, 2001) in the cultural/cognitive view of the institution. As suggested in the introduction, the performative and ostensive views tend to fall into different, non-overlapping streams of literature. The result in Operations Management has been an emphasis on performative aspects ("tools"), with a resulting lack of explanatory power. To cite a well-regarded paper as an example, Flynn, Sakakibara and Schroeder (1995) focus extensively on performative aspects, with results that hint strongly at the importance of an (unidentified) underlying ostensive aspect. Using different terminology, Miller (1996) showed a recognition of this gap by stating that competitive advantage lies "not in specific resources or skills, but in orchestrating themes."

Summary of Key Concepts and Constructs:

The purpose of Part I of this chapter was to establish a list of key concepts and constructs that is grounded in the literature and relevant to the research question. To ensure a sufficiently diverse, yet coherent approach to this task, the literature was examined from three different perspectives corresponding to the key elements in the organizational learning process. These perspectives are those of the in

within

It was

and th

strear

obser

Opera

involv

establ

unders

These

posses

observ

-
-
-
-
-
-
-
-
-

the individual involved, the knowledge that is processed and the organization within which the learning takes place.

It was seen that each of these points of view led to different streams of literature and the result is a blended list of concepts and constructs drawing on the multiple streams. The blending of different points of view is consistent with the observation earlier in this chapter that confining the literature search to Operations Management did not provide adequate explanation of the process involved in organizational learning. By drawing on a wider base of research to establish the research framework, the goal of this research is to arrive at a better understanding of the processes involved.

These concepts do not qualify as constructs in the narrow empirical sense of possessing validated measurement scales; rather they are areas within which observations are indicated on a theoretical basis. The summary list is:

- Knowledge classified as being explicit or tacit
- Transformations of knowledge within and between explicit and tacit
- Knowledge classified by location
- Actions by individuals to retrieve or store knowledge by location
- Processing of knowledge and/or information by individuals (narrative versus paradigmatic)
- Individual cognition as in pre-existing state of knowledge
- Power and/or knowledge as moderators of small group activity
- Shared logics of action (existence of and changes to)
- Changes to performative aspects of routines

Thes

as de

- Changes in situated performance

These concepts will be used in developing the research framework and protocol as described in Chapter Three.

PAR

The
re-er
fram
gaps
draw
broa
affec

A cor
resea
for th
to und
shoul
by Hu
issues
in ano
well-be

This a
intend
explic
perfo

PART II: POSITIONING OF THE RESEARCH:

The bounds within which this research was conceived and conducted should be re-emphasized. It was stated in Chapter One that the research question was framed in the context of Operations Management. As a result, the problems or gaps in understanding that make the question interesting and important were drawn from this field. While it is hoped that the findings may ultimately be of broader interest, the focus on Operations dictates the research design and affects the positioning of the work within the literature.

A consequence of this focus is an admittedly *functionalist* perspective to the research (Bacharach, 1989; Martin, 2002; p. 160). This means that the reason for the research question is the belief or intent that the answer should be relevant to understanding and explaining performance in operations. Note that this should not be confused with the functionalist model of *explanation* as discussed by Hunt (1991). The functionalist perspective serves as a screen to separate issues of interest from those that are not. Although they may be valid concerns in another context, we are not, for example, interested in the personal growth or well-being of participants in the organizational learning process.

This approach also defines the stream(s) of literature in whose footsteps it is intended to follow. There are three interrelated streams of literature that deal explicitly or implicitly with the role of learning in the improvement of firm performance.

Chron

addre

has w

consi

intend

proce

and u

Swink

A mo

capac

capac

exten

proce

predic

The th

Chapt

succes

(TQM

stand

subst

gene

litera

a foc

Chronologically, the first of these streams deals with *learning curves* and addresses the aggregate effect of organizational learning. Interest in this area has waned somewhat in the last decade, and it does not appear that this is considered to be an area for cutting edge research. As the discussion below is intended to show, this may well be a result of a lack of understanding of the processes involved. Although learning curves have ample empirical verification, and useful predictive ability, they are lacking in explanatory power (Schmenner & Swink, 1998).

A more recent stream of literature is centered on the concept of *absorptive capacity* as introduced by Cohen and Levinthal (1990). As such it deals with the capacity for organizational learning and offers a potentially predictive tool. While extensions of this work have broken down the concept into what could be called process steps, this concept is still more outcome than process focused and more predictive than explanatory.

The third stream of literature springs from the researcher's problem noted in Chapter One. Specifically, the problem is: "why do firms differ in their ability to successfully implement specific programs such as Total Quality Management (TQM)?" When viewed from a content perspective, firms implementing a standardized methodology appear to be homogeneous and yet there is substantial variance in their success. The search for an explanation has generated a body of research which lacks a convenient label. Much of this literature is to be found under the general heading of quality, since that has been a focus of many of the initiatives. (Note that other fields have their own areas of inte

inte

Ente

Lu (

For

Het

area

the

seq

that

sup

rela

Ove

lear

Lea

In a

ana

typi

The

proc

indi

(Arg

interest. For example, researchers in information systems struggle to explain inter-firm differences in success of implementation of system initiatives such as Enterprise Resource Planning (ERP); for examples see: Guimaraes, Igbaria and Lu (1992), Sum, Ang and Yeo (1997), Petroni (2002), Marble (2003).

For the purposes of classification, we will refer to this body of work as "Explaining Heterogeneity in Operations." Two distinct camps have emerged within this area. One seeks to explain the heterogeneity through tradeoffs that result from the choice of competitive priorities, while the other offers the cumulative or sequential nature of capabilities as an explanation. The review below suggests that a process perspective has been lacking in this field and that empirical support for any particular explanation is mixed at best. These facts may be related.

Overall, it is proposed that greater insight into the process of organizational learning has the potential to contribute to each of these fields.

Learning Curves:

In a learning curve view of the situation, the firm or business unit is the unit of analysis and the dependent variable is some sort of performance measure, typically a productivity measure such as direct labor cost per unit of production. The independent variable is some measure of experience, with cumulative production volume being the most widely accepted. While the idea that individuals exhibit learning curves has been known at least since the 19th century (Argote, 1999, p. 4), the seminal work establishing the existence of learning

cu
pro
Su
in a
lea
cor
ret
cla
sor
pro
ger
anc
exp
Bec
pos
ope
Hav
an i
(199
sou
are
cree

curves in an organizational context was that of Wright (1936), a study of airframe production.

Subsequent studies have thoroughly confirmed the existence of learning curves in a wide range of organizational activities. Hatch and Mowery (1998) cite at least seventeen examples in the literature. The classical form always shows continuing improvement of performance with experience, but with declining returns to scale. Much research has sought to establish empirically whether the classical shape of the learning curve is indeed a power function as opposed to some other form, and whether the correct independent variable is cumulative production as opposed to time. The answer to both questions has been generally affirmative (see Lieberman, 1984; Darr, Argote & Epple, 1995). Slight anomalies in the functional form have been observed, and the range of experimental error allows for the possibility of other interpretations. Argote, Beckman et al. (1990) found both cumulative volume and time to be useful when postulating that knowledge is perishable and that there is a "forgetting" curve that operates in conjunction with the learning curve.

Having empirically established cumulative production volume as the best fit for an independent variable, it is tempting to infer a causal relationship. Huber (1991) speaks of "the positive effect of experience on performance" which sounds like a statement of causality. Other writers (Argote, 1999, for example) are more careful to disavow statements of causality, but the inference tends to creep back into the discussion.

T

pı

in

in

co

au

dis

Mo

cha

the

to th

on e

Klep

cont

basis

In an

idea

view

frequ

elimi

Othe

distin

(1999

The work discussed to this point has been very much content based. Some progress towards a process view has been made by separate the learning curve into separate components in order to better understand the mechanisms involved. Levy (1965) considered the learning curve to be made up of three components: planned or induced learning, random or exogenous learning and autonomous learning. The second category has not been much studied, but the distinction between autonomous and induced learning has persisted (Hatch & Mowery, 1998; Li & Rajagopalan, 1998; Zangwill & Kantor, 1998). Levy (1965) characterized the induced learning component as a form of investment, made on the basis of an expected return, thereby introducing a forward-looking component to the learning curve. (See also Oi, 1967). The idea that learning is based more on expectations than experience was also suggested more recently by Sinclair, Klepper et al. (2000). Interestingly, from the perspective of the process versus content positioning, this last work is the only one to describe process on the basis of actually observing people at work.

In an attempt to explain the autonomous component, Fine (1988) introduced the idea of "quality-based learning," which is to say, learning from mistakes. In this view, the flattening of the learning curve would be explained by the reduced frequency of occurrence of mistakes as their root causes are progressively eliminated.

Other writers have also made the case that total learning effects are made up of distinct components. Another partitioning of the curve was proposed by Argote (1999), who characterized learning as consisting of improvements in: (a) ir

or

nc

be

err

Bec

hav

as a

addr

proc

(198

finite

netwo

effect.

shape

but off

It is we

& Thon

is not a

betwee

betwe

is *still*

learni

individual proficiency, (b) improvements in technology and (c) improvements in organizational routines. There is some overlapping of terms, so it is important not to mix typologies. For example, improvements in individual proficiency could be the result of planned training (induced learning) or of self-motivated trial and error (autonomous learning).

Because empirical tests of learning result in a consistent pattern of results, there have been attempts to develop models that would come up with the same results as a way to understand the mechanisms involved. Note that while this literature addresses process issues it is not process-based. It is attempting to infer process from an examination of content. The most cited is probably that of Muth (1986), who modeled learning as a random search for better alternatives from a finite set. Huberman (2001) also replicated a power function by starting with a network model. In this formulation, the learning rate is determined by the effectiveness in finding new paths. Both of these models predict the observed shape of learning curves based on variations of sampling without replacement, but offer little insight about why they vary or why they occur at all.

It is well known that learning curves do vary substantially between firms (Dutton & Thomas, 1984; Hayes & Clark, 1986), but is also clear that the "learning rate" is not a fixed property of a firm. Argote and Epple (1990) found that it can vary between plants within the same firm, and Adler and Clark (1991) found it to vary between departments in the same plant. These observations suggest that there is still a lack of understanding about the fundamental nature of organizational learning.

In fa

obs

"exp

revie

has

Of th

foun

take

that

Absc

There

It see

would

first in

an org

from

Venka

must

proce

opera

Coher

conce

apply

In fact, this was the principal point made by Adler and Clark (1991). They observed that the *process* of learning was relatively unstudied and offered their "exploratory" work as encouragement to others to rectify this shortcoming. A review of the 64 papers citing Adler and Clark (1991) suggests that their advice has been little heeded, with only a handful concerning themselves with process. Of those that do, only two (MacDuffie, 1997; Sinclair, Klepper et al., 2000) were found to employ actual observation of the process. This research proposes to take a process perspective based on direct observation in order to begin filling that void.

Absorptive Capacity:

There is a related stream of literature that deals with the firm's *capacity* to learn. It seems reasonable that a better understanding of how firms actually *do* learn would also help explain their capacity to learn. The term *absorptive capacity* was first introduced by Cohen and Levinthal (1990). This is defined as the ability of an organization to assimilate and use knowledge (often technical knowledge) from outside its boundaries. This concept has proved to be popular, but it is what Venkatraman (1989) would call a *criterion-specific* construct, meaning that it must be defined in terms of its outcomes. As such, it is a content view, not a process view. One result of this is the observation that "definitions and operationalizations of this construct vary widely" (Zahra & George, 2002; p. 186).

Cohen and Levinthal (1990) attempted to build a criterion-free base for the concept by attributing to the organization the same cognitive processes that apply to an individual. Following this cognitive model, they argue that an orga

indiv

leve

prop

expe

que

The

and

Szul

abili

mod

case

view

intro

re-co

conte

Reso

they

also

To r

dec

tran

con

organization's ability to absorb new knowledge from external sources is, like an individual's ability to learn new things, shaped by the pre-existing cognition or level of knowledge. Specifically, Cohen and Levinthal (1990) state the proposition that absorptive capacity is a function of the firm's related prior experience. The validity of the analogy to individual cognition is open to question, but it has been adopted by others (Cohen, 1991).

The concept of absorptive capacity has been developed in multiple directions and applied in various settings. It was applied internally to the organization by Szulanski (1996) who coined the term *"internal stickiness."* This refers to the ability, or rather the lack of it, to transmit knowledge internally. Here the cognitive model of learning behavior is on firmer ground; since the recipient is in most cases an individual, although this is not a requirement of the model. A related view of the internal learning process is that of Garud and Nayyar (1994), who introduced the term *transformative capacity*. This is the ability to resurrect and re-combine existing knowledge within the organization and apply it in a changed context, which the authors position as a resource within the context of the Resource Based View of the firm (RBV). As with Cohen and Levinthal (1990), they offer no operational definition of knowledge, so transformative capacity must also remain a somewhat abstract concept.

To make absorptive capacity more concrete, Zahra and George (2002) decomposed the absorption function into four elements (acquisition, assimilation, transformation and exploitation). This has the advantage of defining sub-constructs that are less abstract and facilitates the collection of data for empirical

res

be

knc

To

bet

wh

effi

bet

inte

imp

dee

pro

mar

exa

To c

to p

the v

Exp

As s

Ops

imp

gre

ap

research but does not fully address the issue of explanation. In addition, as will be seen below, this view tends to force a narrow view of what constitutes knowledge.

To summarize a portion of their work, Zahra and George (2002) distinguish between what absorptive capacity *should* be, based on a set of predictors and what it actually *is*, based on outcome measures. The gap is identified by an efficiency factor η, which stands as an indicator of the process differences between firms. Zahra and George (2002) attribute the variance in η to "social integration mechanisms" of the different firms. This clearly acknowledges the importance of the *process* of organizational learning, but without offering any deeper analysis. In a similar vein, Zahra and Nielsen (2002) note that *"the process by which (the integration of external and internal sources of manufacturing capability) occur within technology commercialization should be examined."*

To conclude, absorptive capacity in its many conceptualizations offers an ability to predict outcomes of the organizational learning process, but provides little in the way of explanation of how and why it takes place.

Explaining Heterogeneity in Operations:

As stated in Chapter One, an issue that continues to preoccupy researchers in Operations Management is the question of why firms differ in their ability to implement certain initiatives. In recognition of its importance to operations, a great deal of this literature has dealt with quality, but the question is equally applicable to other fields. The principal conundrum is this: when best practice is rigo

met

cas

In t

per

ber

Lav

ber

Boa

Gre

rese

A p

orig

mor

hypo

expl

invol

the s

subje

ana

Rec

pro

rigorously codified, as in TQM, then firms implementing the standardized methodology should experience very little variance in results, yet this is not the case.

In the area of quality, it is clear that there is substantial variance. A high percentage of firms that implement quality programs fail to realize the expected benefits from doing so (Macdonald, 1996; Choi & Behling, 1997; Krumwiede & Lavelle, 2000; Nwabueze, 2001). More interestingly, firms that do realize benefits often find them temporary and revert to their pre-program status (Dale, Boaden, Wilcox & McQuater, 1997; Buch & Rivers, 2001; Bullington, Easley, Greenwood & Bullington, 2002). The search for an explanation has led researchers in different directions.

A popular line of research has been that into *cumulative capabilities*. The idea originated with Ferdows, De Meyer, Nakane, Miller and Vollman (1985), and was more formally proposed as a theory by Ferdows and De Meyer (1990). The key hypothesis is that it is the *order* in which certain initiatives are implemented that explains variance in success. This approach says nothing about the process involved and deals only with firm-level outcome measures. The central issue of the sequence of actions creates a problem that is both difficult to study and subject to many confounding influences in the course of any longitudinal analysis. As a result, empirical support for the theory has been equivocal. Recently, Flynn and Flynn (2004) concluded that *"support for sequential progression of cumulative capabilities was not evident..."*

Fly

vie

de

int

inf

fo

co

be

an

org

Th

arg

hov

Ma

the

Sch

In *th*

posi

front

telling

case

Hav

the

Flynn, Sakakibara et al. (1995) and Powell (1995) took a related but differing view; both suggesting that it is not necessarily the order that matters, but the degree to which different capabilities are built on common “infrastructure” or intangible factors. In the former work, the observed predictive value of infrastructure elements such as *managerial support* is interesting, but cries out for an explanation of how and why it came to be. In the latter paper, the conclusion was that TQM could represent a source of competitive advantage because the intangible factors that made it successful were poorly understood and hard to imitate. If that is true, it is a clear call for research into the nature of organizational knowledge and the *process* by which it can be created.

The body of literature that cumulative capabilities set out to displace was one that argued that tradeoffs between outcomes were inevitable, and that the choice of how to make them was a matter of choice of competitive priorities. In Operations Management, this view is generally credited to Skinner (1966). More recently, the case for the existence of tradeoffs has been strongly argued by Clark (1996), Schmenner and Swink (1998) and Boyer and Lewis (2002).

In this view of the world, the apparent absence of tradeoffs is just a different positioning of the tradeoff frontier. Clark (1996) refers to this as the *performance frontier*, and speaks in detail of the role of learning in moving it (p. 48). More tellingly, Schmenner and Swink (1998) refer to the *asset frontier* as the limiting case – the best available performance frontier achievable in an existing situation. Having argued in Chapter One that organizational knowledge is a major, if not the largest, asset of the firm, it is no great stretch to argue that the positioning of

the

lea

Ta

cur

tim

und

is k

res

fos

<u>Ch</u>

This

follo

that

iden

mig

esta

grou

The

can

relev

for b

the frontier will have a great deal to do with organizational knowledge and learning.

Taking an integrative view, Schmenner and Swink (1998) note that tradeoffs and cumulative capabilities are not necessarily in conflict when one introduces the time dimension to the picture. The time dimension highlights the critical need for understanding the organizational learning process. To quote Clark (1996): *"little is known about paths for improvement and learning"* and: *"little systematic research has been done on....the organizational and managerial processes that foster learning."*

Chapter Summary:

This chapter set out to accomplish three things: a) to position this research as following in the stream of literature focused on process improvement, b) to show that there is a shortage of process-based literature in this stream, and c) to identify, from multiple streams of literature, the key concepts or constructs that might be expected to fruitful for study. An additional outcome of point c) is the establishment of definitions of organizational knowledge and learning that are grounded in the literature.

The next steps are to develop a research framework within which hypotheses can be stated, and to develop a research protocol that ensures that observations relevant to the framework are captured. The above list of concepts will be used for both of these purposes in Chapter Three.

C

Introd

As pre

"how c

review

unders

in sup

buildin

choice

theory

This w

within

import

from th

devote

observ

the de

threat

scien

An im

anal

rese

The

CHAPTER THREE: RESEARCH FRAMEWORK & METHODOLOGY:

Introduction:

As previously noted, this study strives to answer a simple but critical question: "how do organizations create knowledge in their operations?" The literature review showed that there have been repeated calls for more research and better understanding of the process of organizational learning, suggesting a deficiency in supporting theory. Ultimately, this research must address itself to theory-building. The manner in which this is to be done is a matter of philosophy and choice. This chapter will begin with a discussion of the philosophical approach to theory-building that will be taken in this research.

This will be followed by the definition and development of a research *framework* within which potential theories may be stated. In the context of this chapter, it is important to point out that this framework is derived from the literature, and not from the observations of this study. The balance of the chapter will then be devoted to describing the research design and methodology by which field observations are collected and transformed into elements of theory. Throughout the development of the research design, the central them is the avoidance of threats to validity, which must always be a concern, but particularly in the social sciences.

An important part of the research design is the selection of the appropriate unit of analysis. Since this selection is referenced throughout the discussion of the research protocol, a brief definition is offered here to facilitate that discussion. The unit of analysis ultimately selected is characterized as an *event*, reflecting the c

parti

anal

It ma

can

purp

settir

Rese

The p

(1991

choic

deduc

In the

relatio

of tha

predic

oppos

to yiel

some

Withi

from

dedu

teste

the comment of Rosch (1978) that *"The unit of the event would appear to be a particularly important unit for analysis. Events stand at the interface between an analysis of social structure and culture and an analysis of individual psychology. It may be useful to think of scripts for events as the level of theory at which we can specify how culture and social structure enter the individual mind."* For our purposes, events will consist of a defined set of individuals acting in a bounded setting to effect a verifiable improvement in a production process.

Research Goal, Theory-Building:

The present research is directed towards theory-building, placing it in what Hunt (1991) calls the *context of discovery*. Within that context Hunt (1991) offers two choices for purposeful and systematic efforts at discovery. These are the *deductive* and *inductive* methods.

In the deductive mode, the researcher works from the general to the specific. A relationship is proposed that is assumed to apply generally. The consequences of that relationship in a particular situation are then deduced to arrive at a prediction (hypothesis) that can be tested. The inductive researcher works in the opposite direction. Specific observations are *collected*, *classified* and *analyzed* to yield a consistent relationship can be discerned that is believed to apply with some generality.

Within the model of theory proposed by Bacharach (1989) (see Figure 2, derived from his Figure 1, page 499), the difference would be stated this way: the deductive approach states propositions in order to derive hypotheses that can be tested. The inductive approach observes outcomes that would verify potential hypo

purs

inad

CO

V

The in

overco

threats

proble

one b

paper

intere

The

in the

deriv

hypotheses in order to arrive at more general propositions. This research pursues an inductive approach to theory-building, driven largely by the perceived inadequacy of existing theory in this area (see Chapter Two).

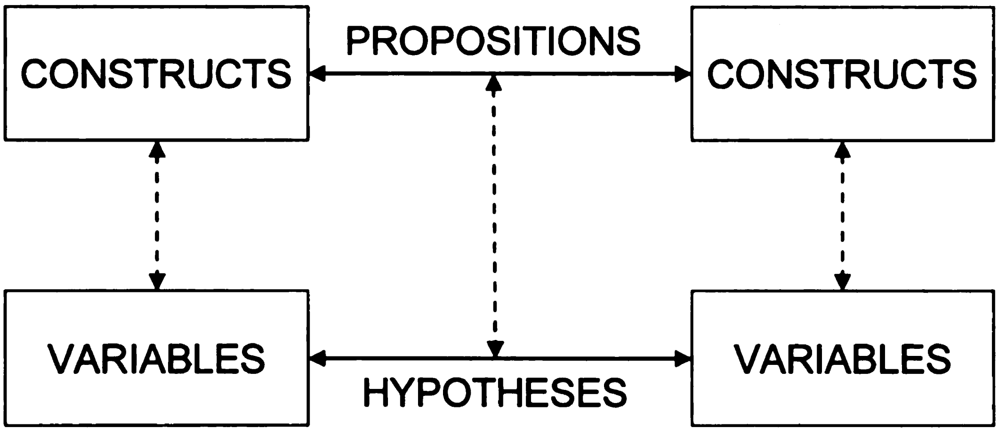


Figure 2: Model of a Theory

The inductive approach brings with it three inherent difficulties that can never be overcome entirely. The goal of the research design must be to minimize the threats that these difficulties pose to the validity of the conclusions. The first problem, noted by Hunt (1991), Eisenhardt (1989) and Ellram (1996) is that when one begins with observations, it is not possible to begin with a clean sheet of paper. It is necessary to establish some *a priori* hypotheses about what will be interesting to observe and what will not. This can, of course, bias the results. The best defense against this sort of bias is a good research protocol, grounded in the literature (Ellram, 1996). Such a protocol is developed in this chapter, derived from the results of Chapter Two.

Th
hy
ch
an
as
pro
are

Wh
the
the
rea
adv
use
cont
from
circu
resea
who
obse

The t
propo
1989
appr

The second difficulty lies in the method by which observations (potential hypotheses) are distilled into propositions. Again, Hunt (1991) offers two choices, neither of them entirely satisfactory. If the observations are quantifiable, and enough data can be collected, then propositions can be derived statistically, as in exploratory factor analysis. This is a somewhat weak method, since propositions derived in this way cannot be falsified; one can only say that they are supported or not within certain confidence limits.

When observations are not quantifiable or are few in number, both of which are the case in this research, the remaining alternative is *pattern matching,* which is the search for distinctive and recurring patterns in the data (Hunt, 1991). The realities of the social sciences dictate frequent use of the method, and it is advocated in this context by Kaplan (1964). While this method can generate useful insight, Hunt (1991) points out that it suffers from a lack of *intersubjective confirmability*. By this he means that if two researchers extract different patterns from the same data, there is no test to determine which is better. Under these circumstances, the best that one can hope for is a degree of consensus. This research seeks to address this problem through the use of a panel of experts who were asked to comment on the validity of some of the key patterns observed.

The third difficulty with the inductive approach is to make the resulting propositions testable. This is typically done (using the model of Bacharach, 1989) by deriving testable hypotheses from the propositions. In the inductive approach however, this involves reversing the process and should return hypoth

to be s

same

testab

setting

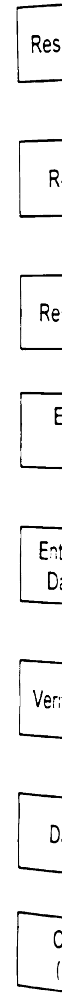
Having

resear

presen

hypotheses that mirror the original observations (minus those that were deemed to be spurious). It is thus improper to both derive and test propositions within the same research setting. This study will end with propositions; their reduction to testable hypotheses must remain a matter for future research in different settings.

Having discussed the research goal at some length, the development of the research design and methodology will proceed according to the flowchart presented in Figure 3.



Fig

Resea

The te

resear

The c

typolo

that ta

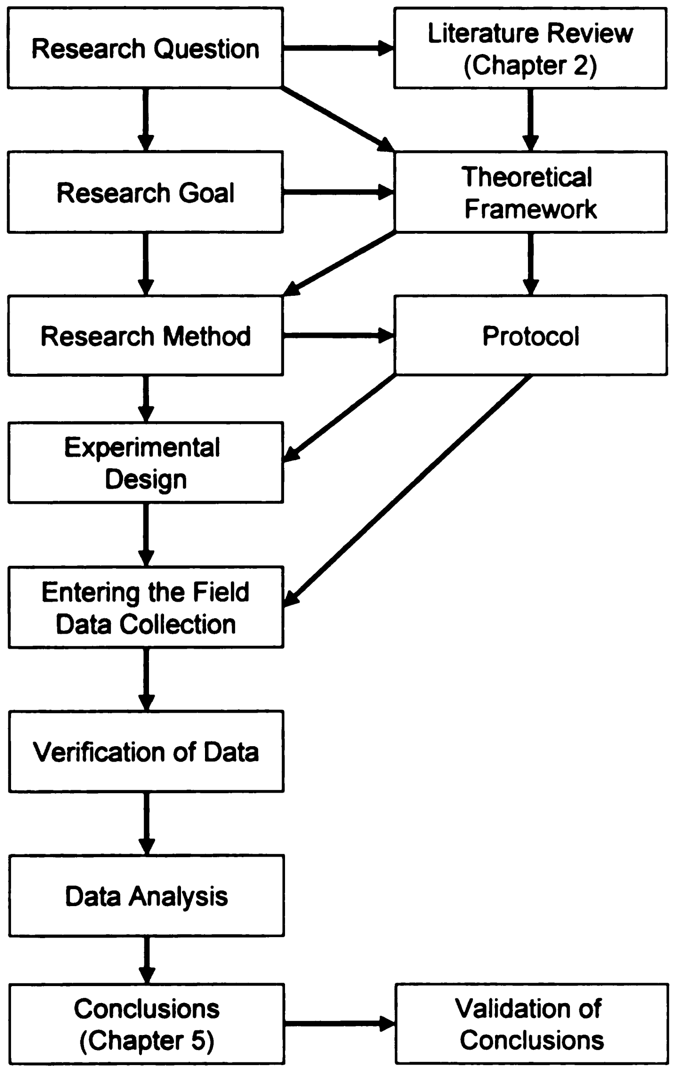


Figure 3: Research Methodology

Research Framework:

The term *framework* is used liberally but somewhat loosely in social science research, so it is appropriate to define what it means here and why we need one. The descriptive definition of a framework is that it is something more than a *typology* and something less than a theory. A typology is a classification system that takes a field of relevance and divides into mutually exhaustive and exclusive ele

ent

sa

ab

are

no

lite

rel

of t

A f

mu

be

It is

rel

in a

this

Pro

Wh

sta

to

da

w

fr

elements (Chrisman, Hofer & Boulton, 1988). These elements may be natural entities or less tangible concepts often referred to as *constructs*. (Note that the same definition may be applied to a taxonomy; there is considerable debate about the distinction between these two terms relating primarily to whether they are empirically or logically derived. We will bypass that debate here and just note that the elements of our framework are derived from a synthesis of the literature.) A theory goes beyond a typology by specifying propositions about the relationships between the entities and constructs in a way that allows the stating of testable hypotheses.

A framework, then, lies somewhere between these states. Like a typology, it must divide the field of interest into elements, but in addition, that division must be somehow relevant to how the elements are expected to relate to each other. It is not necessary at this point to state formal hypotheses about the relationships, but the classification must be such that hypotheses could be stated in a subject-object fashion. Two examples of the term *framework* being used in this way in Operations Management are Jensen (1992) and Kim and Lee (1993).

Properly constructed, the framework serves as a roadmap for the research. While grounded theory development (Glaser & Strauss, 1967) may be an ideal state, the process of discovery is greatly facilitated by having some idea of where to look. Both Eisenhardt (1989) and Yin (1994) note that it is pointless to collect data without some organizing framework or theoretical lens that determines what will be recorded and what will be ignored. This suggests an important role for the framework in the construction of a *research protocol*. Many kinds of fieldwork dem

and

inte

mal

eve

sign

The

Wha

outs

were

wou

ques

exan

answ

proce

of the

illustra

of org

poss

demand the use of a protocol to ensure that all of the relevant points are covered and that each situation is approached the same way. For example, in an interview situation, a protocol might be a pre-determined set of questions that make sure the key points are addressed. In this research, it took the form of an *event checklist* (was there evidence of a certain condition, and what was its significance?) (Ellram, 1996).

The list at the end of Chapter Two is the basis for the framework in this research. What makes this list more than a typology is the way it was constructed. At the outset, attention was given to the principal entities in the research setting. These were the individual, knowledge and the firm. It was presupposed that these would interact with each other in some way that would address the research question. The framework was then populated from the literature by asking, for example, "What does it mean for an individual to interact with knowledge?" The answer to that question led to the inclusion of cognition and information processing as important elements of the framework. Rather than enumerate all of the elements of the framework in this fashion, the range of interactions is illustrated graphically in Figure 4. It can be seen that this is not by itself a theory of organizational knowledge and learning, but it lays out the elements and possible relationships from which such a theory could be expressed.

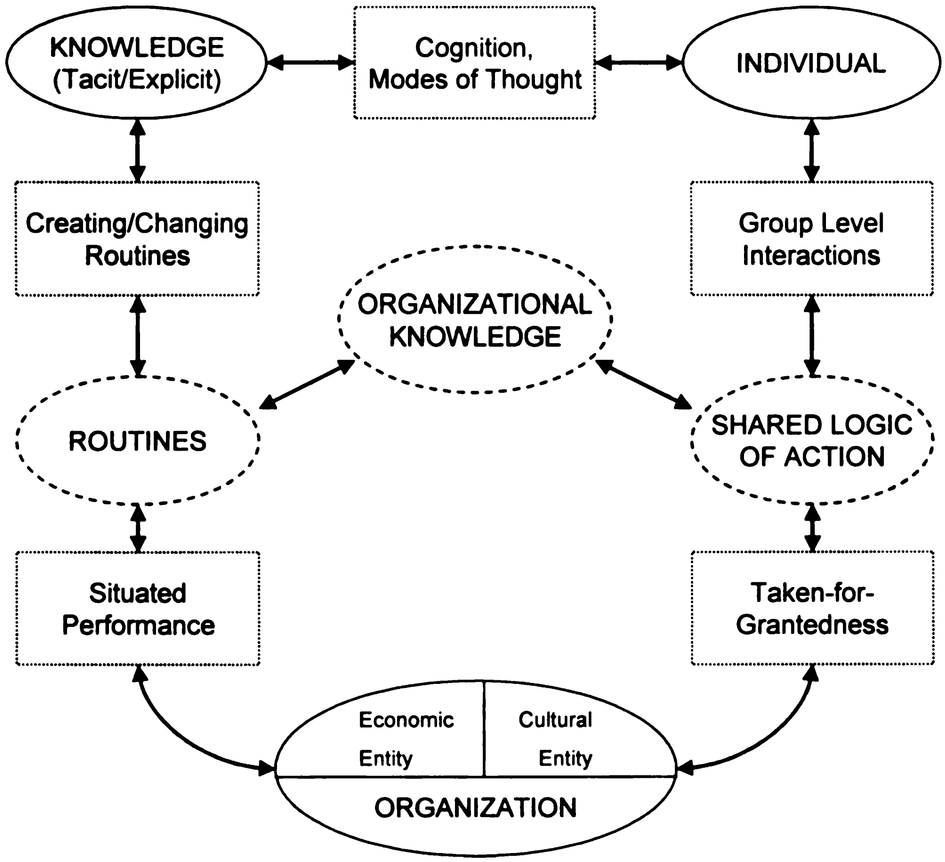


Figure 4: Schematic of Research Framework

Research Method:

The choice of research method is governed by the research question, the goal of the research and the elements chosen for the framework. The focus on theory-building and on process versus content more or less dictates the need for field work. The use of archival data is inconsistent with the process focus of the research, since it tends to be almost exclusively content centered. Surveys or interviews were considered but looking at the elements of the framework, it became clear that it was not feasible to construct a survey instrument or an interview protocol that would generate the depth of insight required. For elements such as a *shared logic of action*, which may involve compliance on the basis

for an

As a r

the se

recom

questi

in natu

consid

Resea

In the

that en

of the r

and so

properl

protoco

in the s

In this r

(and sh

the prot

looks s

been id

preclud

basis of *taken-for-grantedness* (Scott, 2001, p. 52), it may be literally impossible for an insider to recognize its existence (Martin, 2002).

As a result of the above, the decision was made to employ direct observation in the setting of a small number of in-depth case studies. This is consistent with the recommendation of Yin (1994) that case studies are appropriate for research questions of a "how" or "why" type. The data from such studies will be qualitative in nature, which is a strength of the method when multiple alternatives must be considered (Miles & Huberman, 1994).

Research Protocol:

In the context of research, a protocol simply means a set of rules or procedures that ensures that the collection of observations is both consistent with the intent of the research and consistent from case to case. The cases will of course differ, and so will the data collected, but a protocol ensures that common themes are properly identified. If interviews were being used for data collection, an interview protocol would ensure that a core set of questions was asked of all respondents in the same way.

In this research, more passive observation is used, so the researcher does not (and should not) directly influence what the subjects say and do. In this instance, the protocol takes the form of an event checklist to ensure that the researcher looks systematically for evidence of all of the constructs or concepts that have been identified in advance as relevant. The existence of a protocol does not preclude observations of factors not previously identified, but which may emerge as r

bloc

A pr

the

more

char

ques

elem

valid

literat

conte

made

In this

enteri

sensit

to not

of evic

more f

data c

appro

signif

as relevant in the context of the event. In fact, this is a fundamental building block of grounded theory development.

A prior section outlines the framework to be employed in this research and it is the elements of that framework that constitute the event checklist. However, more needs to be done. It is necessary to define in advance the traits or characteristics that the researcher will use to determine whether the element in question is present or not. These characteristics are listed in Table 1. Since the elements of the table must be regarded as tentative constructs, there are no validated measurement scales for them. This list of traits is synthesized from the literature that suggested the elements, and is justified on the basis of face or content validity (Nunnally, 1994). Where this is not entirely obvious, reference is made to the source literature.

In this study, the protocol is used both before and after data collection. Before entering the field, the protocol must be understood by the researcher to provide a sensitization to the traits to be watched for. During observation it is not sufficient to note that a certain trait was "present," it must be tied to some particular piece of evidence. Since a single piece of evidence may reflect multiple traits, it proved more feasible to record a chronology and apply the protocol immediately after the data collection to tabulate evidence of the key factors. An advantage of this approach is that it improves the chances of recording observations whose significance may not be apparent until viewed retrospectively.

Table 1: Research Protocol	
FRAMEWORK ELEMENT	IDENTIFYING TRAITS
Knowledge classified as being explicit or tacit	Knowledge is assumed to be explicit unless identified otherwise. Evidence of tacit knowledge: a) Elements of the work process that people do, but can't tell us exactly how, b) Reasons for the work process that people believe or accept, but can't explain exactly why.
Transformations of knowledge within and between explicit and tacit	When new knowledge is created (use evidence of improvement in situated performance), the idea of a transformation requires identification of a precursor or precursors. Unless the precursor can be broadly classified as knowledge, it is not evidence of a transformation per Nonaka (1994).
Knowledge classified by location	Again, using a broad definition of knowledge, can new knowledge or a knowledge source be classified by location (personal memory, written records, physical artifact, etc.)? Does it make a difference to the process?
Actions by individuals to retrieve or store knowledge by location	Closely related to the above. What actions are taken that result in knowledge being somehow stored in or retrieved from specific locations?

Pro kno info ind (na par
Ind cog pre- of k
Pow know moc grou

Table 1: continued	
Processing of knowledge and/or information by individuals (narrative versus paradigmatic)	This is the top-down versus bottom-up distinction and may be quite hard to observe. The key question is whether individuals engaging in a knowledge creating activity such as problem solving are rearranging and extending known facts or whether they are working with incompletely specified models or principles that are best explained by way of a story or narrative.
Individual cognition (as in pre-existing state of knowledge)	This is also difficult to observe – look for evidence of failure to see, find or understand something attributable to a lack of sufficient background knowledge. How does this impact the performance of the group as a whole?
Power and/or knowledge as moderators of group activity	Note instances of differences in rank in members of the team, particularly cases where there is a reporting relationship. Did this affect behavior? Was a member of the group recognized to have superior expertise in any particular area? Did this affect behavior? (This must be a subjective judgment since there is no control sample available for reference.)

S a o tc
Ch pe asp rou
Ch situ per

Exper

Havin
neces
inves
the e
poter

Table 1: continued	
Shared logics of action (existence of and changes to)	This is somewhat difficult. Martin (2002) notes that "shared" doesn't mean universally agreed upon and it may actually be the case that no one agrees with it as in the "Abilene Paradox" (Harvey, 1988). Rather, is there a recognized dominant logic that motivates the group? Key indicator – do individuals demonstrate a sense that this logic is beyond question, or at least beyond their ability to influence? This may be easier to see as an outsider but there will be no hard evidence, since the insiders typically cannot see that it is an issue. An important question is whether any changes to the dominant logic were observed during the course of learning.
Changes to performative aspects of routines	This is a simple tabulation. What differences are there in the work process as a result of the improvement efforts?
Changes in situated performance	Is the process verifiably better as a result of the "improvement" efforts? By what measures?

Experimental Design:

Having decided on a research method of in-depth case studies, it is still necessary to choose a unit of analysis that will allow the research question to be investigated and in order to define appropriate criteria for case selection. Each of the entities considered in the framework development above represents a potential unit of analysis, as does the work process or routine that is the subject of t

ind

was

act

sta

To c

Prin

bou

evid

occu

litera

To a

esta

The

to m

Spe

so t

of the improvement effort. Each of these is also potentially incomplete as indicated by the web of relationships postulated in Figure 4. What is really wanted is to capture an *event*, defined as a bounded set of individuals and activities within which an operating process of an organization is moved from one state of knowledge to another, as shown in Figure 5.

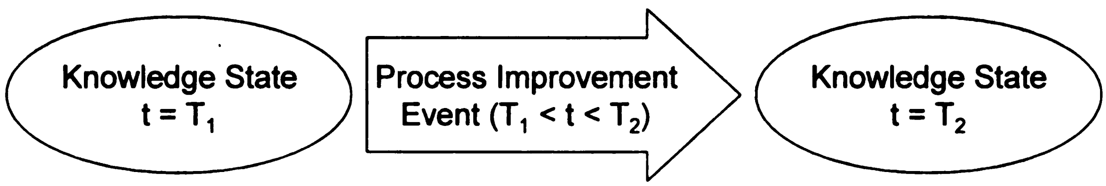


Figure 5: Process Improvement Event

To constitute a useful unit of analysis, such an event must satisfy several criteria. Principally, it must have measurable beginning and ending states. This both bounds the event in time, and allows us to verify that a process improvement (the evidence of learning defined as an increase in situated performance) actually occurred. Additional criteria can be identified from the lessons learned in the literature review of prior process research (Chapter Two).

To avoid the situation of a set of single-sample anecdotes, it is important to establish comparability, as in the ability to observe multiple, comparable events. The intent is to search for similarities (patterns) among events, so we do not want to mask similarities by trying to compare greatly different types of events. Specifically, we are looking for events that conform to some consistent standards so that we can compare the *actions* of different (but comparable) *people* in di

pr

Th

cr

a l

the

ex

de

pu

sta

The

pro

des

imp

usu

prac

a sm

desc

desc

In th

Ter

Act

a s

different (but comparable) *organizations* addressing different (but comparable) *problems*.

There are additional criteria. To properly observe the process of knowledge creation, it is necessary to simulate as, much as possible, a *closed* system, as in a laboratory setting. This requires that the event be bounded in scope so that there is a clear distinction between what is endogenous to the event and what is exogenous (and that the two do not mix). In practical terms, this implies a defined group of people working together for a fixed period of time with a defined purpose. A further consideration is that the event should be continuous from start to finish so that unobservable activities are not part of the process.

These are difficult conditions to establish, illustrating why it is difficult to do good process-oriented research. Such situations do exist however, and the conditions described above are characteristics of a generic class of short-cycle process improvement initiatives known as *Kaizen events*. *Kaizen* is a Japanese term usually translated as *continuous improvement*, and *Kaizen* events as typically practiced are short cycle projects (typically about one week in duration) involving a small, dedicated team focused on improving a single work process. This description corresponds to what Melnyk, Calantone, Montabon and Smith (1998) described as "second level, tactical events."

In their work, the defining traits of these events were listed as: Very Short Term/Finite in Life, Highly Focused, "Creativity before Capital," Team Oriented, Action Oriented, Verifiable Metrics, and Repetitive. Such events have evolved to a standardized event structure consisting of six major phases: (1) Training; (2)

t

Y

(

s

K

ol

th

of

ap

Hc

prc

anc

Ca

Pro

inst

inte

idea

poi

Ho

so

Ac

st

Documentation of the process "as is;" (3) Identification of potential opportunities for improvement; (4) An immediate, iterative process of implementing and verifying the improvements; (5) Presentation of the results to management; and (6) Preparing the action list for next steps (Melnyk, Calantone et al., 1998 and see also Stewart & Melnyk, 2000).

Kaizen events were selected as an appropriate "laboratory" within which to observe the process of organizational knowledge creation. As can be seen from the description above, they provide a consistent format so that recurring patterns of behavior can be observed. They also provide the necessary bounding, approaching a closed system as closely as is possible in an Operations setting. However, identifying an appropriate unit of analysis for study is only part of the process of research design. Selection of appropriate cases is equally important and can support or undermine the experimental design.

Case Selection:

Proceeding to case selection, the nature of the research suggests the use of instrumental cases (Stake, 1994). In other words, the case itself is of no intrinsic interest, it is simply a vehicle for examining the phenomenon of interest. The ideal case should be as typical of a larger population as is feasible. Stake (1994) points out that the case and the unit of analysis do not have to coincide. However, for the purposes of this study, that is a natural choice providing that some additional criteria with respect to feasibility and controls can be satisfied.

Adopting Kaizen events as cases goes a long way towards ensuring feasibility for study by bounding the cases in scale, scope and time, all issues which could

pre
with
inte
qua
feas
hav
and
wor

The
Ther
a rel
samp
envi
This
prem
little r
not a
varia

A crit
corp
The
and
it pr

present problems for a researcher or research team. An additional advantage with respect to feasibility is that the events are scheduled. While it might be interesting and valuable to study unplanned events such as a response to a quality problem, this could only be observed through serendipity. A final issue of feasibility that must be addressed in case selection is that the researcher must have access to the event. Process improvement does not take place in public and may involve proprietary information. An invitation to observe the true workings of the event must be secured.

The issue of the controls to be placed on the case selection is more complex. There is a persistent tension between enhancing the ability to isolate and identify a relationship and enhancing the ability to generalize it beyond the research sample. The former objective would call for comprehensive controls of environmental variance, while the latter would be enhanced by fewer controls. This study will lean in the direction of improving the identification on the general premise that until it is possible to confirm the existence of a relationship, there is little reason to be concerned about generalization. As a result, external validity is not a primary concern of this research, and we will attempt to control for as much variance as possible.

A critical early choice was whether to seek out Kaizen events from different corporations or to study events taking place under a single corporate umbrella. The latter alternative was eventually chosen although it was not a clear choice and there are advantages and disadvantages. The principal advantages are that it provides a consistency in the structure of the Kaizen events and that it aut

disa

anc

add

corp

A ta

conc

perr

wou

The

corp

they

was

resea

produ

quest

which

the se

Withi

many

To e

funct

oper

automatically controls for industry and some firm effects. The major disadvantage is that the "organization" is an element in the research framework and we do not want to remove variance in that element. This issue was addressed by insisting that all cases come from different operating units of the corporation with separate reporting structures.

A target corporation (referred to hereafter as *the Corporation*) that was known to conduct significant numbers of Kaizen events was approached and asked for permission to observe some of the events. It was agreed that a researcher would be allowed to attend a number of events acting as a participant-observer. The significance of this role will be discussed in more detail below. Since the corporation regards the content of these events to be proprietary and because they wish to remain anonymous, a comprehensive non-disclosure agreement was signed. As a result, only generic data and terminology will be used in this research report. This presents no difficulty for the research, since precise product details and measures of improvement are not material to the research question. An overview of the Corporation will be provided in the next section, which will show that it represents an instrumental choice of research setting in the sense of not being exceptional in any way.

Within the corporate family, there was a range of events to choose from, but many were ruled out according to the criteria above and in the previous section. To ensure comparability of the project teams and to control for variance due to functional area, only events focused on process improvement in manufacturing operations were considered. (This is also consistent with the positioning of the *c*

c

in

St

wit

var

me

part

colle

As a

case

Two

separ

third

cases

there

comp

<u>Sam</u>

The

ana

research question.) The requirement that the event be continuous ruled out any event that was conducted in two parts or that represented a continuation of an earlier event. This two-part structure was fairly widely used in the target corporation, and while it has certain practical advantages, it compromised the closed system ideal because the participants cannot be observed in the intervening periods.

Still further restrictions were placed on the case selection. Only cases occurring within English-speaking North America were considered to avoid cultural variance. Also, only operating companies with previous exposure to the Kaizen methodology were considered so that the process itself would not be seen by the participants as a novelty. Finally, a six-month window was placed on data collection, controlling for fluctuations in the economy.

As a result of this rigorous and purposeful selection process, three research cases were chosen from different operating companies within the corporation. Two of these companies were within the plumbing products group (but with separate reporting structures and very different corporate histories), while the third was under Specialty Products. The Kaizen events that comprised these cases took place between December, 2004 and June, 2005 during which time there were no major shifts in the economic environment experienced by these companies.

Sample Size:

The issue of sample size is always a difficult one, particularly in case study analysis with qualitative data, where is no standard for what constitutes "enough"

c

m

th

th

Ko

co

of

the

exp

dat

con

whe

furt

eleg

Afte

suffi

in a

reco

It sh

of s

dire

mu

cases. Conventional wisdom suggests that larger is better. In the inductive mode of discovery (Hunt, 1991), the idea is that more data would convince us of the universality of the patterns being observed and hence, the generality of the theories that can explain them.

Kosslyn (1978) points out an interesting counterargument that hinges on the concept of *elegance* in a theory (elegance being an un-measurable combination of parsimony and "naturalness"). This concept is a sort of *Dutch auction* of theories. The idea is that the full observations of any one experiment can be explained by a number of theories, none of which are likely to be elegant. The data set must be reduced by replicating the experiment and retaining only the common elements. At some point the common themes are reduced to a point where a single elegant explanation is possible. Here one should stop because further simplification of the themes will only result in more and more potential elegant theories that explain less and less of the variance.

After three cases, it was judged that the interpretation of events had stabilized sufficiently that additional research effort would be more productively employed in a different set of cases: perhaps in non-manufacturing settings as recommended in the conclusions.

It should also be noted that counting cases is not necessarily the best measure of sample size. The three cases reported on here represent 21 person-weeks of direct subject observation, 38 identifiable process improvement activities and a much larger number of actions, statements and other data points.

Res

The

div

bui

ove

Co

cab

dec

pro

reta

Con

mar

dem

For

millio

orga

avera

depe

Until

man

man

thes

prov

Research Subject; An Overview:

The corporation that is the subject of this research ("Corporation") and its various divisions manufacture sell and install a wide variety of home improvement and building products, with an emphasis on brand name products. While consisting of over 50 separate operating companies (referred to as "divisions" by the Corporation), the Corporation is organized into five product-based business lines: cabinets and related products, plumbing products, installation and other services, decorative architectural products (e.g., paints), and other specialty products. Its products are sold through a variety of channels, including large ('big box') retailers, distributors, and professional installers (e.g., plumbers). The Corporation is differentiated within the building products and home improvement markets for being one of the few firms that can offer the "one stop shopping" demanded by large chains such as Menard's, Lowe's, and Home Depot.

For 2004, total revenues exceeded $12 billion, with net income totaling over $900 million. Overall, the Corporation is recognized as being a well-managed organization. For the last five years, as an example, net income has grown at an average of 13% per year. The Corporation has developed a reputation for dependable growth even through weak economic times.

Until recently, the Corporation operated in the style of a holding company that managed its businesses as a portfolio of investments. Each of the divisions was managed as an autonomous company. Entrepreneurship was encouraged within these various divisions, with the unintended result that some of the divisions providing either the same or similar products found themselves in competition with each other. While this is changing in response to market forces, the historical legacy of autonomy is strong. Over the last ten years, the Corporation aggressively acquired profitable and well-managed companies with market positions that were competitive or complementary to existing divisions or that enabled the Corporation to expand its product lines in its core markets. While this strategy too is changing, it was complementary with an autonomous structure, since the promise of autonomy was often an advantage in making an acquisition on favorable terms.

The Corporation is changing in response to external pressures, but to understand some of the dynamics at work in these cases, it is necessary to understand the history as well as the current challenges. These external challenges come from three primary areas.

The first is a consolidation of major customers. This consolidation is seen both in the growth of 'big box' retailers such as Home Depot, Lowe's and Menard's, and in the builder market with the growth of Pulte and KB Homes. This has created a fundamental change in how the home improvement business is conducted. The most obvious change is a shift in bargaining power from seller to buyer. The biggest customers now command sufficient market share that there is no alternative but to do business with them on their terms. This has resulted in not only in increased price pressures, but also in demands for improved quality and more flexible delivery schedules.

The second challenge comes from the changing nature of the consumer market itself. In recent years there has been a trend of "bar-belling" demand in many consumer goods markets. That is to say, there is demand for the very best products and for the very cheapest, with diminishing interest in the middle ground. It is precisely this middle ground where the Corporation's major divisions have gravitated, driven by a focus on profitability. As a result, the company is under pressure on both the high end and the low end. The low end pressure is more serious, and is largely the result of the emergence of China as a low-cost manufacturing center. This emergence has been strongly facilitated by the big-box customers, with their global sourcing reach and the ability to create private brands. While some of the Corporation's divisions are insulated (for now) from foreign competition, the divisions selected for these case studies are significantly affected.

The third major challenge to the historical strategy of the Corporation comes from the investor community. In the 90's, the Corporation (like many others) pursued a strategy of growth by acquisition. In an era of rising expectations, acquisitions could be made cheaply with stock and options, and Wall Street rewarded these companies with high valuations. In such a market, the chief role of existing divisions was to increase margins through cost reductions: growth was handled at corporate. This explains the Corporation's receptiveness to Kaizen event methodology as a cost reduction tool.

In the current economy, investor preference has shifted to strategies that emphasize innovation and flexibility. This creates a tension between the old and new ways of thinking in the Corporation that was visible in all of the cases. If there is a bright spot for the Corporation, it is that the housing and home imp

the

tha

Er

As

pa

re

ob

ac

pa

be

to

to

em

the

for

doi

inte

Kai

opp

pa

of

improvement markets have experienced something of a boom in recent years, so the shifts in strategy are being played out in a more benign market environment than is often the case.

Entering the Field: Data Collection:

As previously noted, the role of the researcher in these cases was that of a participant-observer (Martin, 2002). This has a number of implications for the research and explains why it was not feasible to have multiple researchers observing events. The choice of the participant-observer role offers a number of advantages. Principally, it avoids the tension created by the presence of a passive observer. The other team members quickly overcame the sense of being watched and interacted normally with the researcher. This was validated to an extent during some of the cases, particularly Case #2. When the team had to collect data for standard work calculations, it was necessary to observe line employees at work. It quickly became clear that they performed differently when they felt they were being watched; it wasn't until they were engaged in less formal conversation later that they provided a true picture of what they were doing. A secondary benefit of the arrangement was that it was much easier to interact with the subjects to clarify their intents and meanings.

Kaizen events begin as do most team events – with mutual introductions. This opportunity was used to briefly explain the purpose of the research to the participants and to obtain their informed consent. Particular emphasis was made of the fact that the purpose was not to evaluate them. In the context of an inst

doi

Sin

cor

abc

(Ur

Re

of i

forr

ack

con

plac

bei

wor

valid

resp

It is

sou

ava

que

anc

pro

do

instrumental case, it was explained that they were presumed to be normal people doing a good job, and that is why it was of interest to observe them.

Since this is research involving human subjects, certain legal and ethical considerations had to be observed in addition to the informed consent noted above. In accordance with Federal law, approval was obtained from UCRIHS, (University Committee for Research Involving Human Subjects), the Independent Review Board of Michigan State University, to conduct the research on the basis of informed consent (approval: IRB #04-876). To document informed consent, a form was developed which the participants were asked to sign as acknowledgement that they were satisfied with the steps taken to preserve confidentiality. These steps include the elimination of any names (persons or places) from the electronic records of the event. Since the participants were not being asked to do or say anything that they would not have done in their normal work, no one expressed any concerns about confidentiality. In the case of the validation survey given to the expert panel (to be discussed below), the responses were not only kept confidential, but were anonymous as well.

It is recommended by Yin (1994) to triangulate the data by using multiple sources. This was done in these cases as all relevant sources were made available to the researcher. Because of the "how" aspect of the research question, the principle source of data was observation of what individuals said and did. This was augmented by observation of the physical layout of the work process both before and after modification. In addition, various sources of documentary evidence were consulted. These sources included production

c
a
T
c
re
m
sp
th
th
br
qu
pro

schedules and forecasts, previous process flow analyses, bills of material and cost data. Occasionally, non-team members were brought in for consulting, providing yet another view. Most of these supplemental sources tended to be peripheral to the research question, in the sense that they did not address process issues, but are noted in the transcripts when they were used.

Verification of Data:

The data records of the events consisted of a transcript that reflected as accurately and objectively as possible what took place during the event. Verification deals with the question of whether the records are: (a) accurate, and (b) complete. Accuracy was dealt with in the sense of being "not wrong." Copies of the transcripts were sent back to the event facilitators with the request to note any errors of fact. No such errors were reported.

The question of completeness is more difficult, since no record can ever really be complete. A more conservative approach is to consider completeness with respect to the protocol. Even this is not comprehensive since important events might occur that were not anticipated by the protocol. The protocol is also a specialized document, familiar only to the researcher. A common approach to this issue is to use additional researchers (who are familiar with the protocol) so that notes can be compared after the fact. In the case settings described above, bringing additional researchers into the events was considered to be out of the question, so the best insurance for completeness is a clear and comprehensive protocol.

Analysis of Data and Conclusions:

The transcript of the event contains, as far as possible, no interpretation of *why* something happened. This was done primarily to separate verifiable facts from the interpretation. The verification step above was based on the factual layer, while the validation applies to the interpretation. To arrive at the interpretation, once the transcript was complete, it was followed by two layers of analysis. These correspond closely to *open* or *first level* coding as described by Miles and Huberman (1994), and to *selective* coding (Strauss & Corbin, 1990). As explained by Ellram (1996), these categories are iterative and interdependent. It is sometimes advised to use a category in between these called *axial* or *pattern* coding (Miles & Huberman, 1994).

It can be difficult to tell where one technique starts and another one stops. The differences are essentially these: Open coding is used to establish relevant constructs from the data, axial coding is to look for relationships between the identified constructs, and selective coding is to identify and examine alternate patterns. Coding is perhaps not quite the right word for the last instance, since it is more a re-examination of the data with specific patterns in mind.

In these analyses, the first layer is recorded in the form of marginal notes as described by Miles and Huberman (1994). In these notes are included any observations of issues that suggest themselves as important, evidence for issues suggested by the research protocol and some explanation about the significance of what was observed. The concept of marginal notes is important because these observations must be keyed to specific pieces of data to retain their validity. Because of the use of the research protocol, it was possible to effectively combine open and axial coding in this one step. Explanatory and subjective notes were typically added at the end of each day so that the events were fresh in the researcher's memory. Additional notes were added from a retrospective view of significance, corresponding to more purely axial coding.

The second layer of analysis corresponds more to *selective* coding. In this mode the transcripts were reviewed and compared to the protocol. The presence or absence of the traits in Table 1 was noted, along with any evidence confirming or disconfirming their significance. In so doing, different explanatory patterns were being applied to the data in search of supporting evidence (or lack of it).

From these two layers of analysis, some preliminary conclusions were formed. This is largely a synthesis process and is not easily specified in advance. An important part of the synthesis process is an awareness of what was not observed, along with what was. These conclusions are discussed in Chapters Four and Five.

Validation of Conclusions:

When conclusions are formed from a small set of cases it is desirable to test their validity against a larger data set. When the conclusions can be reduced to precise propositions based on validated constructs, a survey followed by statistical analysis is the preferred method. At this stage of the research, the conclusions did not lend themselves to this treatment, so an alternate approach was employed.

A panel of seven experts was assembled from a technical services group in the parent corporation. The bases for considering them to be experts were: (a) significant industrial expertise, (b) a high proportion of that experience devoted to continuous improvement activities and (c) involvement in (as facilitator or participant) a high number of Kaizen or other continuous improvement type events.

The panelists were assembled and given a twenty-minute summary of the research project, its scope and objectives and the preliminary conclusions. This was followed by approximately forty minutes of open discussion. A transcript of this discussion is attached as Appendix VII and is discussed in Chapter Four. At the end of the discussion, the panelists were asked to anonymously answer a short questionnaire on their agreement or disagreement with the conclusions. The questionnaire is reproduced as Appendix I. The results are given in Appendix VI and are also discussed in Chapter Four. These results were incorporated into the propositions that are developed in Chapter Four and in the conclusions that are stated in Chapter Five.

Summary:

In order to arrive at an appropriate research design, this chapter began with a discussion of the inductive approach to theory-building. In this approach, specific observations are collected, classified and analyzed in order to state more general propositions. This approach demands rigor at all phases to overcome the threats to validity that are inherent in the method. While specific details of the research design were chosen to minimize these threats, the principal reliance is on the clc

de

lite

Th

ap

su

ap

se'

im

int

Th

of

co

to

ex

The

closely related research framework and research protocol, both of which are developed in this chapter. Their key features are that they are grounded in the literature and consistently applied in the field.

The detailed design of the research follows from the choice of the inductive approach. A case study method, employing sustained direct observation and subsequent qualitative analysis of the findings was chosen as the approach most appropriate for generating insight relative to the research question. Case selection is a critical phase of the research design, and specific Kaizen process improvement events were chosen as cases that met the dual needs of theoretical interest and feasibility for study.

The field data are qualitative in nature, such that the analysis must be some form of pattern matching (Kaplan, 1964). Given the lack of intersubjective confirmability in this method (Hunt, 1991), a validation procedure was established to confirm that patterns observed in the data were consistent with the experiences of a panel of experts in the field.

The actual recording and analysis of the data are discussed in Chapter Four.

Intro

The

rele

Thre

obse

gen

then

lear

The

indu

som

invo

des

patt

con

tra

cha

Th

of

in

ca

CHAPTER FOUR – RESULTS

Introduction:

The purpose of this chapter is to present the results of the field research that are relevant in the context of the research framework and protocol derived in Chapter Three. Broadly stated, these results are expressed as a summary of observations within the structure of the research protocol that are found to be generally true across the cases studied in this research. These observations are then stated in the form of potential propositions in a theory of organizational learning, following the model of Bacharach (1989) (Figure 2, Chapter Three).

The derivation of these propositions, moving from the specific to the general, is *inductive*, per Hunt (1991). As previously noted, the inductive approach is somewhat limited in the availability of tools of *explanation*. Since this study involves qualitative data, the method used here will be pattern matching as described in the preceding paragraph (Kaplan, 1964; Hunt, 1991). Because pattern matching as a tool of explanation suffers from a lack of intersubjective confirmability (Hunt, 1991), there is an onus on part of the researcher to create transparency in the process so that the reader can retrace the steps. This chapter is organized to present the results in a way that maximizes transparency.

The individual case reports are the foundation of this chapter, but in the interest of clarity, they are not incorporated in the body of the text. Instead, Table 2 is included in this chapter to provide a summary overview of the cases. The actual case reports are attached as Appendices II, III and IV. Each of these appendices is laid out in the same way. The introduction contains an overview of the company setting in which the event took place and summary of what occurred, including the results achieved by the event.

Table 2: Summary Description of Cases

Case #	#1	#2	#3
Type of Kaizen Event	Second level, tactical	Second level, tactical	Second level, tactical
Company type/products	Plumbing products - faucets	Drain cleaning equipment	Plumbing products – shower valves
Dates	December 14-17, 2004	March 14-18, 2005	June 27-July 1, 2005
Location	Ontario	New Jersey	Indiana
Process Selected for Improvement	Semi-automatic brazing carousel.	Steel machining, fabrication and welding cell.	Final assembly and pack-out.
Overall Goals of Event	Reduce time to change fixtures from one assembly type to another.	Reduce WIP between weld and paint, reduce labor hours.	Streamline material flow during part changes, reduce clutter and improve operator efficiency.
Specific Targets	50% reduction in setup time, 4 safety/ergo improvements, 1 poke-yoke implementation.	10% improvement in productivity, 90% reduction of welded frame WIP, reduce floor space by 10%, implement 3 safety/ergo improvements.	Redesign pack-out station, Implement safety/ergonomic improvements, Implement mistake-proofing (poke-yoke).
Facilitation	Dual, one from corporate, one internal. Corporate facilitator had experience of > 50 events. Internal facilitator <5.	Dual, one from corporate, one internal. Corporate facilitator had experience of > 50 events. Internal facilitator <5.	Dual, both internal, one newly trained as facilitator, neither had experience of more than ~10 events.
Participants (total)	9	7	8

T

w

r

r

c

b

th

th

a

c

Table 2: Continued			
Modifications Made	17	14	7
Results Achieved	49% setup time reduction, 7 safety/ergo improvements, 1 poke-yoke implementation.	Implemented cyclical painting schedule and pull system - ~75% reduction in WIP, use of standard work and small batch flow to reduce labor ~14%.	Built new packing tables for better flow and ergonomics, re-organized part stock to match part sequencing, redesigned assembly fixtures with mistake-proofing.
Comments	Important distinction between reduction in man-hours for setup and reduction in down-time – focus was on the former.	Uncertain that improvements will be sustained in face of nervousness about lack of buffer stock.	Company was more concerned with qualitative than quantitative measures (reduction in clutter, operator testimonials).

This is followed by what amounts to *selective coding* (Strauss & Corbin, 1990), where the data are systematically reviewed according to each element of the research protocol for the presence or absence of confirming evidence. This review also includes observations on certain factors that were not specifically considered in the research protocol, but emerged from the actual field notes as being potentially interesting. These observations correspond to *axial coding* in the terminology of Miles and Huberman (1994). Finally, each appendix includes the actual case notes, in the form of a transcript of the event. The transcripts are augmented with the researcher's marginal notes which offer explanations of certain events and serve to tie the conclusions to specific evidence.

I
c
c
i
a
t
c
F
in
th
a
m
a
T
re
fr
of
A
c
q
n
p
t

It will be noted that the case reports and the field notes are sparse in identifying details. This is deliberate in order to protect the subject company from any loss of proprietary information and also to protect the identity of the individuals involved, even within the company. Some terms may seem cryptic in the absence of any definition or explanation, but typically, these are terms that are used locally for identification of specific processes or products and are not considered material to the issues being observed.

Returning to this chapter, the first section is a review of the research protocol that integrates the similar reviews in each of the individual case reports. At this level, the interest is in the presence or absence of confirming evidence that holds across a majority of observations, remembering that each case may contain multiple observations. The additional themes that emerged from the field notes are also considered in this section.

The chapter concludes with the development of a set of statements about relationships that were observed to exist between the elements of the research framework (Figure 4, Chapter Three). These relationships are stated in the form of potential propositions in a theory of organizational learning.

At a preliminary stage, these observed relationships were reviewed and discussed with an expert panel as described in Chapter Three. The qualifications of the panelists as experts in the field are given in Table 3. The notes of the panel discussion are provided as Appendix VII, and the insights provided by the panel are incorporated in the discussion of the research protocol that follows. These comments and insights were supplemented by a survey, the purpose of which was to provide empirical validation of the panel's degree of agreement with the tentative propositions. The survey itself is attached as Appendix I and the results are tabulated in Appendix VI.

Table 3: Qualifications of Validation Panel

Panelist	Years of Industrial Experience	Years of Experience in CI	CI or Kaizen Events
1	20	9	120
2	10	6	130
3	12	2	30
4	17	10	50
5	16	14	75
6	20	10	100
7	40	30	150
Mean	19.3	11.6	93.6
Std. Dev.	9.9	8.9	43.8

Part I: Review of the Research Protocol:

Knowledge Classified As Being Explicit Or Tacit:

The study of epistemology provides us with two major ways to classify and describe knowledge itself. One is a typology or classification according to the essential nature of the knowledge, specifically the classification of *tacit* versus *explicit* knowledge. The tacit/explicit distinction proved to be a valid one, as clear examples of each could be observed. The usefulness of the view, particularly when speaking of organizational knowledge, is less clear, as will be discussed in the next section.

Two types of tacit knowledge were observed in all of the cases. The first type was an individual skill, such as adjusting brazing burners, bending tubes or re-ordering a production sequence. While these skills certainly represent knowledge, they do not meet the definition of organizational knowledge in the sense that the organization can only make use of these skills by employing their owners. A conversion of these skills to some explicit form (see next section) would make them appropriable by the firm, but this did not occur in any of the cases. Given the benefits that these skills confer on their owners, it could be expected that such conversions would be resisted.

A second form of tacit knowledge was observed that was very much a property of the organization. This consisted of a pervasive but largely unspoken sense of priorities and beliefs about "how things should be done around here." This type of knowledge does have certain reflective indicators (performance metrics for example), but these indicators are not always mutually consistent. It is the unstated balance of priorities that makes this knowledge tacit. It was very difficult to observe this type of knowledge, or even to recognize its existence. In this respect, it is an element of culture and probably best understood in that context as will be discussed later.

Under this typology, any knowledge that is not tacit is explicit by default. Certainly any physical changes to observed procedures would qualify as examples of learning resulting in the creation of explicit knowledge. Thirty-eight such examples were noted, providing a fairly large sample for observing the mechanisms at work. The strict count of events should not be taken too seriously however, since the events are not all equally significant and many could be arbitrarily broken down into smaller elements or aggregated into larger ones.

While this classification seems straightforward enough, it proved to be troublesome in a key aspect. The root of this trouble is noted by Pentland and Feldman (2005) when they decompose routines into performative and ostensive components. While the performative aspect of a routine will generally be explicit, the underlying rationale may or may not be. As an example, the case of the revision to the part cooling mechanism (Case #1) had performative and ostensive components that were both explicit. The performative component (the revised "shower head") was purely explicit, and the ostensive part (cool the part sufficiently for the operator to handle it and uniformly enough to release freely from the fixture) was explicit in the sense of being readily articulated and universally understood.

Other examples were mixed. For example, the fabrication of a "supermarket" table for welded frames in Case #2 is again an explicit performative component, but it really only constitutes organizational knowledge if it is instituted with the intent to employ "pull" production. As described above this intent constituted tacit knowledge in the sense that the organization could not clearly or universally articulate why it did (or did not) believe that this was the correct approach and under what circumstances that would be true.

To summarize this section, it can be said that while both tacit and explicit elements of knowledge could be observed, this distinction by itself was not sufficient for a clear and unambiguous classification scheme. It is truer to say that anything qualifying as organizational knowledge (as defined in this research) could contain both tacit and explicit elements in varying proportion. Other elements of this research protocol (to be discussed below) offer more insightful ways to classify organizational knowledge. The tacit/explicit distinction was not discussed explicitly with the expert panel since it did not seem to be an important building block for propositions.

<u>Transformations of Knowledge Within and Between Explicit and Tacit Forms:</u>

In the view of Nonaka (1994), learning requires *transformation* of knowledge from one of these forms to another. Given that there are two classifications, there are four potential transformations that can be considered. We will deal first with the three possible transformations involving tacit knowledge, and preface the remarks by saying that no such transformations were actually observed during the study.

At the individual level, tacit knowledge describes something like a skill or art that can be passed from one person to another through what Nonaka (1994) refers to as *socialization*. Our results contain evidence that this had in fact occurred in situations where an individual trained his or her counterpart on an opposite shift. It was also apparent that much of this individual tacit knowledge could, in principle, be transformed to explicit knowledge with enough effort. Such a transformation would be interesting because it would represent a conversion from a personal form of knowledge to a form appropriable by the organization. This did not actually occur in any of the cases studied.

The situation was less clear with respect to the organizational form of tacit knowledge, especially given the above argument that organizational knowledge can potentially consist of both tacit and explicit components. In fact, it was difficult to define what would constitute a transformation in that context. In any case, if we consider organizational tacit knowledge to be the dominant logic about "how things should be done around here," this was static during the course of all of the case studies, so no transformations were observed.

In principle, the tacit portion of organizational knowledge could be made explicit through means such as performance metrics, but it is not clear how a transformation in the reverse direction might work. It is equally unclear how a tacit-to-tacit transformation might take place with such knowledge, except perhaps the case where newcomers are indoctrinated with the dominant logic. Any change to the dominant logic of an organization would seem to be a replacement phenomenon rather than a transformation, but no such change was observed within the scope and context of any of these cases. With respect to tacit organizational knowledge, the concept of knowledge creation through transformations was not helpful or observable.

Since a large number of explicit outcomes of learning was observed, the remaining transformation proposed by Nonaka (1994), explicit-to-explicit, should have been widely observable. Conceptually, this would take place when a particular instance of knowledge is observed in one setting and subsequently applied in another. This sequence proved not to be observable in practice. To the extent that it is possible to infer mental processes from observation, the sequence went more as follows: An individual encounters an instance of explicit knowledge. From this, the individual abstracts a set of principles and associations, which are then combined with other such sets obtained from other observations to form a mental model. The resulting (abstract) model is then applied to the individual's particular circumstances to create a new form of explicit knowledge.

It was extremely difficult to describe these events in terms of explicit-to-explicit knowledge transformations. For one thing, of the thirty-eight noted examples of explicit knowledge creation, only ten had any observable antecedents. Even in those cases, it was clear that the apparent antecedent was not the only input. The interesting point is that explicit antecedents were not imported in purely explicit form. Rather, they passed through some state of abstraction in personal memory before being applied in a given situation. This is consistent with the observations of El Sawy, Eriksson, Raven and Carlsson (2001).

Some examples: In Case #1, when a sloped parts table with return chute for empty boxes was proposed, the proposer did not have a clear design in mind. Instead, he had a mental picture of what such solution looked like, from which he could sketch up a variation that would fit the particular application. In Case #3, when the new work table was being designed, the designer employed some ergonomic principles. This did not involve any actual measurements or reference to written standards, but he clearly had formed a mental image of what an ergonomically "good" table looked like.

The conclusion from the first section above that organizational knowledge contains elements of both tacit and explicit knowledge is consistent with these observations. However, the learning process is more easily and more meaningfully described in terms of information processing (from psychology) than from a transformation perspective (epistemology). This will be discussed in more detail below. For this reason, the concept of transformations between tacit and explicit knowledge forms was not discussed with the expert panel.

Knowledge Classified By Location

Rather than classifying knowledge according to its type, it is also possible to do so based on its location. This requires adopting a reified view of knowledge as an identifiable thing. This view seemed promising at first, but proved ultimately to be uninteresting. It was not too difficult to catalog the sources that people consulted in the organizational learning process (discussed in the next section); what was difficult was determining exactly what it was that they got from those sources. It was never possible to say that someone acquired a specific piece of knowledge from a specific place and applied it in anything like its original form. Mostly they retrieved certain elements of knowledge that had to be adapted to the situation at hand (see the discussion above about transformations).

These attempts to track knowledge by its location suggest that what constitutes knowledge in one context may not be knowledge in another. This is consistent with practice theory and the definition of organizational knowledge as *situated performance*. In this view, it is more useful to think of knowledge as something that is created at the point of use from some combination of local facts and imported organizing principles (derived from knowledge in other contexts). This view of knowledge can be seen in Hayek (1945) and Greeno, Moore and Smith (1993).

In the cases under study, the creation of new knowledge *always* required some combination of these factors – no examples can be cited where knowledge was retrieved and applied unchanged. Perhaps the closest example is in Case #1 where the idea for cooling water was copied from another line. Even in that instance it was only the concept that was imported; there was still a degree of adaptation required.

Just as philosophers tend to gravitate to the position that knowledge is in some way specific to the knower (Polanyi, 1958), it makes sense to say that organizational knowledge is unique and specific to the organization and its circumstances. Taking that view, it is not meaningful to say that organizational knowledge exists in specified "bins" or even to suggest that it can be stored.

This concept of organizational knowledge as something unique to its setting (and being defined by situated performance) was discussed with the expert panel as a precursor to the preliminary propositions. There was some ambivalence about this definition that pervaded the discussion. It was clear that those on the panel did not make a sharp distinction between individual and organizational knowledge, and tended to apply a fairly broad interpretation of the term knowledge in general. This conflicted somewhat with the research needs for precise definitions, so this difference of interpretation had to be kept in mind during discussions with the panel.

Actions By Individuals To Retrieve Or Store Knowledge By Location:

A consistent pattern of behavior was observed across all cases. When confronted with the need to create knowledge (solve a problem), individuals looked first to their own experiences, second to the experiences of others (through direct questioning), third to observable examples of similar situations and last to archival or documentary information. It is tempting to attribute this to normal human economy of effort, but there are important qualitative differences between these sources that we can describe as a *hierarchy of knowledge density*.

This idea will be developed further in the next section, but the essence is that the story is in many ways more important than the bare facts. It can be seen that these sources are in declining order of richness in terms of their context and associations. When documentary evidence was introduced into these cases, it tended to be devoid of context and was extremely hard to interpret. It had high information density, but low knowledge density. In most of the cases where documentary evidence was consulted (such as production schedules and forecasts or process flow diagrams) it was necessary to find someone who could interpret the data and provide the "rest of the story."

The importance of context has been noted by many researchers. Alavi and Leidner (2001) note that if the context in which knowledge was created is lost; the essence of knowledge itself is lost. Similarly, Bartel and Garud (2003) suggest that the value of narratives in the transmission of knowledge lies in their ability to integrate context. Seen in this light, the distinction between knowledge "sources" is more a matter of the amount of context they contain than one of location. The role of narratives in transmitting context was discussed with the expert panel, and will be covered in more detail in the next section.

<u>Processing Of Knowledge And/Or Information By Individuals (Narrative Versus Paradigmatic):</u>

The psychology literature gives us the "two modes of thought" described by Bruner (1986). He suggested that humans process ideas in two distinct ways – paradigmatic and narrative – that are not ultimately reconcilable with each other. As he describes it, the difference between these modes is the "difference between a logical argument and a good story." Clear examples of both kinds of processing were observed in all of the cases, lending credibility to the usefulness of this distinction.

What was interesting was that knowledge-creating situations seemed to require some intersection of the two modes. Some examples of attempts at pure bottom-up, data-driven problem solving were observed, but except for the very simplest situations this was far too laborious. What was needed was some sort of organizing model or heuristic that could be used to efficiently manipulate the local facts to arrive at a solution. Similarly, a model could not be employed without taking into account the specific facts at hand. This closely parallels the above discussion about the need for apparently explicit knowledge to pass through a tacit phase in the context of what was, on the surface, an explicit-to-explicit transformation. It is this combination of modes that creates the difficulty with the transformation view of learning.

The vectors for these models or frameworks correspond to the sources of knowledge listed in the preceding section and typically consisted of some sort of story or narrative as described by Bartel and Garud (2003). These narratives were typically resident in the memories of individuals rather than embedded in archival material. The key to a good story was its contextual information or associations that it contained which allowed assessment of its credibility and relevance to the current situation. This was the point of Pentland (1999), who suggested that narratives require an "evaluational reference."

Interestingly, as with fables or parables, there was no particular requirement that narratives be factually accurate, as long as they captured the essence of a situation. A good story wouldn't necessarily tell someone how to do something, but would illustrate possibilities, suggest areas of relevance and give clues about where to get more information. In other words, narratives could have low information density, but high knowledge density.

The "two modes of thought" construct appears to be a useful tool in understanding the creation of organizational knowledge. The only elaboration needed is the observation that in any learning situation (where something new was implemented) both modes were always observed to be present to some degree. Generally the narrative mode tended to dominate when it was available. When there was a shortage of narratives (as in many of the activities in Case #2), paradigmatic or bottom-up processing took precedence, but this was relatively unproductive.

The role of narratives was discussed extensively with the expert panel, and there was substantial agreement that narratives are an important mechanism for creating knowledge. A key point raised by the panel was the need for narratives to have some built-in credibility check, similar to the "evaluational reference" mentioned above.

<u>Individual Cognition:</u>

Cognition, as a property of an individual, is a broad concept, defined by DeFillippi and Ornstein (2003) as "thinking, reasoning and memory." In understanding the organizational learning process from the point of view of the individual actor, the role of cognition was selected as important since it is cited in a great deal of work on organizational learning. It was found in these cases that cognition operated in two ways, both of which were important, but neither of which was sufficient to fully understand the process of organizational learning. The two modes that are of interest to us here are *memory*, as in existing personal store of knowledge and *comprehension* as in the ability to process and absorb new information.

First, organizational learning took place in two modes that can be called *active* and *passive*. Most of the activity described in these cases is active learning, where the teams were charged with achieving a goal for which they had to first seek out a solution and then apply it appropriately. In the passive mode, where something is being taught to the subject, the issue is comprehension or ability to absorb the material.

Passive learning in these cases consisted of the tools and principles from the Kaizen training manual that were presented by the facilitators. For the most part, cognition was not a limiting factor in this type of learning; the material presented was not complex and the individuals had sufficient resources to comprehend what was going on. In Case #2 there was an instance where this was not true, but the consequences to organizational learning were insignificant since it was easy to work around the issue, either by putting extra effort into educating the individual(s) or by simply bypassing them.

Where cognition did play a significant role was in the active mode. This was observed when trying to catalog where people turned to for knowledge or information. It is perhaps not surprising that people only consulted sources or pursued solutions that they already knew about. In this way, cognition appeared to place a bound on the effectiveness of their search processes. These limits though, are not based strictly on domain knowledge, but rather on knowledge about knowledge (as in knowledge of the existence of knowledge or knowledge about the location of requisite information). This still fits with the definition of cognition as it is normally understood.

It should be noted that in the discussion with the validation panel, there was some ambivalence on this point. The majority of the panel agreed with the proposition that cognitive limits place a bound on search capabilities, but there were dissenting opinions that people could search beyond those limits if the event were structured in a way that encouraged them to do so. This suggests that while this proposition may true for these particular cases, the generalizability should be considered carefully.

Finally, it was discussed in Chapter Two that there are differing views about whether cognition is purely a trait of the individual or whether it is *situated* and therefore at least partly a property of the environment. What we have considered in this section is the effect that an individual's cognition has on the organizational learning process. The reverse question, which would derive from practice theory, is the effect that the organizational environment would have on the individual's cognition. This could not be observed directly, but some indications can be inferred in the next two sections.

Power and/or Knowledge As Moderators Of Group Activity:

Many small group characteristics are known to moderate the effectiveness of group problem solving, and some of them were observed in these cases. In Case #1, an example was seen where conflict avoidance may have led to incomplete implementation of a solution, although this may have had more to do with the dominant logic of action present (see below) than simply conflict avoidance.

In all of the cases, there were examples where both position and expert power led to some reduction in the level and breadth of discussion. More specifically, a greater differential in positional power seemed to correlate with a reduced usage of narratives and a corresponding increase in the use of paradigmatic processing. One possible explanation is that the presence of higher-level team members suppresses the motivation to introduce any sort of speculative or non-conforming ideas.

While these influences may have affected the quality of the ultimate results, the real issue is whether they altered the how-and-why mechanisms that this research was designed to discover. It was not apparent that they did, in the sense that variance between the cases did not seem to result in qualitatively different patterns of behavior.

Shared Logics Of Action (Existence Of And Changes To):

The term "shared logics of action" derives from Scott (2001) and the cultural/cognitive view of an institution. As previously noted, the use of the word "shared" introduces certain semantic difficulties, and it may be preferable to speak of "dominant logics" (Prahalad & Bettis, 1986; Bettis & Prahalad, 1995). In this view, the basis for acceptance or compliance with the logic is a certain "taken-for-grantedness." It was noted in Chapter Two that culture provides the generally accepted "why" rationale for otherwise unanswerable questions (Martin, 2002), which is a substantially similar statement.

On the basis of these observations, the research protocol sought to identify the existence of these dominant logics and their importance as a factor in the learning process. As the case examples show, this proved to be an important insight that opens a window into an area that has traditionally been of little interest to Operations Management researchers. This research suggests that this is a fruitful area for future work.

A common theme to all of the cases was an attempt to introduce lean production principles into the companies' operations. This was done both through the goal selection for the events and the training materials that were used in the introductory sessions. This played out differently in the three cases, but all of them illustrated the key role of the "dominant logic."

In Case #1, lean production was not the dominant logic. This was evident from the general discussions, and one of the participants stated it explicitly. Some of the team members recognized the weakness of the prevailing logic, but felt powerless to change it. This recalls the institutional theory of Scott (2001), where compliance to a dominant logic can be enforced in multiple ways. The *cultural/cognitive* driver for compliance is the taken-for-grantedness mentioned above. There are also *regulatory* drivers (in this case the performance measurement system, which emphasized productivity measures) and *moral* or normative drivers (in a lean production environment, it is appropriate that certain resources sit idle from time to time, but this is an anathema in a productivity driven culture). The combination of these mechanisms resulted in strong barriers to any change to the dominant logic.

The effect of this logic in Case #1 could be seen when proposals were made for setup time reduction. The reduction of man-hours spent on a setup was fully consistent with a productivity-driven logic, and such proposals were accepted readily. On the other hand, the reduction of setup *duration* by having additional workers perform tasks in parallel was counter to the logic and such ideas were not adopted. In this way it can be seen that there was indeed a dominant logic of action and, more importantly, that it defined the limits within which learning could take place.

Case #2 provided another example. The key recommendation of the team was to change the paint line schedule to reduce batch size and work in process (WIP). This was counter to the prevailing logic of operation as articulated by the Plant Foreman (and as expressed by one of the team members), which involved large batches and substantial buffers. No part of the recommendation was consistent with this prevailing logic, so it was left as an open question whether the change would be implemented effectively or at all. This was another example of the dominant logic acting to limit the range within which learning could occur.

Case #3 was a different situation that confirmed the observation. Here, the dominant logic of the operation embraced the idea of small lot sizes, even to single piece flow. There were dissenting voices, but it was clear that small batches were "how things are done around here." As a result, there was no resistance to implementing changes that facilitated fast changeovers and small lot sizes.

These examples highlight the importance of the underlying rationale for behavior. Several authors have noted the distinction between the "why" and the "what" in an organization. The "why" rationale corresponds closely to the "*theory in use*" described by Argyris and Schön (1978), which is the basis for the second loop of double loop learning. In their definition of learning (*the detection and correction of error*), errors must be corrected in both the *what* and the *why* aspects of behavior. Similarly, Pentland and Feldman (2005) hold that organizational routines consist of *performative* and *ostensive* layers, corresponding to the *what* and *why* respectively and suggesting that routines cannot be properly understood without understanding both layers.

The point of this relatively lengthy discussion is that the underlying rationale for behavior (*shared logic of action* or *theory in use* or *ostensive component*) is important. It is also true that organizations, as institutions, have many ways of enforcing and perpetuating that rationale. This may explain why no changes to a dominant logic were observed in the examples cited above – there is a major cultural component involved, and one Kaizen event with six to eight participants is insufficient to bring about such a change.

Many researchers have commented on the difficulty of effecting changes to the dominant logic of an organization. Much of this has dealt with the unchallengeable nature of orthodoxy, characterized as *myths* (March & Olsen, 1975; Duncan & Weiss, 1979; Hedberg, 1981). Others have focused on the need to unlearn or discredit what previously passed for knowledge (Weick, 1979; Pentland, 1995b).

Since this research did not observe any clear changes to a dominant logic, it is not possible to describe how such changes can be made, but the sources of difficulty can be seen. In particular, a logic is difficult to challenge when it is tacit – that is to say, when many members of the organization cannot articulate *why* a particular logic prevails. Such was the case in Cases #1 and #2. An additional difficulty, noted particularly in Case #1, is that the dominant logic is embedded in the organization in many ways that must be challenged simultaneously if it is to be changed.

The nature of this problem was agreed upon by the expert panel. In particular, it was noted that when a major element of an organization's logic required change, that change would have to originate at the top of the organization. A Kaizen event of the type studied here would not have sufficient reach to make the change.

Changes To Performative Aspects Of Routines

In all of the cases, changes were made to the outward or performative aspects of production processes or routines. This was the expected outcome of the events, so this is not in any way remarkable. The interesting aspects of the changes are how they came about and their congruence (or lack of it) with the prevailing "shared logic of action." Both of these issues have been discussed above.

Changes In Situated Performance

A central premise of this research was that organizational learning would be verified by an improvement in situated performance. Kaizen events are attractive for study in this respect because of their emphasis on data and verification of improvement. A result of this emphasis is a focus on projecting the performance benefits of the changes that are implemented. These benefits tend to be deterministic (*i.e.*: easily calculated) and near-term in their effects.

Even so, the cases studied were all still too short in duration to collect true operating data for full verification of a performance improvement. As a result, reliance is placed on the projections made by the event teams. Because of the relatively deterministic and transparent nature of the linkage, these projections give a level of assurance that an actual improvement had been made.

The issue of using performance improvement as a reflective indicator of learning becomes more complex when the learning involves the "logic of action." Although it was not observed to happen, suppose that the Kaizen event in Case #1 had created a revelation and caused the company to embrace lean production philosophy, altering production schedules and changing performance measurements throughout the organization. How long would it take to see an improvement in performance, and would it then be possible to retrospectively attribute any improvement to the specific instance of learning? Issues of time lags and causal ambiguity have long plagued strategy research, and may explain why this aspect of organizational knowledge has been much overlooked in Operations Management research.

An instance of the type of learning described in the preceding paragraph would take place at a higher level, a broader scope and over a longer time period than could be observed within the unit of analysis of the case (the Kaizen event). This highlights a limitation of the research, one that will not be easily overcome through experimental design. The point here is that the focus on performance may cause us to overlook certain instances of learning – not because the definition is wrong, but because of measurement difficulties resulting from time lags and causal ambiguity.

<u>Autonomous Learning:</u>

Although introduced and defined in Chapter Two, this term was not included in the original research framework or protocol because it was not expected that this particular classification of the process would be observable in these case situations. Nonetheless, all of the cases did provide opportunities to observe examples of this type of learning at work, resulting in the following observations. The first, somewhat obviously, is that autonomous learning requires autonomy. This means not only the autonomy to experiment with or manipulate the work process, but also the autonomy to make occasional mistakes. In practical terms, in a manufacturing setting, this limits autonomous learning to the development of individual skills at a work task. The second observation is that due to the nature of manufacturing tasks this type of improvement plateaus very quickly – typically after a few dozen repetitions.

The significance with respect to this research is that autonomous learning can be used to explain short term adjustment phenomena, but does not appear to be a significant factor in the long term evolution of the performance curve.

<u>Reactive Learning:</u>

This term is used here to mean learning as a response to unexpected events. This is also called quality based learning, as in learning from mistakes. As with autonomous learning, this was not included in the research protocol because it could not be observed in process as a consequence of the experimental design. However, the case studies produced several examples that were evidence of responses to past events. The reason that these examples were visible is that they were apparently non-value added activity. As such, they are evidence that the apparent learning that results from unexpected events may be suboptimal, even to the point of reducing overall performance.

It is important to note however, that the visible examples are a truncated sample. More effective solutions, such as root cause elimination, would be largely invisible in these case studies. As a result, while these observations are interesting and worthy of additional study, they cannot be generalized at this point.

Management Influence:

Within each case, there was a prioritization process whereby it was decided what problems would be addressed and which ones would be ignored. This process was fairly tacit and did not involve any significant debate about the relative merits. While the prioritization followed the stated goals of the Kaizen event in a general way, there was substantial divergence between cases. The interesting observation is that, in two of the cases at least, this prioritization seemed to accurately anticipate the focus of management questioning at the end of the event. (The third case had less management presence and questioning, so was not necessarily representative.)

The question this presents is: does this constitute evidence of a dominant logic? And, if it does, was it the result of managerial priorities? These questions could not be answered within the scope of a Kaizen event, but stand as opportunities for future research.

Summary of Findings:

For clarity and convenience, the findings of the research are summarized in Table 4. This table follows the content of the research protocol, with the addition of the additional factors that were extracted from the case notes.

Table 4: Summary of Findings re: Research Protocol

PROTOCOL ELEMENT	KEY OBSERVATIONS
Knowledge classified as being explicit or tacit	Distinction is clear at the individual level, but less so at the organizational. Both elements can be observed at organizational level, but seem to occur together – not distinct or independent.
Transformations of knowledge within and between explicit and tacit	It was very difficult to describe any learning activities in these terms. In particular, what should have been the easiest to observe (explicit-to-explicit) proved to be the most difficult. In an organizational context, this does not appear to be a useful terminology.
Knowledge classified by location	Again, not a particularly useful distinction. At the individual level it makes some sense, although all knowledge seems to pass through an abstract state in personal memory. At the organizational level, the key finding is that components of knowledge have no location: they are diffused throughout the organization.

Table 4: continued	
Actions by individuals to retrieve or store knowledge by location	Knowledge retrieval (to the extent that the term makes sense) involved generation of a mental model. Preference was for sources where this had already been done (consultations with others, narratives). Knowledge was "stored" incompletely in the form of physical artifacts, procedures or records, and also in personal memories in some abstract form.
Processing of knowledge and/or information by individuals (narrative versus paradigmatic)	Both modes appeared to be necessary simultaneously for creation of knowledge. In particular, the need for narrative processing drove the prioritization of the sources consulted (as in descriptive explanations as opposed to hard data).
Individual cognition (as in pre-existing state of knowledge)	Individual cognition was observed to limit the range of search activities – people only searched for things they expected to find. Individual cognition in the form of processing capability was not observed to be a significant barrier to the absorption or implementation of new ideas once introduced.
Power and/or knowledge as moderators of group activity	Examples of hierarchical power and of expert status were observed. The effect appeared to be a reduction in the use of narratives, but did not change the basic nature of the activities.

Table 4: continued	
"Shared" or dominant logics of action (existence of and changes to)	Logics of action were observed to lie on a continuum from simple and instrumental (easy to test and change) to a state of orthodoxy (based more on communal belief than any empirical evidence). No changes to the latter type were observed in this research; they served to bound the learning that was possible in these cases.
Changes to performative aspects of routines	All cases had concrete examples of changes made to the way things were done. The level of acceptance and implementation appeared to reflect the dominant logic.
Changes in situated performance	All cases had credible projections that the changes made would result in improved performance, but only in the near term. More sweeping strategic changes (not observed) would have been more difficult to evaluate.
Autonomous Learning	Several examples were observed. This appears to be a short-term adjustment issue rather than a long-term performance driver.
Reactive Learning	Some examples were noted, but this is an incomplete sample (only suboptimal outcomes were visible). These observations suggest that the learning that occurs in response to unexpected events may not be uniformly beneficial.
Management Influence	It was observed that the project teams' prioritization of activities seemed to anticipate the direction of management questioning. The existence of a causal mechanism (one way or the other) would be interesting, but could not be derived from these cases.

Part II: Development Of Propositions:

In this section, we consider the patterns noted in the preceding section and express these as statements about the relationships between the elements of the research framework. These statements are in the form of propositions that constitute elements of a theory of organizational learning.

Because this section is following inductive logic, the statements about the relationships should be ones that would, *a priori*, have predicted the patterns of behavior that were observed. Since a theory must not only predict, but explain as well, these statements must contain some explanation of why the observed behaviors occurred. The implications of these propositions and their potential for prediction in other settings will be discussed further in Chapter Five.

The propositions that follow are certainly not the only ones that could be inferred from the data. Following the advice that a theory should be both useful (Bacharach, 1989) and parsimonious (Whetten, 1989), attention is focused on the issues most central to the research question and that have important or interesting implications. A full discussion of those implications is reserved until Chapter Five, which ultimately provides the justification for focusing on these particular propositions. The purpose of the present chapter is to show that these propositions are consistent with observed behavior as repeated in multiple settings.

While the following propositions were developed within the context of the original research protocol (Figure 3), certain modifications were made on the basis of the research findings. In particular, any concept of knowledge as a *thing* to be stored, moved, used, transformed, etc., proved to be problematic in the organizational context. The relationships summarized in these propositions form a revised theoretical framework that is illustrated schematically in Figure 6. The nature of these relationships will be described below, while a discussion of their significance will be given in Chapter Five.

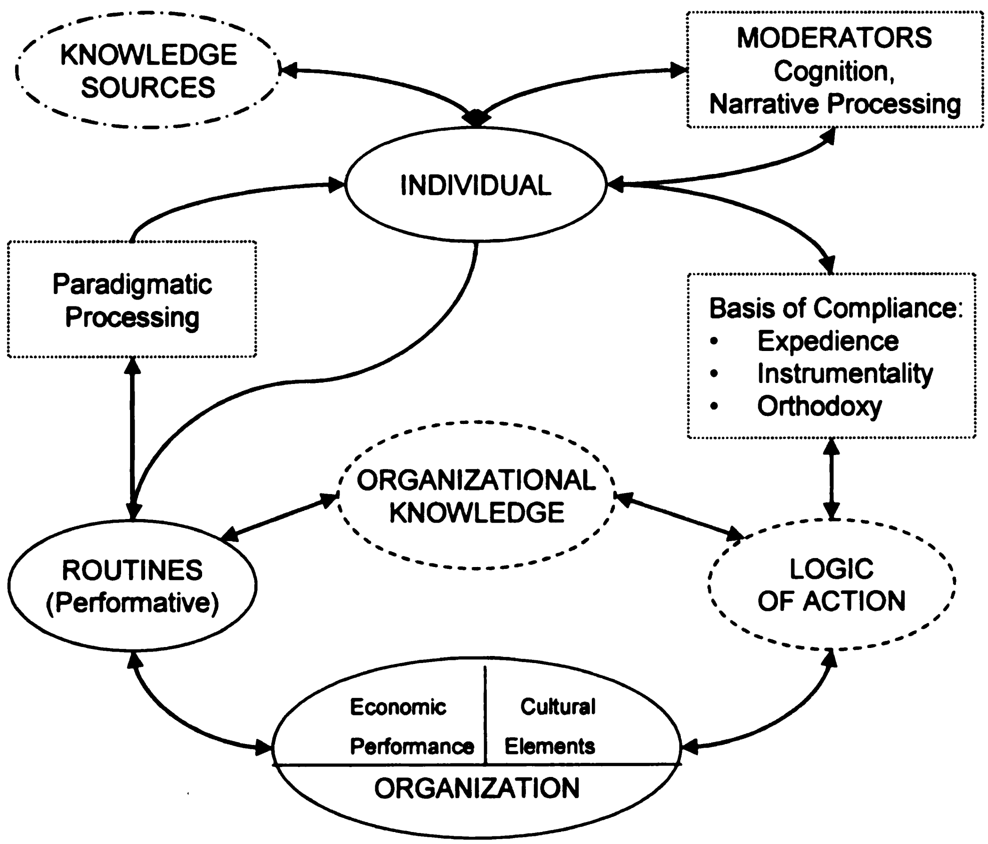


Figure 6: Schematic of Relationships in Propositions

Tentative Propositions:

1. Organizational Knowledge is a 2-Part Construct:

Starting in the center of the framework diagram, we consider the nature of organizational knowledge itself. To be consistent with the definition of organizational knowledge as situated performance, the knowledge must consist of some performative elements that actually create the performance in question. It was found, however, that these performative elements always existed in the context of a theory about how it was that they were expected to result in the intended performance. Organizational knowledge, then, must consist of both performative and ostensive components.

This of course exactly mirrors the description of routines put forward by Pentland and Feldman (2005), which is not a coincidence. There is a very close association between organizational knowledge and organizational routines, to the point where they can be considered synonymous. An alternative typology would be to separate the components and refer to the performative elements as the *routine* and the ostensive part as *organizational knowledge*. This would appear to simplify the terminology, but the point of this proposition is that the two components must be considered jointly, so this report will continue to refer to organizational knowledge as a composite construct comprising both parts.

The implications of the two-part view of organizational knowledge will be discussed in more detail in Chapter Five, but there are a number of possible corollaries. One is that the two components have separate loci in the organization. The performative aspects can be seen in the physical arrangement of the work space, in the procedure manuals and other documentary or physical form. The ostensive aspects are often unspoken and exist primarily in individual memories. They are diffused through the organization in the form of narratives and other abstract means. For example, while specific procedures or performance measurements may be reflective of a particular logic, it is the inference that members of the organization draw from these elements that constitutes the ostensive component of organizational knowledge (for a related discussion about inferring the logic behind performance measurements see: Melnyk, Zsidisin, Luft, Burns, Calantone, Stewart and Hanson (2005).

2. The Ostensive Component of Knowledge is an Element of the Culture of the Organization:

The reason for making this sweeping statement is that the ostensive components of knowledge span a range from simple and explicit to complex and tacit. This aligns very closely with the range that Scott (2001) calls the *pillars of an institution*. Following his terminology, the prevailing logics span the range from *instrumental* to *appropriateness* to *orthodoxy*. Although only the state of *orthodoxy* falls under the *Cultural-Cognitive* pillar in his typology, it is apparent that if one digs below the surface of even the simplest of logics and asks "why?" enough times, one will ultimately uncover a state of "taken-for-grantedness" that signals a cultural element.

Instrumental logics of action tend to be simple, explicit, deterministic and testable. These are the most visible and the easiest to change, based on empirical evidence and appeals to instrumentality. Theories that constitute organizational orthodoxy tend to be complex, tacit, non-deterministic and not testable in the short term. The theories driving larger strategic issues tend to fall in this category and tend to be very difficult to change because their basis for compliance is the state of "taken-for-grantedness" (Scott, 2001). Different levels of organizational knowledge form a continuum between these extremes.

A corollary to this view is that beyond some threshold level, organizational learning increasingly becomes synonymous with culture change. Cultural change is well known to be a difficult and complex process (Martin, 2002, p. 346), and is not normally considered in the course of Operations Management research. This point was validated by the expert panel through the comment that changes to the dominant logic had to be implemented from the top down – it cannot be done through teaching and persuasion.

<u>3. Organizational Learning Takes Place Independently in the Two Components:</u>

In a sense, this follows from Proposition 1; recognizing that organizational knowledge has two components and that those components have different loci within the organization, it is improbable that change would occur simultaneously in both elements, and certainly not through the same mechanism. In fact, in almost all of the examples observed, no change took place to the ostensive components of knowledge, so learning (in the sense of performative improvements) was bounded by the existing theory of action. The implications of this observation will be discussed in more detail in Chapter Five, but this proposition has significant consequences for the imitability of organizational knowledge and for absorptive capacity.

4. Organizational Knowledge is Created by Individuals Using Narrative and Paradigmatic Information Processing Simultaneously:

This addresses the central research question of how knowledge is created. The term *created* is used advisedly, considering the content of Proposition 1. Since organizational knowledge is seen here as the intersection of two independent components, it is something that is unique in a particular context. This point is made by Hayek (1945) and by Greeno, Moore et al. (1993). It is therefore more appropriate to speak of *creating* knowledge than of *applying* or *reusing* other knowledge.

In all of the examples observed, knowledge creation was the work of individuals or groups who invariably combined two types of inputs. The first was the set of quantifiable facts representing the particular situation at hand. This represents the paradigmatic processing of information per Bruner (1986). The other component was some sort of mental image of how things should be rearranged for maximum benefit. These mental images were personal and abstract. When necessary they were shared with team members through descriptions and examples. This is the narrative mode of processing per Bartel and Garud (2003).

This duality mirrors the two-component view of organizational knowledge. The quantifiable performative aspects of the situation can be processed by individuals in a paradigmatic way, while the ostensive component was processed in narrative form. The key point is that both components were always seen to be present: there were always specific local facts to be dealt with and there was always some mental model that shaped the approach.

A consequence of this proposition is that the creation of organizational knowledge is bounded, or at least moderated in some way by individual cognition and by the organizational culture. Both of these acted as filters on the narrative mode of importing and processing information.

The role of cognition was seen when participants in the Kaizen events engaged in search efforts in support of knowledge creation. It was observed that this search was limited by their existing state of knowledge in the sense that they did not look for knowledge or information unless they already knew that it existed. It is not clear that this is a fixed limit: there were differences of opinion among the expert panelists on this point. Several members felt that individuals could be prompted to search beyond their cognitive limits if they were suitably encouraged to do so. Nonetheless, in the context of these Kaizen events, this limiting effect seemed to be present.

The effect of culture could be seen in the use of narratives to inform team members about what was "in-bounds" and what was not. Narratives also served as trial balloons to see what the group would respond to and what would be quietly ignored. A great deal of filtering took place in this way as the group simply failed to respond to ideas that did not fit with the dominant logic. This can be seen as an example of how a culture defines knowledge by influencing what is considered at the level of the individual.

5. Learning is a Function of Expected Utility:

The above propositions have addressed the nature of organizational knowledge and its creation, but to some extent, these are only moderating factors in the learning process. None of them speak directly to the issue of why organizations learn in the first place. The idea that organizations learn because they expect some sort of return from the effort is not novel (Levy, 1965; Oi, 1967), but it does call into question the conventional wisdom of "learning from experience" (Huber, 1991). This proposition was prompted by the observation that none of the instances of learning in these cases had any identifiable direct relationship to past production experience.

This deals with the issue of causality. There is no argument that experience and learning are correlated; that has been amply established empirically. What was noted in this research was a distinct absence of any observable link between experience in the past and learning in the present. If we accept an absence of causality between experience and learning, the remaining plausible explanation in the literature is that learning is in anticipation of future experience and its attendant payback.

The expert panel was generally supportive of this proposition (see Appendix VI), and there was a comment that learning *should* be a function of expected utility. There was, however, a reluctance to let go of the idea that organizations can learn *from* experience. This may be the role of *reactive* learning, which was briefly discussed above, but is beyond the scope of this research.

Summary of Chapter Four:

This chapter has presented the results of the case studies and their reduction to a set of propositions. In the interests of clarity, the actual field notes and case reports are relegated to appendices. The bulk of the chapter is devoted to a review of the research protocol in light of the actual field observations. Some additional considerations are introduced, based on additional findings from the cases.

From the observations, a set of tentative propositions was developed. In the context of this chapter, the key elements of these propositions are that they are consistent with what was observed, and relevant to the research framework. A preliminary version of these propositions was presented to an expert panel for feedback based on extensive industrial experience. The comments and feedback from this panel were incorporated into the results presented here. The justification for this particular set of propositions will be more fully developed in Chapter Five, where the implications and conclusions are discussed.

CHAPTER FIVE: DISCUSSION AND CONCLUSIONS

Introduction:

The purpose of this chapter is to present a summary view of the findings, to discuss their implications and to suggest some potential extensions of this research that are critical to a fuller understanding of organizational knowledge and learning. We will begin with an overview of the findings to highlight what is novel and interesting about them. Note that "novel" here is not meant to imply that these observations have never been made before, but rather that they are in some way inconsistent with accepted wisdom.

These novel findings will then be used to formulate an answer to the research question that was posed at the outset: "how do organizations create knowledge in their operations?" This will be followed by a discussion of the limitations of this research and suggestions about how the generalizability of the findings may be enhanced by additional research. The chapter will close with what is potentially the greatest contribution: the major areas of extension that are suggested by this research as necessary components of a more comprehensive theory.

Overview of the Findings:

In this section, we make a number of statements that summarize what is novel or even surprising about the findings. While similar observations have been made individually by other researchers, it is their juxtaposition that suggests the foundation of a new theory. The outline of such a theory is expressed graphically in Figure 6 (presented in Chapter Four and reproduced below). The fact that these observations present a challenge to conventional wisdom suggests a degree of paradox. Poole and Van de Ven (1989) note that a paradox offers an opportunity for the development of theory and suggest a number of way that this can be approached. Of the methods they list, the approach here corresponds to the introduction of a new variable; specifically the existence of organizational values – the cultural element of organization knowledge. With that in mind, the following is an overview of the more interesting findings:

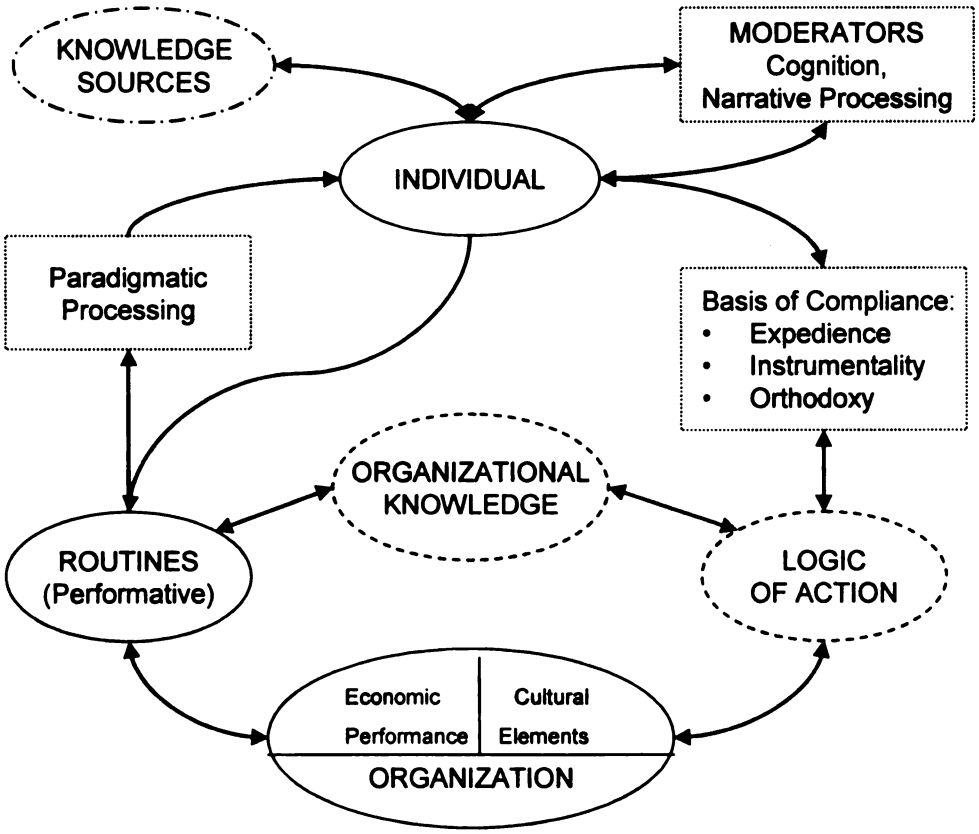


Figure 6: Schematic of Relationships in Propositions

1. To discuss organizational knowledge, the operating routine and its underlying logic must be considered simultaneously. The foundational work on routines (based on Cyert & March, 1963) argued that the knowledge of an

organization was embedded in the operating routines. Subsequently, others have suggested that it is the underlying "theme" or "culture" that captures the knowledge of the organization (Barney, 1986; Miller, 1996). We find that it is not possible to discuss organizational knowledge and learning in terms of one or the other; they are both necessary and interdependent elements. This is of course very much the point of Pentland and Feldman (2005), but it does not appear that the full significance of this insight is yet widely appreciated.

There are a number of important implications of this finding, some of which are elaborated in the additional propositions, but the essence can be summarized as follows: Learning, unless it involves changes to the underlying logic of the organization, will be constrained by that logic. This provides a solid basis for explaining why organizations differ in their ability to implement "improved" or "best" practices. Furthermore, the underlying logic has characteristics that make it a part of the *culture* of an organization – it is self-perpetuating and is extremely resistant to change. It is proposed that the existence of differing logics represents a missing variable that has the potential to explain much of the observed variance in this process.

It is fairly obvious that attempts to improve performance by focusing on tools and practices will have little effect on the prevailing logic. This was confirmed in the research; proposed improvements that were inconsistent with the prevailing logic were simply ignored. The implication is that any attempts to achieve large increases in performance must be prepared to address both aspects of organizational knowledge simultaneously, and by very different means.

The research showed that changes which were seen to be improvements in the context of the prevailing logic were implemented easily and without resistance. From this we can speculate that if some learning event were to result in changes to the prevailing logic, the necessary changes to the operating routines would follow with minimal difficulty. This suggests that the traditional approach to process improvement should be reversed to de-emphasize the importance of specific tools and practices. The organization's logic of operation must be addressed first. Unfortunately, this research does not provide any good examples of how this might be done, but it does suggest the need to pay attention to the cultural nature of organizational knowledge.

2. The process-based view that has been taken by this research has given us insight into the mechanisms of organizational learning and a basis for explaining why organizations increasingly become prisoners of past success. This is the phenomenon noted by Leonard-Barton (1992), Benner and Tushman (2003) and others. The two-part view of organizational knowledge gives us an explanation of the reasons for this by showing that, beyond incremental improvements, learning requires changes to the prevailing logic.

   Changes to logic are rarely incremental, so knowledge is not an absolute state and that one cannot speak simply of greater or lesser knowledge along a continuum. Instead, there are different states of organizational knowledge, defined primarily by their underlying logic, some of which will ultimately be proven to be better than others by the test of situated performance. There are two important consequences of this view, both of which lead directly to the conclusion that organizational knowledge has a fundamental cultural element.

The first of these is that moving from one state of organizational knowledge to a (hopefully) better one is not an evolutionary, incremental process, but requires the absorption of a new logic and practices. More importantly, since two different theories about how to conduct business cannot coexist, it also requires the displacement of the previously prevailing logic. This research suggests that it is ultimately the latter issue that determines an organization's ability to learn. The need for unlearning has been noted in the literature (Weick, 1979; Schein, 1993; Pentland, 1995b), but it is relatively unstudied and little has been said about how it might take place.

The issue of displacement or unlearning has important consequences for the concept of Absorptive Capacity. The literature in this area (reviewed in Chapter Two) focuses almost exclusively on the acquisition and application of new knowledge, yet this research suggests that the limiting factor is actually the ability to displace old knowledge. This theme can be seen very clearly in *The Innovator's Dilemma* (Christensen, 1997) where firms' responses to changing technology are limited much more by unwillingness to abandon previously successful approaches than by any difficulty in the adoption of new ones.

The second critical consequence of the two-part view of organizational knowledge stems from the time component of the underlying logic. This logic typically takes the form of a theory that says, "If we do this today, we will see the desired result in the future." The problem is that, except for trivial cases, the theory is not testable because of the time lags. In other words, the organization must be persuaded to *believe* something that cannot be proven. Returning to an early definition of knowledge (attributed to Plato), organizational knowledge can be considered to be a "justified belief" that certain courses of action will be fruitful. The justification in this setting is largely a matter of faith. This is precisely the role of culture; to provide the "why" rationale for otherwise unanswerable questions (Martin, 2002).

Combining these two consequences, the displacement problem and the cultural nature of the underlying logic, we can see the true magnitude of the problem of organizational learning. Having previously asked an organization to believe and act upon a theory that can neither be proven nor disproven, we must now ask it to abandon that belief and adopt a new theory that cannot be proven either. Experience suggests that this only takes place under conditions of great dissatisfaction with the present state (Schein, 1993) which may be caused by environmental conditions or precipitated deliberately as a management tool (Eisenhardt & Martin, 2000).

3. The role of the individual must be considered since all of the performance improvements observed in this research were attributable to the actions of identifiable individuals. The significant finding here is the manner in which

these individuals processed information in order to make improvements that would constitute organizational learning. Each potential learning situation involved certain established facts that had to be dealt with. The range of potential solutions springing from the facts at hand was always too great to permit any sort of exhaustive evaluation, so the approach was guided by some sort of mental model of how things *ought* to be done.

These mental models are important because they are the means by which external sources of information and knowledge (in the individual, personal sense of knowledge) are imported for application. This means of transmission corresponds to what is often referred to as narrative processing (Bruner, 1986; Bartel & Garud, 2003), and determines the preferred sources of information. Information embedded in stories has high *knowledge density* and is readily usable because it is presented in context and allows the formation of a rich mental model. By contrast, codified information, as in tabulated reports, may have high *information* density but has low knowledge density because it is relatively devoid of context. All of the subjects of this research found such sources to be very difficult to use and demonstrated a clear preference for the richer, narrative forms. This has implications for the field of knowledge management, suggesting that attempting to store knowledge in codified form is ineffective, because this loses the context of the narrative and as a result is rarely consulted. The point about context was made by Alavi and Leidner (2001) and Bartel and Garud (2003). "Primitive" societies have always transmitted their knowledge and culture through sagas, legends and fables. The challenge for knowledge management as a field is to find modern analogs of these narrative methods.

The role of narrative processing is important to the formulation of the theory model shown in Figure 6 because it suggests the mechanism by which organizational culture acts to filter or moderate the incorporation of external information and knowledge. Just as multiple external sources are distilled into a mental model of how things ought to be done, so too are the internal sources – the multiple examples and stories of "how things are done around here." This serves to explain why non-conforming ideas are not so much rejected as they are quietly ignored.

The reliance on narrative processing of information also suggests how individual cognition may play a moderating role in the creation of organizational knowledge. The sources with the highest knowledge density are those closest to an individual's own experience. The preference for these sources and their relative ease of use tends to filter incoming information and to restrict the range of search. Specifically, people tend not to look for things they do not already know something about.

4. The role of experience in organizational learning is equivocal at best. This statement is based on two points. One is the observation in this research that none of the proposed process improvements drew in any identifiable way on the company's prior experience with that process. While many researchers are careful to avoid the issue, others state fairly explicitly that experience causes learning (Huber, 1991; Eisenhardt & Martin, 2000). The alternative

view, proposed here, is that learning is an act involving conscious effort which is motivated by expected future utility.

The second point is that processes were observed that appeared to represent sub-optimal responses to past problems. This would suggest that the "learning" that takes place in response to (negative) experiences may be subject to certain biases (such as an overweighting of the probability of recurrence) and may fail the test of an overall improvement in situated performance.

There is an established body of empirical research that appears to support the position that experience causes learning; see specifically Lieberman (1984), Huber (1991), Darr, Argote et al. (1995) and Hatch and Mowery (1998). However, as demonstrated in Appendix VIII, a model of learning based on expected future utility is also consistent with these empirical results, and may even explain them better. This is an illustration of the difficulty of inferring a process from the outcomes and serves as validation of the importance of observing processes directly.

The implications of this conclusion are already well-appreciated in industry where it is commonplace to demand additional price reductions in exchange for long-term contracts. An expected future utility model as proposed here would predict that costs would be lower at the end of one five-year contract than they would be at the end of five successive one-year contracts, whereas a model based on cumulative experience would not be able to distinguish between these cases.

<u>**The Research Question:**</u>

This research began with the question; "How do organizations create knowledge in their operations?" That question has served as the vehicle for the development of a tentative theory of organizational learning expressed by the framework in Figure 6 and the propositions articulated at the end of Chapter Four. The preceding discussion has focused on the aspects of that theory that are seen to be interesting, important and in need of further study. Before progressing to a discussion of the limitations of these results and suggestions for additional research, it is appropriate to summarize what has been learned and express it as a direct answer to the research question.

Based on this research and the framework presented in Figure 6, the research question can be answered in this way:

1. Organizations learn as a conscious act, in the form of an investment of time or effort that is justified on the basis of its expected returns.

2. The evaluation of those returns is strongly influenced by the prevailing logic of action of the organization. This logic may be simple and transparent, or it may be complex and tacit. The logic may be considered to be a dimension of the *culture* of an organization and reflects its beliefs and values.

3. The creation of organizational knowledge is carried out by individuals (alone or in groups) who combine analysis of the facts at hand with mental models of how things might be improved. The results are embedded within the organization in the form of revised work practices or routines.

4. These mental models are constructed from a wide range of inputs, both from within the organization and without. The preferred inputs are in narrative form and are not readily reduced to codified form. The range of mental models considered is constrained by the cognitive bounds of the individuals, but more importantly, by the culture of the organization.

What remains unexplained in this prototypical theory is the issue of how organizational culture is changed. The research provided no opportunities to observe this in action, which may mean that it occurs in major jumps or that it occurs so slowly and subtly that it is invisible in any short-term study. The former possibility corresponds to the *punctuated equilibrium* view of organizational culture change (Romanelli & Tushman, 1994; Loch & Huberman, 1999; Taylor, 1999; Beugelsdijk, Slangen & Herpen, 2002). While the concept of punctuated equilibrium is consistent with the above observation that displacement of an existing theory is only likely to occur under conditions of extreme dissatisfaction (as created by extraordinary events), we simply do not yet know how organizations "change their minds" about things, particularly of their own volition.

What we have learned is that there is a knowledge-based explanation for a punctuated equilibrium model, where major learning involves discontinuous changes to the prevailing logic of an organization. We have also learned that Kaizen events are too small and too short to effect such changes in an organization. At the shop floor level it is essential but difficult to create an awareness that the existing approaches are not working well enough, which appears to be a necessary condition for change.

Applicability and Limitations:

Having summarized the findings, it is appropriate to explicitly acknowledge the inherent limitations of the research and the range of applicability before proceeding to recommendations for future research. A primary source of recommendations for future research will be to extend the generalizability of the results by addressing their limitations. From the outset, external validity in the sense of universal applicability was not the objective. Rather, the intent was to fill a gap in the research literature by observing carefully what real people did in real situations in order to form the most basic building blocks of a theory of organizational learning. The issue of internal validity of this research and the steps taken to ensure it has been discussed in Chapter Three. The purpose of this section is to review the constraints of the study that might be relaxed in order to increase the range of applicability of the propositions.

- Constrained Format (Kaizen Events): Kaizen events of the type studied here are only a subset of the types of events implemented within the subject corporation. They tend to follow a more or less fixed format, and make use of a common training manual. This prompted the comment: "don't the teams just follow the book?" To an extent they did, for a portion of the event, although the "book" was modified for local conditions by the facilitators. Even within the more tightly defined steps, there was still substantial variety in how people approached the task. In a discussion of this issue, one member of the expert panel asked somewhat rhetorically; "Have you ever been to the same event twice?" This was true in these cases as well; the formal aspects of the events did not appear to impose much constraint on basic behavior.

Nonetheless, to claim generalizability of the findings, it would be appropriate to observe comparable events organized according to different formats. , There was one particular aspect of the event format that may have been important and that was the time constraint. There was pressure to have all the solutions in place by the end of the event. This may have been partly responsible for the observation that people's search efforts were tightly bounded to domains they knew. The availability of more time might encourage more exploratory search and lead to different conclusions about the importance of cognitive limits in search. Observing the same behavior in a less constrained environment would result in a much stronger conclusion.

- <u>Single Functional Area</u>: Consistent with the Operations Management focus of this research, the selected cases involved manufacturing operations in relatively high volume production environments. Two consequences of this choice are that the processes being addressed are: a) relatively simple in nature and, b) involve a large number of repetitions. As a result, autonomous learning effects (introduced in Chapter Two as part of different typologies of learning) play out very quickly and are insignificant in the larger picture. This environment also places a high premium on attributes such as efficiency and reliability – things that may not be as central in other fields. It is not suggested that these conclusions should automatically be applied to fields such as New Product Development where the cycle times are much longer and innovation may be more highly valued than it is in production operations.

- Industry Environment: The industrial market segment occupied by the subject companies is characterized by slow *clockspeed* as defined by Fine (1998), where changes to the dominant process and product technology are infrequent. None of the studied companies had experienced any significant product or process technology changes in at least thirty years. Eisenhardt and Martin (2000) suggest that this may be an important dimension for understanding the adaptability of the companies' culture, which was shown here to be a significant obstacle to discontinuous learning. It is entirely possible that an organization accustomed to more rapid change might behave differently with respect to cultural adaptations.

  A related issue is the economic environment of the business. While all of the companies studied were experiencing competition and price pressures, their economic climate was relatively benign. There was no real sense that they were fighting for their lives. Given the above comments about dissatisfaction with the present being necessary for certain types of learning, we might expect to observe different patterns of behavior in settings where the dissatisfaction is endemic.

- Group Size: All cases involved small groups of about eight people. Some of the work was subdivided into teams of two or three, and some was done by individuals. There were no remarkable differences between these levels, but it was not possible to observe the functioning of groups larger than this.

A key finding of this research is that the culture of an organization influences the mechanisms by which knowledge creation takes place. What was not observed was any example of how learning might act to change the culture. Group size might be important here, since a small group would be expected to exert less influence on culture than a larger one.

- Type of Learning Studied: In the typology of learning (autonomous, induced, and potentially reactive as proposed above), the cases selected addressed only induced learning in the sense that they represented a conscious, planned effort to learn, backed with an investment of time and money. Small examples of autonomous learning were observed within this setting, but they were not seen to be instrumental in the larger picture. As a result, no particular attention was paid to exactly how this took place. In a different setting, such as a much longer cycle activity where autonomous learning cannot be dismissed as a short-term transient phenomenon, this could represent a gap in our understanding of organizational learning. Similarly, learning resulting from unanticipated results could not be observed – a necessary consequence of the experimental design. There was evidence that such learning had taken place, but there was no opportunity to observe the mechanisms at work. Again, in a highly dynamic and uncertain environment, this may be a significant limitation.

- The Definition of Organizational Knowledge: Throughout this research, a great deal of attention was paid to developing a working definition of organizational knowledge (and, by extension, learning) that was both grounded in the existing literature and at the same time usable for field research. Through the literature review and through consultations with researchers and industry experts it became clear that knowledge and learning are highly abstract concepts and that a wide range of meanings is attached to them. The conclusions reported here are, of course, products of the definitions used. To the extent that these definitions are well supported by the literature, this is not seen as a limitation *per se*, but rather as a caution. Any attempt to compare works in this area must carefully consider the operating definitions used before comparing conclusions.

Suggestions for Future Research:

The discussions of the findings of this research and the limitations that apply to them suggest a number of avenues for future research. Three particular suggestions are offered here in the hopes of extending the usefulness and explanatory power of these findings.

1. Attempt to replicate the findings in different settings: There are five particular dimensions of the cases that were potentially limiting. This work may be usefully extended by selecting new cases that vary on these dimensions. It is acknowledged that all of them create methodological difficulties that must be overcome, which is perhaps why they represent unstudied areas.

    a. Process cycle time: For the most part, the cases studied were examples of processes with cycle times that could be expressed in seconds or minutes. Many business processes have cycle times that can be expressed in weeks, months or even years. Being able to observe the differences between successive iterations of a repeated task may add an additional dimension to our understanding of organizational learning.

b. Industrial Environment: This research has identified cultural factors that inhibit change and learning. It may be possible that there are other factors not observed here that stimulate and promote learning. Studying organizations that thrive in situations of high urgency (high clockspeed or economic uncertainty) might uncover such factors.

c. Group size: The project groups studied were all relatively small. What changes as the groups get larger? This question is thought to be particularly relevant with respect to the limits imposed by individual cognition and the ability of the group to influence the culture of the larger organization.

d. Functional Setting: The research was, by design, restricted to studying improvements in high volume manufacturing operations. While innovation was valued in these improvement attempts, it was not pursued with the same intensity as in, say, a new product design environment. Having noted the important role of culture in learning, it is conceivable that different functional areas would have their own distinct cultures as consequences of the type of work and the personnel involved. This may in turn have an effect on the mechanisms of knowledge creation.

e. Time span: The events studied were bounded to one week in duration, which was desirable for the research design. It is easy to suggest conducting longer-term studies, but this is very difficult to do in practical situations. Two things that might be expected to differ in longer term activities would be search behavior and culture change. More time might permit a wider range of search activities and more use of codified information. It is also possible that a longer-term study might start to see evidence of culture change at work.

2. Observe learning from mistakes and other unexpected events: This research provided some opportunities to observe what appeared to be learning from past surprises. Quality-based learning, as this is often called, is generally held to have a positive effect on performance (Fine, 1988), yet some of the examples observed seemed to suggest overreaction and equivocal results. Prospect theory (Kahneman & Tversky, 1979) would suggest that recent memory of an unwanted event would cause an overestimation of the probability of recurrence and result in less than optimal responses. The research question would be, "is there a perceptual bias in the learning that results from unexpected events?" The methodological difficulties of observing unexpected events are acknowledged, but *post mortem* studies may be possible.

3. *Values* as a missing element in performance models: Throughout the discussion of the results of this research, we have emphasized the role of culture in defining how and what an organization learns. However, as a

subject for additional research, the term is problematic. As Smircich (1983) notes: "*The culture concept has been borrowed from anthropology where there is no consensus on its meaning.*" The term *values* was used above to capture the aggregate effect of the shared logics of action that drive an organization and we propose that this term can be defined as a measurable construct. It is proposed here that this represents a missing variable in many attempts to model and explain organizational performance and drawing attention to this may ultimately be the most important contribution of this research.

The term *values* is emotionally laden, but the intent here is to use it in a non-judgmental way. An organization's values are not good or bad, nor are they high or low. They are simply the set of beliefs that drives behavior. Two key dimensions of values that have been identified in this research are *path preference* (means to an end) and *future orientation* (degree of discounting of future returns).

Klassen (2001) showed that a simple proxy for managerial values based on future orientation could improve the ability to predict performance. Hanson, Melnyk and Calantone (2003) showed that when a construct was created from reflective indicators of values as path preferences, it was the dominant predictor of performance in an empirical study. Both of these studies were restricted to a single area of performance (environmentally responsible manufacturing) and the challenge is to further define the construct and extend these findings to a more general context. Similarly, Nahm, Vonderembse and

Koufteros (2004) developed a construct of customer orientation (a potential dimension of a broader construct of values) and showed it to be a useful predictor of performance.

Arguably, values can be measured. Using tools such as conjoint analysis, it should be possible to develop a preference profile of an organization that maps the beliefs about the best path for the firm to pursue (choosing among characteristics such as: price, quality, service, flexibility, customer orientation, environmental responsiveness, etc.). For examples and discussions of the conjoint analysis method, see: Priem (1992), Carroll and Green (1995), Farber and Griner (2000), Reutterer and Kotzab (2000) and Green, Krieger and Wind (2001). To obtain a profile of an organization, such questions can be asked *of* an informant, but *about* the organization to minimize social desirability bias. Such a line of inquiry could identify the dominant logic of an organization, even if many of the informants personally do not understand it or agree with it.

The purpose of developing such a construct is to improve the explanatory power of models that predict organizational performance. The results cited above suggest that this improvement may be significant.

4. Organizations in transition: We still do not know how organizations "change their minds" about the appropriate logic for running their business. This suggests that companies deliberately seeking to change their strategic direction would be ideal candidates for study. The value and richness of this approach is signaled by the importance and need for organizational

unlearning that must accompany such a change, as noted by Weick (1979), Schein (1993) and Pentland (1995b). The difficulty associated with this unlearning process has been observed empirically by Christensen (1997). More recently, Benner and Tushman (2003) have shown that a focus on process control and improvement is inconsistent with attempts to pursue innovation. This work is interesting because it focuses on a problem which appears to be readily explainable by the findings of this research. We found that the knowledge of an organization consists, in part, of a logic about how certain actions will translate into results. An important consequence of this finding is that a firm cannot have a blending of two differing logics during a period of transition. For a new one to prevail, the old one must be displaced. The key difference between the approach suggested here and that of Benner and Tushman (2003) (and that of Christensen, 1997, and of the related work on punctuated equilibrium: Romanelli & Tushman, 1994; Loch & Huberman, 1999; Taylor, 1999; Beugelsdijk, Slangen et al., 2002) lies in the process/outcome distinction. The work cited in this section is outcome-based, meaning that explanation must be inferred from an examination of results. In contrast, the present research has focused on the *process* of organizational knowledge creation. By observing employees engaged in the process of knowledge creation, the sources of difficulty became much clearer. Learning could only take place within the framework of an established logic of action. When the desired change requires a change to the established logic (as it did in the cases studied by Benner and Tushman (2003) there must be some means whereby the previous logic comes to be seen as being no longer tenable.

No such rejection was observed in this research, which is why it is suggested here to study organizations in transition. One possible framework for transition would be intended moves from one of the three strategic categories of Porter (1980) (*differentiation*, *cost leadership* or *focus*) to another, but more subtle transitions might also be of interest. It is hypothesized that organizations making a successful transition will exhibit some mechanism whereby individual decision-makers are induced to abandon a previously-held belief about how to conduct business in favor of a new one.

Such a mechanism may originate outside the organization (poor performance in the marketplace, for example) or may be created within it. Eisenhardt and Martin (2000) allude to a practice of deliberately creating crises in order to facilitate such a change. Other mechanisms of change may be discovered, as may various modes and mechanisms of resistance. The critical point is that such mechanisms cannot be reliably inferred from the observation of outcomes. To develop a better understanding of the issues of organizational change and learning, it will be necessary to adopt a process perspective, which is the central issue in this recommendation for additional research. It is not sufficient to survey top management about their strategic intent and direction; it is necessary to understand just what it is that causes behavior to change at the (figurative) shop floor level.

Concluding Remarks:

This research set out to answer the question of how organizations create knowledge in their production operations. The motivation for the study came from the observation of a pair of problems that have troubled researchers and managers in Operations Management. Specifically, researchers have not yet adequately explained heterogeneity among organizations in their ability to implement specific management initiatives. Managers, on the other hand, are tasked with managing something that they cannot measure – an oxymoron of sorts. It was felt that direct observation of the learning process would shed useful light on both of these issues.

A suitable "laboratory" was sought within which to observe organizational learning in operation, and this was found in the setting of a series of Kaizen events. While admittedly constrained in scope, these events served to isolate the process being studied and to control for a number of potentially confounding factors. A research protocol was constructed from a broad review of the literature to ensure that the process was observed through a wide range of theoretical "lenses." Research followed an inductive approach, in which specific observations are aggregated and generalized to a set of propositions that can be extended to (and tested in) other settings. The logic of explanation that underlies this generalization is that of pattern matching (Kaplan, 1964; Hunt, 1991).

A set of propositions was put forward in Chapter Four. One of the consequences of these propositions is a workable answer to the original research question, but the usefulness of the question extends beyond a simple answer. Specifically, the research motivated careful attention to the natures of organizational knowledge and learning. As a result, the propositions as stated in the context of Figure 6 (in Chapter Four) constitute a prototype theory of organizational learning. Of course much work remains to be done to establish the validity and usefulness of this theory and some suggestions are presented in this chapter.

We close this discussion by returning to the original problems that motivated the research. The researcher's problem, as originally stated at an operational level, is why firms differ in their ability to effectively implement standardized initiatives such as Total Quality Management (TQM). Recalling the comments of Poole and Van de Ven (1989), such an inability to explain often suggests a missing variable. The streams of literature focused on competitive priorities and cumulative capabilities (see Chapter Two) are attempts to provide the missing variable.

This research also suggests that there is indeed a missing variable, but that this variable is a more complex construct reflecting the prevailing logic of the organization about the appropriate way in which to conduct its affairs. This is similar to the concept of competitive priorities, but is more process focused (*how* as opposed to *what*) and hence more deeply imbedded in the organization. Nonetheless, it is argued that such a logic (perhaps better described as the *values* of the organization) can be measured.

The second, manager's, problem relates directly to the issue of measurement. It follows from the belief that "if you can't measure it, you can't manage it." Knowledge and learning are known to be important and must be managed, yet they cannot be measured, hence the problem. This research does not provide a complete answer to this problem, but by better understanding the mechanism involved in organizational learning, it is possible to identify some observable indicators of the process at work. Particular attention is drawn to the role of narrative processing as a means by which *knowledge density* is maintained in an organizational setting and a contributor to the creation of new organizational knowledge.

In a more pragmatic view, this research suggests that learning in a small group setting, such as a manager might control, takes place within the confines of the prevailing logic or values of the organization. Again, it is argued that these values may be measurable, but the more immediate contribution may be simply to draw attention to these constraints and to make them discussable.

Having posited that the values of an organization are an essential component of organizational knowledge, we must then conclude that there is a level of learning that involves changes to these values. If we may close with a single normative statement, we could further argue that the ultimate goal of the manager is not to shape the organization's actions to its values, but rather to adapt the values of the organization to its environment so that the most appropriate actions will follow. The present research identified many of the barriers to such change, but did not allow us to prescribe a solution, so we must consider it to be but one more step in the larger quest to define good management.

REFERENCES

Adler, P. S. and K. B. Clark (1991). "Behind the Learning Curve: A Sketch of the Learning Process." Management Science **37**(3): 267.

Alavi, M. and D. E. Leidner (2001). "Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues." MIS Quarterly **25**(1): 107.

Amin, A. and P. Cohendet (2000). "Organisational Learning and Governance Through Embedded Practices." Journal of Management & Governance **4**(1-2): 93.

Amundson, S. D. (1998). "Relationships between theory-driven empirical research in operations management and other disciplines." Journal of Operations Management **16**(4): 341.

Argote, L. (1999). Organizational Learning: Creating, Retaining and Transferring Knowledge. Boston/Dordrecht/London, Kluwer Academic Publishers.

Argote, L., S. L. Beckman and D. Epple (1990). "The Persistence and Transfer of Learning in Industrial Settings." Management Science **36**(2): 140.

Argote, L. and D. Epple (1990). "Learning Curves in Manufacturing." Science **247**(4945): 920.

Argyris, C. and D. A. Schön (1978). Organizational Learning: A Theory of Action Perspective. Reading, MA, Addison-Wesley Publishing Company.

Austin, R. B. (1996). Measuring and Managing Performance in Organizations. New York, NY, Dorset House Publishing.

Bacharach, S. B. (1989). "Organizational Theories: Some Criteria for Evaluation." Academy of Management Review **14**(4): 496-515.

Barnard, C. I. (1938). The Functions of the Executive. Cambridge, MA, Harvard University Press.

Barney, J. (1991). "Firm Resources and Sustained Competitive Advantage." Journal of Management **17**(1): 99.

Barney, J. B. (1986). "Organizational Culture: Can it be a Source of Sustained Competitive Advantage?" Academy of Management Review **11**(3): 656-665.

Bartel, C. A. and R. Garud (2003). Narrative Knowledge in Action: Adaptive Abduction as a Mechanism for Knowledge Creation and Exchange in

Organizations. The Blackwell Handbook of Organizational Learning and Knowledge Management. M. Easterby-Smith and M. A. Lyles. Oxford, Blackwell Publishing.

Bates, K. A. and E. J. Flynn (1995). "Innovation history and competitive advantage: A resource-based view analysis of manufacturing technology innovations." Academy of Management Journal: 235.

Benner, M. J. and M. Tushman (2003). "Exploitation, Exploration and Process Management: The Productivity Dilemma Revisited." Academy of Management Review **28**(2): 238-256.

Berger, P. L. and T. Luckmann (1966). The social construction of reality; a treatise in the sociology of knowledge. Garden City, NY, Doubleday.

Bettis, R. A. and M. A. Hitt (1995). "The new competitive landscape." Strategic Management Journal **16**: 7.

Bettis, R. A. and C. K. Prahalad (1995). "The Dominant Logic: Retrospective and extension." Strategic Management Journal (1986-1998) **16**(1): 5.

Bettis, R. A. and S. S. Wong (2003). Dominant Logic, Knowledge Creation, and Managerial Choice. The Blackwell Handbook of Organizational Learning and Knowledge Management. M. Easterby-Smith and M. A. Lyles. Oxford, Blackwell Publishing.

Beugelsdijk, S., A. Slangen and M. v. Herpen (2002). "Shapes of organizational change: The case of Heineken Inc." Journal of Organizational Change Management **15**(3): 311.

Boyer, K. K. and M. W. Lewis (2002). "Competitive priorities: Investigating the need for trade-offs in operations strategy." Production and Operations Management **11**(1): 9.

Brainard, W. and J. Tobin (1968). "Pitfalls in Financial Model-Building." American Economic Review **58**(2): 99-122.

Brown, J. S., A. Collins and P. Duguid (1989). "Situated Cognition and the Culture of Learning." Educational Researcher **18**: 32-42.

Brown, J. S. and P. Duguid (1991). "Organizational Learning and Communities-of-Practice: Toward a Unified View of Working, Learning, and Innovation." Organization Science **2**(1): 40.

Bruner, J. S. (1986). Actual Minds, Possible Worlds. Cambridge, MA, Harvard University Press.

Buch, K. and D. Rivers (2001). "TQM: The role of leadership and culture." Leadership & Organization Development Journal **22**(7/8): 365.

Bullington, S. F., J. Y. Easley, A. G. Greenwood and K. E. Bullington (2002). "Success Factors in Initiating Versus Maintaining a Quality Improvement Process." Engineering Management Journal **14**(3): 8-14.

Carroll, J. D. and P. E. Green (1995). "Psychometric methods in marketing research: Part I, conjoint analysis." JMR, Journal of Marketing Research **32**(4): 385.

Choi, T. Y. and O. C. Behling (1997). "Top managers and TQM success: One more look after all these years." The Academy of Management Executive **11**(1): 37.

Chrisman, J. J., C. W. Hofer and W. R. Boulton (1988). "Toward a System for Classifying Business Strategies." Academy of Management Review **13**(3): 413-428.

Christensen, C. M. (1997). The Innovator's Dilemma : When New Technologies Cause Great Firms to Fail. Boston, MA, Harvard Business School Press.

Clark, K. B. (1996). "Competing Through Manufacturing and the New Manufacturing Paradigm: Is Manufacturing Strategy Passe?" Production and Operations Management **5**(1): 42.

Coase, R. H. (1937). "The Nature of the Firm." Economica **4**: 386-405.

Cohen, M. D. (1991). "Individual Learning and Organizational Routine: Emerging Connections." Organization Science **2**(1, Special Issue: Organizational Learning: Papers in Honor of (and by) James G. March): 135-139.

Cohen, M. D. and P. Bacdayan (1994). "Organizational Routines Are Stored As Procedural Memory: Evidence from a Laboratory Study." Organization Science **5**(4): 554-568.

Cohen, W. M. and D. A. Levinthal (1990). "Absorptive Capacity: A New Perspective on Learning and Innovation." Administrative Science Quarterly(35): 128-152.

Collis, D. J. and C. A. Montgomery (1998). Corporate Strategy: A Resource-Based Approach. Boston, MA, Irwin/McGraw-Hill.

Conner, K. R. and C. K. Prahalad (1996). "A resource-based theory of the firm: Knowledge versus opportunism." Organization Science **7**(5): 477.

Cook, S. D. N. and D. Yanow (1993). "Culture and Organizational Learning." Journal of Management Inquiry **2**(4): 373-90.

Cummings, L. L., G. P. Huber and E. Arendt (1974). "Effects of Size and Spatial Arrangements on Group Decision-Making." Academy of Management Journal **17**(3): 460.

Cyert, R. M., P. Kumar and J. R. Williams (1993). "Information, Market Imperfections and Strategy." Strategic Management Journal (1986-1998) **14**(SPECIAL ISSUE): 47.

Cyert, R. M. and J. G. March (1963). A Behavioral Theory of the Firm. Englewood Cliffs NJ, Prentice-Hall.

Dale, B. G., R. J. Boaden, M. Wilcox and R. E. McQuater (1997). "Sustaining total quality management: what are the key issues?" The TQM Magazine **9**(5): 372.

Darr, E. D., L. Argote and D. Epple (1995). "The acquisition, transfer, and depreciation of knowledge in service organizations: Productivity in franchises." Management Science **41**(11): 1750.

Davenport, T. H. and L. Prusak (1998). Working Knowledge: How Organizations Manage What They Know. Boston, MA, Harvard Business School Press.

DeCarolis, D. M. and D. L. Deeds (1999). "The impact of stocks and flows of organizational knowledge on firm performance: An empirical investigation of the biotechnology industry." Strategic Management Journal **20**(10): 953.

DeFillippi, R. and S. Ornstein (2003). Psychological Perspectives Underlying Theories of Organizational Learning. The Blackwell Handbook of Organizational Learning and Knowledge Management. M. Easterby-Smith and M. A. Lyles. Oxford, Blackwell Publishing.

Deming, W. E. (1986). Out of the Crisis. Cambridge MA, Massachusetts Institute of Technology, Center for Advanced Engineering Study.

Denison, D. R. and A. K. Mishra (1995). "Toward a theory of organizational culture and effectiveness." Organization Science **6**(2): 204.

Dess, G. G. and R. B. J. Robinson (1984). "Measuring Organizational Performance in the Absence of Objective Measures: The Case of the Privately-held Firm and Conglomerate Business Unit." Strategic Management Journal (pre-1986) **5**(3): 265.

Dewey, J. (1916). Democracy and Education: An Introduction to the Philosophy of Education. London, Collier-MacMillan.

Dewey, J. (1933). How We Think. Chicago, Henry Regnery.

Dewey, J. and A. F. Bentley (1949). Knowing and the Known. Boston, MA, Beacon Press.

Drucker, P. F. (1993). Post Capitalist Society. New Yourk, Harper Business.

Duncan, R. and A. Weiss (1979). "Organizational Learning: Implications for Organizational Design." Research in Organizational Behavior **1**: 75-123.

Dutton, J. M. and A. Thomas (1984). "Treating Progress Functions as a Managerial Opportunity." Academy of Management. The Academy of Management Review **9**(2): 235.

Easterby-Smith, M. and M. A. Lyles (2003). The Blackwell Handbook of Organizational Learning and Knowledge Management. Oxford, Blackwell Publishing.

Eisenhardt, K. M. (1989). "Building Theories from Case Study Research." Academy of Management Review **14**(4): 532-550.

Eisenhardt, K. M. and J. A. Martin (2000). "Dynamic Capabilities: What Are They?" Strategic Management Journal **21**(10/11): 1105-1121.

El Sawy, O. A., I. Eriksson, A. Raven and S. Carlsson (2001). "Understanding shared knowledge creation spaces around business processes: Precursors to process innovation implementation." International Journal of Technology Management **22**(1,2,3): 149.

Ellram, L. M. (1996). "The Use of the Case Study Method in Logistics Research." Journal of Business Logistics **17**(2): p. 93.

Epple, D., L. Argote and R. Devadas (1991). "Organizational Learning Curves: A Method for Investigating Intra-Plant Transfer of Knowledge Acquired Through Learning by Doing." Organization Science **2**(1): 58.

Fahey, L. and L. Prusak (1998). "The eleven deadliest sins of knowledge management." California Management Review **40**(3): 265.

Farber, S. and B. Griner (2000). "Using conjoint analysis to value ecosystem change." Environmental Science & Technology **34**(8): 1407.

Feldman, M. S. (2000). "Organizational Routines as a Source of Continuous Change." Organization Science **11**(6): 611-629.

Feldman, M. S. and B. T. Pentland (2003). "Reconceptualizing organizational routines as a source of flexibility and change." Administrative Science Quarterly **48**(1): 94.

Feldman, M. S. and B. T. Pentland (2005). Issues in Empirical Field Studies of Organizational Routines. Working Paper.

Ferdows, K. and A. De Meyer (1990). "Lasting Improvements in Manufacturing Performance: In Search of a New Theory." Journal of Operations Management **9**(2): 168-184.

Ferdows, K., A. De Meyer, J. Nakane, J. Miller and T. Vollman (1985). "Manufacturers in U.S., Europe, Japan Disagree Over What Makes a Winner." International Management **40**(9): 82.

Fine, C. H. (1988). "A Quality Control Model with Learning Effects." Operations Research **36**(3): 437.

Fine, C. H. (1998). Clockspeed. Reading, MA, Perseus Books.

Flynn, B. B. and E. J. Flynn (2004). "An exploratory study of the nature of cumulative capabilities." Journal of Operations Management **22**(5): 439.

Flynn, B. B., S. Sakakibara and R. G. Schroeder (1995). "Relationship Between JIT and TQM: Practices and Performance." Academy of Management Journal **38**(5): 1325-1360.

Flynn, B. B., R. G. Schroeder and S. Sakakibara (1995). "The impact of quality management practices on performance and competitive advantage." Decision Sciences **26**(5): 659.

Franz, T. M. and J. R. J. Larson (2002). "The impact of experts on information sharing during group discussion." Small Group Research **33**(4): 383.

Garud, R. and P. R. Nayyar (1994). "Transformative Capacity: Continual Structuring By Intertemporal Technology Transfer." Strategic Management Journal (1986-1998) **15**(5): 367.

Glaser, B. and A. Strauss (1967). The Discovery of Grounded Theory: Strategies of Qualitative Research. London, Wiedenfeld and Nicholson.

Grant, R. M. (1996). "Toward A Knowledge-Based Theory Of The Firm." Strategic Management Journal (1986-1998) **17**(Winter Special Issue): 109.

Green, P. E., A. M. Krieger and Y. Wind (2001). "Thirty years of conjoint analysis: Reflections and prospects." Interfaces **31**(3): S56.

Greeno, J. G. (1989). Situations, Mental Models and Generative Knowledge. Complex Information Processing: The Impact of Herbert A. Simon. D. Klahr and K. Kotovsky. Hillsdale, NJ, Lawrence Erlbaum Associates: 285-318.

Greeno, J. G., J. L. Moore and D. R. Smith (1993). Transfer of Situated Learning. Transfer on Trial: Intelligence, Cognition and Instruction. D. K. Detterman and R. J. Sternberg. Norwood, NJ, Ablex Publishing.

Gruenfeld, D. H., E. A. Mannix, K. Y. Williams and M. A. Neale (1996). "Group composition and decision making: How member familiarity and information distribution affect process and performance." Organizational Behavior and Human Decision Processes **67**(1): 1.

Guimaraes, T., M. Igbaria and M.-T. Lu (1992). "The Determinants of DSS Success: An Integrated Model." Decision Sciences **23**(2): 409.

Gurvitch, G. (1971). The social frameworks of knowledge. Oxford, Blackwell.

Hambrick, D. C. (1984). "Taxonomic Approaches to Studying Strategy." Journal of Management **10**(1): 27-41.

Hanson, J. D., S. A. Melnyk and R. J. Calantone (2003). "Core Values and Environmental Management: A Strong Inference Approach." Greener Management International **In Press**.

Harvey, J. B. (1988). The Abilene Paradox and Other Meditations on Management. Lexington, MA, Lexington Books.

Hatch, N. W. and D. C. Mowery (1998). "Process innovation and learning by doing in semiconductor manufacturing." Management Science **44**(11): 1461.

Hayek, F. A. (1945). "The Use of Knowledge in Society." American Economic Review **35**: 519-30.

Hayes, R. H. and K. B. Clark (1986). "Why Some Factories Are More Productive than Others." Harvard Business Review **64**(5): 66.

Hedberg, B. (1981). How Organizations Learn and Unlearn. Handbook of Organizational Design. P. C. Nystrom and W. H. Starbuck. Oxford, Oxford University Press: 3-27.

Henderson, R. and I. Cockburn (1994). "Measuring Competence? Exploring Firm Effects in Pharmaceutical Research." Strategic Management Journal (1986-1998) **15**(SPECIAL ISSUE): 63.

Hitt, M. A. and D. R. Ireland (1985). "Corporate Distinctive Competence, Strategy, Industry and Performance." Strategic Management Journal (pre-1986) **6**(3): 273.

Holzner, B. and J. Marx (1979). Knowledge Application: The Knowledge System in Society. Boston, Allyn-Bacon.

Huber, G. P. (1991). "Organizational Learning: The Contributing Processes and the Literatures." Organization Science **2**(1): 88-115.

Huberman, B. A. (2001). "The Dynamics of Organizational Learning." Computational and Mathematical Organization Theory **7**(2): 145.

Huff, A. S. and R. K. Reger (1987). "A Review of Strategic Process Research." Journal of Management **13**(2): 211-236.

Hunt, S. D. (1991). Modern Marketing Theory: Critical Issues in the Philosophy of Marketing Science. Cincinnati, OH, South-Western Publishing Co.

Hutchins, E. (1995). Cognition in the Wild. Cambridge, MA, MIT Press.

Hwang, H.-G. and J. Guynes (1994). "The effect of group size on group performance in computer-supported decision making." Information & Management **26**(4): 189.

Imai, M. (1997). Gemba Kaizen: a commonsense low-cost approach to management. New York, NY, McGraw-Hill.

Jensen, A. (1992). "Stockout Costs in Distribution Systems for Spare Parts." International Journal of Physical Distribution & Logistics Management **22**(1): 15.

Kabanoff, B. and G. E. O'Brien (1979). "The Effects of Task Type and Cooperation Upon Group Products and Performance." Organizational Behavior and Human Performance **23**(2): 163.

Kahneman, D. and A. Tversky (1979). "Prospect Theory: An Analysis of Decision Under Risk." Econometrica **47**(2): 263-292.

Kaplan, A. (1964). The Conduct of Inquiry, Methodology for Behavioral Science. San Francisco, CA, Chandler Publishing.

Kim, Y. and J. Lee (1993). "Manufacturing strategy and production systems: An integrated framework." Journal of Operations Management **11**(1): 3.

Klassen, R. D. (2001). "Plant-level environmental management orientation: The influence of management views and plant characteristics." Production and Operations Management **10**(3): 257.

Kogut, B. and U. Zander (1996). "What firms do? Coordination, identity, and learning." Organization Science **7**(5): 502.

Kosslyn, S. M. (1978). Imagery and Internal Representation. Cognition and Categorization. E. Rosch and B. B. Lloyd. Hillsdale, NJ, Lawrence Erlbaum Associates: 217-61.

Krumwiede, D. W. and J. P. Lavelle (2000). "The effect of top-manager personality on a total quality management environment." Engineering Management Journal **12**(2): 9.

Lave, J. (1988). Cognition in Practice: Mind, Mathematics and Culture in Everyday Life. Cambridge, Cambridge University Press.

Lave, J. and E. Wenger (1991). Situated Learning: Legitimate Peripheral Participation. Cambridge, Cambridge University Press.

Leonard-Barton, D. (1992). "Core Capabilities and Core Rigidities: A Paradox in Managing New Product Development." Strategic Management Journal **13**(SPECIAL ISSUE): 111.

Levitt, B. and J. G. March (1988). "Organizational Learning." Annual Review of Sociology **14**: 319-340.

Levy, F. K. (1965). "Adaptation in the Production Process." Management Science **11**(6, Series B): B136-B154.

Li, G. and S. Rajagopalan (1998). "Process Improvement, Quality, and Learning Effects." Management Science **44**(11): 1517-1532.

Lieberman, M. B. (1984). "The Learning Curve and Pricing in the Chemical Processing Industries." The Rand Journal of Economics **15**(2): 213.

Littlepage, G. E. (1991). "Effects of Group Size and Task Characteristics on Group Performance: A Test of Steiner's Model." Personality and Social Psychology Bulletin **17**(4): 449.

Loch, C. H. and B. A. Huberman (1999). "A punctuated-equilibrium model of technology diffusion." Management Science **45**(2): 160.

Lyles, M. A. (1988). "Learning Among Joint Venture Sophisticated Firms." Management International Review **28**: 71-87.

Lyles, M. A. and C. R. Schwenk (1992). "Top Management, Strategy and Organizational Knowledge Structures." Journal of Management Studies **29**: 155-174.

Macdonald, J. (1996). "TQM - does it always work? Some reasons for disappointment." Managing Service Quality **6**(5): 5.

MacDuffie, J. P. (1997). "The road to "root cause": Shop-floor problem-solving at three auto assembly plants." Management Science **43**(4): 479.

Machlup, F. (1980). Knowledge and Knowledge Production. Princeton, NJ, Princeton University Press.

Mahoney, J. T. and J. R. Pandian (1992). "The Resource-Based View Within the Conversation of Strategic Management." Strategic Management Journal **13**(5): 363.

Marble, R. P. (2003). "A system implementation study: Management commitment to project management." Information & Management **41**(1): 111.

March, J. G. (1991). "Exploration and Exploitation in Organizational Learning." Organization Science **2**(1): 71-87.

March, J. G. and J. P. Olsen (1975). "The Uncertainty of the Past: Organizational Learning Under Ambiguity." European Journal of Political Research **3**: 147-171.

March, J. G. and H. A. Simon (1958). Organizations, John Wiley & Sons, Inc.

Martin, J. (2002). Organizational Culture: Mapping the Terrain. Thousand Oaks, CA, Sage.

McCabe, V. and G. J. Balzano, Eds. (1986). Event Cognition: An Ecological Perspective. Hillsdale, NJ, Lawrence Erlbaum Associates.

Melnyk, S. A., R. J. Calantone, F. L. Montabon and R. T. Smith (1998). "Short-Term Action in Pursuit of Long-Term Improvements: Introducing Kaizen Events." Production and Inventory Management Journal **39**(4): 69-76.

Melnyk, S. A. and D. M. Stewart (2000). "Effective Process Improvement: Developing Poka-Yoke Processes." Production and Inventory Management Journal **41**(4): p. 48.

Melnyk, S. A., G. A. Zsidisin, J. Luft, L. A. Burns, R. J. Calantone, D. M. Stewart and J. D. Hanson (2005). Defining Alignment in Performance Measurement Systems: A Case Study in Metrics Deployment. Working Paper.

Meredith, J. (1998). "Building operations management theory through case and field research." Journal of Operations Management **16**(4): 441.

Miles, M. B. and A. M. Huberman (1994). Qualitative Data Analysis: An Expanded Sourcebook. Thousand Oaks, CA, Sage.

Miller, D. (1996). "Configurations Revisited." Strategic Management Journal (1986-1998) **17**(7): 505.

Mukherjee, A. S., M. A. Lapre and L. N. V. Wassenhove (1998). "Knowledge driven quality improvement." Management Science **44**(11): S35.

Muth, J. F. (1986). "Search Theory and the Manufacturing Progress Function." Management Science **32**(8): 948.

Nahapiet, J. and S. Ghoshal (1998). "Social capital, intellectual capital, and the organizational advantage." Academy of Management. The Academy of Management Review **23**(2): 242.

Nahm, A. Y., M. A. Vonderembse and X. A. Koufteros (2004). "The Impact of Organizational Culture on Time-Based Manufacturing and Performance." Decision Sciences **35**(4): 579.

Nelson, R. R. (1991). "Why do Firms Differ, and How Does it Matter?" Strategic Management Journal (1986-1998) **12**(SPECIAL ISSUE): 61.

Nelson, R. R. and S. G. Winter (1982). An Evolutionary Theory of Economic Change. Cambridge, MA, Belknap Press.

Nicolini, D. and M. B. Meznar (1995). "The social construction of organizational learning: Conceptual and practical issues in the field." Human Relations **48**(7): 727.

Nonaka, I. (1994). "A Dynamic Theory of Organizational Knowledge Creation." Organization Science **5**(1): 14.

Nonaka, I. and H. Takeuchi (1995). The Knowledge-Creating Company. New York, Oxford University Press.

Nunnally, J. (1994). Psychometric Methods. New York, McGraw-Hill.

Nwabueze, U. (2001). "An industry betrayed: The case of total quality management in manufacturing." The TQM Magazine **13**(6): 400.

Oi, W. Y. (1967). "The Neoclassical Foundations of Progress Functions." Journal of Economics **77**(307): 579-594.

Okhuysen, G. A. and K. M. Eisenhardt (2002). "Integrating knowledge in groups: How formal interventions enable flexibility." Organization Science **13**(4): 370.

Orlikowski, W. J. (2002). "Knowing in practice: Enacting a collective capability in distributed organizing." Organization Science **13**(3): 249.

Orr, J. (1990). Sharing Knowledge, Celebrating Identity: War Stories and Community Memory in a Service Culture. Collective Remembering: Memory in Society. D. S. Middleton and D. Edwards. Beverly Hills, CA, Sage.

Penrose, E. T. (1959). The Theory of the Growth of the Firm. Oxford, Oxford University Press.

Pentland, B. T. (1992). "Organizing Moves in Software Support Hot Lines." Administrative Science Quarterly **37**(1992): 527-548.

Pentland, B. T. (1995a). "Grammatical models of organizational processes." Organization Science **6**(5): 541.

Pentland, B. T. (1995b). "Information Systems and Organizational Learning: The Social Epistemology of Organizational Knowledge Systems." Accting., Mgmt. & Info. Tech. **5**(1): 1-21.

Pentland, B. T. (1999). "Building process theory with narrative: From description to explanation." Academy of Management. The Academy of Management Review **24**(4): 711.

Pentland, B. T. and M. S. Feldman (2005). "Organizational Routines as a Unit of Analysis." Industrial and Corporate Change **In Press**.

Pentland, B. T. and H. H. Rueter (1994). "Organizational routines as grammars of action." Administrative Science Quarterly **39**(3): 484.

Petroni, A. (2002). "Critical factors of MRP implementation in small and medium-sized firms." International Journal of Operations & Production Management **22**(3): 329.

Polanyi, M. (1958). Personal Knowledge: Towards a Post-Critical Philosophy. Chicago, University of Chicago Press.

Poole, M. S. and A. H. Van de Ven (1989). "Using Paradox to Build Management and Organization Theories." Academy of Management Review **14**(4): 562-578.

Porter, M. (1980). Competitive Strategy. New York, NY, Free Press.

Powell, T. C. (1995). "Total Quality Management as Competitive Advantage: A Review and Empirical Study." Strategic Management Journal **16**(1): 15-37.

Prahalad, C. K. and R. A. Bettis (1986). "The Dominant Logic; a New Linkage Between Diversity and Performance." Strategic Management Journal (1986-1998) **7**(6): 485.

Prahalad, C. K. and G. Hamel (1990). "The Core Competence of the Corporation." Harvard Business Review **68**(3): 79.

Priem, R. L. (1992). "An Application of Metric Conjoint Analysis for the Evaluation of Top Managers' Individual Strategic Decision Making Processes: A Research Note." Strategic Management Journal (1986-1998) **13**(SPECIAL ISSUE): 143.

Pylyshyn, Z. W. (1984). Computation and Cognition: Towards a Foundation for Cognitive Science. Cambridge, MA, MIT Press.

Reutterer, T. and H. W. Kotzab (2000). "The use of conjoint-analysis for measuring preferences in supply chain design." Industrial Marketing Management **29**(1): 27.

Rogoff, B. (1990). Apprenticeship in Thinking. New York, Oxford University Press.

Romanelli, E. and M. L. Tushman (1994). "Organizational transformation as punctuated equilibrium: An empirical test." Academy of Management Journal **37**(5): 1141.

Rosch, E. (1978). Principles of Categorization. Cognition and Categorization. E. Rosch and B. B. Lloyd. Hillsdale, NJ, Lawrence Erlbaum Associates.

Rosch, E. and B. B. Lloyd, Eds. (1978). Cognition and Categorization. Hillsdale, NJ, Lawrence Erlbaum Associates.

Rugman, A. M. and A. Verbeke (2002). "Edith Penrose's contribution to the resource-based view of strategic management." Strategic Management Journal **23**(8): 769.

Sabherwal, R. and I. Becerra-Fernandez (2003). "An Empirical Study of the Effect of Knowledge Management Processes at Individual, Group, and Organizational Levels*." Decision Sciences **34**(2): 225.

Sakakibara, S., B. B. Flynn, R. G. Schroeder and W. T. Morris (1997). "The impact of just-in-time manufacturing and its infrastructure on manufacturing performance." Management Science **43**(9): 1246.

Schein, E. H. (1993). "How Can Organizations Learn Faster? The Challenge of Entering the Green Room." Sloan Management Review **34**: 85-92.

Schmenner, R. W. and M. L. Swink (1998). "On Theory in Operations Management." Journal of Operations Management **17**: 97-113.

Scott, W. R. (2001). Institutions and Organizations. Thousand Oaks, CA, Sage.

Shaw, R. and T. R. Alley (1985). How To Draw Learning Curves: Their Use and Justification. Issues in the Ecological Study of Learning. T. D. Johnston and A. T. Pietrewicz. Hillsdale, NJ, Lawrence Erlbaum Associates.

Simon, H. A. (1991). "Bounded Rationality and Organizational Learning." Organization Science **2**(1): 125-134.

Simon, H. A. and C. A. Kaplan (1989). Foundations of Cognitive Science. Foundations of Cognitive Science. M. I. Posner. Cambridge MA, MIT Press.

Sinclair, G., S. Klepper and W. Cohen (2000). "What's experience got to do with it? Sources of cost reduction in a large specialty chemicals producer." Management Science **46**(1): 28.

Skinner, W. (1966). "Production Under Pressure." Harvard Business Review **44**(6): 139-145.

Smircich, L. (1983). "Concepts of Culture and Organizational Analysis." Administrative Science Quarterly **28**(3): 339-358.

Spear, S. and H. K. Bowen (1999). "Decoding the DNA of the Toyota Production System." Harvard Business Review **77**(5): 96.

Spender, J.-C. (1996a). "Making Knowledge the Basis of a Dynamic Theory of the Firm." Strategic Management Journal (1986-1998) **17**(Winter Special Issue): 45.

Spender, J.-C. (1996b). "Organizational knowledge, learning and memory: three concepts in search of a theory." Journal of Organizational Change Management **9**(1): 63.

Spender, J.-C. and R. M. Grant (1996). "Knowledge And The Firm: Overview." Strategic Management Journal (1986-1998) **17**(Winter Special Issue): 5.

Stake, R. E. (1994). Case Studies. Handbook of Qualitative Research. N. K. Denzin and Y. S. Lincoln. Thousand Oaks, Sage: 236.

Starbuck, W. H. (1992). "Learning by Knowledge-Intensive Firms." The Journal of Management Studies **29**(6): 713.

Stasser, G. and W. Titus (1987). "Effects of Information Load and Percentage of Shared Information on the Dissemination of Unshared Information during Group Discussion." Journal of Personality and Social Psychology **53**(1): 81.

Stewart, D. M. and S. A. Melnyk (2000). "Effective process improvement developing poka-yoke processes." Production and Inventory Management Journal **41**(4): 48.

Straus, S. G. and J. E. McGrath (1994). "Does the medium matter? The interaction of task type and technology on group performance and member reactions." Journal of Applied Psychology **79**(1): 87.

Strauss, A. and J. Corbin (1990). Basics of Qualitative Research. Newbury Park, CA, Sage Publications.

Suchman, L. (1987). Plans and Situated Actions: The Problem of Human - Machine Interaction. Cambridge, Cambridge University Press.

Sum, C.-C., J. S. K. Ang and L.-N. Yeo (1997). "Contextual elements of critical success factors in MRP implementation." Production and Inventory Management Journal **38**(3): 77.

Szulanski, G. (1996). "Exploring Internal Stickiness: Impediments to the Transfer of Best Practice Within the Firm." Strategic Management Journal **17**(Special Issue: Knowledge and the Firm): 27-43.

Taylor, S. S. (1999). "Making sense of revolutionary change: differences in members' stories." Journal of Organizational Change Management **12**(6): 524.

Teece, D. J. (1980). "Economies of Scope and the Scope of the Enterprise." Journal of Economic Behavior & Organization **1**: 223-245.

Teece, D. J., G. Pisano and A. Shuen (1997). "Dynamic Capabilities And Strategic Management." Strategic Management Journal (1986-1998) **18**(7): 509.

Thomas-Hunt, M. C., T. Y. Ogden and M. A. Neale (2003). "Who's really sharing? Effects of social and expert status on knowledge exchange within groups." Management Science **49**(4): 464.

Tobin, J. (1969). "A General Equilibrium Approach to Monetary Theory." Journal of Money, Credit and Banking **1**(1): 15-29.

Tsoukas, H. (2003). Do We Really Understand Tacit Knowledge? The Blackwell Handbook of Organizational Learning and Knowledge Management. M. Easterby-Smith and M. A. Lyles. Oxford, Blackwell Publishing.

Venkatraman, N. (1989). "The Concept Of Fit In Strategy Research: Toward Verbal And Statistical Correspondence." Academy of Management. The Academy of Management Review **14**(3): 423.

Wacker, J. G. (1998). "A definition of theory: Research guidelines for different theory-building research methods in operations management." Journal of Operations Management **16**(4): 361.

Wacker, J. G. (2004). "A theory of formal conceptual definitions: developing theory-building measurement instruments." Journal of Operations Management **22**(6): 629.

Walsh, J. P. (1995). "Managerial and organizational cognition: Notes from a trip down memory lane." Organization Science **6**(3): 280.

Ward, A., J. K. Liker, J. J. Cristiano and D. K. I. Sobek (1995). "The Second Toyota Paradox: How Delaying Decisions Can Make Better Cars Faster." Sloan Management Review(Spring, 1995): 43-61.

Weick, K. E. (1979). The Social Psychology of Organizing. New York, McGraw-Hill.

Weldon, M. S. and K. D. Bellinger (1997). "Collective memory: Collaborative and individual processes in remembering." Journal of Experimental Psychology **23**(5): 1160.

Wenger, E. (1998). Communities of Practice: Learning, Meaning and Identity. Cambridge, Cambridge University Press.

Wernerfelt, B. (1984). "A Resource-Based View of the Firm." Strategic Management Journal **5**(2): 171.

Whetten, D. A. (1989). "What Constitutes a Theoretical Contribution?" Academy of Management Review **14**(4): 490-495.

Williamson, O. E. (1981). "The Economics of Organization: The Transaction Cost Approach." The American Journal of Sociology **87**(3): 548-577.

Winter, S. G. (1987). Knowledge and Competence as Strategic Assets. The Competitive Challenge: Strategies for Industrial Innovation and Renewal. D. J. Teece. Cambridge, MA, Ballinger.

Womack, J., D. Jones and D. Roos (1991). The Machine That Changed the World. New York, NY, Harper Perennial.

Wright, T. P. (1936). "Factors Affecting the Cost of Airplanes." Journal of the Aeronautical Sciences **3**: 122-128.

Yetton, P. and P. Bottger (1983). "The Relationships Among Group Size, Member Ability, Social Decision Schemes, and Performance." Organizational Behavior and Human Performance **32**(2): 145.

Yin, R. K. (1994). Case Study Research Design and Methods. Thousand Oaks, CA, Sage Publications.

Zahra, S. A. and G. George (2002). "Absorptive capacity: A review, reconceptualization, and extension." Academy of Management. The Academy of Management Review **27**(2): 185.

Zahra, S. A. and A. P. Nielsen (2002). "Sources of capabilities, integration and technology commercialization." Strategic Management Journal **23**(5): 377.

Zangwill, W. I. and P. B. Kantor (1998). "Toward a theory of continuous improvement and the learning curve." Management Science **44**(7): 910.

APPENDIX I

Validation Questionnaire for Expert Panel

I have stated the following propositions. On the basis of your experience, please tell me whether you agree, disagree or think I am missing something important. Feel free to use the space available to tell me why; especially in the last instance!	Strongly Disagree	Disagree	Neutral / Not Sure	Agree	Strongly Agree	You're Missing The Point! (see notes)
1. a) They may go together, but experience does not <u>cause</u> learning. Comments:						
1. b) In a production environment, learning is an <u>investment</u> and is evaluated on a forward looking basis. Comments:						
2. "Stories" are very important because they capture a rich range of context and associations that make principles credible and useful. Comments:						
3. Cognition (what a person knows, or knows about) is a strongly limiting factor in the search for new knowledge (self-motivated learning). Comments:						
4. a) The limiting factor in organizational learning is <u>not</u> cognition; it is <u>displacement</u> of what is already "known" (the competing paradigm). Comments:						
4. b) It is important to understand the difference between <u>what</u> the organization does and <u>why</u> it does it (the logic behind it). Comments:						
5. Knowledge is not imported intact. It is created by combining local facts with some organizing framework (almost always external). Comments:						

APPENDIX II

Kaizen Event # 1 - Dec 14-17, 2004

Introduction:

The company studied in this case is a North American manufacturer of plumbing products. The company is part of a larger plumbing products group and has a number of sister plants that manufacture similar products using similar processes. In spite of being part of a corporate group, the company was acquired as a standalone business and retains its own unique culture. The reporting structure also provides a degree of isolation from the business policies of the sister companies.

The business outlook for the company is generally positive, driven by strong growth of the home building and home improvement markets. This growth has been accompanied by consolidation in the customer base, resulting in increased demands for cost reduction and flexibility of delivery. The process improvement event studied in this case is aimed directly at addressing these pressures.

The workforce is stable, unionized and well-educated. The work environment appears to be positive and collaborative. The workforce draws on a pool of Old World immigrants, contributing to a higher-than-average educational and skill level, particularly in the skilled trade functions.

The process under review was a semi-automated brazing carousel that could be configured to assemble multiple product variants. Because of the pressures noted above, there was a desire to implement a more "lean" production regimen, requiring more frequent product changeovers. This was not a priority when the equipment was designed, and product variations have proliferated with the result that a major changeover required several hours. Consequently, these changeovers were made on third shift wherever possible, and runs of less than two shifts were strongly resisted. A stated goal of the project was a 50% reduction in setup time.

The project team consisted of nine members including an outside facilitator and the researcher serving as a participant-observer. The balance of the team was a combination of personnel from the affected area and from other areas in the operation. The individual primarily responsible for changeovers was part of the team, which provided expertise but also created certain tensions as changes were proposed and discussed.

The event uncovered significant opportunity to reduce the changeover time, but the results can only be considered a partial success. The outward evidence for this statement is that no system was put in place to close the loop by measuring and tracking changeover times. Some of the reasons for this are discussed in the analysis of the case transcript. The more subjective reason for this conclusion is the observation that the full benefits of reduced changeover time were not recognized by the system. The only benefit that was fully valued was the direct reduction in labor associated with the changeover.

<u>Review of Field Notes In the Context of the Research Protocol:</u>

<u>Knowledge classified as being explicit or tacit:</u>

Two instances of tacit knowledge were observed in these cases that were part of the organizational knowledge relevant to the process (as opposed to tacit knowledge held by individuals). The first was the body of knowledge needed to set up the burners and soldering equipment. The second form of tacit knowledge was in the form of the shared logic of individuals about the correct way to run a plant.

Some (primarily the facilitators) subscribed to lean principles and saw setup reduction as a key enabler. Others, (primarily those most closely associated with the process), were in the efficiency mindset, where setup time reduction was less important, since the real goal was to reduce the number of setups. Several participants had no particular point of view either way. The justification for calling this tacit knowledge is that most of the participants were not in a position to fully state and justify the logic behind it, but accepted it as the way the company worked. These issues were discussed, but not to any resolution.

The bulk of the activities in this case involved what we would call explicit knowledge. Seventeen instances were noted where the output of the activity was an explicit procedure or artifact that represented an increase in organizational knowledge as previously defined. The antecedents for these pieces of explicit knowledge were less clear. Most of the activity in the event involved some sort of conversion of personal knowledge into an organizational form. This will be discussed more in the next section.

Transformations of knowledge within and between explicit and tacit

No transformations involving the above examples of tacit knowledge took place during the case, although it was evident that such transformations had taken place in the past. An example would be the transmission of the setup knowledge to the night shift setup person, presumably through some sort of "over-the-shoulder" coaching. Transformation of this knowledge to an explicit set of setup rules would have been an interesting result, but this did not take place.

With respect to the tacit knowledge about "how to run a factory", no transformations took place in the sense that the state of knowledge was not observably different at the end of the project. It was possible to see how, through being deeply embedded in the organization, the prevailing logic was strongly resistant to change, even though many in the group could appreciate the logic for a change. In fact, there was a palpable feeling at a couple of points that setup reduction efforts had reached the point of diminishing returns and that it was time to back off. This sort of stress would be unlikely to persist in the long term – eventually a single logic would prevail. The result in this case was a sort of compromise – described elsewhere.

The bulk of the activities in this case resulted in what we would call explicit knowledge, but it proved to be extremely difficult to speak of transmissions or transformations of explicit knowledge. While the outcomes could be observed in the form of equipment or process changes, it was not generally possible to identify a single source or precursor. Of the seventeen instances, only two had any clear origin. Even those examples (the use of a perforated bucket for cooling water or the use of a quarter-turn nut) seemed to have more than a single example as an antecedent. At a minimum, there was an issue of adaptation to the specific local conditions. What this meant was that the team member engaged in the transformation was not simply copying a practice, but rather applying a set of principles that he or she had abstracted from the specific example. Events that would appear to be explicit to explicit transformations seemed actually to be a transformation of multiple explicit sources into some sort of generalized tacit mental model that was subsequently transformed into a specific, explicit form. To usefully describe these events, it seems more useful to consider the mental processing involved (see below). The concept of transformations, specifically explicit to explicit transformations, did not prove to be a useful way to describe these events.

Knowledge Classified By Location

From a knowledge management point of view, it is convenient to think about knowledge as having a place, where it can be stored, retrieved, etc. From that perspective, the form of knowledge that dominated the event was that which existed in personal memories. The other forms that came into play during this case were documented knowledge and knowledge embedded in existing routines or setups.

Documentary materials observed during this case were: the initial training materials (manual and videos), the production forecasts by part number, and the Kaizen event report from a sister plant. Some documentary materials were created as part of the process, notably the video of the setup process and the data collection to assess the need for repacking after bright dip. For the most part, these documentary materials consisted of data for temporary use rather than knowledge. The only real attempts to document learning for future use were in the training materials (and it was not clear that they had any direct influence on the results), and the Kaizen event report. This last item served as a thought starter, but it was not used as a source of definitive knowledge. The reason seemed to be that reports of this kind are lacking in contextual richness, making it hard for individuals to make use of the learning without substantially retracing the steps.

Knowledge was embedded in the production process (including the setup process) that we studied. By observing closely what was done, or by asking "why?" of a knowledgeable informant, the team members could fairly efficiently reconstruct learning that had gone before. Questions about the cleaning routines were a good example. Other processes (routines) within the plant were also available for study, but only one such example was noted. This was the adoption of the perforated bucket sprinkler for part cooling. Interestingly, to judge from the story-telling portion of the event, when individuals reached into their memories for relevant knowledge, what they were often recalling was a routine that had been observed elsewhere. One the routine was recalled, it could then be dissected for its relevant knowledge content.

This suggests a final comment on the role of memory as a knowledge bin. In many cases, what was in personal memory was not the ultimate knowledge itself, but a form of meta-knowledge. If someone didn't know the answer to a question, chances were good that they had an idea of who would. Likewise, a piece of knowledge may have been imperfectly remembered, but the individual knew where to look it up. Unless knowledge had these meta-tags in someone's head, it was inaccessible to the group in practical terms.

Actions By Individuals To Retrieve Or Store Knowledge By Location

It was clear that everyone's first choice of where to look for knowledge was their own memories and experiences. All seventeen examples listed involved some level of personal knowledge. The second favorite choice was to ask someone else to make use of their personal knowledge. Four of the examples involved specifically seeking out someone else's knowledge (as when SS called a gas contractor for an interpretation of regulations). There was a willingness to look at existing routines in order to learn from them. Three examples of this were apparent (the dual burner concept, the bucket for cooling and the sloping parts rack), but this was not a preference. Undoubtedly some of what existed in personal memory was the result of observations of other routines in the past (not observable by the researcher). There was a strong resistance to using documentary materials such as production data or written reports.

The reason for this hierarchy of preferences seems to be related to the ease of extracting what is relevant to the current context. When drawing on memory (one's own or someone else's) it is possible to draw on underlying principles to fit the knowledge to the need. In contrast, in viewing existing processes or consulting documentary forms, one is faced with facts lacking in context. The team found it extremely difficult to use documentary sources without calling in someone who knew the story behind the reports (this was true of the production forecasts for example).

When it came to storing knowledge, the same hierarchy seemed to apply. Although it was not possible to measure it, it seems safe to say that most participants took away more in personal memory than in any other form. The production processes were changed of course, since that was the purpose of the event, but there was little or no attempt to document what was done, or more to the point, why it was done a certain way.

While it was possible to identify "bins" of knowledge by location, it was not so much the location that was interesting as the type of bin. As the above discussion suggests, it is the contextual richness that makes knowledge sources interesting; suggesting a need to consider the processing involved.

Processing Of Knowledge And/Or Information By Individuals (Narrative Versus Paradigmatic)

According to Bruner, 1986, this is the difference between a logical argument and a good story. There was evidence of both kinds of information processing going on in this case, but it is not clear that they were as distinct as Bruner suggests they might be. As far as could be observed, the principal way in which outside information or knowledge was brought into the case was through stories, or narratives as they resided in someone's memory. In these instances, it was the explanatory value of the stories that made them useful; it was not necessary that the actual "facts" contained in the stories be strictly true (the Toyota story for example).

There was also clear evidence of bottom-up thinking as in re-arranging the pieces of a puzzle to get the best solution. This could be seen in the re-design of various fixtures. What is not so clear is the extent to which the imported narratives served as triggers to allow more efficient sorting of the alternative solutions. For example, the idea of re-designing the <rb> fixtures to make use of burner positions that were common to other parts could be seen as a classic bottom-up analysis of the situation, but it seemed to have been triggered by the story about the sister plant using dual sets of burners. While it is possible to recognize the two forms of processing involved, it seems that they may interact in important ways.

Individual Cognition (As In Pre-Existing State Of Knowledge)

It has been suggested that learning can only take place within the cognitive limits of individuals, and that this extends in some way to groups. There was no evidence that this was a limiting factor in the adoption of knowledge this case, with the possible exception of the fact that most team members were not fully aware of the implications and potential benefits of setup time reduction. This may have tempered enthusiasm somewhat, but it certainly did not inhibit the actual efforts. Of course, it is worth noting that the team members were all selected on the basis of having some potential to contribute to the exercise, so it is not surprising that cognitive limits would not be a major factor in this respect.

Where this factor can be seen is in the choice of where to look. As noted above, team members looked first to their own memories. This would certainly suggest a cognitive limit on the group's ability to seek out new knowledge. There is no reason to believe that this is an absolute limit, but in the context of this case, the universe of knowledge to be consulted was more or less what was in the heads of the project team. An exception would be the cases where someone didn't know something, but knew who to ask (for example, the feasibility of the some the control system changes to the machinery had to be checked with a maintenance specialist).

Power And/Or Knowledge As Moderators Of Group Activity

It is known in group dynamics that the power and/or influence of individuals can inhibit the expression of divergent ideas and skew the decision process. This did not appear to be a major factor in the actual development of ideas, although the team members each had their own areas of expertise that were tacitly recognized by the group. Ideas expressed by someone with this level of credibility tended to be accepted quite readily.

There was one area of interpersonal relationships that affected the outcome, and that was the fact that the setup person was part of the team. It was possible that any suggestions that the team came up with could be construed as a criticism of this person's current performance. A desire to avoid conflict may have inhibited the generation of ideas to some extent, and it certainly contributed to the avoidance of a performance measurement to close the loop.

The existence of these factors may have affected the amount of learning that took place (the content view), but there was no clear evidence that they changed the mechanism of learning (process view).

Shared Logics Of Action (Existence Of And Changes To)

The idea of shared logic can be applied at multiple levels of analysis. At the lowest, simplest levels, the logic tends to be transparent, self-contained and readily understood. For example, in the case of the revision to the cooling process, the logic is very basic: cool the part sufficiently and uniformly enough for the operator to remove it from the fixture. The correctness of the logic can be checked very quickly. Cases like this are not very interesting except that they provide a contrast to logics that are not simple, span interdependent functions and cannot be readily tested.

Two examples of these higher-level logics were noted in this case. The first was observed in the prioritization process for the activities to be undertaken. Without any explicit debate, the team gravitated towards a prioritization that weighted safety and ergonomic improvements highly relative to the other cases. This prioritization was mirrored by the questioning of the senior management team after the presentation. This appears to indicate a shared logic or belief within this particular company that safety and ergonomic issues are an important component of success. The "correctness" of this logic is not easily checked, nor is it very transparent. There was no evidence that the team was even aware that they were making a choice in this matter.

The second instance was the "lean" versus "efficient" debate. The comments of many team members indicated that, while they understood (to a degree) the logic of lean, the dominant belief of the company was that efficiency (few setups, long runs) was the path to success. The team was relatively powerless in this respect because the competing logics are not simple to understand and compare, cannot be readily tested for correctness, and span multiple functions which must all act in concert for the logic to be effective.

No changes to either of these logics were noted in this case, which should not be a surprise. In the first instance, there was no evidence that there was any need for a change. In the second instance, an argument for change could be made, but a change would require a massive, simultaneous realignment of all aspects of the production function. This was beyond the scope of the process improvement event being studied.

Changes To Performative Aspects Of Routines

As described in the transcript of events, the team made numerous changes to fixtures and methods that represented the results of a learning process. In fact, from the organization's point of view, these changes stood as the only results of the learning, since there was no other record of what was done, or the logic behind it. Much of this information resided in the heads of team members, but was not necessarily accessible to the organization.

The actual changes are not interesting from a theoretical perspective; what is interesting is whether they are in accord or conflict with some shared logic. Following the theme of the previous section, most of the changes were fully consistent with existing logic, especially at the simpler levels. Even at a higher level, improvements to safety and ergonomic factors were consistent with the company's logic. These improvements were readily implemented and could be expected to work as planned.

The more interesting case was the effort to reduce setup time. Spending less man-hours doing setups is consistent with an efficiency logic, and these changes were readily implemented. Reducing setup duration, so as to be able to do more of them, is not consistent with efficiency logic and some changes were not implemented for this reason. For example, ideas were proposed that would have taken some of the changeover activities off-line so as to reduce the production downtime. Doing things this way was often less efficient, and may have required an increase in indirect labor. Such changes did not make it onto the action list. From a lean production perspective, some of the necessary tools had been put in place, but it was obvious that they would not be used for their intended purpose, which was to do more setups.

The key point of this observation is that changes to the performative aspects of routines can be made, but that is not sufficient. If the changes are to persist and be used, they must be consistent with the "shared logic of action". Where this agreement is absent, it is not fair to claim that organizational knowledge has been increased in a sustainable way.

Changes In Situated Performance

Related to the above discussion, the test of organizational learning is whether performance has been improved. In the short duration of a Kaizen event it is often not possible to confirm this with actual data, so learning must be inferred from projections.

In the case of the setup time reduction effort, it is reasonable to accept the team's projections that fewer man-hours will be required for future setups, so we can say that performance has improved and some learning took place. Realizing the full benefits of setup time reduction however, requires that the number of setups be increased to allow a reduction in inventory. There was no evidence that this would actually happen, so the improvement in performance was less than it might have been under a different logic.

There were also a number of improvements claimed in the area of safety and ergonomics. For these, no quantitative measures are available. It may be fair to claim that organizational knowledge has increased on the basis of face validity – that is, the resulting state is obviously better than what went before, but in the context of this case, this claim is not necessary to identify the case as a learning event.

Observations From the Field Notes In Addition to the Research Protocol:

Some observations were made that were not specifically anticipated by the research protocol, but were considered interesting in the context of the research question. These are noted for comparison to other cases.

Story-Telling:

As the project team became more familiar with each other and with the task at hand, a story telling phase emerged. This could be seen as an example of the narrative mode of thought, but there seemed to be more to it than that. Some possible explanations are:

- A good faith effort to bring information to the table that might be relevant to the problem at hand (this would be the narrative mode).

- Staking out an area of personal expertise and building credibility for that position (this would indicate a presence of expert power in the group dynamic).

- Testing the bounds of the acceptable solution space by noting the reaction of others to the stories (this would be a check on the dominant logic of action).

Evidence of Autonomous Learning:

Taking note of the distinction between induced and autonomous learning (Fine, 1988; Li & Rajagopalan, 1998), it was not anticipated that it would be possible to observe autonomous learning taking place. After all, the unit of analysis was chosen to be an induced learning event. However, such learning was observed following the changes to the operators' work station. The operator who was part of the team wanted to try out the new arrangement to confirm that it was an improvement. The carousel was set up and approximately 30 parts were produced before the operator determined that "learning" was complete and that the result was an improvement. A similar learning process apparently took place on second shift as well, but this was not observed.

This observation showed that autonomous learning, based on experience, does take place. It also suggests that the mechanism is an informed trial and error process, which would be expected to follow the classical learning curve power function. It was clear that this type of learning could only take place on the part of an individual, or a work group small enough and independent enough to autonomously vary their work practices in search of an optimum. It was also clear that in the context of typical high-volume production tasks that this is a short-lived effect. This is consistent with the literature (Epple, Argote & Devadas, 1991).

Evidence of Reactive Learning:

In observing a setup procedure, it was noted that the person doing the setup spent a great deal of time cleaning the mounting areas for the fixtures and their attachment holes. Upon questioning, it was learned that this was because even small amounts of contamination in these areas could result in misalignment of the fixtures sufficient to affect the production process. It became clear that the operator had implemented this procedure in response to problems that had occurred in the past. It is somewhat difficult to categorize this type of learning. It seems to reflect quality-based learning (Fine, 1988), but it falls somewhere between induced and autonomous depending on how problems are resolved. We will use the term reactive learning to identify this situation.

From the point of view of the project team, these situations were interesting because they were often non-value-added steps. As such, they were opportunities for cost reduction if the root cause could be eliminated or addressed in a more efficient way. From a research perspective, they were interesting because the result of this type of learning was often the acceptance of a known added cost in exchange for the avoidance of an uncertain, but probably larger one. Whether or not this is a beneficial tradeoff depends on an evaluation of the expected cost of the negative event. There are reasons to believe that a risk-averse agent will over estimate those costs. This raises the intriguing possibility that quality learning may actually result in a decrease in performance.

What Was Not Done:

The absence of certain behaviors may be as significant as the presence of others, but is harder to observe. The focus on cognition made it obvious that many potential knowledge sources were not being consulted. The boundary tended to align with cognition in the sense that people did not look for solutions that they did not know existed. It is not clear that this is truly a cognitive limit, or just a result of the "budget" of time and energy that the team could allocate to search efforts. It is probably a little of both.

As a corollary to this observation, it became clear after a while that the company's cumulative experience in manufacturing these products was not contributing in any positive way to the search for improvements. This is contrary to the idea of learning from experience. Where experience did come into play was in the knowledge of things that would not work – thus making the search efforts more efficient.

Management Influence:

A final, interesting observation that was not anticipated by the research protocol was the line of questioning by senior management during the presentation of the project results. The priority of the questions seemed to mirror the priority that the team attached to various potential action items. For example, the team seemed to give a high priority to safety and ergonomic improvements, and the questioning suggested a similar priority on the part of management. This raises a question of whether there is a causal relationship between the two, and if so, in what direction.

Transcript of Events (Marginal notes are italicized and indented):

Day 1: 7:00 - 3:30

Participants: Facilitator (also mfg eng.) ("FAC")

Outside facilitator (OS)

Researcher

Tooling expert ("TE")

Assembly worker (in affected area) ("AW")

Setup specialist (in affected area) ("SS")

Warehouse supervisor ("WS")

Tool and Die specialist ("DM")

Quality rep. ("QR")

FAC: intro to Kaizen, key points:

- Kaizen events run in parallel with VA/VE and other CI initiatives
- "Creativity before capital"
- "Quick and crude better than slow and elegant"
- Intended that participants should learn from events and apply learning to other areas.
- Typical goals: floor space reduction, labor reduction, reduction in distance traveled, innovation, set up time reduction, safety improvements
- Point from training material: Kaizen is intended to be data-driven

Specific goals for this event:

- 50% reduction in setup time

- 4 safety/ergo improvements
- 1 poke-yoke implementation
- Plus: investigate elimination of repacking of parts after bright-dip for retesting (external to the actual brazing operation).
    - *In retrospect, the choice of goals was a fairly critical step. Officially, this was billed as a setup reduction event, with the other objectives seemingly thrown in. It is not clear that the team felt that way; in many instances they seemed content to pursue any process improvement that suggested itself. The term "setup reduction" tended to be used among the group to identify the event in a general way, but there was no good read on the relative priorities in the minds of the individual participants. This emerged as an interesting issue as the event progressed and prioritizations were made. Suggests that in future studies there should be some questioning about the source of the objectives, and perhaps a straw poll of the participants' priorities at the beginning.*

- Showed video of die change reduction efforts at another company (not part of the parent corporation) that used a strong analogy to racing pit crews. Ended with a sense that die change reduction had become an end in itself.
    - *This last point made the video a little counterproductive – it seemed that the participants (in the video) had lost sight of the real reason for their efforts. Ultimately, this was an issue for our*

group – how to make improvements in a way that was coherent with the operating philosophy of the plant.

- Also showed video of process flow analysis at Mercury Marine.
  - *This video had no obvious relevance to setup reduction – major takeaway was the prevalence of wasted transportation in the process. Not clear whether the video shaped the mental models of the participants one way or another, but it does raise the general issue of framing of the problem: to what extent does the facilitator influence the outcome of the event by the choice of introductory material?*

Illustrative stories told (during training phase, team members used these to amplify on the points being raised:

- *There was a distinct story-telling mode that emerged here, and re-appeared throughout the event as members tried to make sense of certain issues. There were two phases that appeared in sequence, although they overlapped. The first phase was external stories where participants seemed to be trying to do three things:*
  - *Show themselves to be knowledgeable and credible resources*
  - *Import ideas that are fixed in their minds, with the intent that these might be useful and relevant to the group*
  - *Test their own (and the group's) understanding of the concepts involved using examples that are not too close to home.*

- *The second phase of story telling was stories about "how we do things around here". The purpose of this phase was less clear, but seemed to involve the following:*
  - *Highlight the organizational values and constraints that would impact the project, but do so in a non-confrontational way (also a way of educating the inexperienced team members).*
  - *Test the commitment of the team members to these values and constraints to develop a shared sense of where the team will and will not go to generate solutions*

- TE: example of Toyota downsizing machines to match production volumes, contrast to own process (keep running excess capacity).
- FAC: story of how synchronizing a sub-assembly production to line speed, to reduce WIP, exposed other flaws in the system.
- WS suggested that the idea of using more setups, smaller runs could be extended to incoming materials.
- WS noted problems with the use of efficiency as a key metric: leads to ignoring forecasts and over-producing. This opened discussion on cultural issues; many agreed that there was a problem of performance measurement, but there did not seem to be anyone with the will or ability to challenge the culture.
  - *This appears to be evidence of a dominant logic or belief within the organization that is not necessarily universally shared, but influences behavior in a strong way*

- WS also noted that this led to push processing
- WS, during discussion on 5S, noted need to standardize packaging of incoming material to be able to organize work spaces.
- OS told story of die changes at Ford: preheating of injection molds to speed ramp up.
- OS noted the use of the built-in air jacks on the race cars in the video, led to short discussion of racing practices to speed pit stops (vent lines, brake pad retractors, # of workers involved).

- Assessment: group generally accepted the proposition that reduced setup time was a good thing, but not everyone believed that the company would be able to use the benefits appropriately. SS acknowledged upfront that he was instilled with a culture of high "efficiency", long runs and maximum uptime. There was a delicate balance, since anything the group came up with could be construed as a criticism of his work practices. The group trod carefully around this issue for the whole event.
  - *This last point is fairly key. The story telling process brought out the picture of a company that didn't really embrace the concept of "lean" and one that was not going to be able to make full use of the benefits of setup time reduction. This set up a (very muted) conflict that persisted throughout the event. On the one hand, there was the mission orientation that focused on the goal of reducing setups and wanted to leave no stone unturned. On the other hand, there was a more pragmatic view wherein "hot swaps" were never going to be part*

of the company's operations, with most setups being done on off shifts. In this view, reducing the amount of work in a setup is still a good thing, but solutions that would reduce setup duration by moving tasks "offline" without actually reducing the amount of work are not interesting. At various points in the process it was possible to feel the tension between these views. In the end, the official view prevailed in terms of the results presented, but there were a number of the proposals that the team knew were probably not going to get implemented, and no mechanism was put in place to ensure that they would. See the overall comments about the event.

<u>Review of Existing Process:</u>

- Reviewing assembled data prior to visiting plant floor revealed some uncertainty about what part numbers were active and what the volumes really were.

  - *Even though the group had supposedly complete data on part numbers, forecasts and historical production totals, the data were somewhat equivocal and were devoid of some contextual information. To get the answers we wanted, we needed someone familiar with production to tell us: "there are three main families of parts needing major setups; we cycle through the minor setups for the individual part numbers. The volume splits are about 40/40/20 – you don't see that from the data because this family was introduced late this year and those other part numbers are obsolete now...." There was more in this vein, but the point is that the* *group needed an interpretation of the data, not the data itself. The most efficient way to get that was to ask someone who knew.*

- Team spent about a half hour observing the production process in operation and poking around the equipment.
- On returning to the conference room, the team created the following list of issues with the process (in no particular order):
  - Mounting of fixtures could be made easier to change
  - Front guard too high for operator
  - Operator was boxed in by parts
  - Need for some sort of remote control to operate machine from rear
  - Layer separators in baskets - heavy and in poor condition
  - Different parts baskets at different heights
  - Guards had to be open to allow airflow, didn't act as guards
  - Restricted access around equipment
  - Cooling water flows back onto table, carrying flux residue
  - Loose tools scattered around inside equipment
  - Brazing table too high for operator
  - Parts did not always release easily - some discussion about this, some thought this was a problem with uneven cooling, while others thought that some of the fixtures were damaged.
  - Steam blows back at operator
  - Need key switch for gas mixture switch
  - Adjustments on fluxers too complicated (many fasteners)

- Could move fluxers one station closer to operator (reduce heat problems and need for keeping guard door open)
- Solder feed mechanism could be turned vertical to improve routing of lines.
- General housekeeping issues, clutter
- Anti-freeze leakage from air cylinders with explosive results.
- Drums of acid flux in un-contained area
- No clear identification of rejects
- Broken enclosure door
- Soldering mechanism is “a mess”

o AW and SS drew their issue list from past experience and made no new observations during this exercise. The rest of the team had no accumulated experience; comments were based strictly on observation.

Video of Changeover operation:

The team didn’t have the opportunity to watch a setup “live”, but watched a video of SS doing a changeover. Detailed discussion of this video was deferred until Day 2, but some issues emerged:

- Setups are clearly the personal domain of SS; attempts to reduce setup time will need to be managed in that light. There was a certain resistance to simplifying or standardizing the work. Apparently, the process had evolved to its present state to deal with problems that could come up, but would not necessarily be anticipated by an inexperienced group such as ours. “We tried that before” was heard more than once.

- All of the adjustments (burner positions, flux position and amount, solder position and amount, etc) have major components of tacit knowledge. The specialist knows intuitively how to get them right or close to it, but cannot easily explain how this is done. There are multiple combinations of settings that will work acceptably. SS commented that his counterpart on the night shift who also did setups would do things differently (but obviously in ways that still worked). This presents a barrier to standardizing the process or to speeding it up.
    - *The setup recipe seems to be the only real example of tacit knowledge in the process. Had the team been able to capture this knowledge in a setup procedure or a fixture, it would have represented a transformation (per Nonaka) of tacit to explicit knowledge. In the end, this did not happen: the team spent a good deal of time thinking about it, but in the end, there was some combination of inability and unwillingness on the part of SS to support this. Also, the team couldn't think of any way in which doing so would speed up the changeover process, relative to the "by eye" procedure currently being used. Allowing the continued use of tacit knowledge has both advantages and disadvantages. As already noted, it is fast and cheap. On the other hand, it introduces variance, as between shifts. There is also a suspicion that if the knowledge were captured completely, it would be possible to optimize somewhat on use of flux, solder and gas. There was no enthusiasm on the part of the team for pursuing this line of investigation.*

Day 2 - 7:00 - 7:00

Finished watching setup video. SS stated that fine tuning was always required - this was primarily with respect to burner location, but apparently applied to fluxer and solderer settings too. In fact, watching the operation suggested that the basic setup procedure was to get the settings close on a first pass, knowing that they could be fine-tuned fairly easily and quickly when the heated parts gave a visual indication of the correctness of the settings.

Brainstorming on material handling issues - highlighted distinction between direct and indirect labor costs. Comment by WS re: an additional indirect person reinforced issue. Clear that the accounting for different types of labor does not give a clear picture of the cost of setups and may lead to bad decisions.

SS - discussion of burner adjustments, described it as a balancing act between heat-up and fluxing times. He functions as a walking "expert system" and was unable to be too specific about how he arrives at a correct setup.

Brainstorming of quick-attach fixture design. Issue came more from observation of time spent cleaning mounting positions than from the speed of fixture attachment itself. SS explained that the extensive cleaning was needed because otherwise flux residue (or other debris) could cause the fixtures to not seat properly, resulting in uneven heating or misapplication of flux or solder. The goal was to make the mounting features less sensitive to contamination from flux residue, hence proposal to use studs instead of holes. Idea of TE (stud and 1/4 turn nut) was adopted with little debate. Experience applied was generic in nature, not company specific. Much discussion on details of fasteners, back and forth between DM and rest of team. TE went to get industrial equipment catalog to illustrate idea.

- *Note here that the specific facts (knowledge) needed to design the revised mounting system were contained in the catalog, however, TE didn't search randomly through catalogs to find something that would work – clearly he had a partial image in his mind; enough to go find the rest of the details. This is a recurrent theme: the remembered image that somehow "fits" to the problem and contains enough detail to allow reconstruction of the key elements.*

FAC referred to report of a similar Kaizen at a sister plant to see what they had done (but did not share this report with the group). Found that they used dual sets of burners for 4" and 8" parts to avoid changeovers and raised this as a suggestion. This stimulated discussion about the benefits of the idea. SS was knowledgeable about the specific burner components and felt it might be feasible: action item to check.

- *This other Kaizen event report highlighted the difficulties in transferring "best practices". Even though the other plant produced nominally the same parts on a very similar piece of equipment, the team found the results in the report to be relatively hard to use. Part of the problem is that the report contained the results, but not the learning process, so the team members had to "get inside" the process before they could assess* *the results. Once they did so, they tended to have their own interpretation of the situation, so it was still hard for them to accept outside ideas.*

Brainstorming on improvements to fluxer adjustment mechanisms. DM proposed a revised mounting design - accepted with little debate.

- *It is interesting to consider why this idea was accepted so readily. DM had a certain degree of status as an opinion leader, but this doesn't seem to have silenced critics in other situations. Clearly, no one thought they had a better idea. It seemed to boil down to this: DM was perceived to be competent in the area he was discussing, (even if no one else quite understood what he was proposing), and more importantly, he was offering to assume responsibility for getting it done, making it a non-issue to other participants.*

SS suggested that fixtures for <rb> assembly be redesigned to reposition part for maximum commonality with other parts, particularly so the same burners could be used without replacement. Idea thought to be good, investigation begun. In retrospect, this was probably the most innovative suggestion for setup time reduction; appears to have been stimulated by the discussion on dual sets of burners. Clear that his specific experience allowed him to form a mental picture of the operation (one that the team did not observe) in order to apply lessons from other areas.

- *This is an example of knowledge creation that is very hard to classify, yet proves to be critically important. It is not really meaningful to talk about this as a transformation or movement of knowledge. Certain pieces of* *knowledge may have come together as triggers, but there is still the element of synthesis involved. Likewise, it can be considered to be a form of bottom-up processing of factual data on hand, but there is still the role of these imported triggers. The best explanation for now seems to be that the importation of certain knowledge in narrative form broke some sort of paradigm and allowed for more effective bottom-up processing.*

Ideas prioritized and assigned to champions for investigation/implementation.

Key activities:

1. <rb> assembly fixture redesign - investigation showed that fixtures could be repositioned with adapter blocks, no downtime. Material ordered.
2. Fixture mounting to table - downtime required to implement, prototype to be built, parts and material ordered.
3. Indexer button at rear of machine
4. Controls to cycle fluxer and solderer. This and above: consulted with in-house electrical expert, found to be easily feasible ($25 worth of key parts).
5. Use of fixed, dual burners - of 20 burners on end bodies that needed to be changed between 4" and 8" parts, 10 could be made dual, leaving 10 to be adjusted. (These last 10 are the easiest to adjust.) Estimated cost about $600 for parts, some of which will come out of backup stock. Estimated setup savings about 2 minutes. SS thought that there might be a legal problem with idle burners - consulted outside source (a contractor?) and determined it was OK

- *This last point is another example of needing not the facts, but the interpretation of the facts. This is much more effectively handled by asking someone who has the interpretation than by looking things up in the book.*

6. Modify mounting of fluxer for easier adjustment. After investigation, DM's idea was scrapped for a simpler alternative (by him).
7. Tool and fixture organization - changes largely resisted by SS, didn't see much benefit, but agreed to make efforts in this direction
8. Improve cleaning water hoses - underway
9. Rotate solder feeder by 90 deg. Deemed to be feasible, sketching of brackets begun.
10. Heat shield for flux lines (to allow closing door)
11. Modify front guard for easier access - done
12. Parts presentation improvement - 3-person brainstorm on alternatives. OS described a part presentation table observed elsewhere with sloping top and chute underneath for disposal of empty cartons - this was accepted as a basic operating principle. One alternative mocked up and tried for 31 parts by AW, found to be acceptable. Set up left in place for evaluation by night shift operators.

- *This was the only real example of a classical learning curve that was observed. A new configuration was tried, but it was obvious that it wasn't going to be better right away. In this case it took the operator about 30 repetitions to become adapted to the new routine. Consistent with the literature that "autonomous" learning plays out pretty quickly.*

13. Investigate removing glass panels in doors to allow them to be closed while allowing some airflow.

- *Running with doors open was a "routine" that had been adopted to forestall problems with excessive heat build up in cabinet. While this routine did not have any productivity penalty, it did bypass an intended safety feature. The learning in this case was to revise this routine through better attention to the root cause of the problem.*

14. Move guard rails and basket storage to make more room around machine for working. - underway
15. Revise water cooling system - SS replicated a system used elsewhere in plant (plastic bucket with perforations).

- *This is the best example in this case of explicit to explicit knowledge transformation. Even so, the concept was not imported unchanged. Rather, a core idea was adapted on the basis of local realities and seemed to involve an understanding of how the idea worked and under what conditions.*

16. Key switch for gas mixture - reviewed, is feasible, will be done
17. Relocation of flux barrels (safety) - done

Day 3: 7:00 - 4:00

Day spent primarily in individual efforts as each mini-team attempted to complete their tasks. Activities compared to checklist. The team realized that little progress could be made on the re-packing issue since little was known about the types and frequency of defects. QR undertook to create a defect tracking sheet to capture one month's data. Encountered resistance from production supervisor who didn't want operators taking any extra time to record defects. Eventually reached a compromise with supervisor and union reps to allow operators to use a version of the tracking sheet as their time card on a temporary basis. No action to be taken until data is collected.

A number of the ideas were found to be flawed in some way:

- New burners could only be used for half of the ones that needed to be changed
- Initial idea for fluxer mounting was dropped and replaced with another concept (this was done by DM who had proposed the original ideal and taken responsibility to make it work).
- Heat shield idea for fluxer lines was dropped, then reinstated
- Parts presentation table was an improvement for operator, but created problems with lift height for re-stocking - refinement of idea ongoing
- Windows in doors could not simply be removed (safety issue) - eventually replaced with SS mesh (cut from obsolete parts baskets that were being converted to fixture storage).
- Fixture storage ideas mostly abandoned in favor of cutting down some existing baskets found on the floor (see above)
- Dual control found to be somewhat more complicated than first thought but still feasible

The group re-convened to assess the impact of the changes on setup time. The timed list of steps taken from the setup video was used as a baseline. The validity check on the adjustment (elimination or time change) for each step was this: did it seem reasonable, and did SS agree that it was valid? No actual experiments were carried out. The idea of a tracking sheet to record changeover times surfaced briefly, but the group had no enthusiasm for pursuing it.

Final tally: 49% setup time reduction, 7 safety/ergo improvements, 1 poke-yoke and data tracking set up to investigate the repack issue.

Day 4: 7:00 - 1:00

Morning spent putting finishing touches on some items and preparing the presentation to management. This included a rehearsal of the presentation by all hands.

Results presented to senior management team.

Key observations here were the questions/comments of the management team:

- Noted that 50% reduction of setup time was a BHAG, and complimented team. No challenges were made to the results, method of calculation etc.
- Most comments (favorable) revolved around the safety/ergo improvements:
    - *Key question: was this just a reaction to what the team presented (the only objective that was exceeded), or is it reflective of management priorities that influenced what the team actually worked on?*

- *This is an area that needs more study. A good first step would be to better understand the origin of the project objectives and the basis for prioritization (see introduction). A key question is whether management values are transmitted in a tacit way to the team members in such a way as to influence their choices about priority. This can be thought of as another body of tacit knowledge influencing the project outcome. Even if not all team members share this body of knowledge about "how things are done around here", through prolonged interaction, they will probably arrive at a sort of consensus. (a tacit to tacit transformation or socialization per Nonaka, 1994).*

APPENDIX III

Kaizen Event #2 – March 14 – 18, 2005

Introduction:

The company being studied in this case is a manufacturer of mechanical equipment that is sold to both contractors and home owners. The company is a standalone and has no sister operations. The product line is technically unsophisticated and margins are low. The lack of sophistication is indicated by the fact that the company maintains no design staff as such. All design work is contracted out as needed. The major customers are Lowe's and Home Depot, contributing to the pressure on margins. An opportunity existed for a major new program with one of these customers, but it was known that it would require a very competitive bid. The market for the products is generally stable, with no major changes expected. All of these indicators suggest a continuing pressure on cost efficiency.

The workforce is largely transient in the sense of being hired through contracting agencies. Turnover is very high and many of the workers speak very little English. Multiple languages are spoken on the shop floor, so it is not a given that the workers can communicate with each other either. There is a clear distinction between employees and contract workers, even though they may work side by side. Other than readily transportable skills like welding, the company makes an effort to retain employees with specific knowledge. It was interesting to note that corporate policy on Kaizen events is to make a commitment that no one will be let go if their job is eliminated as a result of the event. In this case, that commitment was not made, ostensibly because of the fluid nature of the contracted workforce. This may have reduced the inputs from the assembly workers.

The operation being studied was an assembly cell that produced frames from steel stock through cutting, bending and welding. The cell had been the subject of a Kaizen event within the last year, aimed at improving the workflow, so no major improvements were expected in that respect. The issue of concern was the lumpy production schedule, resulting in high levels of work in process (WIP) and inefficient use of labor. This was a classic theory of constraints situation where the cell fed a bottleneck operation, but was pushing product.

The project team consisted of seven members including the outside facilitator and the researcher. The Director of Operations was part of the team as were three assembly workers (not from the area under study). This created a clear power differential in the group and may have suppressed innovation to a degree. Of the three assembly workers, two were contract employees and one was not. None of the three spoke English to any useful degree.

The Kaizen event successfully drew attention to the root cause of the problem and proposed a solution. Full implementation of the solution was beyond the scope of the event and it is not known if this is being pursued. Some minor improvements were also made to the production cell itself.

Review of Field Notes In the Context of the Research Protocol:

Knowledge Classified As Being Explicit Or Tacit:

Numerous small examples of tacit knowledge were observed in the production process, the most important probably being in the tube bending area (how to tweak the result to get it to fit). These really did not impact the changes that the team made, or vice versa.

As noted in the previous case, there is a second form of tacit knowledge that resides in the organization and that is the knowledge of the "right" way to do things. As with many organizations, the "right" way seemed to involve large batches to maximize efficiency and generous use of buffer stock to avoid shutdowns. This philosophy came out in the question and answer session at the end of the project, but during the team's work, one of the assembly workers expressed concerns about having enough buffer inventory. This is a predictable view from an hourly employee in a push system.

From the action lists, fourteen examples of explicit results of learning were noted, with varying degrees of significance in the overall picture.

Transformations Of Knowledge Within And Between Explicit And Tacit

The only observed form of tacit knowledge that was relevant to the Kaizen event was the knowledge or sense of "how to run the plant". No changes or transformations were observed that involved this knowledge, but it is possible that the event itself began a process of transformation. By forcing the Plant Foreman to articulate some of this knowledge, it is possible that a debate could be started that might result in some transformation, either to an explicit form or to another form of tacit knowledge.

Of the fourteen noted instances that resulted in some form of explicit knowledge being put in place, eight had some sort of clear antecedent. These were not directly observable, but it could be inferred that the participants involved in them were importing an idea that they had seen elsewhere, relatively unchanged. This importing involved varying degrees of abstraction. Some ideas, like the use of the wire tie gun, were simple repetitions of something seen before. Others, like the pull schedule for welded frames were applications of principles that had been internalized to some extent – in this case by the outside facilitator. The former might be described as an example of explicit to explicit transformation, while the latter could be seen as a tacit to explicit transformation. It is difficult to say where one mode ends and the other starts, and it is even more difficult to see any value in the distinction. It seems fairer to say that every result representing some form of organizational knowledge involved both tacit and explicit antecedents, in varying proportion. The six items for which clear antecedents were not visible were all apparently examples of learning by "rearranging pieces of the puzzle", which is hard to classify as a transformation. The processing model (below) is a more descriptive tool in these cases.

Knowledge Classified By Location

From the point of view of getting or placing knowledge in some location, there were three main "bins". The most-consulted form of knowledge was what individuals carried around in their heads. The first reaction was almost always to dig into one's own memory or to ask somebody. Whether appropriately or not, this method has the advantage of filtering out unnecessary detail and adding an interpretive layer. As in Case I, it wasn't the specific knowledge itself that was so important, but rather the meta-knowledge. The team member had to know that a certain type of solution probably existed, and they had to know who to ask or where to look it up.

The second source of knowledge was the process as it was currently implemented. The main value-adding steps were generally clear enough, but there were also a myriad of small time-saving details in the process, as well as non-value adding steps that were there for the purpose of avoiding certain types of trouble. These last often became obvious when the team proposed elimination of apparent waste but was then informed about the reason for the practice. This embedded knowledge effectively served as an additional set of constraints on the improvement process.

The final source was the collected documentation about the process and the production schedule. Most of the actual process documentation came from a previous Kaizen event and a value stream mapping exercise. As noted in the transcript, the earlier report was not shared with the team, only consulted by FAC. As also noted, the documentary evidence was only useful to a point, and usually had to be augmented by the interpretation of a knowledgeable person.

The hierarchy of preference was clear. People first scan their own memories for either a solution or a pointer to where a solution might be found. The latter alternative often led to consulting others who might have relevant expertise.

Presumably this also led to actually looking something up (documentary evidence). This was observed on a couple of occasions (looking something up in a catalog or consulting a production schedule). This was the source of some of the simple, explicit details, but anything that involved fundamental principles, such as the re-scheduling of the paint oven, depended on personal memories.

Actions By Individuals To Retrieve Or Store Knowledge By Location

Retrieval of knowledge appeared to follow the previously-observed hierarchy: search one's own memory, ask someone, look at the process, and as a last resort, look up archival information. The disadvantages of the last two sources were apparent in this case as the team was repeatedly frustrated in trying to use them. The problem was essentially that it was difficult to get the whole story, and difficult to sort the relevant from the irrelevant. Consulting individual memory (one's own or someone else's) provides a sense of context and completeness that allows for more confidence.

Storage of knowledge was typical. The processes were changed in certain ways, and that stood as the record of whatever learning took place. The participants walked away from the event with whatever they remembered. No one took any notes or documented any form of why things were done.

Processing Of Knowledge And/Or Information By Individuals (Narrative Versus Paradigmatic)

The majority of the effort and activity observed in this particular case was the bottom-up kind of processing as the team members struggled to rearrange the pieces of the puzzle in a logical way. In this case there was very little evidence of the importation of more abstract principles and concepts that would lead to top-down analysis.

It is not always easy to tell which mode is operating. For example, one of the key outcomes of the event was a different schedule for the paint line. On the face of it, this looks like the outcome of bottom-up analysis, but RES made the comment very early in the process that this problem looked like more of a paint line scheduling problem than a weld booth rearrangement problem. Was this observation accepted at face value, did it influence the search process for new solutions, or was it just coincidental? The observations don't give us a clear answer to this, but there does appear to be a level of interaction between the narrative and the analytical modes of processing.

When viewed through the lens of tacit and explicit knowledge and their transformations, it seemed to be the case that there was no such thing as a pure explicit to explicit transformation – there was always a tacit component. Looking now through the lens of narrative versus paradigmatic processing, it seems that any learning outcome involved elements of both, albeit in varying proportions. All fourteen instances of knowledge implementation involved some synthesis of the facts at hand (paradigmatic processing) combined with some organizing principle imported in narrative (not strictly factual) form.

Individual Cognition (As In Pre-Existing State Of Knowledge)

In this case, some severe cognitive limits were observed on the part of individual team members, because of language and potentially cultural barriers. This hampered the working of the team, but was not fatal. As long as there was some core set of members with the necessary skills, the work could progress. An individual who lacked the cognitive base could be educated, or simply bypassed.

That said, there was still an issue with the adoption of lean manufacturing principles. In the presentation, the Plant Foreman showed that he understood the principles well enough; he just didn't believe that they were the best way to run a plant, given their particular circumstances. There were no obvious cognitive barriers to implementation of lean production techniques. The problem was that there was an existing model of how to best run the plant, and until that model could be shown to be wrong, no alternative would be adopted.

Power And/Or Knowledge As Moderators Of Group Activity

Power relationships probably had a significant effect on the behavior observed. As noted in the transcript, the operators likely saw themselves as lower-level players based on their employment status and language barriers. It is not surprising that they would say as little as possible. In a similar vein, QC was relatively new on the job and was also unlikely to challenge anything or anyone. All of the inside team members tended to defer to DIR. This imbalance made a much weaker team than might otherwise have been the case, and likely reduced the amount of learning that took place. As with the previous cases, there was no reason to believe that this effect changed the basic mechanism by which learning took place.

Shared Logics Of Action (Existence Of And Changes To)

As with the previous case, it is the higher-level logics that are interesting. There was clearly a prevailing logic through this plant that emphasized batch mode production and large buffer stocks. This appears to have been the result of each area trying to optimize its performance locally rather than any sort of plant-wide policy. This may also have been driven by the high priority placed by the GM on productivity. While he apparently believed that lean principles would lead to productivity gains; that belief had not permeated the organization.

Often, this is the result of a performance measurement system that measures productivity at each activity level – forcing the local optimization. Questioning revealed that performance measurement at the work area level was, in fact, productivity-based. Given this, large batch "efficient" production is in fact the best way to run an area. No change was observed in the dominant logic during, or as a result of this event.

Changes To Performative Aspects Of Routines

Changes to the outward or performative aspects of work routines were an important part of this and all Kaizen events. As noted above, fourteen instances of changes to routines were noted. These could be grouped into three major areas. The first was the layout of the equipment to streamline the work flow. The effect of this was not quantified, but should result in some productivity gains.

The second change was to introduce a standard work process into the machining steps using small transfer batches as a way to approach one piece flow. During initial trials, this did not result in increased productivity, but a certain amount of autonomous learning had to take place before that determination could be made. It was unknown whether this change would be sustained.

The third change was to the scheduling of the paint line, where batch sizes were to be reduced from a day's demand to an hour's. If implemented, this will reduce work in process substantially. Again, it was unknown as of the close of the event whether this change would be fully implemented and sustained.

Changes In Situated Performance

As suggested by the previous section, no verification of improvement was obtained during the course of the event, so it is necessary to rely on the projections of the team for improved productivity and reduced work-in-process. This case is similar to the first; the tools for improvement were implemented, but unless there is a corresponding shift in the shared logic of action (to run the plant more according to lean principles) it is unlikely that the full benefits will be realized or sustained.

Observations From the Field Notes In Addition to the Research Protocol:

Some observations were made that were not specifically anticipated by the research protocol, but were considered interesting in the context of the research question. These are noted for comparison to other cases.

Story-Telling:

It was noted in Case I that a story-telling phase occurred as the team started to come to grips with the problem. In this case, attempts were made by a couple of participants to start such session, but it was not picked up by the others and it died out fairly quickly. This seemed to be in some way reflective of the problems of team dynamics that persisted throughout the event.

Evidence of Autonomous Learning:

As with the first case, there were opportunities to observe autonomous learning when revised procedures were tried out. Three specific instances were observed; one was the increased changeover frequency on the paint line and the other two were in the machining area where small batch processing was implemented. In the case of the paint line, four changeovers were performed in a four hour period, which the operators felt was sufficient to establish the routine. In the case of the machining operations, approximately five batches were run of each process. This was not enough to achieve the best possible results, but was felt by the operators to be close enough for evaluation purposes.

It was clear that the operators would have little tolerance for routines that would require more than one shift to optimize. This reinforces the finding that autonomous learning by doing is a short term phenomenon, at least in a high volume manufacturing context. This form of learning curve is best seen in the reverse sense; as a period of inefficiency following the implementation of a supposedly improved routine.

Evidence of Reactive Learning:

In the analysis of the process flow for standard work determination, a number of non value adding steps were observed. Actually, they were seen during informal observations; when the operators knew they were being timed, they tended to omit these steps. Specific examples were a slug clearing step in a hole drilling process and two different deburring operations. None of these steps were strictly necessary; rather they prevented potential problems in later operations. They had apparently been instituted by the operators, which perhaps explains why they tended to be omitted when the operators felt they were being watched.

The interesting question is whether these were cost-effective solutions to the problems. It did not appear that the operators had the resources to do a root cause analysis, or any cost-benefit analysis. The pattern emerging here is that production processes tend to accumulate an overhead of insurance steps to protect against events that had caused problems in the past but that may, or may not, occur again. This suggests that the role of reactive learning may be indeterminate in its effect on performance.

Management Influence:

While the main stated goal of the project was reduction in work-in-process, the team tended to place more emphasis on productivity issues. This was echoed in comments by the Director of Operations during the event, when he stated that it was really all about labor cost reduction. When the results were presented, the greatest management enthusiasm was for the productivity improvements. There was an equivocal response to the WIP reduction proposals; the General Manager was in favor, but there was some dissension in the management ranks. Some safety and ergonomic improvements were made, but these were not a high priority for the team or for the management audience. Overall, the team seemed to be able to accurately gauge management's priorities.

Transcript of Events (Marginal notes are italicized and indented):

Day 1: 1:00 – 5:00

Defined scope of event: frame assembly cell from cutoff saw to paint line

Project goals: 10% improvement in productivity, reduction of welded frame WIP by 90%, reduce floor space by 10%, implement 3 safety/ergo improvements.

> *Before the event started, the origin of the goals was discussed with FAC (see list of participants below). As far as local management was concerned, the visible presence of WIP after the welding operations was the indicator that improvements were needed, so this was the key objective. The productivity goal was added because this is a key concern at this plant, and even though the work cell had been re-arranged several months earlier, this goal was kept to encourage some stretch. The remaining goals seem to have been added to round out the process and broaden the thinking. It was not specifically stated, but it appeared that the motivation for including them came mostly from Corporate. As a backdrop to the proceedings, it should be pointed out that normal Corporate procedure was to insist that prior to conducting a Kaizen event, the company should issue a statement that no one who was displaced as a result of the event would lose their job. This company had elected not to make such a statement, partly because of their heavy reliance on temporary, contract labor. It is hard to identify exactly what impact this had, but it would suggest a lack of incentive for shop-floor participation.*

Participants:

- Facilitator from Corporate (FAC)
- Researcher (RES)
- Director of Operations (DIR)
- Quality Control representative (QC)
- Operator from large machine assembly area (OP1)
- Operator from cable assembly area (OP2)
- Operator from paint line (OP3)

Notes on participant team: DIR and OP1 had multiple years experience with the company; the others were 1 yr or less. The three operators spoke extremely limited English although DIR stated that they understood most of what was going on. Their inability to communicate severely limited their contributions, and the latter point was never convincingly demonstrated.

> *The severe limitation on communication immediately suggests a very real impact of individual cognitive limits. It appeared that the operators were unable to make much of a contribution because they simply didn't understand what was going on, nor could they articulate any ideas they may have had. There is also the question of whether they were cognitively able to deal with the concepts of lean production, but being unable to penetrate the first layer, this was not relevant. It is important to note that cognitive limits were not the only possible reasons for silence and passive participation. The operators were sitting with their bosses'*

bosses' boss, who could dismiss them easily, especially since two of them were contract employees (see note above). Furthermore, given the company's refusal to adopt the no layoff policy, there was a good chance that the outcome of the event could involve some job losses. While this may not have affected them personally, there was certainly the possibility of repercussions through their plant networks. Whatever the reasons, they could not or would not participate in any meaningful way. This left a very small "team" to accomplish the tasks.

General Manager attended opening session and wrap-up (GM)

GM's opening comments: the stated goals are only guidelines; the team is free to redefine them as appropriate; made a point of emphasizing the competitive environment and the need to stay competitive (i.e.: reduce costs).

In opening remarks, DIR suggested that the prevailing idea was to physically relocate the assembly cell so that the weld booths were adjacent to the paint line so that frames could pass directly from the welder to the line instead of being stacked in batches and carried to the paint line. Clearly this solution anticipated the findings, and he admitted this. He had also done some preliminary investigation of the feasibility of the physical move.

At this point, RES suggested that the controlling factor was not the physical arrangement of the weld booths, but the scheduling of the paint line, which was technically out of scope. It was not clear that any thinking was changed at this point, but this ultimately proved to be the central issue.

RES asked FAC offline about the source of the objectives. Answer was that they came from findings of earlier Kaizen events, problems that were observed (but not necessarily well understood) and from interaction with the corporate facilitating group. It was not explicitly stated, but the impression was that the WIP and productivity goals were mainly from the company, while the safety/ergo and floor space goals probably came mostly from corporate.

Training portion proceeded following the standard manual, thru the Standard Operations section.

Operators were totally silent throughout – not clear at all how much they were getting.

QC would respond to occasional points with stories from his previous job – echoes of the story-telling that occurred in the first case study, but the group dynamics did not support it very well.

> *In the previous event, the story-telling phase was more developed. It appeared that the participants used stories to a) establish their credentials in front of the group, b) test their understanding of the project scope against the expectations of others and c) to introduce ideas that they felt would be helpful. It seemed that QC was attempting to do these things, but didn't get much support. In keeping with their roles, FAC and RES were mostly silent, as were the operators (as previously discussed). DIR participated to a small degree, but the dynamic never developed.*

Showed the Mercury Marine video as example of value stream mapping – led into discussion of waste and non-value added operations. No response from participants.

Showed HP video to introduce lean production concepts – again, no clear response.

Ended day at 5:00

Day 2 – Tuesday, 8:00 – 5:00

Training continued with stop watch exercise for timing standard work.

Operators had some difficulties understanding the precise procedure that was being explained, but seemed to generally get the concept. For this and pretty much all further activities, operators were teamed with a participant who spoke English. Not clear whether this helped or inhibited their expression of ideas.

5-S section of training was presented by DIR.

Close of training was the section on managing Kaizen events – repeat of philosophy of "quick and crude better than slow and elegant" and emphasis on "learning by trying".

> *Not clear at this point that the group was ready, willing or able to tackle the job.*

Event goals were re-stated and some data introduced.

The baseline for welded frame WIP was given as an average of 133 frames, or slightly less than one day's production.

A value stream map was copied and circulated to the team. This had been done about six months earlier and contained information on cycle times for all operations. FAC also had a report from an earlier Kaizen event on this same cell that had more recent cycle time data. This report was not distributed to the team, but FAC consulted it from time to time throughout the event, mostly as a check on the results that were being obtained.

Additional data distributed to team: report of last 12 months production by part number and a summary of staffing and productivity of "shop and weld" area as it was called.

> *The data were helpful to a point, but often failed to correspond to what was observed. It was often necessary to ask for interpretations or explanations from someone "in the know". It turned out that there was much more going on than the basic production numbers would indicate (certain re-work operations, jobs for other production cells, extra steps for product variations that were captured by part numbers, but not noted in the value stream map, etc.). Not clear why FAC did not distribute results of previous Kaizen event (this seems to be standard practice). Presumably, the idea is not to constrain the thinking in the present by what went before. If this is true, it is an interesting commentary on the idea of learning from experience.*

After some discussion of this data, the team went to take a first look at the production area. The team spent about 45 minutes observing the operations as individuals, then came back to the conference room to share what was found:

RES:

- ad hoc batching of parts through shop area
- cramped work area around bender
- makeshift stands for cooling fans using wire carriers
- welding curtains torn or missing
- too much equipment on floor (not in use)
- scheduling of paint line not obvious – impacts our work

OP1:

- nothing

OP2:

- Bender looks hard to use (note: there was a used NC-controlled bender sitting next to the area that was supposedly in the process of being refurbished to replace the manual one in use – didn't appear that any progress was imminent.)

OP3:

- Nothing

QC:

- Loose power cords strung around
- Paint line loading area too spread out

- Frames were being wiped down prior to loading on paint line; why?

DIR:

- Unguarded foot switch on one machine
- Mixed parts in bins
- Unsafe air hose (bulged) and non OSHA approved blow gun
- Loose cords – trip hazards
- Too many boxes of powder at paint line (surplus inventory)
- Carts of defective parts – looked like they had been there a long time
- Fan cords – trip hazard
- Air line trailing across floor behind grinding booth

FAC:

- Parts coming off paint line are too hot to touch
- High volume parts were using 2-pc hangers (two operations to load)
- Cooling after welding
- Layout of machines used for nosepiece production too spread out (forces batching)
- No means for chip clearing or collection at milling machines
- Bent parts need a lot of tweaking after they come off machine

Team deployed in groups to measure standard work operations.

RES paired with OP1 to measure nose piece production and tube bending.

During this process, all teams spent a considerable amount of time observing and talking with the operators.

Of the five primary operators in the area, only one was a native English-speaker. This individual was engaged in the process and had numerous ideas. Because of the language barriers, the team probably relied too much on this person to the exclusion of others who may have had better insights or ideas. Certainly a cognitive barrier.

Returned to the team room to add up the cycle times and compare to existing data.

Biggest discrepancy was in welding – seemed that 2 welders on 1 shift would be adequate to handle production, but staffing is 2/2. DIR said that they were planning to take that down to 2 on first shift, one on second. Called in area supervisor who said that welders could do 45 frames/day, but our cycle time measurements suggested that they could do 45 in 4 hours. This gap was never satisfactorily explained.

There seems to be a recurring gap between what people "know", what is recorded and what is observed. Recorded data is generally hard to interpret, and often wrong or incomplete. Observing is too tedious, so people seem to gravitate to and accept what others "know".

Group discussion (note: "group" does not include the 3 operators who were generally silent throughout) about the true issues and root causes.

Much discussion focused on the cutoff saw – the only operation with significant automatic machine time (about 30 sec. per cycle, each cycle produced 2 parts).

The waiting time during this operation was the only clear-cut example of waste in the process.

Attempted a line rearrangement exercise to streamline motion and reduce space. RES, OP1 and QC were assigned to this task.

RES suggested using paper cutouts as a language-free way to allow the operators to express their ideas. It didn't work very well; there was scant evidence that they even understood what we were trying to do and we got minimal input.

We did get some small efforts from OP1, but observed that he only seemed to conceptualize moving one piece of equipment at a time.

Additional evidence of cognitive limits?

The group struggled with finding an improved layout – prompting QC to ask "Don't you sometimes reach the point where it is as good as it gets?" He also expressed concern with the process – that we were treating people like robots and trying to drive them to maximum production 100% of the time without any allowance for human variability. (On a related note, DIR privately expressed some cynicism to RES about the process; that it was all about head count reduction and nothing else was important.)

These comments suggest a deeper cultural layer of understanding about what we were doing – and disagreements about the rightness of the model. It certainly appeared that QC and DIR were not committed to the sort of productivity goals that GM had in mind.

Broke for the day with very little progress on rearrangement.

Day 3 – Wednesday; 8:00 – 6:00

Resumed team work on rearrangement

Called in one of the more articulate cell operators to get opinions on the layout we were proposing – had no real objections or alternate suggestions.

Discussion moved to feasibility of actually moving the welding booths as originally conceived, particularly with respect to the fume extractors.

Discussed these difficulties with DIR – he decided to call a contractor for an opinion.

Sub-team made one more trip out to the cell for fact-finding, measurements.

Brainstorming session led by QC at easel on rearrangement alternatives.

OP1 started to express some suggestions and ideas, but was very difficult to understand. The English-speaking members of the group made an effort to understand him, but this level of effort could not be sustained for any length of time. (Note: OP1's native language was not the same as that of OP2 and OP3.)

Sense of frustration was building in the team: rearranging things really didn't seem to improve anything.

> *This was entirely bottom-up thinking – there was no evidence of new ideas being introduced from the outside.*

DIR also experiencing frustration – advised that moving weld booths was not feasible on any short-term schedule, contrary to what he believed prior to event. This put the team back to square 1 on rearrangement.

Parallel activity – RES consulted industrial supply catalogs to identify solutions to issues identified on second day and observed during the timing exercise. Parts placed on order with exception of an automated cooling system for one mill (catalog did not have enough information, plus needed to consult with Maintenance first). Also, RES observed an operator on a different line using clumsy, manual operations to tighten and cut off wire ties. Showed DIR the range of guns available in the catalog and agreed to order one to try out.

> *Key to ordering in parts was knowing that solutions to the issues existed, and where solutions would likely be found – example of meta-knowledge.*

RES, QC and OP1 continued brainstorming on rearrangement without getting very far – could not find any examples to import from other areas.

Consulted line workers again for ideas – as ideas were discussed it became clear that the shop area performed many more jobs than was first assumed. The "shop" title was appropriate, because in many ways this was a general purpose machine shop.

> *This started to expose the limitations of documentary knowledge.*

When it became clear that QC and OP1 were not going to come up with any proposals, RES more or less dictated a rearrangement plan. It put the machines in the correct production order and streamlined the flow from one to the other.

There was also potential for a slight floor space reduction which couldn't be fully realized because of some clearance issues. Mostly it was a cosmetic rearrangement.

Went out to plant to start implementing rearrangement (other sub groups were doing the same with some of their improvements).

Saw plenty of evidence of learning by trying – people would rearrange things, try it out, see how it looked, then adjust.

> *This could be called autonomous learning – it just didn't apply to the production process itself.*

Observation: on the plant floor, the operators were much more in their element; if given a clear task to do, they were quite effective and innovative in implementation.

Additional observation: when the team entered and left the conference room, the three operators always used the back door; even though this was not the most direct route to the plant floor (everyone else used the front door!)

> *This could be evidence that power and cultural issues were more important than cognitive ones.*

Broke for the day with most of the physical rearrangement complete.

Day 4, Thursday 8:00 – 5:00

Day was spent primarily finalizing and trying out ideas proposed on previous day. Most work was in small sub-groups.

Additional information was sought from accounting about what parts went through the paint oven. It became clear that the original idea of synchronizing the welders to the paint line could never have worked.

Based on this, a cyclical painting sequence was proposed where the bulk of the day shift would be spent cycling back and forth between the two highest volume parts on an hourly cycle (for WIP reduction). The paint line supervisor came in and discussed the process and agreed to try it out for part of the shift. (This was done and it seemed feasible.)

> *Another example of autonomous learning – in this case roughly 4 changeovers were sufficient to decide that the process was feasible.*

A pair of carts was fabricated to serve as "supermarkets" for welded frames to hold roughly an hour's production.

RES consulted with maintenance person and used internet to research options on automated coolant dispenser for mill – made proposal to be followed up on 30-day list.

The team proposed small batches of nose pieces and cross members as way to approach one-piece flow. Actual batch sizes were 4 for nose pieces and 5 for cross members. Both modes were tested – initially took about twice as long as larger batch processing, but some improvement doubtless possible with practice.

More evidence of autonomous learning. Would guess that it might take a day or two to reach a steady state (roughly: 50 - 100 cycles).

It seemed like every time the team went out into the plant, they saw operations being performed that had not been taken into account. Many of these were small production jobs for parts other than the primary ones we were studying; others were additional steps or rework operations that were not documented. This made it very difficult to propose a standard work regimen. The team was handicapped by not having any member who really knew what went on in this production cell. Most of this sort of information came from one of the production workers, but it came in bits and pieces and the team was never sure when or if they had it all.

Also saw evidence of little details and maintenance type steps that had been omitted during the timing exercise, perhaps because the operators wanted to look better. These included periodic cleaning of chips from the mill, cleaning out the fixtures between each piece and a de-burring step.

The team was left with significant discrepancies in time required. The welding time standards were mentioned before – these were never resolved. The team also felt that, based on what was observed and measured, that all work other than welding could be covered with 2 people on one shift when the actual staffing was 3 on first shift and 1 on second. Eventually proposed 2/1, believing that implementing standard work for the primary parts would allow them to be completed on one shift and one person on the second shift could take care of all the other jobs.

The elements proposed were: cyclical painting schedule, supermarket for welded frames, standard work in shop with small transfer batches. This put in place the major elements of a lean production system where only the painting is scheduled and everything else runs on Kanban signals. What is not clear is whether a true understanding of the concept exists within the operation.

The overall concept was discussed in the full group.

OP3 expressed concern that too much time would be lost in paint changeovers because of the different bake and line speed requirements of the different colors. The supervisor was invited back in to discuss this issue – explained that it was not a big deal since the difference in speeds was not great and didn't hurt to have parts in a little longer than necessary. The result would be a very slight loss in painting capacity, but that is not currently a constraint. There is still the issue of overspray and how much separation needs to be maintained between colors.

OP1 expressed concern that the cyclical painting sequence would cause problems for the assembly area (his work area). He was not able to articulate why this would be, but presumably he was afraid that without a large buffer, they would be in danger of running out.

Day 5 – Friday – 7:30 – 1:00

First few hours spend preparing for the presentation.

To their credit, OP's 1-3 agreed to participate although it was very difficult for them.

The presentation drew relatively few questions.

GM focused primarily on the claimed productivity improvements and head count reductions.

There were no questions about the safety and ergonomic issues, although these were looked at during the tour of the cell.

> *This seems to confirm the company's priorities as discussed at the beginning. It is probable that everyone in the company is well aware of the prioritization that goes on, and will reflect that in their areas. It is probably no accident that the safety/ergo areas seemed to have been largely overlooked in the past.*

The general foreman expressed concern about operating with reduced levels of WIP. He said that he didn't feel comfortable with less than one day's buffer because of the unreliable labor situation. He was never sure who was going to show up and felt that he would be in danger of shutting down production.

The GM responded with the rocks and stream analogy – if the rocks are the problem, don't cover them up by raising the water level; get rid of them. Clearly this issue was far from being settled.

> *This invites a discussion of absorptive capacity; specifically, the ability of the company to absorb and utilize lean production practices. Absorptive capacity is traditionally framed as a cognitive issue, and there were obvious cognitive issues here. It is not clear that cognition is a concept that applies readily to an organization, but individual cognitive limits come*

into play. On reflection, individual cognition did not seem to be a limiting factor – certainly there were individuals who didn't understand the concept or significance of lean production, but those individuals could be educated, replaced or bypassed. The issue seemed to be at a deeper, cultural level. There was a prevailing "justified belief" about how the operation should be run, per the foreman's reaction. The ability of the company to "absorb" lean production depended on its ability to displace an existing paradigm. The more widely shared the paradigm, and the more tacit it is (as in not being articulated), the more difficult this will be. This suggests that organizational cognition can be viewed as a cultural phenomenon.

Reflections on what is being left behind in this process:

Hard details (artifacts):

- Revised machine layout
- Supermarket tables for welded frames
- New air vise and fixture on a drill press
- Prototype of revised frame hanger for paint line
- Cooling fan for parts coming out of paint oven
- "Sanitized" work area (loose cords tied up, new floor mats, new blow guns, torn welding curtains replaced, etc.)
- Self-ejecting chuck key
- Quarter turn knob on tumbler
- Wire tie gun in use

Soft details (documentation, but no implementation)

- Proposal for smoothed production plan in painting
- Proposal for pull system for welded frames
- Proposal for small batch flow in shop
- Proposal for automated coolant dispenser
- Revised staffing schedule for shop, based on standard work

Abstract details (ideas, concepts)

- General ideas about lean production, pull systems, one-piece flow
- Some person-to-person transfers of ideas (ex: in talking with one of the workers, RES suggested use of an expanding collet to fixture the nose piece which was too big for a conventional collet)

APPENDIX IV

Kaizen Event #3 – June 27 – July 1, 2005

Introduction:

The plant in which this case is set is a North American manufacturer of plumbing products. It is a sister plant to the one studied in event #1, but has significant differences in its corporate history, reporting structure, employee demographics and in local culture. The business outlook for the company is generally positive, driven by strong growth of the home building and home improvement markets. This growth has been accompanied by consolidation in the customer base, resulting in increased demands for cost reduction and flexibility of delivery. In response to these pressures, local management has embraced a flexible manufacturing strategy with lot sizes of finished goods SKUs as low as one. Continuous improvement is a high priority within the plant as evidenced by the fact that this Kaizen event was #64 for the facility.

The workforce in the plant is drawn from a rural area and is characterized by high average seniority. Industrial experience in other facilities is rare, as is post-secondary education (at least within the event team, but apparently this is true of the plant in general). The plant is not unionized, and the work environment appears to be reasonably cooperative.

The work area that was the subject of this event was a packing line where end-item SKUs are packed for shipment to the customer. Approximately 15 items go into a box to form the final SKU. The packing line is synchronized to the output of a "racetrack" production line that produces a family of core valve components around which the final product variants are built. As a result of the diversity of product, it is normal to change end-item SKU as often as 90 times per shift; each change requiring a shuffling of components to and from the line. It was the difficulties created by this situation that the event set out to address.

The event was undertaken without specific metrics or numerical targets; success was measured by visual reduction in clutter, operator testimonials that things were improved, and it was expected that longer term (month to month) improvements would be seen in quality costs. In this respect, this event was unlike the previous cases where specific improvement targets were identified. This event was much more a case of purposive experimentation, an element of the Toyota production system as described by Spear & Bowen, 1999. The prevailing philosophy seems to be to use Kaizen events as a way to introduce a controlled amount of variation into an otherwise rigid system so that the better ideas can be retained. Failures to improve the process at hand are not necessarily viewed as failures of the philosophy. The fact that this was event #64 in this plant supports this view.

Review of Field Notes In the Context of the Research Protocol:

Knowledge Classified As Being Explicit Or Tacit:

Two types of tacit knowledge were visible in this case. The clearest example was the process used by the team leaders to optimize their production schedules. They used similar heuristics to do this, but appear to have arrived at their present level of knowledge independently. In a simple test aimed at making the process explicit, they did not come up with the same results.

The second form of tacit knowledge is more debatable. This was the prevailing philosophy within the plant that flexible production with lot sizes down to one was the correct way to run the business. This rationale was accepted but not shared by several members of the project team. These individuals felt that small lot sizes created more work and trouble than they were worth.

All of the improvements put in place by the team could be classified as explicit forms of organizational knowledge. Seven examples were noted where the process left the work processes in a different (and hopefully improved) state.

Transformations Of Knowledge Within And Between Explicit And Tacit

Some attempt was made during the event to convert tacit knowledge to explicit knowledge by making the decision rules for scheduling more explicit so that the task could be automated. This was not very successful for two reasons: a) even with the simplest decision rule (minimizing component part changes) the production scheduling problem is a large scale example of the traveling salesman problem and is very computationally intensive, and b) the actual decision rules involve a tradeoff between minimizing component changes and spreading them out over time. There is no simple substitution elasticity for these criteria, making this a very complex, non-linear problem.

Another attempt to convert tacit knowledge to explicit was to rearrange the supply shelves to group the component parts by the final assembly "family". On the surface, this may appear to be a fairly simple-minded improvement, but it can also be seen as a transformation of tacit knowledge (the ordering rules for scheduling) to explicit knowledge (the efficient ordering of parts on the shelves).

As with the prior cases, the large majority of the work that was done in this event involved very explicit forms of knowledge, principally the physical arrangement of the work space. None of the seven explicit results had any visible antecedent, with the possible exception of the new packing bench which was generally similar to other designs in use in the plant. The rest were examples of common sense rearrangement of the particular elements present; perhaps guided by some principles observed over time. Trying to analyze these events as transformations is not particularly useful.

Knowledge Classified By Location

It is fairly easy to identify the new knowledge created within this event and to categorize it. Overwhelmingly, it is embedded in the physical layout of the work area – the racks, shelving and assembly fixtures that were modified. There was no documentary record of lessons learned, except perhaps to the extent that the researcher began to document the decision rules for production scheduling for future use. It could be suggested that some lessons learned might reside in the memories of the individuals involved, but there is a difficulty with this view.

The difficulty arises when we try to identify sources of knowledge. No documents or experts were consulted; the source of everything that was done was the collective memory of the participants. This collective memory consisted (as far as could be observed) of what they had seen being used elsewhere, primarily in the same plant. This being the case, it would not be expected that the participants would take away any new knowledge, although the mixing of people from different areas of the plant may have broadened the experience base of some or all of them. This was not observable.

More likely, what was taken away was the experience of what details did not work out quite as planned. This would be consistent with a view that the chief value of experience is in knowing what *not* to do. Overall, attempting to identify sources of knowledge is a frustrating exercise. This is leading to a view that knowledge, at least in the narrow *pragmatic* definition, is not something that one simply gets in one place and applies at another; rather it is something unique that is created *in situ* each time it is needed.

As in previous cases, the preferred source of knowledge was the individuals' own memories. The hierarchy was more pronounced in this case, with very little consultation of others and no observable use of any documentary form.

Actions By Individuals To Retrieve Or Store Knowledge By Location

As mentioned, the storage of the new knowledge is easy to observe – it resides exclusively in the physical arrangement of parts and fixtures. The only documentation observed was a single, back-of-the-envelope sketch of how one of the racks would look.

As with previous cases, the overwhelmingly preferred source of knowledge was the team member's own memory. Occasionally, they would go to look at another line to see how something was done. No outside sources were consulted.

Processing Of Knowledge And/Or Information By Individuals (Narrative Versus Paradigmatic)

Bottom up processing was very evident in this event, and appeared to be the dominant mode of thought. Most of the racks, fixtures, etc. were built with little more than a sketch on the back of an envelope, and there was a great deal of rearranging things until they fitted. That said, this was not random trial and error. There were clearly some organizing principles that were being applied. For example, ergonomic considerations were important in determining the height and angle of the flow racks. In this example, these principles were not expressed in any objective form such as number of inches off the floor, but rather in the form of a mental model of what a "good" rack looked like. This is clearly a narrative or top-down form of processing. As with the previous cases, any implementation of an improved work practice had identifiable elements of both kinds of processing, suggesting that the combination of the two may be a necessary condition for organizational learning, as it is defined in this research.

Individual Cognition (As In Pre-Existing State Of Knowledge)

In the previous cases it was noted that cognition played a role in limiting the scope of search efforts, in the sense that people did not look for things that they did not already know something about. On the surface, that seemed to be the case in this event as well. As described in the overview, most of the participants lacked any post-secondary education, or any industrial experience outside their present company. In part this was a consequence of the plant's small town location, which also dictated that there was very little surrounding industrial infrastructure that could have served as a resource. As a result, it was not surprising that the universe of potential ideas was limited to what existed in the plant.

On the other hand, it should also be pointed out that the preamble to the Kaizen event and the definition of scope and objectives did little or nothing to encourage more speculative search. While search efforts were definitely constrained, it is perhaps not fair to draw the inference that cognitive limits are the causal factor. In the previous event it was also remarked that the cognitive limits of individuals had surprisingly little impact on the ability of the organization as a whole to absorb new ideas that were presented. This situation did not really arise in this case, so there was no additional light to be shed on this issue.

Power And/Or Knowledge As Moderators Of Group Activity

Both organizational and expert power tended to come into play. In this event, one of the facilitators was a production supervisor, and so was nominally higher in rank than the participants. This did not appear to influence the progress of the event in any way. The two shift team leaders from the assembly line were also participants, and their knowledge and experience constituted a source of expert power. Generally speaking there was a tendency to defer to their assessment of the situation and to accept their ideas. This facilitated a certain degree of learning from experience as will be discussed below.

Shared Logics Of Action (Existence Of And Changes To)

A familiar conflict was apparent during the course of this event, the conflict between a "lean" philosophy (characterized by one piece flow) and the "efficiency" model that emphasizes batching and large runs. In this case, the situation was reversed from prior cases: plant management had embraced at least the flexibility aspect of lean and would schedule runs as small as one piece. The performance metrics in place however, still reflected the efficiency paradigm with work cells being judged on parts per labor hour. Those whose perspective on the business was limited to an assembly line (such as the participants in this event) tended to embrace the efficiency model and wanted to see longer runs, at least partly because of the metrics. This caused no particular problems in this event, but the conflict was visible nonetheless. Although there are inconsistencies, and pockets of resistance, the dominant logic of the company appears to be one-piece flow. No changes to this logic were caused or observed during the course of the event.

On a smaller scale, another example was observed. When the team leader for the first shift was presented with the mistake-proofing fixture, it required that he change the direction in which he had his shift assemble the part. This procedure had been implemented for a logical and valid reason. Because the revised procedure also had a clear and valid logic, it was a simple matter for him to weigh the benefits and agree to the change. There was no conflict with the basic beliefs about how parts should be assembled.

Changes To Performative Aspects Of Routines

As with the other cases, the sole output of the event was a revised set of fixtures and processes. What is interesting is the way that this came about. Kaizen events are examples of induced learning more or less by definition since they represent an investment in improvement of the process. Autonomous learning on the other hand has been observed to only occur within work units (typically an individual) that are capable of autonomously generating variation in their work processes to effect a process of artificial selection. This event was unique among those studied so far in that it combined the two. By bringing the two shift team leaders together and encouraging them to experiment as opposed to making a specific improvement, the event allowed the packing line as a whole to make one iteration on a classical trial-and-error learning curve. Furthermore, this was not random trial and error. The experience of the team leaders allowed them to bring their past thinking to bear on the situation. Much of what they did in this event was enacting ideas for improvement that they had been accumulating through observation and analysis.

As such, this is the first example seen where the company has actually been able to learn *from* experience. This connection is still somewhat tenuous since it depends on the experience of the individuals involved rather than the experience of the company. It also requires that those individuals be insightful observers and devote some effort to thinking about how things might be improved. This still does not support the argument that experience causes learning, but it suggests a way that experience might moderate learning in a positive way.

Changes In Situated Performance

This case was somewhat different from the previous two in that there were no specific improvement targets stated at the outset. As a result, there were no metrics used that would define an improvement in performance. The most that can be offered in this case was the visual reduction of clutter in the work area and the testimonials from the operators that the new racks and fixtures were an improvement. This is a somewhat weak argument, but if these issues are considered to be important to the company, then they are sufficient to state that some degree of learning took place.

Observations From the Field Notes In Addition to the Research Protocol:

Some observations were made that were not specifically anticipated by the research protocol, but were considered interesting in the context of the research question. These are noted for comparison to other cases.

Story Telling:

Story telling was present in this case as with the others, but it was much more social in nature and less task oriented. The examples that were task oriented were very focused. This can perhaps be explained by a couple of factors. One is that there was not much sense of task ambiguity at the outset, so there was less pressure to feel out the situation. Another possible explanation is that the participants had a homogeneous industrial background, with little diversity of experience to bring to the table. The task-focused stories tended to be a way that lessons from the past were passed along to the newer team members.

Evidence of Autonomous Learning:

As discussed above, the entire event could be considered as an attempt to promote autonomous learning for a whole work area. This is interesting because it is something that would not otherwise take place. It is the first instance seen of induced variation and selection to simulate autonomous learning.

The typical examples of autonomous learning were seen when the revised procedures were turned over to the regular operators. When the mistake-proof fixture was introduced, one of the team leaders tried it out for a few repetitions and pronounced it acceptable. Both shifts used the new fixtures, and while the learning effects were not observed directly, both shifts reported that they worked satisfactorily. This would suggest that any learning effects were incorporated very quickly.

Evidence of Reactive Learning:

No specific instances of reactive learning were observed in this case. One reason for this might be that the object of the project was a layout more than a process, so less attention was paid to what the operators actually did. Another reason might be that the company had a history of repeated Kaizen events, which may have previously eliminated the more obvious band-aid fixes on the line. If this were actually the case, it would be an interesting commentary on the results of reactive learning.

Transcript of Events:

Day 1: Monday; 11:00 am start:

Present:

FAC1 (Co-facilitator from HR)

FAC2 (Co-facilitator; Production supervisor)

TL2 (Team Leader, second shift)

TL1 (Team Leader, first shift)

CL3 (Chem lab tech, 3rd shift)

TST (Tester)

ASM (Assembly)

RES (Researcher)

Event began with opening remarks by the Plant Manager:

- Emphasized the importance of Line 10 to the company (highest volume line)
- Also, competitive situation, need to embrace "lean" production (interestingly, the competition was not only other companies and China, but other plants within the same company – apparently they can compete for jobs).
- Described the Kaizen process as being important in its own right – even if no dramatic improvements are made, it sets the stage for the next event.

These remarks were delivered in a low-key, conversational style. This was not something dramatically new to the company.

Review of Scope and Objectives:

Scope: "Improve material flow at Line 10 pack-out"

Objectives:

- Redesign pack-out station
- Implement safety/ergonomic improvements
- Implement mistake-proofing (poke-yoke)
- "Implementation of BOMs" (no explanation of this item provided at this stage)
- Improve return system for carry-over parts.

FAC1 reviewed standard ground rules for Kaizen events, followed by self-introductions.

Round table discussion of expectations for the event:

- "Fresh ideas"
- "easier processes"
- "More efficient way to pack"
- RES asked if there were any measures or standards for these objectives ("how will we know if we've been successful?") Group agreed that there was no good measure, particularly for the first objective; developing some kind of measure needed to be one of the action items.
- Success was not necessarily an expectation – the culture was such that an intelligent failure would be OK – consider the event to be an experiment.
    - *This is significantly different from the previous events studied where there were specific improvements that were expected. This was more of an experimental mode to facilitate trial and error learning of the type normally*

seen in autonomous learning. This almost seems to be a new category: "Induced autonomous learning."

- Reduction in rejects (customer returns or internal audits).
- Reduction in supply stock at line.

FAC1 continued with standard training manual material: "what is Kaizen?", etc.

Discussion of history of Kaizen at company – very slow acceptance at first; history of "fad of the month" type programs. Comparison to older CI events – current style is more democratic.

- *This represents evidence of management commitment to the process that is sustained over time – clearly an important factor.*

CL3 asked whether the company did or could learn from what others did and from previous Kaizen events. FAC2 answered that this was done to some extent as innovations on one line were transferred to another, but also acknowledged that it wasn't always feasible. He spoke of working with three sister plants, but not being able to transplant ideas from one to the other – in fact, plants have a history of going in different directions. He attributed part of this to logistical issues that influenced a plant's ability to implement Kanban type systems.

This is consistent with the emerging finding that knowledge in one context is rarely usable in another without significant adaptation.

(Side note: on a pre-event tour of the plant with the local CI manager, he pointed out the parts "supermarkets" for pull replenishment. RES asked if this was working in the sense of preventing stockouts without people

maintaining secret stashes of inventory. He replied that it was, and while it took time to build trust, management now believed in it and wanted it replicated throughout the plant.)

TL1 raised complaints about material storage in the plant, as it affected Line 10. As background, he explained that the line might run as many as 100 part numbers on a shift, with an average run size of about 40 parts, but many in the 2 or 3 unit range. This prompted remarks from CL3 and ASM about wanting to see larger minimum run sizes and fewer changeovers. They felt that the company was committed to following lean principles without recognition of the difficulty it caused for them.

This is evidence of the continuing struggle between "lean" and "efficiency" paradigms. It was clear that local management were committed to the ideal of single piece flow and that this was not negotiable, but those actually working on the line felt that efficiency was being compromised and that the tradeoff was not necessarily a good one. Later it became clear that efficiency type metrics were still very much in force; likely contributing to this conflict.

Lunch Break

Considerable discussion over lunch, primarily between TL1, TL2 and ASM, about ways to improve their jobs, organize the line and improve material handling.

Evidence of prior thinking about these issues. No mention of any outside reference points or examples.

Strong reaction to the overall complexity of the job – wanted more support on commonizing parts and packaging. Definitely wanted longer runs – a pack out might consist of 10-15 parts, so the problem is to change over all these parts just to run 3 units.

Historical stories emerged about designing and building racking, reworking the mistakes, throwing away the non-flexible designs. Mostly a distinction between assembling "fast-tube" structure and welding up angle iron.

> *Further evidence of the lean/efficient conflict and the tendency to pursue local rather than global optima. Story telling starting to emerge at this stage – in contrast to other events, the stories seemed to be tightly focused on the status and history of the process at hand. This may be because of the relative lack of outside experiences to bring to the table (see overview). Another reason might be the way the problem was framed initially: there was no particular encouragement to import ideas from elsewhere, only to bring out the ideas that individuals already had.*

Visit to work area:

Overall description: the production line portion is a conveyor loop ~30' long that produces the main valve body. There are a number of different variants, but they are based on a common design and changeovers are not difficult. The valve body is the last part to go in the retail package, and it goes straight from the line into the box, which is then sealed. There is a packaging line about 15' long that prepares the packages before they receive the main valve body. As noted above, there are about 10 - 15 other items that go into the box, including internal packaging. These other items are purchased parts or are manufactured elsewhere in the plant. They are delivered to the area in boxes or tubs of 20-50 pieces. Furthermore, many of these parts must be handled carefully since they are cosmetic in nature and cannot be simply dumped into bins for line replenishment. This creates difficulties with the up-to-100 changeovers required per day. TL1 explained that his first task every day is to sort the production schedule into the most feasible sequence for changeovers. TL2 does the same thing, but with slightly different decision rules.

> *This would be an example of tacit knowledge, given the complexity of choosing between finish commonality and component commonality. Each team leader apparently had his or her own heuristics for this process, which they were not able to articulate fully.*

Behind the packing line is a large holding area for supply stock, which is in addition to the main inventory holding area in the warehouse. The area by the line handles a lot of partially used containers.

During the line tour, TL1, TL2 and ASM spent much of the time showing others what their ideas would look like in practice. Other team members were observed studying elements of the process and thinking out loud about improvements.

These were mainly local optimization type efforts, and didn't consider the larger picture (accepted it as given). No outside themes or ideas were observed in this process.

Back in the meeting room, the following problem areas were identified:

- Parts flow
- Finding parts
- Rack design
- Need for more shelving (!)
- Need for more pre-staging of parts

Up to this point, information processing has been entirely bottom up or paradigmatic – no evidence of any concepts or ideas imported from outside sources. Also, this event has been unique in that there was no real story-telling session – other than the "war stories" about shelving and the discussion over lunch. Clear that the participants had some ideas about how to organize things, but the source of those ideas was not so clear. They appear to have been internally generated. The general lack of storytelling may have been due to the fact that the participants already had a high comfort level with the process and just wanted to "get on with it", or may have been due to a lack of use of examples by the facilitators (who were insiders).

2:00 Continuation of the training materials: Takt time, etc.

Showed the Deep Dive video.

3:00 Reconvened to discuss action plans

Question about whether it would be feasible to rearrange parts in holding area by finish instead of by type – to facilitate changeovers. Generally agreed to be a lot of work, but doable in a week. TL1 started telling a few war stories from the line, started to illuminate some of the issues that come up.

Discussion about what we might do about the mistake-proofing goal – suggested that plaster guard reversal might be a mistake that could be addressed.

3:30 – Break for the day.

Day 2: 7:30 am.

FAC2 reported that he had checked into getting BOM's to use for our planning – had been informed that they "weren't too well maintained" and may not be useful for our purposes.

> *This recalls the comment by one of the panel of experts in the validation process that getting clean data was difficult to the point that he had more or less given up on it. Typically it seems that even a slight uncertainty about archival data throws the whole set into question – there is not sufficient context to sort out what is useful.*

Discussion about moving parts out of original shipping boxes and into more standardized containers like baskets for bringing to line. Preferred method is to bring boxes to line except for very short runs – less handling, damage, easier to return. Problem is that incoming boxes are not standard sizes (and not consistent run to run).

Discussion about rack design (flat versus angled, right height). Seemed predetermined that the existing racks would be replaced.

Team leaders wanted to see different arrangement for making up boxes and inserting trim plate (first part in). Current arrangement requires walking around table (and into aisle) often. Discussion involved a lot of thinking out loud about different alternatives.

Discussion revealed that those with experience on the line had a set of historical production standards in their minds as reference points.

"Rack" team of TL1, CL3 and ASM went out to the line to brainstorm their new design and to ask operators for input.

RES and FAC2 put heads together to design a mistake-proofing device for the assembly fixtures. Worked up a preliminary design and took to model shop to mock up.

9:00

Team met back in room to review rack designs and mistake-proof design.

TL1 pointed out a flaw in mistake-proof fixture – a minor modification was needed to address this.

Some discussion between TL1 and TL2 on this design. As background info, three different bodies can be run on this fixture. One can only be positioned one way, while the other two can be run frontward or backward. One of these two is already mistake proof by its design. The last one, which needs mistake-proofing and can be run either way, is the high volume unit. First shift runs the part backwards to make it easier to install a screw, while second shift runs it frontward to keep it the same as the other parts. Neither shift wanted to change, but it was clear that one of them would have to. After the modifications to address TL1's issues, all parts would have to run frontward; not the way he liked to do it. He saw the reason why it had to be that way and agreed to go along.

> *This illustrates the point that for a new routine to be adopted, the ostensive part of the new routine must replace the corresponding part of the old one. When the ostensive parts of the old and new routines are based on clear and articulated logic, it is easy to evaluate the change objectively and adopt it or not.*

Discussion about rack designs – involved a lot of thinking out loud; "what-if" sorts of discussions. No reference made to any external principles or examples.

Also discussion about how parts should be stored in racks (by finish, by family, etc.). This mirrored the previous day's discussion about how production should be scheduled. This showed that the team leaders had certain decision rules about this, but could not articulate them completely and liked to feel that they exercised some creativity in this.

Some of the ideas proposed were certainly replications of things seen elsewhere, but this was not stated explicitly. Given the long tenure of the participants, they reacted mostly to things that had been introduced elsewhere in the plant. No outside ideas were identifiable.

Given the demographics of the participants, this was not too surprising as very few had ever worked anywhere else comparable.

Also seemed clear that because of their long experience, the team had a list of accumulated ideas that they had thought about and wanted to try, but couldn't outside of the Kaizen framework. This seems to be a case of autonomous learning, but requires a catalyst (inducement).

Hence the previous comment about induced autonomous learning.

9:30 am:

Out on floor in teams: rearranging existing racks and shelving and building new racks.

Considerable evidence of trying things to see how they looked. Quite often, the participants were not comfortable articulating their ideas in words or drawings; they preferred to explain by showing.

At the same time, they were testing their ideas for feasibility – not all of them looked so good when tried out.

Ideas would occasionally run into a wall, when there seemed to be a consensus that some things were just too much work for the benefits expected.

This is a tension that was observed in both the other events. There is a sort of mental fatigue level that is reached where it seems easier to accept the process as it is rather than deal with all the issues of changing it.

3:00 pm:

Review of progress:

Rearrangement of the work area provided more room for staging parts – presumed to be an improvement, but no good metrics. Should save labor and reduce mistakes.

4:00 pm: break for day.

Day 3, 7:30 am:

Team meeting: review of progress and assignments

RES to make sketch of fixture modifications for model shop – went to see machinist, laid out dimensions and set up a drilling fixture to prepare for changeover.

CL3 to tear down old fast-tube area

TL1 and TL2 to take pictures of line ("before")

9:00 am: RES, TL1, CL3, ASM, FAC2 worked in fast-tube area, tearing down old racking and building new. Observed that there was a need for better sorting and storage of components, both new and re-used. TL1 knew of some available racks that would work. Group agreed to add a 5-S of the area to project scope.

TL2 and TST re-arranged parts in the pack supply area, grouping parts by finish.

Lunch Break – group discussion agreed that enough progress was made to add the above-mentioned 5-S to objectives, also to rearrange "shower-guard" area (specifics not discussed).

Lively discussion over lunch, covering areas such as flooded basements, mole eradication, swimming pool maintenance, etc. (no task-related discussion).

> *The story telling impulse seems to be alive and well, just not directed at the problem at hand.*

1:00 pm: First shift went home early to allow for changeover of fixtures.

RES, TL1 and FAC2 stripped fixtures off line and took to machine shop. Returned with modified parts and re-installed. TL1 tested a few parts and agreed that concept worked. Total time 1:45.

TL1 commented that second shift was a good place to introduce new techniques because the workers weren't old-timers who were set in their ways; less likely to complain. Also noted that they could tell the first shift that "the second shift had no trouble with it."

TL2 agreed to stay late to show the second shift the changes and explain how it worked. TL1 agreed to come in early the next day to do the same with first shift.

3:30: Break for day.

Day 4; 7:30

Reassemble in team room. Report back from second shift that the mistake-proofing fixtures worked perfectly.

Morning to be spent putting finishing touches on the new racks, ready for installation at 1:00 as per previous day.

5-S on fast tube area completed during morning.

RES and TL1 went to production control office to print out sample BOMs for five part numbers. RES wrote a small spreadsheet program to put part numbers in best production order as test of heuristics used by TLs. TL2 selected the same order that the program showed to be optimal. TL1 chose a sequence with about 15% more part changes.

Lunch Break

Report back from first shift that there were no problems with the modified fixtures.

1:00 Changeover time

Old tables and bins removed from line, new ones installed.

Numerous small problems discovered, several hours spent trying out the new procedures, modifying aspects of it, suggesting changes. Very similar to design process on Day 2, much trial and error, explaining ideas by showing. Many of the ideas implemented, some held over for the morning.

> *Again, a fatigue limit seemed to be reached; some of the details seemed too much to deal with at the moment – address later or work around.*

3:30 RES and FAC2 met with plant manager to discuss build schedule optimization idea. He seemed very receptive and noted that they already did something similar with the changeover schedule for the automatic screw machines. Agreed to devote some manpower to making it work. Was fully aware of the problems associated with replicated data if the scheduling is done external to the plant's MRP system.

4:00 Break for day.

Day 5, Friday 7:30

Morning spent getting pictures, putting together the presentation and rehearsing the parts.

The presentation was uneventful and there was minimal questioning. Part of this may have been due to the absence of the General Manager. Some questions from the Unit Manager about how we expected an improvement in quality problems as a result of the changes.

> *It did not seem that he considered the plaster guard problem (the subject of our mistake-proofing device) to be a significant issue. In this respect it seems that the team may have had a different perception of the situation and a different prioritization of issues than did management – but this was not clear.*

APPENDIX V

PRESENTATION TO EXPERT PANEL

Study of Kaizen Events

John D. Hanson
Michigan State University
East Lansing, MI 48824-1122
Phone: (517) 353-6381
e-mail: hanson@bus.msu.edu

The Research Question:

- ☐ How do firms access and apply knowledge in their process improvement initiatives?

Why the question?

- ☐ Much has been written, but very little shop-floor observation.
- ☐ Want to know more about how firms generate competitive advantage.

Why Kaizen Events?

- ☐ Bounded in scope and time – can observe the whole process.
- ☐ Data-driven, provides verifiable results that allow us to say that learning took place.

Reporting Preliminary Results

- ☐ May be interesting and useful.
- ☐ "Interesting" academically – conflicts with literature.
- ☐ Feedback and validation – are these findings consistent with your experience?

Definitions and Limitations:

- ☐ Context is high-volume production environment under stable conditions.
- ☐ *Knowledge* narrowly defined in organizational sense: "situated performance".
- ☐ *Learning* is the "detection and correction of error".

1. Experience Does Not Cause Learning

- Key observation: ideas not rooted in experience.
- Innovations came from outside.
- Experience provided constraints: ("that won't work because....").
- The "learning curve" is forward-looking, not experience-based

1. Experience Does Not Cause Learning (cont'd)

- Three types of learning:
  - **Autonomous** - Traditional learning curve at the individual level.
  - **Induced** learning: planned, based on future payback, draws from the outside
  - **Reactive** learning – "insurance" against a recurrence of past problems.

1. Experience Does Not Cause Learning (cont'd)

- Why is this important?
  - Productivity gains not automatic; based on expected future volumes.
  - Firms learn from past mistakes, but the results are mixed (insurance).
  - Need to focus on external sources of learning.

2. Cognition Is A Strong Limit:

- "Knowledge is knowing where to look it up."
- People don't look for what they don't know about.
- "Tags" are key to learning (*meta-knowledge*).
- Stories are important because they are rich in tags.

2. Cognition Is A Strong Limit (cont'd):

- Why is this important?
  - Knowledge management – oxymoron?
  - Manage the tags, not the knowledge.
  - Story telling is important – should be encouraged.
  - Stories are how outside ideas are imported in context.

3. "Absorptive Capacity" Is Not An Absorptive Phenomenon

- ACAP – ability to absorb and use knowledge from outside the firm.
- Assumed to be cognitive: based on related prior experience.
- Cognitive limits are not hard to work around.

3. "Absorptive Capacity" Is Not An Absorptive Phenomenon (cont'd)

- Explaining the concepts is not hard.
- Problem is conflict with existing theory of "why".
- The tools cannot be used until the old theory is displaced.
- Existing theory may not be clearly articulated - an element of **culture**.

3. "Absorptive Capacity" Is Not An Absorptive Phenomenon (cont'd)

- Why is this important?
  - Displacement problem is often ignored.
  - Requires different tools.
  - Culture change – known to be difficult; culture is good at perpetuating itself.
  - Need new tactics – critical mass, simultaneous changes.

4. Knowledge Isn't "Accessed"; It's Created As Needed

- Did not observe any instance of knowledge being imported unchanged.
- Application was always unique.
- Two components: the facts at hand and some organizing framework.
- These represent two modes of thought – striking the right balance is important

4. Knowledge Isn't "Accessed"; It's Created As Needed (cont'd)

- Why is this important?
  - Can't manage knowledge; manage the precursors: data and narratives.
  - Getting good, clean data is hard – usually have to re-create it, or rely on an interpretation.
  - Re-emphasizes importance of stories for importing frameworks.

Thank You For Your Attention

- These are the major points that I wanted to emphasize
- Your feedback is valuable and appreciated:
- Do these observations ring true to you, or do you feel that something is missing?

Appendix VI

Validation Survey Results and Supplemental Comments							
Question:	1a)	1b)	2)	3)	4a)	4b)	5)
Responses	2	4	5	4	5	3	4
	4	4	4	3	5	5	5
	4	5	5	4	3	4	5
	2	5	5	2	4	4	3
	5	5	5	5	5	5	5
	4	4	5	4	4	4	4
Mean	3.5	4.5	4.8	3.7	4.3	4.2	4.3
Std. Deviation	1.2	0.5	0.4	1.0	0.8	0.8	0.8

Additional Comments by Respondents:

Question	Comments
1 a)	- no comments
1 b)	- learning should be evaluated on a forward looking basis
2)	- no comments
3)	- cognition not a "strong" limit – can go beyond it - "people don't want to move outside their box"
4 a)	- idea makes sense, just not sure it's true - the longer the old paradigm has been in place the tougher it is (age demographics a factor) - leadership needs to force displacement
4 b)	- no comments
5)	- no comments

Appendix VII

Notes of Discussion with Expert Panel

The following is a loose transcript of the discussion that followed the presentation. The primary emphasis was on capturing the essence of the individuals' comments. To preserve their anonymity, participants in the discussion are labeled by letter in the order in which they entered the discussion.

A: Liked the point about stories; agreed about their value, but noted that "there are stories and there are stories" – meaning that some were credible, others not. Felt that the most effective stories were those that reflected first-hand experience.

B: (reacting to the comment about knowledge being created at the point of use from two components): saw the Kaizen methodology itself as the organizing framework being applied to the specific company situation. Felt there was a third component – the skill or personal experience of the facilitator in knowing how to adapt the framework to the situation. This discussion made it clear that this view can be applied at multiple levels of analysis, from the entire event as a unit, right down to an individual participant wrestling with a small sub-component of the problem.

C: countered this view by asking "have you ever been to the same Kaizen event twice?" – meaning that the Kaizen event methodology didn't really serve as a uniform organizing framework; each event took on a life of its own.

D: Noted that he prepared for an event by selecting what stories he was going tell.

This led to a discussion about matching the stories to the audience, knowing that some audiences would relate better to some stories than others. Point was made by several participants that the credibility of the stories was critical.

D: Commenting on the displacement argument: agreed that this was an important mechanism, but pointed out that this could not happen at the level of an individual Kaizen event – had to involve direct action by senior management. Said he had seen examples where this had happened (and many more where it didn't).

Discussion arose about the idea that knowledge is created uniquely in each situation and how that related to attempts to replicate lessons learned in other areas. The researcher suggested that both components would still be necessary; the lessons learned somewhere else would be the organizing framework, which might dominate, but would still need to take into account local conditions.

E: Agreed with this point – said company Z had learned this the hard way. Having made a number of improvements at one site, they attempted to transfer the results wholesale to another. They found they were unable to make it work and had to break it up into pieces to get acceptance at new location.

The researcher recalled the example of GM building 3 identical plants in different parts of the world with the idea that lessons learned would be transferable – suggested that it probably wouldn't work very well.

A: agreed and said "maybe that's why you don't hear about it any more."

A: commented that this research had looked at Kaizen events in a way that none of them had ever thought about - found it interesting.

A: reacting to point about how hard it is to get clean data – said he had been fighting that one for 40 years and had given up.

F: said very little during the discussion, but was generally supportive of the points made. Body language however suggested that he wasn't completely comfortable with the narrow definitions of knowledge and learning – as a result, probably felt that the findings were not as broadly applicable as they might have been.

Appendix VIII

DERIVATION OF THE LEARNING CURVE FROM AN EXPECTED UTILITY MODEL:

Proposition 5 states that learning takes place as a result of some expected future utility. This was based on repeated observations that no causal link could be seen between past experience and present learning activities. The alternative view is that learning involves some sort of investment that must be justified by a forward-looking return model. This approach to formulation of a learning curve was proposed by Oi (1967), but was dismissed by Muth (1986) on the grounds that in such a model, all improvements with a net present value (NPV) greater than zero would be implemented right away and there would be no learning curve thereafter.

This view seems unrealistic. Potential improvements are not all known in advance; they must be searched for, and *a priori* estimates must be made as to whether they are even worth searching for. When found, they cannot be implemented instantly. Furthermore, firms do not have unlimited resources to devote to search and implementation; it is not uncommon for positive NPV projects to languish simply because there are more attractive ones available.

It seems more useful to denote a forward-looking factor M (which would normally be expressed in units of currency) as the *motivation* for productivity improvements, and postulate that the actual *rate* of implementation of the improvements (in the time domain) will be some company-specific function of M.

This rate would vary linearly with M over time if worthwhile productivity improvements were infinitely available, but would follow a power function as the firm starts to exhaust a finite supply of ideas (per Muth's model). Consider first the conventional formulation of a learning curve:

$$y_t = ax_t^{-b} \tag{1}$$

where:

y_t = the time or cost required per unit of production at time t

a = the initial time or cost per unit of production

x_t = cumulative production experience (units) at time t

b = a "learning" rate

In the revised, forward-looking formulation, the *motivation* would follow a discounted cash flow format:

$$M(t) = k_1 \int_t^{\infty} V(\tau) e^{-r\tau} d\tau \tag{2}$$

where:

M is the motivating force, typically expressed as the dollar value of potential improvements

$\boldsymbol{k_1}$ is a conversion constant to reduce the result to dollars or any other desired unit

V(τ) is the production rate in units per unit of time at time = τ

r is the appropriate discount rate

In the steady-state, infinite horizon case, this reduces to a constant:

$$M = \frac{k_1 V(t)}{r} \tag{3}$$

We would then suggest that the actual rate of improvement in, say, cost would be:

$$\frac{dC}{dt} = -Mf(\bullet) \tag{4}$$

where:

> $f(\bullet)$ is a declining, convex power function of cumulative improvements to date, per the conventional formulation.

An interesting consequence of this formulation in the infinite horizon case is that if production rate changes, perhaps as a result of changes in the economy, to V', such that $V'/V = \alpha$, M'/M will also equal α, as will $(dC'/dt)/(dC/dt)$. However, because of the change in production rate, when transformed to the volume domain, dC/dV will appear to be unchanged. So, even though improvements are evaluated and implemented according to varying constraints in the time domain, the apparent learning curve will appear to be a constant function of cumulative production experience when viewed in the volume domain, consistent with empirical findings.

The point of this exercise is to show that it is possible to make the argument that learning is not motivated by past experience without thereby contradicting the mass of empirical work that has been published to date. Assuming that managers' volume forecasts are more or less accurate, and that they make rational choices, when viewed retrospectively, and in the volume domain, process improvements will appear to follow a conventional learning curve, creating an illusion that experience is somehow causal for productivity improvement.

This formulation takes no notice of competitive dynamics and would be appropriate in commodity markets where the firm is a price-taker. In a more competitive market (specifically, one with a downward sloping demand curve), managers' forecasts may tend to become self-fulfilling prophesies. A higher sales forecast than one's competitors would lead to greater cost reductions through learning, which would lead to a better competitive position, which would lead to more sales, further reinforcing the apparent robustness of the empirically observed learning curve.

Another interesting insight from this formulation is that the motivation for learning, and hence the rate of learning is dependent upon an *opinion* about the present value of future improvements. In the case of a cost saving, this is (*ceteris paribus*) relatively straightforward, depending only on a sales forecast and an appropriate choice of discount rate. If the intended improvement is in quality, the situation is much more complicated, requiring an assessment of the present dollar value of future improvements in quality. Clearly, this assessment will be a function of the organization's "shared logic" about the right way to compete and the value of quality improvements. Thus organizations might be expected to (reasonably) differ in their choice of k_1 in Equation (2) above. In the more conventional formulation of the learning curve in Equation (1), this would be an explanation of variance in *b*, the so-called learning rate.

The idea of a learning curve being based on matters of opinion offers an alternate explanation to that of Muth (1986) who noted a slight anomaly in many learning curves. He noted that the very earliest stages of learning curves tended to exhibit a slight concavity to the origin, unlike the convexity that prevailed over the rest of the curve. He attributed this to a pull-ahead of some improvements prior to launch. A plausible alternative explanation in light of the above formulation is that managers would tend to be skeptical of sales forecasts at the time of launch and would discount them more heavily than they would once some history was established.