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**The differential effect of applying quality processes and having
a creative environment on developing continuous improvements
and breakthroughs**

Russell, Jennifer Alison, Ph.D.

California School of Professional Psychology - Los Angeles, 1992

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Los Angeles

The Differential Effect of Applying Quality Processes
and Having a Creative Environment on Developing
Continuous Improvements and Breakthroughs

A dissertation submitted in partial satisfaction of the
requirements for the degree of Doctor of Philosophy in
Psychology

by

Jennifer A. Russell

1992

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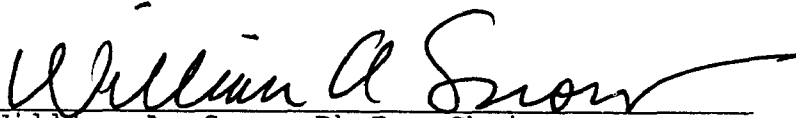
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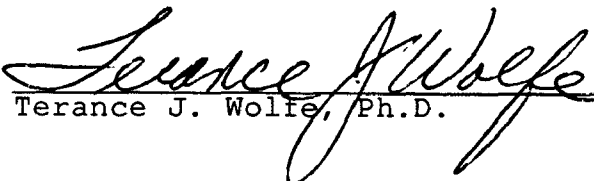
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DEDICATION

This dissertation is dedicated to my mother, Molly Russell, and my grandmother, Mike Palmer, for inspiring me to embark upon this significant task.

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ABSTRACT OF THE DISSERTATION

The Differential Effect of Applying Quality Processes and
Having a Creative Environment on Developing Continuous
Improvements and Breakthroughs

by

Jennifer A. Russell

Doctor of Philosophy in Psychology

California School of Professional Psychology, Los
Angeles

1992

William A. Snow, Ph.D., Chairperson

Quality processes are being implemented consistently throughout all organizational departments despite differing departmental objectives and levels of resistance to their use. Subjects were 19 researchers and 19 educators from a multinational document processing company. A semi-structured interview was conducted and the Work Environment Inventory was administered to all subjects. The findings from a Z test ($Z = 3.89$, $p < .001$) showed a significant difference between a positive correlation representing incremental improvement and quality processes, $r(38) = .36$, $p < .02$, and a negative correlation representing breakthrough and quality processes, $r(38) = -.53$, $p < .001$. The

implications are that quality processes have a distinct role in different departments due to the departments' varying objectives. For departments interested in making incremental improvements, training in quality processes would be useful. On the other hand, departments interested in achieving breakthroughs in technology should not enforce the use of quality processes. Instead the following work environment factors are related to breakthrough: creativity, sufficient resources, work group support, challenging work, and freedom.

Chapter 1.

Introduction

The world that we have made as a result of the level of thinking we have done thus far creates problems that we cannot solve at the same level at which we created them.

-- Einstein

Background

American industries are eagerly adopting quality management practices to better compete with Japanese industries which are adopting more creative management practices. American industries are using strategies such as benchmarking, employee involvement, and quality improvement teams while Japanese industries are building brainstorming rooms, putting up office partitions for privacy, and setting up labs where researchers can work on projects with no commercial value.

With these changes in corporate strategy both cultures are trying to adopt corporate cultures that are different from their respective national cultures. For example, Americans view creativity as more of an individual than team endeavor. They are more familiar with the type of breakthrough thinking required for new inventions than the incremental changes needed for continuous improvement. In many respects the individualistic spirit of America lends

itself well to breakthrough creativity and less well to quality improvement. In contrast, Majaro (1988) says the Japanese industrial environment and culture are in harmony with the quality control philosophy. In Japan there is a blending of one's life goals with the company's goals such that the success of the organization represents the success of the individual. Furthermore, "groupism" provided by quality improvement teams makes the Japanese worker feel happier and more secure.

Some leaders of Japanese industry see a downside to these cultural traditions. Mitarai, senior managing director of Canon's basic research laboratory, sees Japan as "a single race-country where everybody thinks the same." According to Mitarai "Creativity is very much rooted in the individual, so you have to give the individual freedom and time to think. But creativity is also associated with interacting with colleagues and stimulating each other. We try to do both." The founder of Kyocera Corporation, Inamori, is quoted as saying the following:

There are deep-rooted historical reasons why Japanese society has not engendered the kinds of individual freedom and leaps of intuition that produce creative breakthroughs. In a rice-growing culture, group effort is critical. Taking risks with cultivation could spell disaster for an entire village instilling a reluctance to gamble that persists today.

Conformity and the ability to work within the group are more highly valued than individuality in Japanese culture.

Although many facets of Japanese society still stifle invention, Smith (1984) finds that the world's most successful imitators are beginning to figure out how to organize themselves to become innovators. Japanese industries are unusually good at spotting the germ of an idea in the West and growing it into something useful in the East says Makoto Kikuchi, director of Sony Corporation Research Center.

So while the Japanese are realizing the importance of individual creativity and building it into their corporate environments, the Americans are realizing the importance of quality and likewise implementing it as a competitive strategy. The question that arises is what will adopting a quality strategy that has worked so well in Japan be like for American business, particularly on its ability to remain creative and innovative. Since the Japanese are perfecting quality improvement and are now looking toward individual creativity, it follows that quality strategies that have matured in Japan are not the most conducive to this type creativity. American industries are likely to face challenges in maintaining creativity and the spirit of innovation within a quality improvement culture.

Roth (1991) points out that America is losing its competitive advantage in market after market to countries with the ability to learn lessons America offered and then go beyond. One product of this unappreciated decline in its

preeminence is that Americans have plunged into the quality improvement movement.

In a move to increase competitiveness with other countries, especially Japan, many companies in America have embraced Total Quality Management (TQM) as their solution. Total Quality Management is being implemented at companies as they respond to competitive pressure not only from Japan, but now from a more competitive Europe as well. While Total Quality Management has gained increased popularity over the last decade, there has been very limited academic research on its effects. In fact, much of the research on TQM is being conducted in Japan and later translated into English for American audiences.

Brief History of Total Quality Management

The three most well known "gurus" of Total Quality Management are Deming, Juran, and Crosby. These gurus define Total Quality Management as an approach to improving the effectiveness and flexibility of businesses as a whole (Deming, 1982; Juran, 1982; Crosby, 1984). The concept of quality control was introduced in Japan in 1950 when the Union of Japanese Scientists and Engineers (JUSE) invited Deming to give a seminar on statistical quality control for managers and engineers. The statistical tools (cause-and effect diagram, control chart, Pareto chart, etc.) were valuable for production problems, but were problematic for managing the process of getting workers to use them.

Juran's visit in 1954 helped to shift Japan's quality control emphasis from the factory floor to an overall concern for the entire management of the organization. Thus, the initial concept of Total Quality Control (used interchangeably with Total Quality Management) emerged from that shift in thinking.

Kim (1989) mentions that quality control (QC) began with an emphasis on inspecting-out defects and evolved into the concept of controlling manufacturing processes to keep defects from being produced at all. This idea was later extended to include the product development process - to design-in quality from the very beginning. By including quality concepts in the product development process, the entire company became involved.

The philosophy of Total Quality Management (TQM) is holistic in nature -- involving employees at all levels to promote the well being of the company as a whole. However, TQM is both an all-encompassing philosophy about the whole enterprise of running a business and a set of specific tools applied at the lowest levels of an organization. The blend of the micro and the macro makes it a potent discipline -- either element by itself would not be revolutionary. The success of TQM comes from linking top management goals with a set of tools to enable employees at all levels to achieve those goals. All quality efforts are carried out with the purpose of improving the product or service provided as seen

by the customer.

The tools and methodology of TQM gained widespread acceptance because they fit in with the traditional model of problem solving that is based on reductionism and analysis; breaking up a problem into pieces which can be solved individually. The application of the traditional TQM tools to manufacturing has been relatively successful.

The fact that TQM embodies more than improving methods and procedures -- that it's an organizational culture change effort -- is readily acknowledged by those in the quality field. For example, Deming will not even begin to discuss quality improvement methods and programs unless the organization first addresses issues relating to the company's philosophy, its mission, and attitudes about worker roles. Despite this acknowledgment of cultural change by quality experts, Kim (1989) feels that the problem with TQM as a change process lies in the lack of appreciation for how important and difficult the change process actually is. Kim (1989) believes there are two reasons for why TQM underestimates the importance of the change process. One reason is that TQM is not well-equipped to address issues surrounding the change process itself (i.e. methods are aimed at the actual "doing" of quality improvements). One weakness of this approach is witnessed by Juran (1964, 157) who says, "In dealing with cultural patterns we are at our worst, hampered as we are by our

limited basic knowledge and by our own emotional involvement." Another vulnerability stems from the tendency of managers to grossly underestimate the importance of the philosophical and cultural elements of the TQM process. The emphasis on action without regard for theorizing or philosophizing is described by Ishikawa (1985, 118) who writes the following:

As quality control activities become widespread, group psychologists want to get a part of the action. There are theorists who create Theory X, Theory Y, and Theory Z and provide their critiques of our activities. My response to them has remained the same. All such theories are contained in our activities. We do not present them as theories, however, we simply practice them.

Furthermore, the lack of TQM tools for dealing with the dynamics of the change process itself forces one to focus on the tools that are available (e.g. statistical tools). The very characteristics that make Total Quality Management appealing -- its holistic qualities -- are also cause for concern. For instance, Kim (1989) believes Total Quality Management, though useful for operational requirements, falls short in the conceptual area. Roth (1991) agrees at least partially when he states the following:

Unfortunately, the quality improvement movement has fallen victim to the same deeply ingrained habits that thwarted acceptance of the systems perspective. American industries have broken what must necessarily be a holistic effort (the whole being more than the sum of its parts) down into

its critical pieces and have focused attention on perfecting those pieces.

A systems view of innovation looks at the process and the product of innovation. The systems view helps an innovating firm decide when a new product is likely and when gradual or incremental improvements to its existing technology are the preferred strategy. According to general systems theorist von Bertalanffy, analysis yields information of the component parts, general systems theory explores the interrelationships between parts and the nature of wholeness. Systems thinking is finding favor as a means of dealing with the sort of complex phenomenon that has resisted efforts at being dissected into non-interacting component parts.

Quality improvement focuses on a single problem and dissects it by analyzing it through its causes. One danger with using quality improvement without applying it systematically is that there could be many quality improvement teams working separately on problems that all have the same underlying cause. Viewed in a broader systems perspective, the problems could be solved by changing the system rather than implementing several independent solutions. Senge (1990), in his book, The Fifth Discipline, describes a recent group of executives in a high-technology firm who were deeply concerned that their company was "losing its edge" by not bringing dramatic new products to

market. Senge (1990) related:

It was less risky to improve existing products. However, they feared that a culture of "incrementalism" rather than "breakthrough" was being fostered. The safer, more predictable, easier-to-plan-for-and-organize processes of improvement innovation were becoming so entrenched that the managers wondered if the company was still capable of basic innovation.

According to Buderer, Weber, Hoots, & Neff (1991) global competition and the recession have quickly led to cost-cutting and a shift in the research and development spending balance from the research to the development. Buderer et al. (1991) believe this shift may deliver the faster payoff many U.S. companies need to catch the Japanese, but it runs the risk of focusing so much on small improvements in existing processes that many experts fear America's strength in innovation may suffer.

Mohr (1991), in comparing the strengths and weaknesses of work design and Total Quality, believes the future orientation of work design allows for quantum leap breakthroughs and more strategic innovation than Total Quality. In contrast, Total Quality's strength lies in continuous improvement, customer requirements, and commitment at the operator or service provider level. Mohr (1991) argues for an integrated approach that he labels "Total Quality Work Design." If Total Quality Management is being touted as the whole solution then it must be able to

address all aspects of organizational systems effectiveness. The real question lies in Total Quality Management's ability to be "Total."

Total Quality Management at a Multinational Document
Processing Company

To become the clear leader in the document processing industry and achieve status as a world-class company, the subject company began to demand a high level of continuous improvement from its employees in 1983. According to quality experts at the company the need for giant steps forward comes from breakthroughs in technologies and processes that are the result of relatively few employees' efforts -- managers and specialists. For the balance of Company employees, the remaining 90% -- the opportunity comes in the form of small daily steps to improve the quality and efficiency of their work. Rickards (1985) feels that attempts to find a few top-level creative people to improve the innovative performance of an organization can be criticized if they take attention away from the opportunities of developing creativity more widely within the whole system.

At the company, quality improvement teams and individuals use their creativity to solve problems in a well defined and structured capacity, namely through the Quality Improvement Process (QIP) and the Problem Solving Process (PSP). However, the expression of creativity outside these

well defined and structured processes may not be encouraged enough because it is not supported by quality principles and a creative environment.

The goal of the company's Leadership Through Quality strategy is to obtain 98% conformance to customer requirements. Nadler and Hibino (1990), in describing what they call "fix it before it breaks" programs, say the Leadership Through Quality program is one of the best they have observed, however, they noticed that the notes for employee training sessions use conventional approaches (gather information, analyze, and so on) within the current job environment, thus building in thinking limitations.

The Role of Creativity in Organizations

Fernald (1989) writes that although standards and procedures are needed for consistency in any organization, a somewhat chaotic environment that encourages new ideas is needed for long-term survival. American industry has discovered that survival in today's volatile, global marketplace means finding, developing, and sustaining the very concepts it rejected only a few years ago. Entrepreneur-type individuals who can better spot options and create new directions are an asset in today's hyper competitive world marketplace. "The bottom line," says Fernald (1989), "is that organizations, plants, companies, national industries, and even entire countries must develop the capacity to be creative and innovative in order to

compete successfully." Examples of companies that are both creative and innovative in their everyday dealings are 3M, Intel, and the Saturn Corporation.

Some chief executive officers such as Paul Allaire of Xerox Corporation now believe that unleashing creative energy is the best hope for American competitiveness, better than any quality program. Allaire explains in an interview with Fortune Magazine in June, 1991, "We're never going to out discipline the Japanese on quality. To win, we need to find ways to capture the creative and innovative spirit of the American worker." The management of Sherman's (1984) "Eight Big Masters of Innovation" is convinced of the need to innovate, regarding new ideas as the essence of long-term survival. Sethia (1989) agrees as he says, "creativity and innovation are becoming key factors in an organization's continuing survival especially as Japan is challenging America's reputation for creativity and innovation.

In this age of tough competition, resource scarcity, and high labor and equipment costs, anything that leads to more efficient and effective operations increases an organization's chances to survive and succeed. Equally important, creativity also enables the organization to anticipate change. This has become very important as new technologies, products, and methods of operation make old ones obsolete. Furthermore, the rising expectations of these fast-changing times are a source of serious problems

for many institutions. As a result, the rapid adoption of Total Quality Management programs such as the one at the company under study may have some negative repercussions if creativity is diminished since it is such an important part of organizational life.

Sethia (1989) suggests that considerable innovative research in various fields of organizational studies is needed to identify all the major dimensions of organizational context that can enhance or hinder creativity. Staw (1984) argued that the study of organizational innovation is probably the best current candidate for progress in integrating micro and macro research. Given the importance of creativity for organizational survival and renewal and the rapid implementation of Total Quality Management business strategies, there is a need to explore the relationship between quality and creativity to find out how they support or hinder each other.

Statement of the Problem

Purpose of the Research

The purpose of this research is to find out if there is a difference between the tools and processes needed for incremental improvement and what is needed for breakthrough developments for radically new products or services. According to Nadler and Hibino (1990) and the Hoshin Planning Research team (1989) there are differences. Hadler

and Hibino (1990) believe in the application of "Breakthrough Thinking" concepts which go beyond the use of statistical tools or processes. The Hoshin Planning Research team advocate a strategic planning process which uses a whole new set of tools (Seven Management Tools) in addition to the Seven Quality Tools. Others such as Kanter (1989) are not as explicit about what tools and processes are needed, but have the sense that continuous improvement is not enough.

This research will test the assumption that quality processes help an organization and its people be more creative. One reason for examining the processes of quality and breakthrough is to determine the differences between improving already existing processes and creating altogether new processes or breakthroughs. Companies which are currently striving for quality as their first priority have not been the most innovative and those striving for innovation are doing so at the cost of not achieving high quality levels, at least not initially. In general, high technology companies are either maintaining a competitive advantage through supplying innovative products and services or ones of high quality. Although it is possible to achieve both innovation and quality, corporate environments tend to support one more than the other.

While creativity can take place as part of the quality improvement process, this research examines a different type

of creativity. It examines the type of creativity that occurs when a process needs to be changed or completely abandoned -- breakthrough creativity. This is the creativity seen as lacking in Japanese business. Japanese industries have been known so far for producing quality goods and making incremental changes to improve products. Japanese industries have not been as well known for achieving breakthroughs. While Americans have been successful innovators, they have not achieved the levels of high quality of their Japanese counterparts. In an attempt to increase their competitiveness with the Japanese, many American companies, such as the company under study, have made a strong commitment to quality strategies. The aim of this research is to examine the effect that a primary emphasis on quality has on the company's ability to be creative.

Being creative may mean following quality principles and, at times, it may mean not following quality principles. Situations in which being creative means not following quality principles include the following: Exceeding customer requirements by offering a more creative solution and anticipating customer requirements by including extra features, benefits, or information. As previously mentioned, the quality principles suggest that suppliers meet customer requirements at least 98% of the time. Exceeding or anticipating customer requirements is

discouraged.

There are certain instances in which being creative and striving for quality would solve the same problem, but through different means. For example, one person may generate a solution by first identifying a problem and analyzing its causes while another person may realize that a solution to another problem can be similarly applied to the problem at hand. There are other instances when being creative would mean going beyond solving problems in order to meet customer requirements. Quality improvement supports the type of normative creativity Majaro (1988) describes as the process of applying creative ideas towards solving a problem. However, quality improvement does not support what Majaro defines as exploratory creativity which occurs when ideas are generated to develop future opportunities which are not necessarily related to known requirements or recognized demand. Exploratory creativity is confined to 10% of the company's personnel, particularly those in research divisions such as Palo Alto Research Center (PARC).

Scope of the Research

The scope of this research is to develop and test the environment-process creativity model. The purpose of this theoretical model is to show how quality processes (Quality Improvement Process and Problem Solving Process) are related to continuous improvement more than breakthrough and that creative environments are related to breakthroughs more than

continuous improvement. Policy deployment (Hoshin planning), a broader level quality process designed to surface breakthroughs, is hypothesized to be related to breakthrough more than the Quality Improvement Process and Problem Solving Process, but not as strongly as creative environments. Policy deployment is also related to continuous improvement more than creative environments are, but not as much as the Quality Improvement Process and Problem Solving Process. In other words, policy deployment lies in the middle between the Quality Improvement Process and the Problem Solving Process and creative environments in terms of the type of creative output (breakthrough, continuous improvement).

The theoretical model tests the following premises:

1. Creative environments are strongly related to breakthroughs.
2. Quality processes such as the Quality Improvement Process and Problem Solving Process are strongly related to continuous improvements.
3. Creative environments are not as strongly related to continuous improvements as quality processes.
4. Policy deployment is related to both breakthroughs and continuous improvements.

Table 1. shows the Environment-Process Creativity Model developed to test the relationships among the above variables.

Table 1

Environment-Process Creativity Model

High use of Quality Processes (QIP, PSP)	Higher Frequency of Incremental improvement Lower Frequency of Breakthrough
Hoshin Planning	Medium Frequency of Incremental improvement Medium Frequency of Breakthrough
Low use of Quality Processes (QIP, PSP)	Higher Frequency of Breakthrough Lower Frequency of Incremental improvement
Low	High
Creative Environment	

The Definition of Terms and Hypotheses

Quality Terms

The definition of quality at the company is conformance to customer requirements, internal and external. Customers are the people who receive the output, the product or service produced or performed. Suppliers are the people or group who produces or delivers the output. Customer requirements are what the customer needs, wants, and expects of the output. These requirements may be general or specific; the important thing is that both the supplier and the customer agree on what they are and what they mean. Conformance means that the output produced and passed on to the customer meets or matches all the requirements that the supplier and customer agreed upon. When the output doesn't meet (e.g. exceeds or falls short of) customer requirements, it is called non-conformance.

Quality Improvement Process

The Quality Improvement Process (QIP) is a nine step process that is widely used within the company. The QIP is taught in the quality training courses along with the Problem Solving Process (PSP). The Problem Solving Process is a six step process that is actually contained within the Quality Improvement Process but commonly used alone as well.

Using Quality Processes Operationalized

The use of both the Quality Improvement Process (QIP) and the Problem Solving Process (PSP) as well as Hoshin

Planning is measured through a semi-structured interview format that has both quantitative and qualitative items. Refer to the semi-structured interview guide in the methods section. On the following page is a description of the steps and tasks of the Problem Solving Process which starts with "Identify and Select Problem" and ends with "Evaluating Solution." Table 2. displays the Problem Solving Process and Table 3. shows the Quality Improvement Process with each of the nine steps and a definition for each step.

Table 2

Problem Solving Process

Steps	Tasks
1. Identify & Select Problem	Identify problem. Examine available data about the extent and nature of the problem. Objectively describe "as is" and "desired state" in problem statement.
2. Analyzing Problem	Identify potential causes. Collect and analyze data. Identify key causes.
3. Generating Potential Solution	Review problem statement. Generate lots of ideas for solutions. Clarify each solution.
4. Selecting and Planning Solution	Develop criteria for selecting optimum solution. Select and agree on solution to implement. Develop plan to implement solution, including measures to evaluate effectiveness of solution.
5. Implementing Solution	Follow the plan in Step 4. Use a control system to monitor progress. Collect data for evaluating the effectiveness of the solution. Implement contingency plans as required.
6. Evaluating Solution	Collect data according to plan. Compare with "desired state." Compare with data collected to analyze problem in Step 2. Check for new problems created by solution. Recycle to address additional problems or causes as needed.

Source: Multinational Customer and Service Education (1988).

Table 3

Quality Improvement Process

Steps	Definitions
1. Identify Output	A product or service produced as part of job and passed on to the next person in the work process.
2. Identify Customer	The next person or group in the work process; receiver of the output and the next to act on it.
3. Identify Customer Requirements	What the customer wants, needs, expects of the output.
4. Translate Customer Requirements into Supplier Specifications	Translation of the customer requirements into supplier terminology.
5. Identify Steps in Work Process	Use a systematic way of defining what must be done in order to produce the output.
6. Select Measurements	A systematic plan for collecting information about the quality of the output.
7. Determine Process Capability	Can It Produce Output? No - Problem Solving Process Yes - Exit to Work Process
8. Evaluate Results	Is there a Problem? Yes - Problems Solving Process No - Exit to Recycle
9. Recycle	If there is opportunity for improvement or customer requirements change, recycle and apply process from beginning.

Source: Multinational Customer and Service Education (1988).

Work Environment Creativity Operationalized

The creativity of the work environment is measured by an instrument called the Work Environment Inventory developed by Teresa M. Amabile and the Center for Creative Leadership in 1990.

Background and Development of WEI

The basic theoretical model underlying the WEI proposes that individual creativity within an organization depends, in addition to the individual's own skills and motivations, on three basic components of the organization: skills in innovation management occurring primarily at the level of the local supervisor; motivation to innovate, evident as a commitment to innovation at the organizational level; and resources, including materials, personnel, and time (Amabile, 1988).

Development of the WEI went beyond a review of theory and research on creativity in organizations. In order to identify the important elements in detail, Amabile and Gyskiewicz (1987) designed a study to specifically capture the broad range of environmental factors that might influence creativity in organizations. An initial set of WEI items was developed from a content analysis of critical-incident interviews with 120 research and development scientists from a variety of organizations. Each was asked to describe the personal and environmental factors present in (a) a high-creativity event from his or her work

experience, and (b) a low-creativity event from his or her work experience. Detailed content analysis of interview transcripts by teams of independent raters yielded 9 categories describing environmental stimulants to creativity and 9 categories describing environmental obstacles to creativity.

Definition of Incremental or Continuous Improvement

Incremental or continuous improvement is defined as a small, gradual increase in value of an existing product or process. Incremental improvement will be measured through quantitative and qualitative items in the semi-structured interview guide. A table containing a detailed match of this variable and the items which measure it is presented in the methods section.

Definition of Breakthrough

Breakthrough is defined as a sudden illumination upon the discovery of a new paradigm or matrix characterized by a release of tension or restraint. Breakthrough will also be measured through quantitative and qualitative items in the semi-structured interview guide. A detailed match of this variable and the items which measure it is presented in the methods section.

Organization of the Dissertation

Chapter I. has provided some background to the problem under study, the statement of the problem, and a definition of terms and hypotheses. Chapter II. presents a review of the literature that is relevant to the problem under study. This literature review includes quality and Hoshin planning theorists and/or practitioners, system theorists, creativity theorists, and breakthrough theorists. Chapter III. describes the methods that were used to gather data and test the hypotheses. Chapter IV. presents the statistical results of the quantitative analyses and quotes and thematic findings from the qualitative analyses. Tables and figures are provided to visually depict some of the results. Chapter V. discusses the results and how they support the hypotheses. Implications of the findings, limitations of the research, and conclusions are presented.

Chapter II.

Review of the Literature

The Corporation's History with Quality

Garvin (1988) in his book Managing Quality believes external threats played an important role in sparking the company's interest in quality. In the mid-1970's a number of Japanese manufacturers introduced low-priced copiers that were reliable and easy to use. Between 1970 and 1980, the company's share of the U.S. copier revenues fell from 96% to 46%, largely because of Japanese competition. These inroads led to a restructuring of the company and the initiating of several ambitious quality programs. The first was competitive benchmarking. Comprehensive surveys were developed to monitor customer satisfaction and to compare customers' reactions to the company's products and to competitors'. The second program involved the product development process and required fundamental changes in the way products were made. Lastly, the company introduced a company wide quality control process, anchoring it in a clear statement of philosophy and goals. The group developed the following Quality Policy:

[The company] is a quality company. Quality is the basic business principle for [the company]. Quality means providing our external and internal customers with innovative products and services that fully satisfy their requirements. Quality improvement is the job of every employee.

Since Japanese companies in the office equipment industry were eroding the market share of American companies such as the company under study, these companies adopted quality strategies to better compete with their Japanese counterparts. With the quality strategy came an orientation to the customer and meeting the needs of the customer. There was an accompanying shift in power away from the research department toward departments closer to the customer such as sales and marketing. Furthermore, rather than taking orders from the research department on what products and features should be produced, the development and manufacturing organization began to hold the research department accountable for researching products and technologies that they identified the customer wanted. In quality terms, the development and manufacturing organization became the internal customer to the research department rather than the other way around.

This move toward customer orientation and continuous improvement changes the way in which breakthroughs are motivated. Whereas before the researcher had the opportunity to create breakthroughs based on research interests, now the researcher is being told to create technological breakthroughs which satisfy customer requirements. The researcher is now encouraged to use the Quality Improvement Process and the Problem Solving Process as a means to translate their customers' requirements into

supplier specifications. The question remains what happens to the intrinsic motivation of the researcher to follow research interests and create breakthroughs that do not satisfy an identified customer requirement, but instead go beyond the customer's imagination and delight them. After all, nobody told Alexander Graham Bell that a telephone would solve their communication problems, but the development delighted its users.

Background on Quality Movement and Key Theorists

To establish a background on quality concepts and practices, some of the most well known and prolific quality theorists and/or practitioners will be presented.

Deming

Deming (1982) has written 14 points for management which are his principles for transformation of Western management. These 14 points are the following:

1. Create constancy of purpose toward improvement of product and service, with the aim to become competitive and to stay in business, and to provide jobs.
2. Adopt the new philosophy. We are in a new economic age. Western management must awaken to the challenge, must learn their responsibilities, and take on leadership for a change.
3. Cease dependence on inspection to achieve quality. Eliminate the need for inspection on a mass basis by building quality into the product in the first place.
4. End the practice of awarding business on the basis of price tag. Instead minimize cost. Move toward a single supplier for any one item, on a long-term relationship of loyalty and trust.

5. Improve constantly and forever the system of production and service, to improve quality and productivity, and thus constantly decrease costs.
6. Institute training on the job.
7. Institute leadership. The aim of supervision should be to help people and machines and gadgets to do a better job. Supervision of management is in need of overhaul, as well as supervision of production workers.
8. Drive out fear, so that everyone may work effectively for the company.
9. Break down barriers between departments. People in research, design, sales, and production must work as a team, to foresee problems of production and in use that may be encountered with the product or service.
10. Eliminate slogans, exhortations, and targets for the work force asking for zero defects and new levels of productivity. Such exhortations only create adversarial relationships, as the bulk of the causes of flow quality and productivity belongs to the system and thus lies beyond the power of the work force.
11. Eliminate work standards (quotas) on the factory floor. Substitute leadership. Eliminate management by objective. Eliminate management by numbers, numerical goals. Substitute leadership.
12. Remove barriers that rob the hourly worker of his right to pride of workmanship. The responsibility of supervisors must be changed from sheer numbers to quality. Remove barriers that rob people in management and in engineering of their right to pride of workmanship. This means, inter alia, abolishment of the annual or merit rating and of management by objective.
13. Institute a vigorous program for education and self-improvement.
14. Put everybody in the company to work to accomplish the transformation. The transformation is everybody's job.

Deming (1982) emphasizes the "constancy of purpose for the improvement of products and services" as an absolute necessity. In addition, he stresses the importance of

"profound knowledge," principally the understanding of variation through the use of statistical analysis. Deming (1982) believes data must be used to analyze apparently random events -- e.g., the appearance of a few defective parts -- in an otherwise stable process. Statistical analysis can determine whether a process such as the manufacturing of a part or the serving of customers at a bank is "in control" or "out of control".

In an "out of control" process, problems are the result of "special causes", such as unusual defects in raw materials, a breakdown of machinery, or human error. When such "special causes" are eliminated and a process is in "statistical control", some problems will remain, but they will appear in a pattern that indicates they are caused by the inherent variability in a stable system rather than by individual causes.

According to Deming (1982), this statistical understanding of systems allows accurate diagnosis and solution of problems. Deming (1982) says there are two problems for the company that hopes to stay in business -- problems of today and problems of tomorrow. Problems of today encompass maintenance of product quality, regulation of output, budget, employment, profits, sales, public relations, and forecasting. Deming (1982) warns, "It is easy to stay bound up in the problems of today, becoming ever more and more efficient in them."

Problems of the future command constancy of purpose and dedication to improvement of competitive position to keep the company alive. Establishment of constancy of purpose means acceptance of obligations like the following:

(a) New marketable services and products that may help people to live better materially, (b) new materials, (c) methods of production and possible changes in equipment for production, (d) new skills, (e) training and retraining of personnel, (f) training of supervisors, (g) production costs, (h) marketing costs; plans for service; service costs, (i) performance in the hands of the user, and (j) satisfaction of the user.

Deming believes innovation, the foundation of the future, can not thrive unless top management has declared unshakable commitment to quality and productivity. Another requirement for innovation is to constantly improve the design of the product and service. However, it is a mistake to suppose that efficient production of product and service can with certainty keep an organization solvent and ahead of competition. In fact, Deming warns that it is possible and fairly easy for an organization to go downhill and out of business making the wrong product or offering the wrong type of service, even though everyone in the organization performs with devotion, employing statistical methods and every other aid that can boost efficiency.

Feigenbaum

Feigenbaum (1988) supports a management approach aimed at enlisting parts of corporations in a systematic effort for quality with marketing departments tracking customers' needs and willingness to pay for quality, engineering departments designing products accordingly, and manufacturing departments assuring that specifications are met. Feigenbaum originated the concept of "cost of quality". He taught that managers should track the total costs of product and process failures, quality appraisal measures such as inspection systems, and quality prevention measures such as training. The sum of these costs consistently represents 10 to 40 percent of companies' annual sales. Feigenbaum says the cost of quality concept both motivates managers to improve quality and enables them to track their success or failure.

At the multinational company under study, Feigenbaum's concept of cost of quality is part of the suggestion program process and the performance evaluation process. Suggestors must be able to show that their suggestion will lead to a "total cost savings." This is achieved by calculating the difference between the cost of implementing the suggestion (cost of conformance) and the cost of maintaining the status quo (cost of nonconformance). Additionally, employees have as part of their performance evaluation plan the objective to meet a certain dollar amount in cost of quality savings

each year. Employees have presented the argument that they do not want to be expected to come up with suggestions as part of their performance appraisal because "creativity cannot be forced on us."

Crosby

Philip Crosby Associates promotes the relatively simple four "absolutes" of quality management. These absolutes are: Quality is defined as conformance to requirements, the quality system is prevention, the performance standard is zero defects, and the measurement of quality is the price of non-conformance. Crosby's first absolute of quality, conformance to requirements, implies that he believes that quality involves meeting but not exceeding requirements.

Japan Union of Scientists and Engineers (JUSE)

Ishikawa and other leaders of the Japan Union of Scientists and Engineers (JUSE) moved away from sophisticated statistical methods because they found these methods often made the understanding of quality problems more difficult than necessary. Their new emphasis was on quality as a sort of mass movement within corporations.

Japan's central techniques for solving problems have been the so-called Seven Tools as taught by Ishikawa. These tools incorporate many of the ideas taught by Juran, Deming, Feigenbaum, and Crosby, but distill them into techniques simple enough for factory workers to teach to other factory workers. The seven tools are Pareto charts, cause-and-

effect diagrams, stratification, the check sheet, the histogram, the scatter diagram, and control charts. Table 4. shows a comparison of quality practitioners.

Table 4

Comparison of Quality Practitioners

Quality Practitioner	Principles
Deming	<ul style="list-style-type: none">- Statistics- Plan-Do-Check-Act Cycle- Management
Crosby	<ul style="list-style-type: none">- Motivation- Cost of Quality- Management
Feigenbaum	<ul style="list-style-type: none">- Quality Systems- Engineering- Management
Ishikawa	<ul style="list-style-type: none">- Employee Involvement- Tools- Management

(Fiorelli, 1991)

Total Quality Control at the Systems Level

As quality continues to improve at companies engaging in Total Quality Management (TQM) activities, there is no doubt that a great deal of learning continues to take place at the operational level. Aside from the initial mental breakthrough required at the outset of instituting TQM, however, new learning opportunities at the conceptual level become less available. A manager can focus on advocating improvements *within* the current framework of organization policies and traditions without gaining much insight about the whole system with which to reframe problems in a totally different context. Systems Thinking (ST) represents a school of thought whose strength lies in the conceptual plane, where current TQM methods may be less than effective. Systems Thinking provides a methodology for thinking about the ways in which prevailing mental models may restrict learning, gaining deeper insights into the nature of complex systems, finding high leverage points in the system, and testing one's assumptions about the efficacy of a specific policy choice. Total Quality Management and Systems Thinking have complementary strengths that can greatly enhance an organization's ability to achieve higher levels of performance through a more balanced learning process.

Total Quality Management is well-equipped to advance learning at the operational level. The seven tools of TQM (Pareto chart, cause-and-effect diagram, stratification,

check sheet, histogram, scatter diagram, and control charts) are relatively easy to understand with well-defined guidelines for their use. Through the use of control charts and Pareto analysis, operators can understand and improve their production steps. Under the TQM umbrella, engineers can design experiments and collect data on the factory floor to better understand manufacturing processes and make improvements on them. Improvement through operational learning involves an incremental process whereby a particular problem is worked on bit by bit. All such improvement efforts, however, are bound within the current definition of the problem under investigation.

Conceptual learning, on the other hand, emphasizes the why of doing things -- that is, it has to do with the thinking behind the doing of things. Conceptual learning deals with issues that challenge the very nature or existence of prevailing conditions, procedures, or conceptions. The perspective of conceptual learning is not limited by the current framing of the issue; it is possible to go beyond and reframe the issue in a totally different way. There are opportunities for discontinuous steps of improvement where, reframing of a problem will bring radically different potential solutions. TQM provides limited methods and tools for organizational learning at a deeper level whereby managers can gain a better understanding of their organization and improve the way they

manage. That is, TQM is very good for enhancing learning at the operational level but provides limited help in the way of advancing management thinking at the conceptual level.

Current TQM tools and methods are poorly equipped for tackling a class of problems labeled as a mess, a system of problems. The traditional way of managing is to take a mess and break it up into problems and solve each problem separately, with the assumption that the mess is solved if we solve each part of it. According to Kim (1989), if a system is broken into parts and every part is made to behave as effectively as possible, the whole will not behave as effectively as possible. Therefore, the solution to a mess does not consist of the sum of the solutions to the problems that make it up.

Shift from Apparent to Latent Customer Requirements

Up until 1960, Japanese companies were primarily engaged in meeting the "fitness for standards" criterion and then came the "fitness for use" criterion which was pursued heavily until the 1970's. The criterion shifted to meeting the "fitness for apparent requirement of the customer" up to 1980 and now the criterion has become the "fitness for latent requirement of the customer" which requires discovering the needs of the customer even before he or she becomes conscious of them.

The shift from "fitness for apparent requirement" to "fitness for latent requirement" is a move in the direction

of having the supplier identify more of the customers' requirements. This move puts more creativity in the hands of the organization's researchers to "discover the needs of the customer before he or she is conscious of them." Rather than merely meeting customer requirements, the organization is asked to find ways to meet needs that are unstated. This shift requires more innovation on the part of the organization in terms of discovering needs and translating these needs into new technologies.

Edosomwan

According to Edosomwan (1987) productivity and quality improvement result from both the ability to generate new ideas and techniques and the ability to apply such new ideas to improve current operations. Edosomwan (1987) believes encouraging research activity for the improvement of productivity and quality also helps create a fertile climate for innovation of new products, new services, and new techniques of management.

In addition to encouraging teamwork at all levels, organization leadership may elect to use experienced managers and technical personnel, consultants, and a task force such as a quality improvement team, to resolve productivity and quality issues. The use of individual efforts, such as experienced technical personnel within the organization, allows those most intimately familiar with the current work processes to suggest and implement

improvements. This follows the concept of employee involvement. The danger in using an individual approach, however, is that people may not want improvement in the processes within their realm of authority. It also may be difficult to see improvement within a given process as well as creative options, given that participants have been used to performing the same functions the same way for a long time. Edosomwan (1987) believes organizations that choose this approach must be willing to share gains with their employees and managers on new ideas about productivity and quality management. The second alternative is to use task forces thereby reducing training costs, increasing objectivity of members, and comprising members from all functions and sectors. The drawback to this approach is that a commitment for follow-up on improvement projects could be missing after the task force is dissolved. The way to avoid this is to assign a specific department or person full accountability of improvement projects provided by the task force.

Quality Control Circles

The quality circle concept which Edosomwan alludes to above is one technique which puts the philosophy of involving the whole organization into practice. According to Wood (1988) quality control circles, the forerunners of the wider quality circles, started in Japan in the early 1950's. The concept emerged from the work of Deming and

Juran, whose influence caught the imagination of Japanese management.

Majaro

Quality circles represent an institutionalized and participative mechanism for diagnosing and solving productivity and quality problems. The process makes use of a small group of voluntary members who meet at regular intervals in order to: (a) identify, diagnose, and solve problems; and (b) improve communication and commitment and quality among the various parts of the organization.

Typically quality circles consist of a leader and eight to ten employees from a given work area. The group may be smaller or larger depending on the personal preference and experience of the leaders and/or facilitators. Meetings take place regularly, typically one or two hours per week. According to Majaro (1988), quality circles select their own problems for analysis with the view to identifying causes or sub-causes or in some cases they respond to problems submitted to them by other parts of the firm. Circle members generate or evaluate solutions to problems, select the 'best' solutions, and then develop and communicate action plans. These solutions are then implemented and circle members check that problems have been eliminated or solved.

Looking at quality circles in the much broader perspective of creativity, the following benefits can be

ascribed to the quality circles concept. They have helped to create a climate in which the search for quality and productivity excellence has been greatly enhanced. They have increased employee motivation and morale. Quality circles have improved communication among employees, functions, management and, in some companies, with unions. They have acted as a valuable catalyst in enhancing managerial skills through the intensive training involved and practical experience gained during the problem-solving exercises. Lastly, they have helped to improve financial performance.

Majaro (1988) believes that the whole modus operandi of quality circles, the structure of the terms and the routines are perfectly appropriate to the more ambitious and all-embracing task of responding to the firm's need to innovate. Firms that have successfully adopted the quality circles concept are in a good position, Majaro asserts, to extend the system to the total creativity and innovation cycle by turning their circles into creativity circles.

Concepts of Creativity

Creativity is typically defined as the generation of new ideas (Sethia, 1989; Kuhn, 1985; Kanter, 1983; Mohr, 1969). Innovation, closely linked to creativity, is the translation of ideas into a new process, product, or service (Kanter, 1983; Mohr, 1969). In the words of Mohr (1969), creativity implies "bringing something new into being;

innovation implies bringing something new into us."

Creativity has also been defined more explicitly by Perkins (1985) as involving a drive (a) to reduce complexity to order and simplicity, (b) to understand not only the nature of a problem but change the way it is approached and defined, and (c) to cut across traditional boundaries and make unexpected connections.

Associationists believe productive thinking was related to making connections or associative bonds between clusters of memory traces; richer responses included more unexpected associations. Gestalt theorists also have views on the creative process and translate "Gestalt" to mean pattern, shape, configuration, theme or meaningfully organized system. Of particular importance to any study of the creative process according to Gestalt theorists is the mechanism whereby one switches understanding from one possible interpretation to another. The Gestalt switch or insight turns thinking around so that previously insignificant elements which made up the background to the Gestalt come into focus while earlier significant aspects are pushed into the background.

Edward deBono (1980) likens creativity to lateral thinking which occurs when the mind interrupts its habitual, organized thought process and leaps sideways out of ingrained patterns. When this happens, deBono (1980) says the brain often links unrelated patterns to solve problems

or to come up with new ideas.

Creativity is traditionally associated with right hemisphere behavior. Accomplishing work requires non-conforming individuals inventing something new combined with people with an eye toward improving something. Indeed there is a left dominant mode of creativity (verbal and logical) as well as a right dominant mode (visual). Within the self-structuring theories of creativity, Kelly believes that creativity begins when constructs are loosened and ends with the newly formed or validated constructs.

Majaro (1988) finds there are three kinds of creativity: normative, exploratory, and serendipity. Normative creativity refers to the process of applying creative ideas toward solving a problem. Normative means responding to a defined goal, need, desire or mission. The measure of success or achievement in this respect is when the problem has been solved and innovation attained. 'Creativity of objectives' is another way of describing the process. Problems can only be solved if their precise nature and causes are known. A careful analysis of cause-and-effect has to be undertaken and only when the real cause has been established and defined can the problem-solving process commence.

Exploratory creativity occurs when ideas are generated to develop future opportunities which are not necessarily related to known requirements or recognized demand. It

attempts to extrapolate from present day knowledge and technology towards a futuristic scenario which may not meet future needs. Exploratory creativity highlights opportunities that are not always exploitable in commercial terms. Majaro (1988) feels it is difficult to measure the quality of the output inasmuch as one is not responding to a specific marketing or technical need. However, the impact of this type of creativity on an organization's overall direction can be of the highest value. Exploratory creativity can help an organization get itself out of a strategic rut in which it has found itself stuck.

The difference between the two types of creativity is quite subtle. The main importance lies in the fact that the techniques used for generating ideas in normative creativity differ from those that one tends to use in exploratory creativity. In the former case, one uses techniques like brainstorming, synetics, or trigger sessions. In the latter, one uses morphological analysis, scenario writing or scenario daydreaming. In normative creativity one tries to focus the idea generation activity upon a defined problem. In exploratory creativity one tries to direct the creative process in an outward direction towards a futuristic dream-world with the hope of striking gold at the end of the cycle.

Creative breakthroughs take place by serendipity when the ideas underlying the breakthrough are discovered by an

unexpected accident. Three main characteristics typify those who generate this kind of creative idea: (a) they possess an acute observing skill; (b) they also manifest an inquisitive mind, and (c) they have developed a lateral thinking capability -- they are able to extrapolate a set of facts from a chance event to a totally different environment.

This is the point at which quality circles and creativity circles diverge. The main rationale of the quality circle is the development of a corporate system designed to solve problems. Its aim is to institutionalize normative creativity in such a way that an infrastructure exists to identify, analyze, and solve problems at work. Few quality circles undertake exploratory creativity activities in areas outside the immediate work environment of the circle members. Table 5. compares quality circles with creativity circles.

Table 5

Quality and Creativity Circles Compared

<u>Quality Circles</u>	<u>Creativity Circles</u>
Main purpose is to identify, analyze and solve problems at work.	Terms of reference can be broadened to encompass exploratory creativity, at all levels, and the development of the appropriate skills that make managers alert to accidental or chance innovations (serendipity).
Mostly concerned with problems affecting immediate work area.	Can be invited to generate ideas and/or solutions to problems outside direct area of responsibility. Act as a Think Tank for other parts of the firm.
Tendency to concentrate upon manufacturing, quality, productivity matters.	Can deal with every facet of the organization, commencing with the search for strategy, mission statement, marketing strategies, product development.
Conducted under the leadership of a department's supervisor.	Can be led by any member of organization. It is important that the individual have experience in leading creative sessions.
Emphasis on a "bottom up" approach. Most group sessions are held at operational level. Top management seldom takes part in circle meetings.	Successful implementation demands a "top down" strategy. Top management must be seen to participate in group activities and support their efforts at all times.

Majaro finds that "creativity circles" are the logical extension of the quality circle concept to the management of modern operations.

Virtual Teams

Similar to Majaro's "creativity circles" are Savage's (1990) "virtual teams". The primary objective of these task focusing teams, virtual teams, is to discern the themes coming from the market, competition, suppliers and partners, and within their own company. Team members must design products, processes, and service strategies to support the products throughout their life cycles. By working together, on a peer-to-peer basis, they can iterate possible solutions until they develop a plan.

Networking of vision and knowledge allows virtual teams to see the patterns of the present and to express their own patterns. Human networking involves drawing upon visions and knowledge to develop quality actions in the present, in concert with a team. These teams of professionals are charged with recognizing, interpreting, deciding, and implementing responses to windows of opportunity that will meet both the customer's expectations and the teams' enterprise vision.

Peters and Waterman

Peters and Waterman (1982) believe there is absolutely nothing wrong with the idea of quality circles, but they believe that quality circles are only the latest in a long

line of tools that can be either very helpful, or can simply serve as a smoke screen while management continues to get away with not doing its job of real people involvement. The importance and necessity of not just applying a few of the tools but rather embracing the holistic nature of Total Quality Management which requires employee involvement is evident in the above statements by Peters and Waterman.

Peters (1987) talks about a core paradox in Thriving on Chaos. According to Peters, this core paradox is fostering or creating internal stability in order to encourage the pursuit of constant change. He feels the organization's vision must be clear and consistent enough to encourage continual risk-taking and failing, or else the continual testing and stretching and enhancing -- changing -- of everything will not occur, or not occur fast enough.

The dichotomous task of preaching a vision and simultaneously testing and re-forming the very same vision has not been imposed upon leaders before. Peters (1987) suggests that organizations will now seem somewhat out of control by the old standards. That is, the madness of thousands of simultaneous experiments -- including some by the newly hired reservations clerk -- is the only plausible path to survival. What once amounted to being "in control" is a design for disaster. In control by the old standards is out of control (fast slipping away) by the new standards. This raises the issue of whether practices designed to

measure stable processes can truly be applied to these "out of control" times.

Peters (1987) believes that more appropriate measurement is achieved with fewer measures. He says these measures should emphasize the vital performance parameters - e.g., quality, service, flexibility, responsiveness, and employee skills or capabilities. Peters (1987) also believes it is vital to engage in multifunctional problem solving to target business systems that cross several functional boundaries. Ford and IBM both say they wasted years before realizing that most quality improvement opportunities lie outside the natural work group.

Kanter

Kanter (1989) writes that the idea of at least modest change everywhere in the corporation is becoming orthodoxy. She says among the most promising "themes" adopted by businesses to encourage incremental innovation are the concepts of "total quality" and "continuous improvement" -- both predicated on the assumption that continual striving to reach higher and higher standards in every part of the business will provide a series of small wins that add up to superior performance. Kanter (1989) feels such efforts point in the right direction -- toward organizations able to learn and adapt to the demands of a rapidly changing business environment, however, she questions whether "continuous improvement" will be enough. Kanter feels that

more dramatic changes in structure and systems and sensibilities are required to meet the pressures that businesses face today.

Creative Corporate Strategy

Kanter (1983) believes that empowering lower levels of the organization to initiate new ideas in the context of a supportive environment is a valuable means of implementing successful innovations. The management of organizational creativity requires an understanding of the creative process and how it can be stimulated. Kanter mentions brainstorming, the nominal group technique, synetics, and creative group decision making as possible ways of stimulating creativity. Similarly Freedman (1987) believes that creativity comes not so much from genius or luck as from a determination to construct an idea nurturing environment. Kanter, Freedman, Amabile, Gyskiewicz, and Sethia (1983; 1987; 1987; & 1989) stress that individual creativity can be powerfully influenced by elements of the organization. As an illustration, goals and priorities of the organization tend to dictate if creativity is desirable in the first place, and if there are opportunities for people to be creative. Sethia (1989) finds that creative achievement is shaped as much by organizational factors such as leadership, organizational structure and reward systems as it is by individual talent and motivation.

The culture of an organization provides a system of

rules and guidelines for perceiving, believing, prioritizing and acting, and therefore it inevitably shapes the dedication and support for innovation. Examples abound of inhospitable cultures frustrating the effective exploitation of even the highest quality R&D. In an article entitled "The Lab that Ran Away from Xerox," Uttal (1983) identifies a "culture-clash" at Xerox and found that translating advanced research into marketable products was made very difficult by the company's management style. While culture can be a roadblock to innovation it can also be the major facilitator of innovation as is the case with 3M where there is a strong respect for ideas and individuality, combined with tolerance for deviance, support for risk-taking, and openness for learning.

An organization's culture represents a distinctive pattern of relatively enduring beliefs, values, and norms shared by the organization's members. In day-to-day life, culture finds tangible expression in the ends or goals people pursue, the means or methods they adopt, and when and how they act. Therefore innovation is highly dependent on culture.

According to Sethia (1989) the cultural differences found in organizations are best interpreted on the basis of two fundamental criteria: the basic mode of thinking in the organization and the basic mode of acting in the organization. The mode of thinking can be characterized as

having primarily an external or internal focus; and the mode of acting can be described as showing typically a proactive or reactive bias. An external focus in thinking indicates a propensity to read environmental signals and heed outside developments. An organization with this mode of thinking shows awareness of changes in the external environment -- particularly the changes pertaining to technological trends, competitor strategies, market needs, and regulatory climate. In contrast, an internal focus suggests insensitivity to the external environment and preoccupation with developments inside the organization. Thus, an internally focused organization defines its own technological standards, disregards competitors, and takes the market for granted. Proactive bias connotes self-motivated initiative and dynamism, optimism and risk-taking, and the desire to originate a new order of things. A proactive bias suggests the quest to explore and lead, and constantly renew. Reactive bias, in contrast, implies inherent inertia and conservatism, caution, risk-aversion, and an inclination to preserve the existing order of things. Organizations with a reactive bias are satisfied being a follower or an imitator and preserve themselves through defensive maneuvers. The combination of thinking mode and acting mode form the dominant culture of an organization and corresponds to one of the four cultural patterns below: The resistive culture (internal focus and reactive bias), the imitative culture

(external focus and reactive bias), the adaptive culture (external focus and proactive bias), and the creative culture (internal focus and proactive bias).

As the name implies, the resistive culture is the least hospitable to innovation. A somewhat more hospitable mode is the imitative culture which cautiously accommodates innovation. Then there is the adaptive culture where innovation is positively valued, but is balanced against other practical considerations. Lastly there is the creative culture where innovation is considered the organization's basic purpose.

The imitative culture of Compaq provides success that isn't from the latest technology or a lot of razzle-dazzle, but from coming out with what dealers and customers want. For these organizations, revolutionary innovations are too costly and too risky. Consequently, they concentrate on imitating products or modifying and improving the available products and offering them at lower prices by tightly controlling manufacturing and operating costs. The imitative culture, present-oriented and risk-minimizing, has a conservative stance toward new ideas and changes when threatened by competition.

Imitative organizations innovate only as an effective answer to competitive challenges that serve to assure the organization's stability and profitability. Moreover, the innovation effort is geared not to radical advances but to

gradual improvements or incremental changes. Being geared to gradual improvements and incremental changes, the imitative culture follows the quality philosophy.

In an adaptive culture, innovation is highly valued, but the direction as well as the intensity of the innovation effort is consciously controlled to make it consistent with the organization's overall business plans. Innovation is not a spontaneous and random occurrence but a strategically, or even bureaucratically, orchestrated activity. In this culture, calculated risk-taking is encouraged and enterprising behavior is rewarded. This type of organization wants to be a leader in innovation -- but more as the one to apply and fully exploit innovations than as the one to introduce them. The orientation to innovation is consistent with a market-focused business philosophy. The adaptive organization continually strives to upgrade its existing products and devise new spin-off products from the current core. It considers price-performance advantage as the key product attribute, and therefore tries to be a low cost producer of high quality goods. The organization's marketing function is dedicated to developing the market and cultivating customers by being extremely responsive to their needs and preferences. The adaptive culture, similar to the imitative culture, follows the quality philosophy but this time because of its market focus and extreme responsiveness to the customer.

By contrast, the creative organization considers innovation a meaningful goal in itself. These organizations possess high degrees of dynamism and initiative, but tend to operate in an environment that is relatively free from competitive pressures -- primarily because they have novel or unique products for selectively targeted markets. They often view themselves as devoted to some special goals which go beyond mere business objectives. Polaroid and Apple Computer, Inc. are examples of creative organizations. In these types of organizations, innovation sets the pace of business, creativity is worshipped, and a vision of how things ought to be serves as a basis of change. In such organizations, inventive behavior is highly valued and there is a sense of romanticism about new ideas. A case in point is 3M -- an organization that might appear quite "down-to-earth" compared to Polaroid or Apple, but still is a good example of the creative culture. In the creative culture, individuals are willing to take significant risks and they are set on a future that is a dream waiting to be transformed into reality. Such organizations seek to be pioneers in their fields and derive self-fulfillment from successful innovation. Innovation is directed at achieving significant breakthroughs and products are promoted on the strength of their originality. Another example of a creative organization is Hewlett-Packard, which in a recent Fortune survey was rated higher than any other industrial

company for innovation. In considering entry into a new field, the important criterion is whether Hewlett-Packard can make a real contribution by providing something new and needed -- not just another brand of something already available.

The internal orientation of the creative culture actually indicates its basic weakness: excessive preoccupation with the "create" functions in innovation and the neglect of the "make" and "market" functions. All four creative organizations described have lately recognized that they will not be able to fulfill their promise and realize their potential unless they can learn to pay attention to their customers and take notice of their competitors.

The Total Quality Management philosophy is conducive to the goals of the imitative and adaptive cultures, but not the goals of the creative culture. The weakness of the creative culture in that it doesn't pay enough attention to its customer goes against the basic premise of the quality movement, satisfying the customer. What makes an organization creative -- its internal focus and its pursuit of innovation as a meaningful goal in itself -- makes it un-quality like as well.

The Balancing Act

In all organizations where technological innovation plays a key role, a state of creative tension exists between those responsible for technological development of new

products and the organization's need to satisfy customer's demand. According to McDonough and Leifer (1986) a balanced state of tension is needed. They believe that when the balance swings too far in the direction of technological development, technological wizardry is prevalent. They also say that when it swings too far in the direction of satisfying customer demands, innovativeness can be stifled and technological stagnation can result. Consequently, McDonough and Leifer (1986) stress that maintaining a state of creative tension is important for producing viable and technologically innovative products.

McDonough and Leifer (1986) found that firms need to maintain a business orientation in their organization culture while simultaneously foster an R&D culture which emphasizes creativity, innovativeness, and inventiveness. They indicated that at a first glance, these cultures seem to be at odds with each other, and in some respects they are at odds.

According to Roussel, Saad, & Erickson (1991) if research and development concentrates on research that is more closely integrated with the firm's overall strategy, the department's ability to make incremental developments of existing products will certainly improve. However, Roussel et al. (1991) believe the trade-off may be that the chance of R&D producing an off-beat blockbuster will be greatly reduced since commercial realities tend to stifle

innovation.

R&D scientists and engineers have recently accepted the idea of planning, but not of scheduling innovation, and remain fearful of being micro managed. According to Miller (1986, p:11) "the influence of business schools on the management of technology has come dangerously close to causing business leaders to kill the goose that lays the golden eggs -- the creativity of individuals." The negative impact is caused by overly tight management and financial control of the front end of the creative process. Miller (1986) believes there is room for compromise of this issue, and designing appropriate controls can lead to improved output. The challenge is to acknowledge that there is a conflict of values and to manage in such a way that this conflict does not have a negative impact on innovation.

Creative Work Environments

At 3M, 20 to 25 percent of each year's sales are the result of products or services introduced in the last five years. Chief executive officer Lehr (1980) says that the salesmen do not stop listening when they do not have the product a customer needs. In fact, Lehr says that is when they really start listening. The salesmen play an important part in what he calls imagineering activity -- the integration of creativity among researchers, marketers, manufacturers, and customer service engineers in each division. From the very beginning 3M grew on new products

developed by lab technicians and others who persisted, often against the wishes and directives of management and despite frequent setbacks. The freedom to persist implies the freedom to do things wrong and to fail. 3M accepts that and believes that every one of their senior managers has backed a few losers along the way. But at the same time 3M expects any mistakes to have originality -- that they can afford almost any mistake once.

Taylor (1990) says, "The most important thing we [Raychem management] do is build an organization -- a culture -- that encourages teamwork, that encourages fun and excitement, that encourages everyone to do things differently and better -- and that acknowledges and rewards people who excel." Taylor (1990) believes too many American companies are only immersed in their markets bringing along whatever technology they think is necessary to satisfy a market need. In contrast, Taylor's mission at Raychem is to creatively interpret core technologies to serve the marketplace.

To develop an in-depth understanding of markets, Raychem has salespeople and marketers, most with technical training, who are superb at understanding customer needs. Taylor asserts that the person who can combine deep knowledge of the technology with deep knowledge of the customer is the most important person in the process of innovation. The biggest obstacle to innovation, according

to Taylor (1990) is success itself. All too often a company will develop an important new product and spend years making it a little better, a little cheaper, a little more sophisticated. Those are all important since there's always room for incremental improvement, but Taylor insists you can't let the entire innovative thrust revolve around making products faster, better, cheaper. A truly innovative company never stops asking more fundamental questions about its most successful products such as are there whole new ways to solve the problem -- ways that might cut costs in half or double or triple performance?

Raychem introduces new products even before old products "run out of steam." Their customers had virtually no complaints about it, but because technologists knew the product and its applications even better than their customer, they were able to upgrade performance significantly by using a new technology.

Hisrich (1990) believes the first ingredient of creativity is to operate on the frontiers of technology and to encourage and support new ideas. Along with Lehr, Hisrich (1990) says experimentation must be encouraged and an environment which allows mistakes and failures must be established. An organization should also ensure there are no initial opportunity parameters to inhibit free creative problem solving and the resources of the firm must be available and easily accessible. Hisrich (1990) recommends

that a multidiscipline, team-work approach needs to be encouraged such as a quality circle or quality improvement team. Additionally, the spirit of creativity cannot be forced on persons; it must be on a volunteer basis. The creator needs to be appropriately rewarded for all the energy and effort expended in the creation of the new venture. For example, implementing a recognition program is an effective way of ensuring appropriate rewards. A corporate environment favorable for creativity has sponsors and champions throughout who not only support the creative activity and any resulting failures but have the planning and flexibility to establish new objectives and directions as needed. Finally, and perhaps most importantly, the creative activity must be wholeheartedly supported and embraced by top management.

Amabile and Gyskiewicz

Amabile and Gyskiewicz (1987) notice that environmental factors, described as any factor outside the problem solvers including other people, seem to consistently influence creativity positively or negatively. They found that as influencers of creativity in organizations environmental factors were mentioned much more frequently than personal qualities. The most frequently mentioned environmental feature surrounding the high creativity events was freedom. This freedom encompassed deciding what to do or, more frequently, how to do one's own work; a sense of

control over one's own work and one's own ideas; a freedom from having to meet someone else's constraints; and a generally open atmosphere. Encouragement and support of ideas were also a positive factor for organizational creativity with three major points: management enthusiasm for, interest in, and commitment to a particular research idea or to new ideas in general; an orientation toward risk and acceptance of failure on the part of management; and an atmosphere without destructive criticism or excessive concern over evaluation. This encouragement and enthusiasm seemed to be most effective if it came from the highest levels of the organization.

High creativity events described by those interviewed by Amabile and Gyskiewicz had a sufficiency of resources, including facilities, information, funds, and people -- stimulating people both within and outside the work group. These events were also marked by a sufficiency of time to think creatively about the project. According to Amabile and Gyskiewicz (1987) thirty-five percent of those interviewed described recognition or appropriate feedback as conducive to creativity. Another positive factor was a generally cooperative and collaborative atmosphere within and between divisions, with good communication throughout.

Amabile and Gyskiewicz (1987) found that the opposite of encouragement took several different forms that proved destructive to creativity. The most prominent of these can

be termed "organizational indifference" -- a lack of psychological support within the organization, a lack of faith in the project, and/or a general apathy or complacency toward research. One of the most striking organizational factors named as a detriment to creativity was the reward system -- either too much emphasis on rewards, or insufficient or unfair distribution of rewards (including recognition for good work). Overly formal and complex structures, procedures (including quality processes), and communication channels within the organization can be detrimental to creativity. According to Amabile and Gryskiewicz (1987) feelings of evaluation pressure can severely curtail any risk taking and, as a result, severely undermine creativity. An exclusive or primary focus on rewards -- on what employees can get for doing each specific job -- leads to an extrinsic motivation and lower creativity. The balance must be between explicitly holding rewards out as carrots for specific jobs and implicitly making it clear that creative work is always recognized and rewarded in the organization.

Evaluation pressure can also be considered as opposite to the kind of encouragement that is conducive to creativity. Such pressure takes several different forms: inappropriate evaluation or feedback procedures, unrealistic expectations, pressure to produce something (anything) appropriate, and a general concern about criticism and

external evaluation of work. Another factor that can undermine the encouragement to be creative is an overemphasis on the status quo within the organization, particularly at the highest levels.

Geis

Geis (1985) offers the following three suggestions to encourage the type of risking that must occur for innovation: provide professional, collegial, and financial support to allow an individual to perceive a reduction in the odds of failure, explore options for diversifying or sharing risk from financial and psychological perspectives, and have top management socially encourage risk taking. An example of encouragement is the statement, "If you don't make at least three mistakes a day, you're not doing your job." Furthermore, Geis (1985) believes limits must be placed on the social downside of failure.

Gluck

Gluck (1985) mentioned that Sherman's 1984 article in Fortune which identified eight companies as leaders in innovation left him with a sense of frustration because he believes there is a sizable gulf between the kind of innovation represented by Apple Computer and Intel and that of Philip Morris and General Electric. Gluck (1985,p.90) states, "We need to understand the significance of the difference between what might be called, at one end of the spectrum, the 'suggestion box' innovation (i.e., product

line extensions, cost reductions, and the like) -- in other words, incremental type of innovation -- and, at the other end of the spectrum, the 'big bang' type of innovation that Apple Computer represents. Gluck (1985) feels that very few of the largest and most successful corporations have really solved the problem of how to renew themselves when major shifts in the environment occur. According to Gluck, corporations don't seem to be able to rethink how they do business when the fundamental nature of competition in their industries changes or new market opportunities open up. The fundamental reason for the above problem is, as Gluck points out, the substantial difference both culturally and conceptually between what it takes to successfully pursue suggestion box innovation and what it takes for big bang innovation. Suggestion box innovation requires a great deal of highly specific information on a particular aspect of a business. The new insights are usually limited to small, incremental improvements in that function. But when the entire business concept is threatened through radical technological change, globalization, and/or deregulation, there is a different problem. Gluck's prescription for a creative organization includes the possession of a tremendous store of raw information, and the ability to combine, order, or connect this information in a novel and better way. The lifeblood of the creative organization is uncategorized, unanalyzed, undigested, messy information.

Gluck (1985) states the following:

The first requirement for a creative organization is a method or approach to information acquisition that puts a great deal of raw information in the hands of many people -- planners, market researchers, designers, and most importantly, line managers. The second requirement is to have decision makers involved in the unstructured, playful, contentious, and rambling process of discerning patterns from raw, undigested information. The third requirement which enables an organization to convert creativity into innovation is the ability to execute.

Gluck (1985) believes top management determines whether incremental and big bang innovation will be supported. He stresses the importance of having top management deal with raw information in a way that makes ordering it in new ways possible. Raw information is defined as detailed understanding of customers, competitors, markets, technologies, and the implications of how they are all interacting and changing. Equally important is providing management the opportunity for wide-ranging debate which can lead to different interpretations of these facts in order to arrive at creative solutions. Typically, management demand digested information and all too frequently embraces tools and methodologies that give the appearance of precision and insight, but are simply highly digested summaries of the status quo. Gluck (1985) finds that top-level managers do not feel they have the time to tolerate contradictory and ambiguous information. He seriously questions using tools and techniques for digesting information when things are

changing fast. For example, this suggests that the statistical quality control tools which measure stable processes and pinpoint variability are not as useful as they were in more stable times. Digesting information must be done with great circumspection by people with a broad understanding of the factors that challenge the corporation and who have the responsibility and power to act upon the challenge.

Creativity at the Process Level

The creative problem steps shown below is designed for an individual and shows that time must pass in the third incubation and gestation phase without attention to the problem at hand. This particular creative problem solving is even more divergent than Iasken's model since the subconscious mind is considered to be accessed to "mull over the material."

Creative Problem Solving Steps

1. Problem finding or sensing. The individual selects a problem to work on or, more likely, becomes aware that a problem or disturbance exists.
2. Immersion or preparation. The individual concentrates on the problem and becomes immersed in it, recalling and collecting information that seems relevant and dreaming up hypotheses without evaluating them.
3. Incubation and gestation. After assembling the available information, the individual relaxes and lets his or her subconscious mull over the material. In this little-understood but crucial step, the individual often appears to be idle or daydreaming, but his or her subconscious is in fact trying to arrange facts into a new pattern.

4. Insight or illumination. Often when least expected -- while eating, or falling asleep, or walking -- the new, integrative idea will flash into the individual's mind. (exploratory/serendipitous creativity)

Iasken (1988) developed a model of a creative problem solving process that is based on a series of stages of mental activity consisting of alternating phases of divergent and convergent thinking. The process is designed to generate and develop alternatives followed by a selecting, choosing, or narrowing down of the alternatives. In each stage, two complementary types of thinking are necessary. The model, shown in Table 6, is based on the belief that effective problem solving relies upon both creative and critical thinking. Iasken (1988) defines creative thinking as making and communicating meaningful new connections to think of many possibilities; think and experience in various ways and use different points of view; think of new and unusual possibilities; and guide in generating and selecting alternatives. Critical thinking is defined as analyzing and developing possibilities to compare and contrast ideas; improve and refine promising alternatives; screen, select, and support ideas; make effective decisions and judgments; and provide a sound foundation for effective action.

Table 6

Creative Problem Solving Process

Divergent Phase		Convergent Phase
Experiences, roles and situations are searched for messes. . . openness to experience, exploring opportunities.	Mess Finding	Challenge is accepted and systematic efforts undertaken to respond to it.
Data are gathered; the situation is examined from many different viewpoints; information, impressions, feelings, etc. are collected.	Data Finding	Most important data are identified and analyzed.
Many possible statement of problems and sub-problems are generated.	Problem Finding	A working problem statement is chosen.
Many alternatives and possibilities for responding to the problem statement are developed and listed.	Idea Finding	Ideas that seem most promising or interesting are selected.
Many possible criteria formulated for reviewing and evaluating ideas.	Solution Finding	Several important criteria are selected to evaluate ideas. Criteria are used to evaluate, strengthen, and refine ideas.
Possible sources of assistance are considered; potential implementation steps are identified.	Acceptance Finding	Most promising solutions are focused and prepared for action; specific plans are formulated to implement solution.

In the 1960's the major emphasis in creative problem solving moved from brainstorming alone to a "delicate balance" between divergent (many possibilities) and convergent (one response) thinking. According to Iasken and Teffinger (1985) creative problem solving helps in dealing effectively with future problems and challenges that aren't even anticipated at the present time. The six major stages in the creative problem solving process are the following: mess-finding, data-finding, problem-finding, idea-finding, solution-finding, and acceptance-finding. Following are six ground rules for the divergent aspect of each stage to assist in searching for a truly extensive collection of ideas: defer judgment, look for lots of ideas, accept all ideas, make yourself "stretch," take time to let ideas simmer, and seek combinations - be a "hitch-hiker." Iasken and Teffinger (1985) also offer some basic principles for being more efficient and effective during the converging phase of each of the six creative problem solving stages which include the following: be deliberate, be explicit, avoid premature closure, take the risk to look at difficult issues or "sneaky spots," develop a sense of "affirmative judgment," and keep the objectives in mind. The steps in Iasken and Teffinger's creative problem solving process differs from Leadership through Quality Problem Solving Process (PSP). In PSP, the six steps are identify and select a problem, analyze the problem, generate potential

solutions, select and plan a solution, implement the solution, and evaluate the solution.

The subject company's problem solving process has fewer divergent phases because it begins at a later stage and carries the process through to the implementation and evaluation stages. Iasken and Teffinger's (1985) creative problem solving process starts the process prior to problem identification with both a "mess- finding" and "data- finding" stage that come before the problem is defined in the "problem-finding" stage. In general, the company, as a quality organization does not have as divergent nor creative a problem solving process as that developed by Iasken and Teffinger (1985).

Corporate "Imagineering" Research

Brown (1991) explains the role of corporate research in a business environment characterized by tougher competition and nonstop technological change. To better assimilate the latest innovations and quickly incorporate them in new products companies are shifting the focus of their research department away from radical breakthroughs toward incremental innovation, away from basic research toward applied research. Palo Alto Research Center (PARC) has chosen a different approach, one that cuts across both of these categories and combines the most useful features of each. It is called "pioneering research." Like the best applied research, pioneering research is closely connected

to the company's most pressing problems, but like basic research, it seeks to redefine these problems fundamentally in order to come up with fresh - and sometimes radical - solutions. Brown (1991) feels that when corporate research begins to focus on a company's practice as well as its products, another principle quickly becomes clear: innovation isn't the privileged activity of the research department. It goes on at all levels of a company -- wherever employees confront problems, deal with unforeseen contingencies, or work their way around breakdowns in normal procedures. The problem is that few companies know how to learn from this local innovation and how to use it to improve overall effectiveness. At PARC, Brown and his staff are studying the process of local innovation with employees on the front lines of the company's business and they are developing technologies to harvest its lessons for the company as a whole.

In fact, Brown (1990) believes the company's future competitive advantage will depend not on just selling information-technology products to customers. It will depend on coproducing these products with customers -- customizing technology and work practices to meet their current and future needs. One role of corporate research in this activity is to invent methods and tools to help customers identify their "latent" needs and improve their own capacity for continuous innovation.

The successful company of the future must know how to create an environment for continual innovation on the part of all employees. It must rethink traditional business assumptions and tap needs that customers don't even know they have yet. At PARC, Brown and others (1991) are studying some of the company's most adventuresome product-development programs to learn how the larger organization can sometimes obstruct a new product or work process. By learning how the corporation rejects certain ideas, they hope to uncover those features of the corporate culture that need to change. By challenging the background assumptions that traditionally stifle innovation, Brown (1991) hopes to create an environment where the creativity of talented people can flourish and "pull" new ideas into the business. Brown and his staff are studying the organizational barriers that stifle innovation or keep it useful only at the local level.

While Brown discusses the organizational barriers that stifle innovation Nadler and Hibino (1990) talk about destroying inhibiting mental walls by putting aside cultural traditions and norms. Nadler and Hibino (1990) coined the principle "solution-after-next" to describe a common failing among problem solvers -- neglecting to look beyond the immediate problem and its solution. The solution-after-next principle helps develop alternative solutions that take into consideration future needs. It creates an image of what the

system, product, or organization will look like in the future and joins the daily decision making in the organization to bigger purposes. The solution-after-next principle undermines the mental walls or conceptual blocks that inhibit people from perceiving the right problem or developing creative solutions. According to Nadler and Hibino (1990) this principle demands that decision makers view a problem from various perspectives, putting aside cultural and environmental taboos and traditions; challenging the propensity to avoid risk; encouraging the generation and growth of innovative ideas; and maintaining an openness to using a wide variety of tools, techniques, and modes of expression. The important idea to remember is to avoid the conventional approach to analyzing and subdividing the problem.

Nadler and Hibino (1990) find that the quality problem-solving approach has limitations in several areas. First, the approach assumes that solving the smaller problems will supposedly solve the larger problem. Second, quantitative and objective data are relied on and qualitative data is undervalued. Thirdly, the quality problem solving approach assumes that once facts are analyzed one solution will emerge on which all reasonable people can agree. Nadler and Hibino (1990) insist that breakthrough occurs when the daily decision making is joined to bigger purposes so that an image of the system, product, and/or organization is

created.

According to Nord and Tucker (1987) implementing incremental improvement is the process of introducing "something" that can be implemented with only minor adaptation of existing organizational routines and that fits within the existing norms and values of organization members. Breakthrough is the process of introducing something that is new to the organization and that requires the development of completely new routines, usually modifications in normative beliefs and value systems of organization members. Structures that make it possible to adapt quickly to knowledge gained through trial and error aid breakthrough. Nord and Tucker (1987) believe that a breakthrough adopts the organization rather than the organization adopting the breakthrough.

According to Normann (1971), continuous improvements or what he called variations involve only minor changes in the task system which can be accommodated without major adjustments within the existing political system. Variations can be handled with few changes in the cognitive orientations of organizational members. In contrast, radical innovations or what he called reorientations involve basic changes in the task system; they necessitate new types of knowledge and new specialists. Normann believes new values, goals, power structures, and cognitive systems (such as attention, decision, and interpretation rules) are

needed. Normann (1971) suggested that radical innovations introduce more uncertainty and therefore require more organizational change, more entrepreneurship, and greater involvement of top management than continuous improvements do.

Breakthroughs, in contrast to continuous improvement efforts, are the type of development that lends itself more to patent considerations. The more breakthroughs that exist in a research department the more patents or patent applications there are likely to be. Since breakthroughs are thought to warrant patents, the literature on patent criteria is helpful in differentiating breakthrough from continuous improvement. A key concept in whether an invention or development passes the requirements for patenting is whether it can be proven to be an "unobvious" development.

"Unobviousness" means the difference between the invention and "prior art" must not be obvious to one with ordinary skill in the field. According to Pressmen (1988) "unobviousness" has even been equated with "a flash of genius" and "a synergistic effect (the whole is greater than the sum of its parts)." Unobvious inventions produce "new and unexpected results" when considered by a person having ordinary skill in the art to which the subject matter pertains.

Intellectual Breakthrough

Axelrod (1979) views intellectual breakthrough as a social phenomenon. He believes there is a tendency of an intellectual community to restrict the individuality of its members and that "breakthroughs" are a result of the struggles of certain members against restrictors imposed upon them. The intellectual breakthrough is the overcoming of some imposed restrictions by developing a new idea, a new style, a new paradigm, or a new teaching. According to Axelrod (1979), intellectual breakthrough is distinguished by the following: a tension between the individual and the group, a search for theoretical grounds, and the fact that a discursive event surfaces as a challenge to the conventions of an intellectual community's paradigm.

Examples of Breakthroughs

Axelrod (1979) gives three examples of individuals who have come up with breakthroughs: Freud, Simmel, and Buber. Freud's breakthrough was the "symbol" since it represents a concrete life adhering to the limits of unequivocal speech and a hidden life responding to the plurivocal capacity of speech and from which the suppressed and mutual voice of desire speaks. Thus, with the symbol, Axelrod believes Freud can preserve science as the pursuit of practical wisdom while simultaneously exposing the violence it does to human expression. Simmel's breakthrough was his fragmentary character since fragmentation provides a commitment to meet

every situation directly without the imposition of an alien structure and method imposed upon a topic of inquiry before the inquiry begins. Simmel alludes to the restrictive capacities of systematic unity in writing and expresses a commitment to the achievement of individuality. The fragmentary character of Simmel's writing constitutes a style of opposition to certain restrictions imposed upon inquiry from the outside community. Axelrod (1979) believes Buber's breakthrough came in the form of recognizing the limits of objective speech. Buber believed that the philosophical community that cannot recognize the limits of objective speech fails to realize the essential purpose of speech.

Intellectual communities adopt particular orientations to intellectual work (a paradigm) while expecting its members to mimic the same orientation. Axelrod (1979) states, "Intellectual institutions on our society that claim to understand and speak for Western intellectual tradition, have often lost the very spirit of that tradition because of their self-limiting orientations. Their structuring of thought has made it inconsistent with thinking itself."

Axelrod (1979) finds that breakthrough begins with estrangement -- a relatedness to the tension between the individual and the group. Freud, Simmel, and Buber expressed their estrangement in a certain way; not by escaping or declaring indifference, but by attempting to

generate more relevant and crucial possibilities for inquiry. They chose to struggle with the restrictions of their membership in an attempt to re-negotiate conditions suitable to their own experience of theorizing. To amend or dissolve the accepted paradigm, they articulated their critiques and provided a higher rationality -- one that allowed their work to reach an audience and to re-enter the community of discourse.

Bisociation and Breakthrough

Koestler (1964) describes bisociative thinking as a manager tackling a problem moving around on a plane or matrix. The manager is kept on the surface of the plane by all the conventional rules and habits of analytical thinking and does not find an acceptable solution. Koestler (1964) imagines a second plane or matrix cutting the first. The manager meets this second plane and moves into it to find a possible answer to the problem. The two planes are unrelated until the manager establishes a relationship and finds the possible answer to the problem in the second plane. The establishment of the relationship, or bisociation, is usually accompanied by a release of tension -- the 'Aha' reaction or flash of illumination revealing an answer.

Examples of Bisociative Thinking

Gutenberg's Printing Press.

Gutenberg went to a wine harvest, and in the

celebration party saw the wine press as the solution to the problem of printing evenly from hundreds of individual seals or letters.

Professor August von Kekule.

Kekule, the founder of organic chemistry, dreamed of a snake biting its tail and this led to the ring structure of six carbon atoms in Benzene.

Alexander Fleming.

Fleming noticed that spores of penicillin notatum which had blown through his lab window onto a dish of staphylococci had the same effect as one of his fallen tears in a dish of yellow bacteria many years earlier.

These examples of bisociation emphasize that the information must be there to be combined in different and new ways.

Association versus Bisociation

One criterion that separates bisociation from association is the previous independence of the mental skills or universes of discourse which are transformed and integrated into a novel synthesis of the creative act. The more unlikely or "far-fetched" the mediating matrix, i.e., the more independent from the other matrix -- the more unexpected and impressive is the achievement. In new discoveries, the previous independence of the components that went into the 'good combination' is a measure of achievement, e.g., frames of reference for magnetism and

electricity, of physics and chemistry, of corpuscles and waves, developed separately and independently, both in the individual and the collective mind, until the frontiers broke down. According to Koestler (1964), this breakdown was not caused by establishing gradual, tentative connections between individual members of the separate matrices, but by the amalgamation of two realms as wholes, and the integration of the laws of both realms into a unified code of greater universality. In comparing artistic and scientific bisociations, Koestler (1964) states the following:

The true creativity of the innovator in the arts is more dramatically evident and more easily distinguished from the routine of the mere practitioner than in the sciences, because art (and humor) operate primarily through the transitory *juxtaposition* of matrices, whereas science achieves their permanent integration into a cumulative and hierarchic order.

Another criterion of bisociation which sets it apart from associative habit is the involvement of several levels of consciousness. These underground levels of the hierarchy which are normally inhibited in the waking state play a decisive part. The emotional manifestations of the Eureka act -- sudden illumination followed by abreaction (the relief of a past disagreeable experience by reliving it) and catharsis -- also testify to its subconscious origins. Below is Table 7. showing the criteria for associative habit

compared to bisociative originality.

Table 7

The Criteria for Associative Habit Compared with Bisociative Originality

Associative Habit	Bisociative Originality
Associations within the confines of a given matrix	Bisociation of independent matrices
Guidance by pre-conscious or extra-conscious processes	Guidance by sub-conscious processes normally under restraint
Dynamic equilibrium	Activation of re-generative potentials
Rigid to flexible variations on a theme	Super-flexibility
Repetitiveness	Novelty
Conservative	Destructive-Constructive

(Koestler, 1964)

Breakthrough as the Emergence of New Paradigms

Kuhn (1962) believes theories do not evolve piecemeal to fit facts that were there all the time. Rather, he thinks theories emerge together with the facts they fit from a revolutionary reformulation of the preceding scientific tradition, a tradition within which the knowledge-mediated relationship between the scientist and nature was not quite the same.

A few considerations which Kuhn (1962) thinks lead to new paradigms are a sense of aesthetics, an intense concentration upon crisis-provoking problems, and a youthful or new view of the crisis-ridden field.

One sort of consideration that can lead scientists to reject an old paradigm in favor of a new are the arguments, rarely made entirely explicit, that appeal to the individual's sense of the appropriate or the aesthetic -- the new theory is said to be "neater," "more suitable," or "simpler" than the old. Though aesthetic considerations often attract only a few scientists to a new theory, it is upon those few that its ultimate triumph may depend. If they had not quickly taken it up for highly individual reasons, the new candidate for paradigm might never have been sufficiently developed to attract the allegiance of the scientific community as a whole.

Resistance to New Paradigms

The transfer of allegiance from paradigm to paradigm is

a conversion experience that cannot be forced. Lifelong resistance is not a violation of scientific standards but an index to the nature of scientific research itself. The source of resistance is the assurance that the older paradigm will ultimately solve all its problems, that nature can be shoved into the box the paradigm provides. Any new interpretation of nature, whether a discovery or a theory, emerges first in the mind of one or a few individuals. It is they who first learn to see science and the world differently, and their ability to make the transition is facilitated by two circumstances that are not common to most other members of their profession. Invariably their attention has been intensely concentrated upon the crisis-provoking problems; usually, in addition, they are so young or so new to the crisis-ridden field that practice has committed them less deeply than most of their contemporaries to the world view and rules determined by the old paradigm. Trial attempts by a scientist are only possible so long as the paradigm itself is taken for granted. Therefore, paradigm testing occurs only after persistent failure to solve a noteworthy puzzle has given rise to crisis. In the sciences the testing situation never consists, as puzzle-solving does, simply in the comparison of a single paradigm with nature. Instead, testing occurs as part of the competition between two rival paradigms for the allegiance of the scientific community.

Axelrod (1979) believes breakthrough involves a tension between the individual and the group. Similarly, Koestler (1964) thinks individuals making new discoveries use subconscious processes normally under restraint and Kuhn (1962) sees the overcoming of resistance from other scientists in the field as necessary for the emergence of a new paradigm. The tension, restraint, and resistance that these authors refer to is one of the most significant elements of breakthrough and is what likely gives breakthrough its name. An individual must literally "break through" the limiting framework of a current paradigm.

Hoshin Planning: TOM Breakthroughs

The members of the Hoshin Planning Research Team define Total Quality Management (TQM) as a system for meeting and exceeding customer needs through company-wide continuous improvement based upon the implementation of the "Plan-Do-Check-Act Cycle" supporting processes, organization, and tools by every manager and employee. Hoshin Planning is a system that is a component of the larger TQM system that allows an organization to plan and execute organizational breakthrough. Daily Control can be viewed as the application of "Plan-Do-Check Act" to daily incremental continuous improvement. Hoshin Planning draws information from the ongoing data collection and analysis of the daily control processes to identify broad system problems in which breakthrough is needed. The research team (Lord, 1989)

asserts that once breakthroughs have occurred they can then become the focus of daily continuous improvement. The research committee members believe that Quality Function Deployment (QFD), a key system for listening to and incorporating the "voice of the customer" can identify areas for planning breakthrough. Along with the seven basic quality control tools (check sheet, pareto chart, run chart, cause & effect diagram, scatter diagram, histogram, and control chart) Hoshin Planning methods include seven management and planning tools. These tools are the affinity diagram, the interrelationship digraph, tree diagram, prioritization matrices, matrix diagram, process decision program chart, and the activity network diagram. According to the research team these seven management and planning tools are indispensable in surfacing breakthrough ideas out of chaos and converting them into implementable plans.

Even though Hoshin Planning has been developed and refined in Japanese companies for nearly 25 years, it is still in its infancy in the United States. Widespread interest in Hoshin Planning has only occurred in the last two years. Florida Power & Light and Hewlett-Packard are the most visible U.S. examples of companies that are truly serious about Hoshin Planning implementation. One fact that deserves highlighting is that Hoshin Planning is the one element of TQM that is most consistently applied in Japanese companies of all sizes and in all industries. In other

words, if U.S. companies are serious about adapting and adopting a TQM model that works, a key ingredient is the ability to consistently identify, plan for, and achieve strategic objectives. Along these lines, GOAL/QPC research members (1989) state, "It is not enough to have everyone doing better everyday in every way."

The one key difference between the U.S. and Japanese Hoshin Planning models is that in the Japanese models there is a stronger ongoing link between Hoshin Planning and performance data generated through the daily quality control tools. The day-to-day process by which incremental improvement happens in TQM generates constant data that pinpoints performance strengths and weaknesses. The Japanese feed this into the Hoshin Planning priorities. Within the Hoshin Planning process, the affinity diagram is used to identify patterns among seemingly unrelated factors. Data is also used to identify broad patterns among problem areas in order to truly recognize the "broken" systems.

According to Dr. Kano, "[Hoshin Planning] is a marriage between the East and the West: the strong leadership exercised by Western top management with the organization-wide consensus of traditional Japanese organizations." Unheard of levels of quality and breakthroughs are being achieved in Japanese companies. This unrelenting pressure is the result of a planned process, not good fortune. U.S. competitors must respond with an equally effective process,

not simply the "genius approach." Hoshin Planning capitalizes on widespread participation while allowing "the genius" to pursue his/her often spectacular, but unpredictable, projects.

While Axelrod, Koestler, and Kuhn describe the individualistic properties associated with breakthrough, the Hoshin Planning Research Team have found evidence of institutionalized means of bringing about breakthrough. The Hoshin Planning Research Team believe that opportunities for breakthrough can be linked to daily continuous improvement efforts. The planning team asserts that examining the problems associated with continuous improvement using the seven management tools can bring about breakthrough at a managerial level. While this type of breakthrough requires a broader level of analysis than most continuous improvement activities, it falls short of requiring new paradigms in which to explain the causes of problems.

Summary of the Literature

Limiting Focus of TOM

The limitations of a continuous improvement culture are a focus on advocating improvements within the current framework of organization policies without gaining much insight about the whole system with which to reframe problems in a totally different context. As Deming mentioned, it is easy for an organization to go out of business making the wrong product or offering the wrong type

of service, even though everyone performs with devotion, employing statistical methods and every other aid that can boost efficiency. For breakthrough, Nadler et al.(1990) believe the conventional approach to analyzing and subdividing the problem must be avoided. Kim (1989) confirms what Nadler et al. are saying when he proclaims that "the solution of a mess does not consist of the sum of the solution to the problems that make it up." Improvement through operational learning involves an incremental process that is bound within the current definition of the problem under investigation. TQM and Systems Thinking have complementary strengths that can enhance an organization's ability to achieve higher levels of performance through a more balanced learning process. Opportunities for discontinuous steps of improvement are needed for reframing a problem to bring radically different solutions. The commonality among these above theorists is that they are all suggesting that a larger framework is needed to bring about solutions that address system level problems.

The Japanese have shifted their customer satisfaction strategy from identifying the apparent requirements of the customer to identifying the latent requirements of the customer. This shift means that it is not enough to meet their stated requirements but instead partnerships between the customer and the organization are necessary to discover their needs. Consequently, breakthroughs rather than just

continuous improvements may be required to address these needs. While it is fairly easy for a customer to express their apparent requirements as an improvement to the product or service, it is much harder for a customer to express their latent requirements. In fact, it is highly probable that what makes their requirements more latent than apparent is that a breakthrough is needed to address them.

Most of the quality gurus such as Crosby and Feigenbaum believe that quality involves meeting but not exceeding requirements. In terms of cost of quality estimates, the difference between meeting and exceeding customer requirements is considered a cost of non-conformance. These costs of non-conformance are then targeted for reduction or elimination. However, companies with more innovative cultures such as 3M have quality policies that endorse exceeding customer expectations.

Quality processes such as the Problem Solving Process and the Quality Improvement Process provide the opportunity for the expression of normative creativity but not exploratory and serendipitous creativity. According to Majaro (1988), the main purpose of a quality circle is to identify, analyze and solve problems; although he believes they form the basis upon which creativity circles can be implemented. For instance, the terms of reference for creativity circles can be broadened to encompass exploratory creativity at all levels. Appropriate skills that make

people alert to accidental or chance innovations would need be developed. For example, breakthrough is aided by acute observation skills, even though it is said to also be related to having an inquisitive mind and a lateral thinking ability that causes one to extrapolate a set of facts from a chance event to a totally different environment.

Edosomwan (1987), on the other hand, believes that encouraging research activity for the improvement of productivity and quality is enough to create a fertile climate for innovation of new products, services, and techniques of management. Despite Edosomwan's claim, Majaro asserts that few quality circles undertake exploratory creativity activities in areas outside the immediate work environment of the circle members. Furthermore, while the Hoshin planning quality process draws information from on-going data collection and analysis to identify broad system problems in which breakthrough is needed, its purpose is more to identify opportunities for breakthrough than to produce breakthroughs.

Other teams similar to creativity circles which Savage (1990) calls virtual teams are charged with recognizing, interpreting, deciding, and implementing responses to windows of opportunity that will meet both the customer's expectations and the teams' enterprise vision.

Continuous Improvement vs. Innovation

Kanter (1989) believes that continuous improvement is

not enough and that more dramatic changes in structure and systems and sensibilities are required to meet the pressures that businesses face today. Gluck (1985) suggests the need for an understanding of the significance of the difference between the 'suggestion box' innovation (i.e., product line extensions, cost reductions, and the like) -- in other words, incremental type of innovation -- and the 'big bang' type of innovation. He asserts that the lifeblood of the creative organization is uncategorized, unanalyzed, undigested, and messy information. Taylor (1990) indicates that the biggest barrier to innovation is success on a product and then concentrating efforts only on making the new product a little better, a little cheaper, and a little more sophisticated. The entire innovative thrust of the organization must not revolve around making products better, faster, and cheaper. Peters (1987) mentions that what was in control by the old standards is out of control (fast slipping away) by the new standards. The role of quality in measuring variation to bring processes into statistical control loses relevance in a time when processes become obsolete in a matter of months. In general, while the quality circles or improvement teams are appropriate for problem solving, broader level environmental approaches are needed to encourage the type of creativity that generates breakthroughs within organizations.

Creative Environments

Kanter, Freedman, Amabile, Gyskiewicz, and Sethia (1983; 1987; 1987; & 1989) stress that individual creativity can be powerfully influenced by elements of the organization. One of these elements crucial for a creative environment is an orientation toward risk and acceptance of failure on the part of management (Hisrich, 1990; Kanter, 1983; Sethia, 1989; Lehr, 1980; Quinn, 1985; Geis, 1985). For example, mistakes fit with the corporate culture as long as they are original at 3M. To facilitate a creative culture, Taylor (1990) encourages teamwork, fun and excitement, everyone doing things differently and better, and acknowledges and rewards people who excel. Rewards must be appropriate, however, since a strong detriment to creativity is either too much emphasis on rewards or insufficient or unfair distribution of rewards. Additionally, overly formal and complex structures and procedures are also detrimental to creativity.

Creative cultures tend to have an internal focus which suggests insensitivity to the external environment and preoccupation with developments inside their organization. As a result, an internally focused organization usually defines its own technological standards, disregards competitors, and takes markets for granted. These creative cultures also have a proactive bias which connotes self-motivated initiative and dynamism, optimism and risk-taking,

and the desire to originate a new order of things. Innovation in these creative cultures is directed at achieving significant breakthroughs and products are promoted on the strength on their originality. The focus and biases that make an organization creative -- its internal focus and its pursuit of innovation as a meaningful goal in itself -- makes it unquality like as well.

McDonough and Leifer (1986) suggest the need for a business orientation in the broader organizational culture and a creative orientation in R&D. By acknowledging the subsequent conflict of values and managing the conflict, they believe innovation can be positively impacted. 3M's answer is imagineering which is the integration of creativity among researchers, marketers, manufacturers, and customer service engineers. Similarly, Taylor (1990) says the most important person in the process of innovation is the person who has a deep understanding of technology and a deep understanding of the customer. At Raychem, Taylor says, "We creatively interpret core technologies to serve the marketplace." Similarly, the company endorses "pioneering research" which is closely connected to the company's most pressing problems, but it seeks to redefine these problems fundamentally in order to come up with fresh - and sometimes radical solutions. At the multinational document processing company, Brown (1991) hopes to create an environment where the creativity of talented people can

flourish and "pull" new ideas into the business by challenging the background assumptions that traditionally stifle innovation.

Breakthrough

The process of coming up with a breakthrough often follows a pattern similar to the one listed below.

After assembling available information, the individual relaxes and lets his or her subconscious mull over the material. In this little-understood but crucial step, the individual often appears to be idle or daydreaming, but his or her subconscious is in fact trying to arrange facts into a new pattern. Often when least expected -- while eating, or falling asleep, or walking -- the new, integrative idea will flash into the individual's mind.

According to Nadler and Hibino (1990) breakthrough thinking demands that decision makers view a problem from various perspectives, putting aside cultural and environmental taboos and traditions; challenging the propensity to avoid risk; encouraging the generation and growth of innovative ideas; and maintaining an openness to using a wide variety of tools, techniques, and modes of expression. Creative thinking is defined as the following activities: making and communicating meaningful new connections; thinking of many possibilities; thinking and experiencing in various ways; using different points of view; thinking of new and unusual possibilities; and guiding the generating and selecting of alternatives.

Breakthrough connotes breaking out of a conventional view, matrix, or paradigm after an individual feels a degree of restraint or tension (Axelrod, 1979; Koestler, 1964; and Kuhn, 1962).

Towards a Theory: Process Oriented Continuous Improvement
and Environmentally Dependent Breakthrough

Continuous quality improvement is facilitated by the use of processes such as the quality improvement process and the problem solving process. An output is clearly defined or a problem is clearly identified and almost always improvements are made within the defined framework (Majaro, 1988; Kim, 1989). Improvement is achieved through the use of analytical and reductionist techniques rather than systems level changes.

Breakthrough, in contrast, does not depend on the use of processes to facilitate its development. In fact, breakthrough may be facilitated by ones understanding that the current framework is limiting in explaining the causes of a particular phenomenon (Axelrod, 1979; Koestler, 1964; & Kuhn, 1962). Breakthroughs are typically the result of new paradigms, views, or matrices; and therefore an environment that permits the testing of current paradigms is conducive to breakthroughs. Environments which support freedom, challenging work, and have an orientation toward risk and acceptance of failure provide the opportunity for creative breakthroughs (Amabile & Gryskiewicz, 1987).

Research Questions

1. What is the difference between how quality processes support incremental improvement and how they support breakthrough?
2. What is the difference between how work environment supports incremental improvement and how it supports breakthrough?
3. Is using the quality improvement process and problem solving process more strongly related to incremental improvement or breakthrough?
4. Is a more creative work environment more strongly related to incremental improvement or breakthrough?
5. Is using Hoshin Planning more strongly related to incremental improvement or breakthrough?

Research Hypotheses

- Hypothesis 1: The use of structured quality processes (QIP and PSP) is more strongly related to incremental improvement than the use of structured quality processes (QIP and PSP) is related to breakthrough.
- Hypothesis 2: A creative work environment is more strongly related to breakthrough than a creative work environment is related to incremental improvement.
- Hypothesis 3: The use of Hoshin planning is more strongly related to breakthrough than the use structured quality processes (QIP and PSP) is related to breakthrough.
- Hypothesis 4: A creative work environment is more strongly related to breakthrough than the use of Hoshin planning is related to breakthrough.

Chapter III.

Methods

Subjects

The subjects for this research were 38 employees at an organization that has adopted a Total Quality Management strategy. These employees have also been responsible for developing incremental improvements and/or breakthrough developments. The subjects have a working knowledge of quality processes and tools used in The Leadership Through Quality Strategy. Nineteen of the subjects were from Palo Alto Research Center (PARC) and nineteen were from Customer and Marketing Education. The subjects represented an age range from 31 to over 50 years of age and 26 of them were male while 12 of them were female. While most subjects represented Caucasian ethnicity, there were American Indians, African Americans, and Hispanics represented as well. Educational level for the subjects ranged from high school to post-graduate level.

Research Charter

Corporate Research conducts basic and applied research, exploratory development and engineering to create new technologies that can be applied inside and outside the company by development, manufacturing, and marketing organizations. The multinational has three research portfolios: marking technology, systems technology, and materials science. Palo Alto Research Center is responsible

for managing systems research.

Customer and Marketing Education Charter

Customer and Marketing Education designs, develops, delivers, and evaluates training for external customers and sales and marketing representatives.

Design

There was a purposive sampling of 38 employees from the research facility and education department who met the criteria stated above. The type of research design was a within subjects design since all subjects were measured on both independent variables.

Instrumentation

All subjects participated in a semi-structured interview and filled out the Work Environment Inventory (WEI). The Work Environment Inventory (WEI) is a paper-and-pencil instrument designed to assess stimulants and obstacles to creativity in the organizational work setting. The WEI assesses perceptions of the work environment by employees at all organizational levels, including managers. The WEI focuses on those factors in the work environment that may be most likely to influence the expression and development of creative ideas. Conceptually grounded in previous empirical and theoretical work on creativity and innovation, the WEI has been administered to nearly 2,000 respondents drawn from over a dozen companies. Psychometric analyses indicate a high degree of internal consistency in

the WEI scales, as well as high test-retest reliability over time. Furthermore, preliminary validity analyses indicate that the WEI discriminates between different work environments, and that most of the scales are significantly related to creativity within the organization.

The Work Environment Inventory (WEI) is designed to aid organizations concerned about their current and future creativity, given the recognition that creativity is essential to innovation and long-term organizational success. In addition, the WEI can be used as a research tool to test hypotheses about creativity in organizations. In 1982, research at the Center for Creative Leadership began from the assumption that large percentages of employees are capable of generating and developing creative ideas, given a conducive organizational environment.

The 78 items on the WEI are written as simple descriptive statements of the work environment. In order to avoid response bias, some items are worded positively and some are worded negatively. A 4-point response scale is presented to force respondents away from a neutral default option: 1 = never or almost never true of your current work environment; 2 = sometimes true of your current work environment; 3 = often true of your current work environment; and 4 = always or almost always true of your work environment. The current WEI (version 4) contains 6 scales that describe potential environmental stimulants to

creativity, 2 scales that describe potential environmental obstacles to creativity, and 2 criterion scales that are included as assessments of the perceived creativity and productivity of the organization.

Brief descriptors of the scales are quoted below along with sample items (Amabile & Gryskiewicz, 1990). The sample item is the one that had the highest statistical loading on that scale.

Stimulants to Creativity

1. FREEDOM (4 items): freedom in deciding what work to do or how to do it; a sense of control over one's work. Sample item: "I have the freedom to decide how I am going to carry out my projects."
2. CHALLENGING WORK (5 items): a sense of having to work hard on challenging tasks and important projects. Sample item: "I feel challenged by the work I am currently doing."
3. SUFFICIENT RESOURCES (6 items): access to appropriate resources, including funds, materials, facilities, and information. Sample item: "Generally, I can get the resources I need for my work."
4. SUPERVISORY ENCOURAGEMENT (11 items); a supervisor who serves as a good work model, sets goals appropriately, supports the work group, values individual contributions, and shows confidence in the work group. Sample item: "My supervisor serves as a good work model."
5. WORK GROUP SUPPORTS (8 items): a diversely skilled work group in which people communicate well, are open to new ideas, constructively challenge each other's work, trust and help each other, and feel committed to the work they are doing. Sample item: "There is free and open communication within my work group."

6. ORGANIZATIONAL ENCOURAGEMENT (15 items): an organizational culture that encourages creativity through the fair, constructive judgment of ideas, reward and recognition for creative work, mechanisms for developing new ideas, an active flow of ideas, and a shared vision of what the organization is trying to do. Sample item: "People are encouraged to solve problems creatively in this organization."

Obstacles to Creativity

1. ORGANIZATIONAL IMPEDIMENTS (12 items): an organizational culture that impedes creativity through internal political problems, harsh criticism of new ideas, destructive internal competition, an avoidance of risk, and an overemphasis on the status quo. Sample item: "There are many political problems in this organization."

2. WORKLOAD PRESSURE (5 items): extreme time pressures, unrealistic expectations for productivity, and distractions from creative work. Sample item: "I have too much work to do in too little time."

Criterion Scales

1. CREATIVITY (6 items): a creative organization or unit, where a great deal of creativity is called for and where people believe they actually produce creative work. Sample item: "My area of this organization is innovative."

2. PRODUCTIVITY (6 items): an efficient, effective, and productive organization or unit. Sample item: "My area of this organization is effective."

The last page of the WEI includes additional questions including 3 open-ended questions to which respondents are asked to write their answers: (a) "What is the single most important factor supporting creativity and innovation in your current work environment? Be specific." (b) "What is

the single most important factor inhibiting creativity and innovation in your current work environment? Be specific."

(c) What specific suggestions do you have for improving the climate for creativity and innovation in your daily work environment?" Instructions for these questions assure respondents that their answers will be combined with those of other respondents and presented in typed format, ensuring anonymity.

Reliability

Scale reliabilities (Cronbach's alpha internal consistencies) are the following: Freedom (.69), Challenging Work (.80), Sufficient Resources (.82), Supervisory Encouragement (.92), Work group Support (.86), Organizational Encouragement (.92), Organizational Impediments (.84), Workload Pressure (.77), Creativity (.84), and Productivity (.88). All test-retest reliabilities were higher than .70.

Validity

The WEI differentiates between work environments and there are significant differences in the predicted direction between real and ideal environments for creativity. Some of the scales are significant concurrent predictors of creativity and simple correlation analyses revealed that 20 single environment items correlate .40 or higher with the creativity scale. These correlations were all significant beyond the .0001 level.

Procedures

Pilot Testing

The semi-structured interview guide and the administration of the Work Environment Inventory were pilot tested to ensure that the data gathering methods were a valid measure of the research variables. The semi-structured interview items measuring unobviousness were deleted since they were too ambiguous.

Conducting the Research

Subjects received an electronic mail note requesting voluntary participation in the study. They were instructed to send a response by electronic mail to the primary investigator to schedule a time to be interviewed. Subjects were informed that they were part of a research study. The topic of the study was discussed only very generally as not to bias their responses. The researcher interviewed subjects for approximately 1 to 1 1/2 hours using the semi-structured interview guide. In the presence of the researcher, subjects filled out the Work Environment Inventory and then handed it to the researcher during the interview to guarantee a full return rate.

Data Analysis

The data gathering methods for use of quality processes, continuous improvement, and breakthrough consisted primarily of qualitative methods with a few interview items eliciting quantitative data. The Work

Environment Inventory is primarily quantitative with some qualitative, open-ended questions at the end of the inventory. As a result the data was analyzed using qualitative and quantitative procedures. For the qualitative data, the researcher content analyzed the data to find support or lack of support for the research hypotheses. Content was analyzed according to the qualitative methodology table (See Table 10.).

For the quantitative analyses of the data gathered using the semi-structured interview guide and the Work Environment Inventory, correlation analyses were computed. For each hypothesis, two correlation coefficients were obtained. To determine if there was support for each hypothesis, a Z test was computed to find if there was a statistically significant difference between the two correlation coefficients.

Correlation Analysis

Using correlation analysis results in an equation that represents a best-fit line between a continuous dependent variable and one or more continuous or dichotomous independent variables (Tabachnick & Fidell, 1983). The purpose of correlation is to illuminate the relationship between the dependent variable of interest and one or more independent variables. The strength of correlation analysis is its ability to analyze the relationship between a dependent variable and one or more independent variables

that can be correlated or uncorrelated, continuous or dichotomous.

Number of Cases and Variables

According to Tabachnick & Fidell (1983) a suggested minimum requirement for a correlation analysis is to have at least 4 to 5 times more cases than independent variables. Ideally one would have 20 more cases than variables. Since for each hypothesis in this research there are 40 cases and 2 independent variables, the ideal of having 20 times more cases than variables is met.

Comparing Two Sets of Predictors

A multiple correlation is a simple correlation between criterion scores and the scores that are predicted from a set of variables. If there are two sets of predictors, a comparison of their relative effectiveness in predicting the criterion can be made by testing for the significance of the difference.

The test to compare the two or more elements is not straightforward because correlation coefficients measured on the same individuals are not independent. However, within the last 20 years, mathematical statisticians have developed efficient methods for comparing correlation coefficients including techniques that yield improved small-sample performance and computational efficiency. Monte Carlo simulation experiments have confirmed that the Z statistic below can be used with confidence when sample size exceeds

20 (Steiger, 1980). The Z test for the difference is computed as follows:

$$\bar{Z}^* = (N-3) (z_{ya} - z_{yb}) (2-2S_{ya, yb})^{-1/2}$$

(Steiger, 1980)

The quantitative data was statistically analyzed using correlation analyses as described in Table 8. below. Table 9. shows the variables and items for the quantitative methods and Table 10. shows the variables and items for the qualitative methods.

Table 8

Hypothesis 1-4 Quantitative Analyses Description

Hypothesis 1

The use of structured quality processes (QIP and PSP) is more strongly related to incremental improvement than the use of structured quality processes (QIP and PSP) is related to breakthrough.

Independent Variable: Use of structured quality processes
Measurement scale - continuous, 0-2
Items on semi-structured interview guide #14,15

Dependent Variable 1: Incremental improvement
Measurement scale - continuous, 0-4
Items on semi-structured interview guide #23,24,25,26

Dependent Variable 2: Breakthrough
Measurement scale - continuous, 0-5
Items on semi-structured interview guide #28,29,30,31,32

Statistical analyses: Pearson correlation, Z test to
compare correlation coefficients

Hypothesis 2

A creative work environment is more strongly related to breakthrough than a creative work environment is related to incremental improvement.

Independent Variable: Creative work environment
Measurement scale - continuous
Work Environment Inventory 78 items

Dependent Variable 1: Breakthrough
Measurement scale - continuous, 0-5
Items on semi-structured interview guide #28,29,30,31,32

Dependent Variable 2: Incremental improvement
Measurement scale - continuous, 0-4
Items on semi-structured interview guide #23,24,25,26

Statistical analyses: Pearson correlation, Z test to
compare correlation coefficients

(table continues)

Table 8 (continued)

Hypothesis 3

The use of Hoshin planning is more strongly related to breakthrough than the use of the structured quality processes (QIP and PSP) are related to breakthrough.

Independent Variable 1: Hoshin planning

Measurement scale: continuous, 0-5

Items on semi-structured interview guide #19,20a,20b,21a,21b

Independent Variable 2: Use of structured quality processes

Measurement scale - continuous, 0-2

Items on semi-structured interview guide #14,15

Dependent Variable: Breakthrough

Measurement scale - continuous, 0-5

Items on semi-structured interview guide #28,29,30,31,32

Statistical analyses: Pearson correlation, Z test to compare correlation coefficients

Hypothesis 4

A creative work environment is more strongly related to breakthrough than the use of Hoshin Planning is related to breakthrough.

Independent Variable 1: Creative work environment

Measurement scale - continuous, 78-312

Work Environment Inventory - 78 items

Independent Variable 2: Hoshin planning

Measurement scale: continuous, 0-5

Items on semi-structured interview guide #19,20a,20b,21a,21b

Dependent Variable: Breakthrough

Measurement scale - continuous, 0-5

Items on semi-structured interview guide #28,29,30,31,32

Statistical analyses: Pearson correlation, Z test to compare correlation coefficients

Table 9

Quantitative Methodology

Variable	Type of Variable	Quantitative Measurement
Demographic items		
Gender	Nominal	#1
Age	Ordinal	#2
Ethnicity	Nominal	#3
Tenure	Interval	#5-7
University degrees	Ordinal	#9
Quality trained	Nominal	#16
Collaborative group member	Nominal	#17
Patent Application	Interval	#33
Patent Award	Interval	#34
Use of quality processes	Continuous	Semi-structured Interview Items
- Problem Solving Process		#14
- Quality Improvement Process		#15
Hoshin Planning (Policy Deployment)	Continuous	Semi-structured Interview Items #18, 19, 20a, 20b, 21a, 21b
Work environment creativity	Continuous	Work Environment Inventory 78 items
Breakthrough	Continuous	Semi-Structured Interview #28, 29, 30, 31, 32
Incremental improvement	Continuous	Semi-Structured Interview #23, 24, 25, 26

Table 10

Qualitative Methodology Table

Variable	Qualitative Measurement
Demographic items	Semi-structured Interview Item(s)
Area of work	#4
Field of educational study	#8
Use of quality processes	Semi-structured Interview Items
- Problem Solving Process	#12, 13, 14, 27, 35
- Quality Improvement Process	#10, 11, 15, 17, 35
Hoshin Planning (Policy Deployment)	Semi-structured Interview Items #18, 19, 20a, 20b, 21a, 21b
Work environment creativity	Work Environment Inventory 3 items A. What is the single most important factor supporting creativity and innovation in your current work environment? B. What is the single most important factor inhibiting creativity and innovation in your current work environment? C. What specific suggestions do you have for improving the climate for creativity and innovation in your daily work environment?
Breakthrough	Semi-Structured Interview #28, 29, 30, 31, 32, 35, 36
Incremental improvement	Semi-Structured Interview #23, 27, 36

Chapter IV.

Results

Quantitative Results

A Z^* test revealed a significant difference between the two coefficients representing the correlation between incremental improvement and structured quality processes and the correlation between breakthrough and structured quality processes, $Z^* = 3.89$, $p < .001$. The Pearson correlation coefficient for incremental improvement and structured quality processes was in the positive direction, $r(38) = .36$, $p < .02$, while the Pearson correlation coefficient for breakthrough and structured quality processes was in the negative direction, $r(38) = -.53$, $p < .001$.

A Z^* test also showed a significant difference between two coefficients corresponding to the correlation between incremental improvement and work environment creativity and the correlation between breakthrough and work environment creativity, $Z^* = -2.01$, $p < .05$. The Pearson correlation coefficient between incremental improvement and work environment creativity was in the negative direction, $r(38) = -.32$, $p < .05$ whereas the Pearson correlation coefficient showing the relationship between breakthrough and work environment creativity was in the positive direction, $r(38) = .17$, $p > .05$.

The third Z^* test performed show a significant difference between the two coefficients representing correlations between Hoshin planning and breakthrough and the correlation between structured quality processes and breakthrough, $Z^* = 2.83$, $p < .05$. The Pearson correlation coefficient between Hoshin planning and breakthrough and the one between structured quality processes and breakthrough were both in the negative direction and were $r(38) = -.17$, $p > .05$ and $r(38) = -.53$, $p < .001$, respectively.

The final Z^* test did not reveal a significant difference between the coefficients representing the correlation between work environment creativity and breakthrough and Hoshin planning and breakthrough, $Z^* = 1.25$, $p > .05$. The Pearson correlation coefficient showing the relationship between work environment creativity and breakthrough was in the positive direction, $r(38) = .17$, $p > .05$. The Pearson correlation coefficient corresponding to Hoshin planning and breakthrough was in the negative direction, $r(38) = -.17$, $p > .05$. The above correlations are shown in Figure 1. and Table 11. shows the values for the Pearson correlations and their corresponding significant levels. Table 12. gives the values of the Z test.

Figure 1

Comparison of Pearson Correlation Coefficients Testing the Four Research Hypotheses

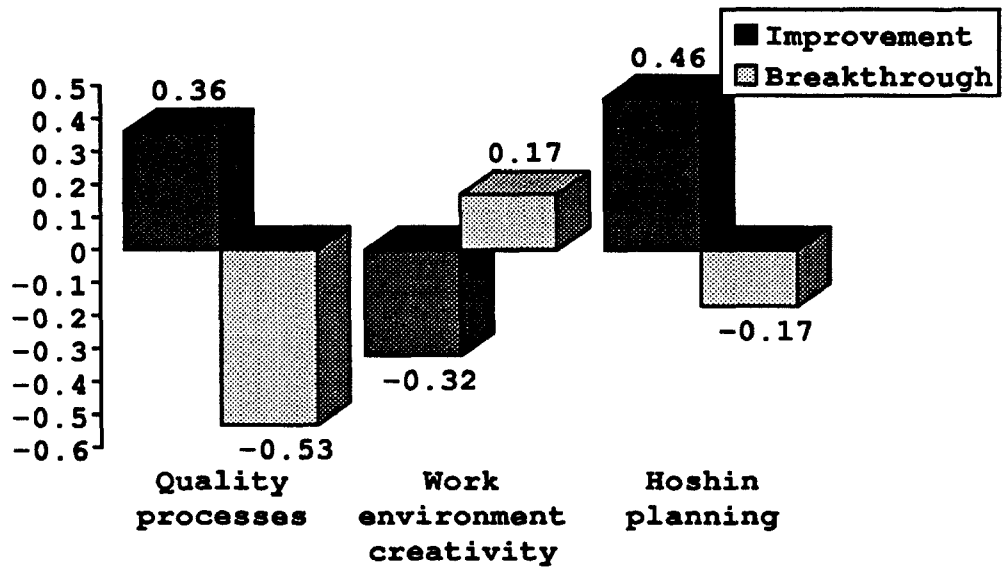


Table 11

Comparison of Pearson Correlation Coefficients Showing Significant Levels

Variables being correlated	Pearson correlation coefficients
<u>Hypothesis 1</u>	
Incremental improvement and structured quality processes	.36***
Breakthrough and structured quality processes	-.53****
<u>Hypothesis 2</u>	
Incremental improvement and work environment creativity	-.32**
Breakthrough and work environment creativity	.17*
<u>Hypothesis 3</u>	
Hoshin planning and breakthrough	-.17*
Structured quality processes and breakthrough	-.53****
<u>Hypothesis 4</u>	
Work environment creativity and breakthrough	.17*
Hoshin planning and breakthrough	-.17*

* $p > .05$, not significant. ** $p < .05$. *** $p < .02$. **** $p < .0001$

Table 12

Z* Values for Correlated Correlation Coefficients

Between	Correlation of Correlated Correlation Between	Correlation Coefficients Z* Value
Incremental improvement and structured quality processes	Breakthrough and structured quality processes	3.89***
Incremental improvement and work environment creativity	Breakthrough and work environment creativity	-2.01**
Hoshin planning and breakthrough	Structured quality processes and breakthrough	2.83**
Work environment creativity and breakthrough	Hoshin planning and breakthrough	1.25*

* $p > .05$, not significant. ** $p < .05$. *** $p < .001$

Table 13. on the next page shows a comparison of percentages between the research and education departments for demographic variables and variables to test the hypotheses. Table 14. depicts a comparison of correlations between variables for the two departments for work environment creativity and breakthrough, incremental improvement, and Hoshin planning as well as incremental improvement and breakthrough. Table 14. shows how the two departments differ on their ratings.

Table 13

Demographic and Variable Comparisons between Research and Education Departments

	Research	Education
Demographics	(In percents)	
<u>Gender</u>		
Male	84	53
Female	16	47
<u>Age (in yrs.)</u>		
30-40	42	32
41-50	37	58
50+	21	10
<u>University degree</u>		
None	0	37
B.A./B.S.	5	37
M.A./M.S.	10	26
Ph.D.	84	0
<u>Quality</u>		
PSP	47	100
QIP	37	100
<u>Hoshin planning</u>		
Written objectives	53	90
Department goals	21	95
<u>Incremental improvements</u>		
Make incremental improvements	79	95
<u>Breakthrough</u>		
Two greater than one	95	73
Had breakthrough	79	63

Table 14

Comparisons between Research and Education Departments

	Research	Education
<u>Correlations between variables</u>		
Work environment creativity and breakthrough	-.06	.45
Work environment creativity and incremental improvement	-.44	.04
Work environment creativity and Hoshin planning	-.40	-.09
Incremental improvement and breakthrough	.01	.30

Since there was no variability in how education participants rated the variable structured quality processes, comparisons between the research facility and the education department were not possible. Instead, provided in Table 15. below is a comparison between the research facility and the sample overall to show the effect of the ratings from the education department.

Table 15

Comparisons between Research and the Overall Sample on
Quality Processes and Breakthrough, Incremental Improvement,
and Hoshin Planning

	Research	Overall
Correlations between variables		
Incremental improvement and structured quality processes	.16	.36
Breakthrough and structured quality processes	-.50	-.53
Hoshin planning and structured quality processes	.25	.65

Demographic Trends

Gender

Female responses showed a higher correlation between structured quality processes and incremental improvement than male responses, $r(12) = .65$, $p < .05$ and $r(26) = .37$, $p > .05$, respectively. The correlation between Breakthrough and Structured quality processes was more negative for males, $r(26) = -.52$, $p < .05$ than females, $r(12) = -.20$, $p > .05$. Female ratings revealed a higher negative correlation between Work environment creativity and Hoshin planning than male ratings, $r(12) = -.51$, $p > .05$ and $r(26) = -.24$, $p > .05$.

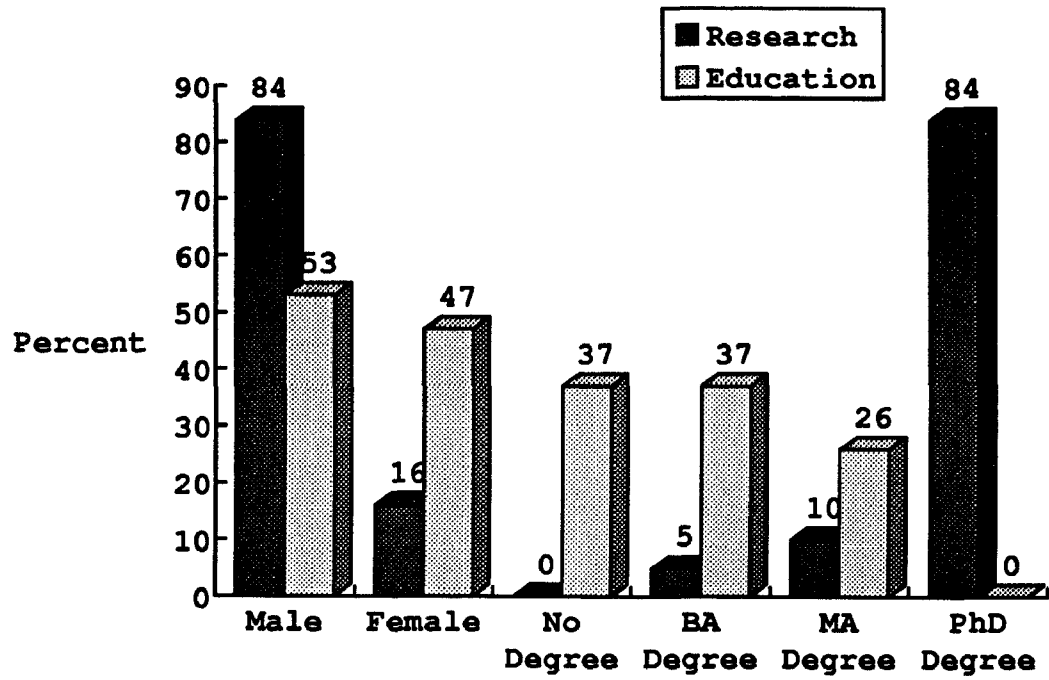
Age

The correlation between incremental improvement and Work environment creativity increases with age. There is a negative correlation for those 30-40 years of age, $r(14) = -.40$, $p > .05$, a slightly weaker negative correlation for those 41-50 years of age, $r(18) = -.37$, $p > .05$, and a positive correlation for those over 50 years of age, $r(6) = .23$, $p > .05$. The correlation between Hoshin planning and breakthrough increases with age from $-.48$ at 30-40 years to $-.12$ at 41 to 50 years of age to $.32$ for those over 50 years old. In contrast, the correlation between Structured quality processes and Hoshin planning decreases with age from $.79$ at 30-40 years to $.60$ at 41-50 years down to $.46$ for those over 50. Figure 2. shows a comparison between the

departments on the demographic variables.

Figure 2

Comparison of Demographic Variables between the Research and Education Department.



Reliability

Cronbach's alpha coefficients were computed for the Work Environment Inventory and semi-structured interview items. Table 16. below shows that Cronbach's alpha was above .45 for all the Work Environment Inventory scales.

Table 16

Work Environment Inventory Reliabilities

	# of Items	Correlation with Total	Cronbach's Alpha
<u>Environmental Stimulants to Creativity</u>			
Freedom	4	.56	.59
Challenging work	5	.67	.57
Sufficient resources	6	.47	.58
Supervisory Encouragement	11	.48	.56
Work group supports	8	.61	.55
Organizational encouragement	15	.68	.48
<u>Environmental Obstacles to Creativity</u>			
Organizational impediments	12	.52	.81
Workload pressure	5	.18	.68
Creativity	6	.84	.51
Productivity	6	.49	.59

Performing Cronbach's alpha on the interview items revealed very high reliabilities for variables Quality and Hoshin planning, ~~alpha~~>.75. Cronbach's alpha for the variable incremental improvement ranged from .32 to .57. Table 17. on the next page shows that the variable breakthrough had Cronbach's alphas that ranged from .29 to .65.

Table 17

Semi-Structured Interview Guide Item Reliabilities

	# of Items	Correlation with Total	Cronbach's Alpha
Quality	2	--	.77
Problem Solving Process	1	.62	--
Quality Improvement Process	1	.62	--
Incremental improvement	4	--	.57
Existing products	1	.26	.57
Minor changes	1	.26	.57
Minor adjustments	1	.39	.48
Process more capable	1	.54	.32

(table continues)

Table 17 (continued)

	# of Items	Correlation with Total	Cronbach's Alpha
Hoshin planning/ Policy deployment	5	--	.91
Written objectives	1	.65	.92
Department goals	1	.82	.89
Link between objectives and department goals	1	.82	.89
Corporate goals	1	.78	.90
Link between objectives and corporate goals	1	.84	.88
Breakthrough	6	--	.47
Develop future opportunities	1	.21	.46
Had 'aha' experience	1	.47	.38
Two greater than one	1	.37	.41
Different project could benefit	1	.09	.48
Had breakthrough	1	.64	.29
How many breakthroughs	1	.41	.65

Validity

Work Environment Inventory Validity

It is important to determine which environment items and environment scales significantly correlate with creativity as assessed on the WEI. Simple correlation analyses revealed that 18 single environment items correlate .40 or higher with the Creativity scale (these correlations are all significant beyond the .001 level). Each is listed here with the scale to which it belongs and the creativity correlation:

Freedom.

In the daily work environment, I feel a sense of control over my own work. (.60)

Challenging work.

I feel challenged by the work I am currently doing. (.54)

The tasks in my work call out the best in me. (.66)

Sufficient resources.

Generally I can get the resources I need for my work. (.53)

I have trouble getting the materials I need to do my work (-.59)

The information I need for my work is easily obtainable. (.53)

Supervisory encouragement.

My supervisor supports my work group within the organization. (.53)

My supervisor values individual contributions to projects.
(.54)

Work group supports.

There is free and open communication within my work group.
(.56)

People in my work group are open to new ideas. (.56)

The people in my work group are committed to our work. (.50)

Organizational encouragement.

People are encouraged to solve problems creatively in this organization (.58)

People are rewarded for creative work in this organization.
(.54)

I feel that top management is enthusiastic about my project(s). (.52)

Performance evaluation in this organization is fair. (.63)

Organizational impediments.

There are many political problems in this organization.
(-.51)

People in this organization are very concerned about protecting their territory (-.52)

This organization is strictly controlled by upper management. (-.50)

Semi-Structured Interview Validity

Listed below are the items for each variable that correlate .40 or higher with the variable that they measure (these correlations are all significant beyond the .005 level).

Breakthrough.

Have you had a "flash of genius" or "aha" experience while you've been here at the research center? (.46)

Have you been responsible for a breakthrough or breakthroughs at this facility? (.60)

How many [breakthroughs]? (.91)

Quality.

Have you ever used the Problem Solving Process what has been taught in quality courses here? (.91)

Have you ever used the Quality Improvement Process which starts with "Identify Output", "Identify Customer", and "Identify Customer Requirements"? (.89)

Incremental improvement.

Do you make incremental improvements to already existing processes or products? (.61)

Do you make minor changes to a product or process to meet the needs of the user? (.61)

Have you made minor adjustments to a product or process in response to a particular problem (.64)

Have you made an existing process more capable? (.79)

Hoshin planning.

Have you developed written objective that you want to achieve? (.77)

Do you know what CRG's/CME's objectives are for 1992? (.89)

Are your objectives linked to CRG's/CME's objectives? (.89)

Do you know the company's four common goals? (.86)

Are your objectives linked to the company's four common goals? (.90)

Qualitative Results

Qualitative results were obtained from a content analysis of interview notes. The notes were transcribed and the responses for each variable were grouped together. Common themes were used to further consolidate related comments. Numbers that appear in parentheses refer to the frequency of subjects who indicated the response.

Improving processes

Research Department.

The most common response for how participants improved processes in the research facility involved some type of interaction with other people. Participants talked about "working better together," "connecting people up," and "finding out what others around me are doing." Other participants mentioned more abstract types of improvement activities such as "working to achieve awareness of the things that might need to be done to move the area" or "getting a sense of the situation in which problems occur."

Quite a number of participants (7) explained that improving processes was not their focus. Comments ranged from "It may not be true for my work" to "[I] have trouble with improving." Only one person mentioned getting feedback from a customer.

Four respondents in the research facility made reference to talking with other people as a way of improving their own processes which determine how they do their

research. Three participants indicated that they write papers and four mentioned reading literature as ways to improve how they go about doing their research. For example one person said, "[I improve by] reading professional literature, some outside my related area and some related [to my area]." Another talked about getting other people to critique papers. There were many responses that could be considered experimentation as a way of improving. Comments included the following: "[I'm involved with] programming to test ideas out to see if they fly", "[I improve through] experimentation." "[I] try an approach I haven't tried before," "I think of neat things and build them," and "I improve the processes by exploration, I'm curious and open -broadening the scope I was willing to look at."

Education Department.

Many of the participants in the education department referred to customers and suppliers to the process when they were asked about how they improved their processes. One respondent stated, "[I] ask for feedback from the users of the process and whoever gets results, e.g. How is it going? Is the process working?" Another mentioned, "[I] involve people who are affected for input and buy-in to the proposed solution." Many made reference to steps in the problem solving process such as "identify problem," "look for problem indicators, and/or "evaluate the effectiveness of the solution." There were eight explicit references to

using either the problem solving process (PSP) or the quality improvement process (QIP).

There were ten references to the PSP or QIP. Some of these references included comments such as "by re-examining our processes to identify which area in the process I have the least customer satisfaction," or "formulating and understanding customer requirements." Nine of the respondents discussed communicating with others as a way to improve their work processes. These comments included either asking for help or getting others involved. Three participants improved through customer feedback and three used manager feedback as a way to improve their work processes.

Quality Improvement Process

Not surprisingly, seven respondents made explicit references to quality improvement teams or QITs when asked for what have they used the QIP. Other responses mostly included using the QIP for meetings and other group interactions.

Results.

While most reported successful results, two mentioned that their projects were canceled despite reportedly successful results. Two others mentioned that they were frustrated the process took so long. There were many comments related to perspective such as "[It] helps you gain perspective, focuses you on the customer," or "[It's] good

way of organizing who and what -- laying down the work process, evaluating, and measuring." One person said, "A few years ago [I] belabored the steps, but when you've been through it, you get better the more you do it, like playing the piano." Another mentioned that the QIP "helps focus, really identify the problem -- not get global."

Not Using the Quality Improvement Process

Research Department.

The reasons for not using the QIP were related to not identifying with the concept of customer or customer requirements. All responses are from participants at the research facility. Responses included the following: "Who is my customer? Our problem is to open up opportunities. I don't know how it fits in that process. I'm trying to discover what a good output would be." "What does the customer want? Well, what the hell do they know what they want [or] what's possible? They're limited and very conservative. The customers [suggest] minor variations of what they have now." "[A] customer is a fuzzy thing -- things don't work in that top-down way." "[I] go back and forth from identifying output to [identifying the] customer." "[It is] inappropriate for what I'm trying to do because a lot of times I don't have an identified output." "I'm not dealing with customers on that level. It's a production [or] manufacturing model."

Comments About the Use of Quality Processes

Research Department.

Many felt the interactive skills portion of the quality course was valuable and should have been emphasized more. One researcher referred to the quality strategy as "intellectually dishonest" and made reference to 1984. A lot of researchers use the brainstorming as a stand-alone tool rather than going through the whole problem solving process. One researcher stated, "[The] elaborateness of the process could disable creativity. Creative solutions are not obtained by going through the steps. The organization of the process constrains the freedom to get a direct solution. Researchers operate with more freedom to achieve creative jumps. The quality processes can be applied in a systematic way to force exposure to the breakthrough ideas. Quality processes [can be] used in the interfacing, not for breakthrough, but as a way to ensure looking at new ideas." Another researcher believes the form of the quality processes is incongruent with the quality philosophy. The participant stated, "The delivery of the process itself didn't embody the philosophy."

There were a number of responses related to questioning the relevance or appropriateness of the QIP for the research environment. Comments included the following: "Quality processes which are attuned to manufacturing would not be right for us." "[The] QIP or PSP are inappropriate for

research." "[The] PSP is a superficial glaze on what researchers do for a living." "The PSP for getting results is absurd and insulting." "QIP is just not the right model for research" "[I'm] cynical about Leadership through Quality - its relevance."

Education Department.

In contrast, the participants in the education department mentioned their initial skepticism about quality but after seeing the results over the years appear to have endorsed the quality processes wholeheartedly. As an example, one respondent stated, "When it first came out, I thought it was a crock - putting labels on things, [that] nothing would change. [Now I believe it is an] excellent tool that has absolutely transformed the way we do business. Other comments include the following: "Never have I seen something take hold like quality has. [It] clearly makes a difference in how we do our business. Initially [I believed it was just] lip service, but the change in culture has taken a long time to develop." "I went from thinking it was a waste of time to a 180° turn. [Now that quality principles are] followed [we have] made tremendous improvement. "Quality has become a way of life at [the company]. I wouldn't have thought that when it was first implemented."

Research and Education Departments.

Participants from both the research and education

departments mentioned that quality processes have helped to empower lower level people. One person stated, "It has put tools in everybody's hands, not just management's hands to do a better job." Another indicated, "Quality processes have helped people empower themselves."

Why the QIP or PSP Was Not Used for Breakthroughs

The most common reason stated for why the QIP or PSP was not used for coming up with breakthroughs was there was no clear problem or output. For example, one participant said, "[I] didn't understand what the problem or output was. The hardest part is coming up with the question -- the problem statement."

Other reasons for not using the processes were that they didn't seem relevant, they were too linear, or participants used their intuition. As one person stated, "[It's] so blatantly apparent. Why should I go through all that [the process]?" Another respondent explained that "processes don't lead to creative inspiration, but give a framework for accumulating the critical mass."

Comments About Continuous Improvements and Breakthroughs

A poster on a researcher's office wall quoting Einstein reading, "One can organize to apply a discovery already made, but not to make one," sums up what many participants from both departments were saying. Comments included the following: "PSP or QIP is more applicable to group meetings." "Coming up with a concept takes an individual.

Implementation involves a group." "Individuals come up with more breakthroughs, [yet they may be] group stimulated.

There were comments about the nature of breakthroughs and continuous improvements and their relationship. For example, one person stated, "Breakthrough is kaboom! and it's there. [You] plan for continuous improvement." Another participant described some precursors to breakthrough in the following quote: "[I have the] impression that we could make more breakthroughs if we communicated differently. Breakthrough occurs when you get something from somewhere else, [for instance when] groups are working together, [but] not in one afternoon -- connections take longer." "[Breakthrough] is based on known facts -- the knowledge base of the individual. [One needs to be] abreast of the environment [you're] working in for breakthrough.

Another did not identify with the concept of continuous improvement as evidenced by the statements below. "All improvements are discontinuous. There are little jumps and big jumps. The size of the jump is not understood except in hindsight. Little jumps could be major enablers. [A] series of minor jumps enabled [me to make] a major conceptual jump."

One respondent from the education department explained, "Continuous improvement is structured and focused on what you're working on," and one of their colleagues explained

that "Breakthrough is using a new technology, e.g. computer-based training for self-paced training." An individual from the education department presented the relationship between continuous improvement and breakthrough with the following comment: "Continuous improvements and breakthroughs are somewhat in conflict."

Solving Problems

Research Department.

Ten of the researchers responded with some activity not involved with solving the problem. Some of these included taking long walks, working on something else for a while, taking a shower, sleeping, and/or driving. One researcher explained, "I live, eat, drink and live, and then I get a bright insight."

About a dozen research participants mentioned talking with someone else to help them solve problems. There were six references to problem solving process steps such as collecting data, proposing generalizations, brainstorming, and/or analyzing causes. One person described that he or she likes to work on all parts of the process at the same time.

Four people mentioned using some form of information search such as going to the library or accessing an electronic bulletin board. A few explained that they design prototypes and test them as a way of solving problems.

Education Department.

Nine references were made explicitly to the problem solving process. These included such comments as the following: "[I've been] using the PSP tools such as the steps of problem solving, collecting data, brainstorming, creating fishbones, [using] force field [analysis], and using tools to analyze the problem and generate solutions." "[I] use an abbreviated approach and go around the wheel myself. When others are involved, we work the PSP on a larger scale." "[I] use an abbreviated form, brainstorm fewer solutions, [and] analyze informally in my head."

There were seven comments involving interaction with other people and some of these were also in reference to using the problem solving process with others in a group. For example, one of the participants said, "[I] ask 'Who can help?' [and if there's a] problem with the process, [we] work together on it."

Problem Solving Process

Eleven participants indicated that they use the problem solving processes for meetings or on quality improvement teams. Three mentioned that they used it to improve processes and two said they used it to improve customer satisfaction.

There were two references about the benefit of either resolving conflict or getting to agreement. Two participants discussed the empowering nature of using the

PSP as one stated, "[The PSP] teaches people to be respectful of others' ideas. People who are quiet and have good ideas can contribute." Other responses were related to the PSP's helpfulness in guiding and structuring the process and ensuring follow-up. For example one person responded, "[It] provided a loose structure, a skeletal shape, and a road map to follow."

One participant from the education department described several concrete results including reducing turnover from over 18% to less than 8%, training new hire employees 30 days ahead of schedule, and receiving a National Quality Award certification of end-point vision. One person commented that using the PSP provides on-going steady improvement, but that they do not expect breakthroughs.

Why the Problem Solving Process Was Not Used

Four people made reference to the inefficiency of the process -- that it could waste their time. Eleven participants mentioned that the problem solving process was inappropriate for the type of work they do. Some of their comments included: "[It is an] overly structured approach to the problems." "That's not how I solve problems -- [it's] too systematic. Creative solutions are not obtained through systematic, known ways." "[It] doesn't honor the skill that researchers have -- that intuition to both execute the steps and come up with profound insights that

help solve the problem." "[I have a] problem with the linearization. It's better for people who aren't sophisticated. I like to skip and jump around."

Incremental Improvement

Six respondents stated in general that they spent more time improving than creating new. One person said almost 100% of his or her time is spend on continuous improvement. Other percentages were as high as 85% (1), 75% (2) and 70% (2) of time spent improving existing processes. Some participants mentioned that the percentage varies with time and that the high percentage of time spent on improvement reflects the maturity of their processes.

In contrast, other participants explained that they spent more time creating new processes than improving existing processes. Some comments included the following: "[I am making] mostly discontinuous [improvements] to change the way we do business." "[I have been doing] a little improving, but it's not the main thing." Percentages ranged from approximately 33% to 75% of time spent creating new processes.

Four subjects indicated that they spend about the same amount of time doing each activity and four participants explained that they could not make the distinction between improving existing processes and creating new processes.

Using the OIP or PSP to Come Up with Improvements

Five people mentioned that they used either the PSP or

QIP in an abbreviated form. For example, some of their comments were "[I] use the PSP more informally," "[I] always think of customer satisfaction and customer requirements, the capability of the process, its implementation, and monitoring or evaluating [the solution]." Five respondents indicated that they used the PSP to come up with the improvements and two mentioned using the QIP.

Breakthrough: Generating Ideas for Future Opportunities

Research Department.

A few researchers talked about developing future opportunities because they anticipated a need. One researcher stated, "... recognizing a latent demand often in the context of reading something -- that's an opportunity." Another researcher said, "[There has been] no known requirement, but the anticipation of the future." Other comments seemed to suggest that developing future opportunities was their main job or part of their job. For example, one explained, "How we do research and the research we do [is a] future perfect style of work. [I have] reactions to imaginary [things], and develop intuitions about them, then I look at the research impact and implications." Another researcher mentioned, "[I] push out into areas, do something and then find a use for it." Other comments included the following: [The] entire technology research project I'm on is one of those. [It's]

hard to convince the company to do something with ideas. Generating ideas is easy." "[That's] part of the job of research...to change people's eyeglasses.

Education Department.

Six participants from the education department mentioned applying a technology to a project as developing an opportunity. One person described the use of interactive video for improving education and another discussed implementing a database system. When talking about using technology for educating the sales and marketing representatives one commented, "The field sometimes doesn't know what they don't know." Aside from using technology, there were five comments from educators who mentioned improving processes as developing opportunities. Some of their comments included the following: "[I'm working on] sales negotiating training to improve sale range profit margin." "[For my long-term strategy to improve the training development process, [I] continually ask questions regarding direction and business policy. [I] will recommend a strategy for 1995."

Having "A Flash of Genius" or "Aha" Experience

Research Department.

Below are five quotes made by researchers when they were describing their "flash of genius" or "aha" which are related to their unconsciously motivated realizations. These comments are the following: "[You'll be] confused

[because] pieces of information are inconsistent and then you have a different way of thinking about it. Sometimes you just wake up with it." "Over night I'll find a solution. [I'll] work on a problem for a long time and don't get anywhere. [Then I] get away from it [and it] comes out of nowhere." "[That occurs] once every 2-3 years. [There was a] particular bug that was causing people to have trouble. [I] worked on it for 2 1/2 weeks, [then I] had to set it aside. I just knew where it was in the code. [It was] unconscious. [That is the] key step after which everything falls into place. [You say] I know I'm going to solve the problem." "[I] dreamt it. That's why creative people need some time for small improvements, recognizing what had been in their subconscious." "[Only when I take a shower. [I] have flashes and make connections."

Three comments were made more about the nature of research than any particular "aha". These are the following: "The nature of mathematical research is that you have to have Eureka." "[That's] the classical definition of a patent: [a] paradigm shift in your own mind." "People lust after this. [They] judge themselves if they haven't [had an 'aha']. [It's a] real adrenaline rush. [You] see clearly what few other people understand or see."

Three researchers made reference to first using something and then realizing its implications. "[I was experimenting with a] new style of interfaces, managing

screen space, clustering windows based on tasks -- rooms. [You do] it and figure out what it was." "[There are] all kinds of little 'aha' phenomena. You do it and see if it really works later. Insights are easy. [The] work to determine value or "right" is hard."

Education Department.

A few educators mentioned that the "aha" was achieved during a group discussion. As one stated, "[We achieve a] breakthrough when there is a problem. [We] churn it around with eight people. [When there is a] break in the flow on something, a creative solution is required."

Five participants implied that the "aha" occurred after some foundation of knowledge was established. Their remarks include the following: "[I] recognize a situation. [I] accumulate facts about it, [and] see the opportunity or potential for change. [Then you] say to yourself "This could be done a whole new way." "[You're] thinking out of the box, looking at it through another window. [You] look for things that don't quite fit. [You] get towards the big picture, and experience a perspective shift. [The] fog accumulates into a cloud and then it rains." "[I was wondering] why product launch materials weren't meeting the field's needs. After 3 hours of listening to a roundtable, [I] found out they thought product marketing was their customer." "All of a sudden an underlying problem was revealed. [There was a] sudden awareness of the

interrelateness. [There was a] common cause. [The] walls were plastered with flip chart pads."

Putting Together Two or More Ideas

Research Department.

Five of the responses were about the synergistic effect being preceded by exposure to related information. One person mentioned, "[I] work on an area of focus for a long time. [I] explore different angles, dissect the pieces, improve, [and] add features. During making these improvements, the nature of things is such that the whole is greater than the sum of its parts." Another researcher explained, "[I was] hearing a talk. [It was a] great idea except it had some problems. [There was some] research that someone was doing and I thought, 'Your networks would solve this.'" Other descriptions included the following: "[I] look at what's known in the literature. Two people have two different views or techniques. [The] proper combination gives a better solution to the problem frequently. [The] strength of the techniques together [provides a] better solution." "[I was] reading about something. [Then] in the shower, suddenly [I] become aware that with that piece and this piece something could be put together that would be interesting." "[The] synergistic sum is greater than the parts. [For] invention there is cross-fertilization. [Going from] one dimension to two or three dimensions is the element of solving really tricky problems."

A few of the comments researchers made about putting together two or more ideas for a better result surrounded their work on multiple projects. Following are three quotes: "[I was] intently working on one and jointly working on another and it was just what the other needed. The impact of one was not as great. They needed to be together." "[I was involved with] two different research areas. [I realized] that combining them together would get better behavior." "[I was doing] work on two projects at once. [You] keep your mind open [and] keep narrowing down. [You have a] very, very broad perspective [and a] very open mind."

Education Department.

There were four references to the quality term "build" which means to springboard off someone else's idea and use it as part of your idea. It is common to build on other people's ideas in meetings. One participant described, "[That occurs] when we are in a PSP meeting, [when we're] brainstorming, and when we build. We are getting synergy."

Generalizing Benefits to Different Projects

Research Department.

Being involved with multiple projects or being exposed to problems seemed to prompt the realization that work on one problem or project could benefit others. One person explained that he or she works on fifteen projects that are evolving, splitting, and/or combining. Others talked about

two problems looking unrelated yet quite unexpectedly found that the ideas could be used for another problem. Yet another described, "[I] take something interesting and then find the relevance. [I have been involved with] combining technologies which have been developed in other groups and integrating separate elements into an interesting system."

The main cause that seemed to prompt others to make the generalization to another project was intentional collaboration on projects. One explained, "[While I'm] relating ideas under consideration, a lot times -- aha! [There is] a lot of cross-fertilization designed to capitalize on those things." Another researcher commented, "[I] look at the big picture. [I'm] more aware of outside activities."

Education Department.

The responses to using work on one project for another were predominately related to awareness or communication of other people's projects. One educator stated, "[You] find out they're working on it, too. [There has been a] lack of communication followed by accidental communication and [then you] act on it." Other comments included: "[It happens] because there are so many projects going on here. All programs are related to a certain extent because all the products are linked. We share information as a team." "We build on each other's. The XEN process was built off of the project management process." "[I was] working on multiple

problem solving teams for new product launch training. [We] discovered that we weren't integrating work done in system reprographics."

Creating Breakthroughs

Research Department.

Three of the instances involved doing some other activity such as driving or taking a shower when the breakthrough occurred. One person noted, "[It was] mystical. [I was] loaded with information. [I would] walk away and keep coming back and walking away." Another researcher described, "In the shower or driving to work, [I] make connections. [There is a] constant stream of connections made, but the breakthroughs are the ones that pan out. [The] important ones [I know] only months later after building things and seeing what works." One participant explained, "[You] organize development which leads to opportunities. Major breakthroughs occur two to three years apart. On a Saturday night in the bathtub, [one] just clicked. After several discussions of the conceptual breakthrough, [you can] then focus your understanding."

Four researchers referred to being prompted by interaction in a group or with one other person. Their responses were the following: "[It was a] subtle one. [It was] so straightforward it took us a while to find out. [We] asked ourselves, 'What's patentable about this?'" "[It

was the] synthesis of three or four other people's ideas.
[We had to] unify and [it] became bigger with explanation
because [people] requested, 'Why is this so big?'"

"Suddenly, unexpectedly [it happened]. No one else thought
about it. [The] problem had been the solution.

Education Department.

Most of the educators referred to obtaining knowledge
around systems rather than processes when they discussed how
their breakthroughs occurred. Their comments included the
following: "The project could have been killed, but I saw a
way out after analyzing the situation and taking a look at
what needed to be done and having contacts and resources."
"[I] looked at the systems and tried to understand the
systems that we work with and how they work together." "[I]
play around, pushing the system, finding out what doesn't
work. [There are an] accumulation of failures leading to
success."

Work Environment Inventory: Factors Supporting Creativity

Research Department.

About seven researchers mentioned that their peers were the single most important factor supporting creativity and innovation in their work environment. Some of their write-in responses included the following: "Smart and motivated colleagues," "The diversity of backgrounds in my work group and our willingness to work together," "The fact that most people around are creative and enthusiastic." Six responses to what supports creativity and innovation were related to organizational encouragement factors. The diversity of research interests and approaches, the long term support of individuals and projects, and the research culture were mentioned by participants as supporting factors. Two researchers commented that supervisory factors were the most important and two mentioned freedom as the single most important factor for creativity and innovation.

Education Department.

Six of the responses from participants in the education department were related to supervisory support. Participants referred to supervisors encouraging new ideas and providing constructive feedback. Three respondents felt freedom was the single most important factor stimulating creativity and innovation in their work environment. One participant commented, "We are free to handle our jobs our way. [We are] subject only to feedback

and review by others. We're not ordered around."

A different three believed that work group support was the single most important enabler. They mentioned open communication between peers and work group members who really care about giving customers a timely and quality product.

Work Environment Inventory: Factors Inhibiting Creativity
Research Department.

Five of the researchers believed that organizational factors were inhibiting their creativity and innovation. Two of the comments were about the expectation of researchers to be relevant to the immediate needs of the corporation. Other responses referred to a lack of trust to present new and possibly still incomplete ideas. A few other participants mentioned mistrust of management and criticism and negativity of peers. In addition to the five researchers above, there were five who believed that a lack of sufficient resources was the single most important factor inhibiting creativity and innovation. Their comments included references to poor communication of information from development, a shortage of qualified assistants, and inadequate systems.

Education Department.

Seven education department participants referred to some type of workload pressure as inhibiting their creativity. Their comments included topics about time

pressure, unrealistic deadlines, and time constraints. One person explained, "I go back to the way it had been done before because I don't have the time to investigate new processes with check points and measurements to ensure success." Another wrote, "[I have] too much to do and not enough time or resources to allow time for creative thinking and/or innovation." Four participants from the education department believed that a lack of work group support was the single most important inhibitor of creativity. For example, participants mentioned the need for getting buy-in from all team members and one complained about the competitive desires of other team members. Three educators felt that insufficient resources was the most important inhibitor. One stated, "We don't always have the time or money to do what's best for the customer and frequently can't meet their requirements as a result." Two people discussed more systems level organizational obstacles such as rewards and recognition and standards.

Work Environment Inventory: Suggestions for Improving the Climate for Creativity

Research Department.

Five comments made by researchers concerned not having sufficient resources. Their responses ranged from wanting more personnel to providing research models and having easier access to databases of journal articles. Four

researchers discussed organizational factors which need to be addressed. These include empowering middle management to control combativeness and negativity, increasing levels of trust, openness, and honesty, and nurturing the expression of dissent or disagreement. Three research participants suggested improving work group support factors. Two specifically wrote about increasing open communication among work groups and the other suggested more critical evaluation of projects. Three participants believed that supervisory factors were the most inhibiting to creativity in the work environment. One had a desire for more openness from management and another saw a need for better management and coaching skills.

Education Department.

Five participants from the education department mentioned improvements surrounding supervisory encouragement. Their comments included encouraging employees to try new things, take risks and take a broader view of the business world as well as recognizing contributions. Other comments were related to improving the performance evaluation process, channeling creativity better to provide more consistency for customers, and continuing quality. Two participants suggested more freedom for improving the creativity in the work environment. One wrote, "Allow the people who are implementing the solution to participate in decisions affecting them," while the other

suggested, "Increase the cascade of empowerments with total accountability!" The last two suggestions were related to work group support. These included educating personnel about creativity and interpersonal skills so that they can support others in their endeavors and ensuring all team members are "on board" with group goals.

Table 18

Summary of Major Qualitative Themes

Research	Education
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Structured Quality Processes

QIP Uses

Meetings	Providing perspective
	Empowering lower level people

Reasons for Not Using QIP

Don't identify with customer or customer requirements

Question the relevance or appropriateness

PSP Uses

Resolving conflict or getting to agreement	Guiding and structuring processes
	Ensuring follow-up

(table continues)

Table 18

Research	Education
Reasons for Not Using PSP	
Inefficiency of the process (4)	
Inappropriate for their type of work (11)	
More applicable to group meetings	
Incremental Improvement	
Percentage of improvement varies with time	Structured Focused Percentage of improvement varies with time Time spent on improvement reflects process maturity
Useful for Coming Up with Improvements	
	QIP/PSP in an abbreviated form (5) The PSP (5) The QIP (2)

(table continues)

Table 18

Research	Education
Breakthrough	
QIP or PSP Was Not Used Since:	
No clear problem or output	Used intuition
Not relevant	
Too linear	
Developing Future Opportunities	
Anticipated a need	Applying a technology to a project (6)
Perceived as main job or part of job	Improving processes (5)
"Flash of Genius" or "Aha"	
Unconsciously motivated realizations (5)	During a group discussion
First using something then realizing its implications (3)	
After some foundation of knowledge was established	
Synergistic Effect	
Preceded by exposure to related information	Preceded by exposure to related information
Work on multiple projects	Work on multiple projects
	"Building" (4)

(table continues)

Table 18

Research	Education
<hr/>	
Generalization to Another Project	
<hr/>	
Involved with multiple projects	Awareness or communication of other people's projects
Being exposed to problems	
Intentional collaboration on projects	
<hr/>	
Creating Breakthrough	
<hr/>	
Doing other activity, e.g. driving, taking a shower	Interaction in a group or with one other person
Interaction in a group or with one other person	Obtaining knowledge around systems
<hr/>	
Work Environment Creativity	
<hr/>	
Supporting Factors	
<hr/>	
Work group support (7)	Supervisory support (6)
Organization encouragement (6)	Freedom (3)
	Work group support (3)
<hr/>	
Inhibiting Factors	
<hr/>	
Organization encouragement (5)	Workload pressure (7)
Sufficient resources (5)	Work group support (4)
	Sufficient resources (3)
	Organization encouragement (2)
<hr/>	
Suggestions for Improving the Climate for Creativity	
<hr/>	
Sufficient resources (5)	Supervisory encouragement (5)
Organization encouragement (4)	Organization encouragement (3)
Work group support (3)	Work group support (2)
Supervisory encouragement (3)	Freedom (2)
<hr/>	

The above qualitative data will be used in connection with the quantitative data to establish support or lack of support for the four research hypotheses.

Chapter V.

Discussion

The results of the Z^* test correlating the two coefficients for the variables in the first hypothesis was significant and therefore supports the hypothesis that structured quality processes are more strongly related to incremental improvement than structured quality processes are related to breakthrough. In fact, the Z^* value was significant at $p < .001$ because incremental improvement and structured quality processes had a fairly high correlation and breakthrough and structured quality processes had an even higher negative correlation.

These findings imply that structured quality processes are useful for achieving incremental improvement. However, since the usage of these same processes is related negatively to breakthrough, these findings suggest that structured quality processes are not as useful for achieving breakthrough. In fact, using structured quality processes tends not to give rise to breakthrough and may inhibit breakthrough.

Qualitative data generally supports the quantitative results for the hypothesis that structured quality processes are more strongly related to incremental improvement than breakthrough. One theme that emerged from the interviews supporting this hypothesis is that creative solutions are

not obtained through systematic or procedural methods. The most common reason stated for why the QIP or PSP was not used for coming up with breakthroughs was there was no clear problem or output. There was consensus that structured quality processes could be useful for laying the foundation of knowledge upon which breakthroughs could be developed, but not useful for coming up with the breakthrough since the elaborateness of the process could inhibit creativity. There was a sense from the responses that freedom was needed to be able to achieve "creative jumps." The following quote seems to sum up the difference between incremental improvement and breakthrough quite well. "Breakthrough is kaboom! and it's there. [You] plan for continuous improvement."

Statements made by Mohr (1991), an advocate of total quality work design, support the above findings. Mohr (1991) believes that the strength of quality lies in continuous improvement and meeting customer requirements, not in allowing for quantum leap breakthrough.

The Z^* test was significant for the difference between the two correlations, incremental improvement and work environment creativity and breakthrough and work environment creativity. These findings support the second hypothesis stating that work environment creativity is more strongly related to breakthrough than work environment creativity is related to incremental improvement. While the correlation

between work environment creativity and breakthrough was fairly weak, the correlation between work environment creativity and incremental improvement was actually negative. These findings indicate that more creativity in the work environment is better for breakthrough than incremental improvement. The strength of the negative correlation between creativity in the work environment and incremental improvement was unexpected. Further analyses were conducted to examine which particular work environment inventory scales had the strongest negative correlations with incremental improvement.

These analyses revealed that the organizational stimulant scale of freedom had the largest negative correlation with incremental improvement, $r(38) = -.34$, $p < .05$. The creativity criterion scale ($-.28$), sufficient resources ($-.26$), work group supports ($-.25$), and supervisory encouragement ($-.25$) were also negatively correlated with incremental improvement although not at a significant level. Incremental improvement was positively correlated with both of the work environment inventory scales measuring organizational obstacles: organizational impediments and workload pressures, $r(38) = .41$, $p < .01$ for both.

Although causation cannot be determined, these further analyses suggest that creativity in the work environment is not necessary for incremental improvement. It is possible

that the relationship works in the opposite direction -- that making only incremental improvements inhibits the perception of creativity in the work environment.

This unexpected finding that incremental improvement is so strongly negatively correlated with work environment creativity is interesting. Comments from the qualitative findings such as, "Continuous improvement is structured and focused on what you're working on," imply that divergent, creative activities would be disruptive to the continuous improvement effort. Since continuous improvement is driven by process improvement, it appears that using the QIP and PSP would be much more appropriate than providing individuals freedom. Yet within the steps of structured quality processes, brainstorming is used to generate alternatives or identify causes to problems. The creativity of the brainstorming when it is applied within such a structured process would be necessarily limited. As the researchers implied, the structured quality processes are more useful once a problem or output has been defined. There is a need for creativity in defining the "box" but more structured and focused activities are needed to work within the existing framework. There seems to be support in the literature for the difference between the methods of working within the existing framework compared with challenging the existing the framework. For example, Kim (1989) states, "Conceptual learning deals with issues that

challenge the very nature or existence of prevailing conditions, procedures, or conceptions. The perspective of conceptual learning is not limited by the current framing of the issue; it is possible to go beyond and reframe the issue in a totally different way." Kim (1989) also believes that TQM provides limited methods and tools for organizational learning at this level.

The implication of these findings is that developing a creative work environment may run counter to the culture necessary for making incremental improvements. If incremental improvements are the desired result, then training in structured quality processes is recommended. However, if breakthroughs are the desired result, then the use of structured quality processes is not recommended. Unfortunately, this complicates the interaction between the two cultures of research and development where one is geared to major breakthroughs and the other to improving the manufacturing process. The realization that structured quality processes need to be implemented differentially throughout an organization is valuable. Researchers could be trained together with personnel from development and manufacturing on the structured processes knowing that they are useful for process improvement, not breakthroughs.

The third Z^* test showed a significant difference between the correlation of Hoshin planning and breakthrough and structured quality processes and breakthrough. As a

result, findings support the third hypothesis stating there is a stronger relationship between Hoshin planning and breakthrough than structured quality processes and breakthrough. The finding that structured quality processes and breakthrough were negatively correlated was expected. The results indicating that Hoshin planning and breakthrough were also negatively correlated was not expected, although the negative correlation was very weak at $-.17$.

This negative correlation represents a trend that suggests developing objectives and linking them to both departmental and corporate objectives (Hoshin planning) does not lead to breakthroughs. One of Hoshin planning's goals is to surface areas for breakthroughs. Apparently, the activities that are related to identifying the need for a breakthrough are quite different from those related to making a breakthrough.

A theme that emerges from the qualitative data regarding breakthrough supports the trend that Hoshin planning and breakthrough are negatively correlated. Quality processes may be useful for interfacing and ensuring that people look at new ideas, but not for breakthrough. Many researchers do not have any written objectives on which their performance is measured since written objectives imply that there are specific goals that are known. As an example, one researcher explained that he or she is working to achieve awareness of the things that might need to be

done to move the area. This type of job description does not lend itself to the development and implementation of objectives other than very generally stated ones.

While Hoshin planning is not a structured quality process, its current implementation is more directive than participative. Linking the accomplishment of annual objectives to the performance appraisal process can limit performance latitude for employees. Developing future opportunities that were not negotiated at the annual performance review meeting becomes an activity that is rewarded intrinsically but not financially for the employee. While Hoshin planning may not be as inhibiting as structured quality processes for breakthrough, the results reveal a trend that the current implementation of Hoshin planning is far from meeting its goal of encouraging breakthroughs.

It is important to develop, communicate, implement, and assess strategies, goals, objectives, and plans. In other words, Hoshin planning is a valuable strategy for achieving alignment in corporate goals at all levels of the organization. The role of Hoshin planning for surfacing breakthroughs seems to be confused with its ability to generate breakthroughs. Hoshin planning is a collective strategy whereas breakthroughs tend to be an individual undertaking. The foundation of knowledge that is accumulated perhaps during team meetings and from literature searches preceding breakthrough would correspond to the

daily information gathering of Hoshin planning. The implications of the findings to the third hypothesis are that the activity between establishing the foundation and generating the breakthrough is not conducive to structured quality processes nor Hoshin planning, but rather better left to unconscious or informal activities.

There was no significant difference between the two coefficients computed to test the fourth hypothesis. The findings do not offer statistically significant support for the hypothesis that work environment creativity is more strongly related to breakthrough than Hoshin planning is related to breakthrough. Although work environment creativity and breakthrough were positively correlated and Hoshin planning and breakthrough were negatively correlated, neither correlations were strong enough and therefore were not significant.

Further analyses were conducted to determine which work environment creativity scales correlated more highly with breakthrough than others. These analyses showed that the criterion scale of creativity correlated the highest with breakthrough, $r(38) = .38$, $p < .05$. All other scales correlated positively with breakthrough except for one, productivity ($-.02$). More specifically, there were three items from the productivity scale which correlated negatively with breakthrough. These items from the work environment inventory productivity scale were the following:

"Overall this organization is productive" (-.15), "Overall this organization is effective" (-.15), and "Overall this organization is efficient" (-.13). In light of what these particular items are measuring it is not surprising that two of them were negatively correlated with breakthrough. The productivity gains from breakthroughs come from their effective implementation rather than their generation. Additionally, generating breakthroughs is not known to be nor attempts to be an "efficient" undertaking. That the organization is not perceived as effective in relation to breakthroughs could be due to the generation of breakthroughs which have not been accepted as avenues to explore.

The two organizational creativity obstacle scales, organizational impediments and workload pressures, which normally correlate negatively with work environment creativity, unexpectedly correlated positively with breakthrough. The following organizational impediment items in order of strength of correlation were positively correlated with breakthrough: "Destructive criticism is a problem in this organization" (.42), "There is destructive competition within this organization" (.21), "Procedures and structures are too formal in this organization" (.15), "People are too critical of new ideas in this organization" (.04) and "People are quite concerned about negative criticism of their work in this organization" (.01). The

following workload pressure items in order of strength of correlation were positively correlated with breakthrough: "I have too much work to do in too little time" (.31) "I feel a sense of time pressure in my work" (.28), " There are unrealistic expectations for what people can achieve in this organization" (.21), and "There are too many distractions from project work in this organization" (.09). Those who are involved with activities related to breakthrough may be very sensitive to these measures of organizational obstacles to creativity and therefore rated them higher than people not involved with breakthrough.

On the following page in Table 19. is the Environment-Process Creativity Model with the average frequencies and number of subjects displayed. Implications of these findings will be discussed.

Table 19

Environment-Process Creativity Model with Average
Frequencies for All Combinations

High use of Quality Processes	(m=3.8, n=13) Incremental improvement	(m=3.5, n=11) Incremental improvement
(QIP, PSP)	(m=3.8, n=13) Breakthrough	(m=4.7, n=11) Breakthrough
Hoshin Planning	(m=3.8, n=18) Incremental improvement	(m=4.4, n=18) Breakthrough
Low use of Quality Processes	(m=5.8, n=6) Breakthrough	(m=6.4, n=8) Breakthrough
(QIP, PSP)	(m=3.8, n=6) Incremental improvement	(m=2.8, n=8) Incremental improvement
	Low	High
	Creative Environment	

Note: m=mean frequency, n=number of subjects

Implications of the Environment-Process Creativity Model

Number of subjects

There are differing number of subjects for each combination as the subjects fell into different cells depending on their ratings of structured quality processes, Hoshin planning, and work environment creativity. As a result, some of the cells in the model have very few subjects. The small number of subjects for each cell makes interpretations difficult to draw since the findings have a more probable chance of error than significant findings. Implications can be drawn with the above limitations in consideration.

Incremental Improvement

Incremental improvement is not as sensitive to use of structured quality processes as breakthrough. This is evidenced in the model since the average frequency does not change from high to low use of quality processes. The one factor that is related to less incremental improvement (an average of only 2.8) is the level of creativity in the environment. As previously mentioned, the WEI scales of freedom, creativity, sufficient resources, work group supports, and supervisory encouragement were all negatively correlated with incremental improvement. Organizational impediments and workload pressures were positively correlated with incremental improvement. These findings seem to indicate the need for incremental improvement is

related to the perceived existence of organizational obstacles and possibly a lack of organizational stimulants such as sufficient resources.

The relationship between incremental improvement and work environment creativity is negatively correlated. Yet to suggest that creativity in the work environment should be reduced to allow for incremental improvement would erroneously assume that high creativity causes low incremental improvement. Rather a more plausible explanation is that high incremental improvement causes a perception of low creativity. The implications of these findings are that if the perception of a creative environment is desired than involving employees in incremental improvement activities would be counterproductive. If high incremental improvement is desired, then use of quality processes and other factors rather than the creativity in the work environment need to be addressed.

Breakthrough

The highest level of breakthrough ($m=6.4$) occurred with a high work environment creativity and low use of quality processes. Interestingly enough, the next highest level ($m=5.8$) occurred with low work environment creativity and low use of quality processes. The third highest level of breakthrough ($m=4.7$) was with high work environment creativity and a high use of quality processes. Hence, the

use of quality processes seems to be a better predictor of breakthrough than the level of creativity in the work environment. The lowest level of breakthrough ($m=3.8$) was with a high use of quality processes and low work environment creativity.

High breakthrough levels along with more respectable incremental improvement levels occur with a low use of quality and low creativity or to a lesser degree with high creativity and high use of quality. High use of quality processes is associated with lower levels of breakthrough. The implications of these findings are that if only high breakthrough is desired than having a creative work environment and no quality processes would be the best combination. If some compromises between the levels of incremental improvement and breakthrough are desired, the best alternative seems to be with low use of quality processes and low work environment creativity. This alternative follows from the results that high levels of quality are negatively associated with high levels of breakthrough and high work environment creativity is negatively associated with incremental improvement. Apparently it is better to do away with the inhibiting factors than to simply increase the supporting factors.

Link with Organizational Culture and Strategy

There are three possible permutations of breakthrough and incremental improvement that can be discussed from the

model: (a) a high level of breakthrough and low incremental improvement, (b) a high level of incremental improvement and a low level of breakthrough, or (c) a medium level of each. Whether the choice is to only make incremental improvements to existing technologies or to only achieve breakthroughs the choice is determined by organizational strategy. Only making incremental improvements is conducive to the imitative culture described by Sethia (1989). This culture has an external focus that is responsive to market needs but a reactive bias that makes the organization cautious, risk-averse, and satisfied with being a follower or imitator. Breakthroughs are not encouraged in this culture due to an inherent inertia and conservatism.

Being concerned only with breakthroughs is conducive to the creative culture Sethia (1989) describes. This culture has an internal focus such that it is preoccupied with developments inside the company and defines its own technological standards. The creative culture also has a proactive bias characteristic of self-motivated initiative, risk-taking, and a desire to originate a new order of things.

The compromise for fairly high levels of both breakthrough and incremental improvement may lie within the adaptive culture. This culture has an external focus and a proactive bias. The other alternative is the resistive culture which has an internal focus in that it defines its

own technological standards, but a reactive bias which is related to risk-aversion. The resistive culture seems to represent the low use of quality processes and low work environment creativity combination.

Implications for National Culture and Strategy

American and Japanese Values Compared.

"While Americans think they're pretty good at quality improvement, the reality is that, at best, they will maintain parity with the Japanese. It will not create a large enough lead to be a sustainable competitive advantage," says Allaire (1992). Part of the reason for this is values. According to Allaire (1992) Total Quality Management is built on an implicit values position, one that emphasizes one of the following: Discipline, uniformity, sense of obligation and duty to others, identification with the total enterprise, and conformity. Many of these values are the same values that have been identified as being at the core not only of Japan's industrial culture but its national culture as well. These values are built into their society and provide a context for their quality improvement work.

In contrast, some of the strongest American values are: Entrepreneurism, innovation, autonomy, diversity, identification with the small group, and the energy level of the American worker. These national cultural differences imply that Americans should not expect to do better than the

Japanese at TQM. The Japanese have an inherent structural advantage by the very nature of their society. America's competitive advantage comes from an environment of diversity, creativity and entrepreneurial energy. The challenge of American companies is to move beyond quality and find ways to leverage the inherent competitive advantage of the American worker and the American work culture.

Breakthrough work processes, a total rethinking of processes often from different perspectives, is required for the alignment of American values and goals. Allaire (1992) believes that this is only possible by first starting with quality processes. Allaire (1992) finds there is the potential for a uniquely American solution which can provide a not easily replicable competitive advantage in the global marketplace.

Hofstede's Dimensions Support Cultural Distinct Competitive Advantages.

The high uncertainty avoidance of the Japanese national culture and the comparatively low uncertainty avoidance of the American national culture have implications for the competitive advantages of these nations. According to Hofstede (1983) a high uncertainty avoidance is characteristic of feeling threatened by uncertain and ambiguous situations. Such situations are avoided by establishing formal rules, being intolerant of deviant ideas or behaviors, and believing in absolute truths. These

rules, intolerances, and beliefs characteristic of high uncertainty avoidance are not conducive to breakthrough since deviant ideas which are encouraged by a lack of formality and a belief in conditional truths tend to create breakthroughs. As a result, the high uncertainty avoidance which is characteristic of the Japanese national culture indicates that their culture is maladapted to creating breakthroughs. On the other hand, the low uncertainty avoidance of the American national culture indicates that the American culture is more conducive to breakthroughs. Consequently, the American national culture has a natural competitive advantage when it comes to breakthrough.

The Japanese and American national cultures also differ on another dimension developed by Hofstede (1983). This dimension is referred to as the individualism-collectivism dimension. The individualism-collectivism dimension represents the relationship between an individual and society as a whole. In countries where collectivism predominates, people's involvement is likely to be moral and people may transfer part of their extended family allegiances to the organizations to which they belong. By contrast, involvement will tend to be calculative where an individualistic ethos exists.

A high collectivism national culture would be resistive to breakthroughs that require an individual to go against the accepted truths of the intellectual community. For

example, Axelrod (1979) believes breakthrough involves a tension between the individual and the group. According to Kuhn (1962) any new discovery or theory emerges first in the mind of one or a few individuals. These individuals, Kuhn says, are usually so young or so new to the field that practice has committed them less deeply than most of their contemporaries to the world view. Thus, both Axelrod (1979) and Kuhn (1962) suggest that it is the individual acting freely against collective truths that permits breakthroughs. Consequently, both the uncertainty avoidance and the individualism-collectivism dimensions put forth by Hofstede imply that the American national culture is more supportive of breakthroughs than the Japanese national culture. The findings from the research indicating such a high negative correlation between quality processes and breakthroughs support the idea that there are culturally distinct competitive advantages. It comes as no surprise then that Japanese companies are admired for their quality products and American companies are admired for their breakthroughs.

Limitations of the Research

Sampling

This research was limited to 19 subjects in each department yielding a total of 38. Although this sample size was large enough to show support for the first three hypotheses, support for the fourth hypothesis could not be

established. The fourth hypothesis which revealed a trend would have been significant at a sample size of 90 given similar responses to those items.

Response Bias

The interviewer was an evaluation consultant within the education department at the time of the research. Although subjects were ensured confidentiality of responses, there may have been some socially desirable response bias.

Validity

The variable breakthrough was measured by six items in the semi-structured interview guide. The item that measured generalizability of concepts from one project to a different one correlated .25 with breakthrough which represents a fairly low correlation. Cronbach's alpha coefficient was as low as .29 for one item. The operationalization of theoretical breakthrough is difficult by its nature since breakthrough represents abstract thinking. In operationalizing an abstract concept such as breakthrough, it is necessarily made more concrete for measurement purposes. Examining the breakthrough from the measurement perspective, the variable appears to lack clarity and objectivity. In operationalizing the variable, an attempt was made to come to a compromise between keeping it abstract enough to correspond with theory, yet concrete enough to create a valid measure. If future research on breakthrough is conducted, this research will be beneficial in

establishing some items which are more valid such as those measuring "aha" and synergy. Rewording the question on generalizing from one project to another is recommended.

Suggestions for Further Research

Since this is the first research combining quality concepts and creativity theory, many variables had to be operationalized for the first time. Some of the items used to measure the variables need to be revised and other measures could be added to validate current ones. This research utilized a semi-structured interview and an inventory, but future research could include participant observations and be conducted over time. Also future research may examine the differences between companies within the same department to evaluate the impact of different implementations of quality.

While this research was focused on three processes, the problem solving process, the quality improvement process, and Hoshin planning, there are many other aspects of quality strategies that could be examined for their impact on creativity, incremental improvement, and breakthrough. One area that deserves particular attention is the boundary activities between two or more departments that influence the communication and implementation of new ideas. Further research examining the relationship between quality strategies and processes and creativity would be valuable since a hybrid of quality and creativity would provide

company's with a valuable competitive advantage.

Conclusions

Adapting Principles of Quality for R&D

The role of quality in research where innovation, particularly breakthrough development, is the objective needs to be different from manufacturing, marketing, sales, or service. Szakonyi (1992), director of the Center on Technology Management at IIT Research Institute, believes R&D managers need to adapt general principles of quality improvement to their own function's specific operations. According to Szakonyi (1992), an R&D department can guide its efforts within the laboratory with the following five actions for improving quality: (a) strengthen laboratory technical capabilities, (b) improve the management of R&D, (c) increase technical personnel's training related to improving quality, (d) improve the work environment within the laboratory, and (e) strengthen analytical, information, and computer capabilities.

Quality Training Course Revisions

In accordance with Szakonyi's third action above to increase training to improve quality, the quality training that researchers receive could be modified to consider their differing needs. Many of the researchers valued the interactive skills portion of the training. This training includes identifying, scoring, and profiling effective initiating, reacting, clarifying, "bringing in" and

"shutting out" behaviors. While some researchers in the social science laboratory found the scoring and profiling to be an oversimplification of group dynamics, others found the skills training helpful in improving collaborative group interactions. The quality training should be revised to include more time on the interactive skills portion and less time on the Problem Solving Process, since researchers are familiar with problem solving models.

Additionally, to encourage collaboration between research and development, personnel from these departments could receive training together solving actual problems and improving existing processes.

Using Quality Principles to Improve the Work Environment

While many researchers did not believe the quality processes were useful for helping them conduct their research, some of them thought that these processes could be used for improving the infrastructure within which they worked. Solving known environmental issues or improving already existing systems and processes which influence work environment creativity would be an appropriate application of quality processes.

Structure Incompatible with Breakthrough

The research findings imply that using quality processes will result in incremental improvements but not breakthroughs. It may appear that the data gathering phase of the Problem Solving Process could provide the necessary

foundation upon which the problem could be identified. A breakthrough in this instance would be problem solving in reverse. However, one of the major concerns with the quality processes is that they are too structured and linear to promote breakthroughs. The concept of structuring any portion of breakthrough is objectionable, whether it is laying the groundwork through information gathering or obtaining a realization by identifying a problem. The structuring runs counter to the fact that many breakthroughs are unconsciously motivated. Work environment creativity is only weakly related to breakthrough perhaps for some of the same reasons, even a creative environment is still somehow molding the environment.

Summary

This research tested some of the assumptions that were being made about quality strategies that had thus far gone untested. For instance, the notion that quality processes promote creativity for solving problems and creativity for developing breakthroughs was assumed. With findings that show such a negative correlation between structured quality processes and breakthrough, the validity of these assumptions is questionable at least as they apply to research and education departments.

Quality principles need to be implemented differentially throughout an organization at some phase in the quality strategy implementation. Initially quality

principles that better apply throughout the organization, for example, interactive skills, could be taught consistently. The second phase would be a local adaptation of quality principles with more authority at the managerial level rather than the corporate level.

Breakthrough developments are so important to American industry as a whole. Since American industries have had a competitive advantage when it comes to breakthrough creativity, it is important that this advantage is not given up for quality, but that organizational environments and processes support both quality and breakthrough creativity. This research begins to show how organizations can design strategies that support both quality to satisfy current market needs and breakthroughs for long-term profitability.

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Appendices

Appendix A

Semi-Structured Interview Guide

Demographics

1. Gender: Male ___ Female ___
2. Age: Under 30 ___ 30-40 ___ 41-50 ___ 50+ ___
3. Ethnicity: Amer. Indian ___ Asian ___ Caucasian ___
Black/African Amer. ___ Hispanic ___ Other ___
4. What area of work are you involved with specifically?
5. How long have you been in your present position? _____
6. How long have you been at this research facility? _____
7. How long have you been with this company? _____

Educational Background

8. What field did you study for your formal education?
9. What university degree or degrees do you have?

Use of Processes

Technological Improvement Processes

10. How do you go about improving processes which you are working on within your research?

Work Improvement Processes

11. How do you go about improving your own processes which determine **how** you do your research?

Problem Solving Processes

Technological Problem Solving

12. How do you solve problems you run into when you're doing your research?

Work Process Problem Solving

13. How do you solve problems related to how you go about doing your work?

14. Have you ever used the Problem Solving Process that has been taught in quality courses here at the company?

Yes ___ No ___

[If yes] For what kinds of things?

What have the results been?

[If no] Why not?

15. Have you ever used the Quality Improvement Process which starts with "Identify Output", "Identify Customer", and "Identify Customer Requirements"?

Yes ___ No ___

[If yes] For what?

What were/was the result(s)?

[If no] Why not?

Quality Training

16. Have you taken any Quality Training?
Yes ___ No ___

[If yes] How long has it been since the training? _____

17. Are you a member of a collaborative group? Yes ___ No ___

Policy Deployment

18. Are you familiar with the term "policy deployment"?
Yes ___ No ___

[If yes] How would you describe it?

19. Have you developed written objectives that you want to achieve?
Yes ___ No ___

[If yes] Is accomplishment of your objectives measured more in terms of how you do your work (processes) or what kinds of results you get?

20a. Do you know what CRG's objectives are for 1992?
Yes ___ No ___

[If yes to 19.] 20b. Are your objectives linked to CRG's objectives? Yes ___ No ___

21a. Do you know the company's four common goals? Yes ___
No ___

[If yes to 19 & 21] 21b. Are your objectives linked to the company's four common goals? Yes ___ No ___

22. Other comments about the use of quality processes.

Creative Output

Incremental improvement

definition - a small, gradual increase in value

23. Do you make incremental improvements to already existing processes or products? Yes ___ No ___

[If yes] How much time do you spend improving existing processes compared to creating new processes or products? In terms of the percentage of your time?

24. Do you make minor changes to a product or process to meet the needs of the user? Yes ___ No ___

25. Have you made minor adjustments to a product or process in response to a particular problem? Yes ___ No ___

26. Have you made an existing process more capable? Yes ___ No ___

27. Did you use the QIP or PSP to come up with any of the improvements?

Yes ___ No ___ [If yes] Please explain.

Breakthrough

28. Have you generated ideas to develop future opportunities which were not related to known requirements or recognized demands? Yes ___ No ___
[If yes] Please explain.

29. Have you had "a flash of genius" or "aha" experience while you've been here at the research center? Yes ___ No ___ [If yes] What was this like?

30. Have you put together two or more ideas such that they produced a result which was much greater than they would have produced individually? Yes ___ No ___

[If yes] How did this occur?

31. Have you been working on a particular project and suddenly realized that a different project would benefit from whatever it was you were thinking about? Yes ___ No ___

[If yes] What prompted that?

Breakthrough - a sudden illumination in the solution of a problem or discovery of a new technique

32. Have you been responsible for a breakthrough or breakthroughs at this facility? Yes ___ No ___

[If yes] How many? ___ Please explain the breakthrough(s).

Probe: How did the breakthrough occur?

33. How many patents have you or a team you've been involved with applied for since you've been here? _____
34. How many patents have you or a team you've been

involved with been awarded since you've been here? _____
35. Did you use the QIP or PSP to come up with any of the
breakthroughs? _____yes _____no [If yes] Please explain.
[If no] Why not?

36. Other comments about continuous improvements and
breakthroughs.

Appendix B

WORK ENVIRONMENT INVENTORY

Teresa M. Amabile, Ph.D.
Brandeis University and Center for Creative Leadership

INSTRUCTIONS

The purpose of this confidential questionnaire is to obtain an accurate picture of your current work environment. A number of people in your organization will be completing this inventory. The questions identify both the strengths and the weaknesses of the environment. Your responses to this questionnaire will be strictly confidential. This is a survey, not a test; there are no right or wrong answers.

This inventory asks questions about your impression of your current work environment, which is defined as the day-to-day social and physical environment in which you currently do most or all of your work.

This questionnaire is accompanied by an answer form for questions 1-78 and should take only a few minutes to complete. A prepaid, self-addressed envelope is attached for your convenience. It is important that you return your completed answer form promptly along with this questionnaire.

Please be sure to use only a #2 lead pencil. *Do not use a pen.* Make sure your marks are dark and completely fill the circles. If you wish to change a response, erase the first mark completely. Be sure to answer all questions on both sides of the answer form.

Before completing this inventory please read the attached cover letter pertaining to your particular use of this inventory.

Here are definitions of some terms used in the questions:

- **work group:** the people with whom you currently work most closely on a day-to-day basis; the group of people with whom you do your major project(s).
- **supervisor:** the person who manages your major project(s); the person to whom you report for most of your work.
- **project(s):** the major work that you do, whatever it may be.
- **this organization:** the company or organization within which you currently work.
- **my area of this organization:** the department, branch, or division within which you do most of your work; the unit that you see as your area of the organization.

Please answer each question in terms of the feeling or impression you most often have about your current work environment.

- 1 = Never or almost never true of your current work environment
- 2 = Sometimes true of your current work environment
- 3 = Often true of your current work environment
- 4 = Always or almost always true of your current work environment

1. I have the freedom to decide how I am going to carry out my projects.
2. I feel that I am working on important projects.
3. I have too much work to do in too little time.
4. This organization is strictly controlled by upper management.
5. My area of this organization is innovative.
6. My coworkers and I make a good team.
7. The tasks in my work are challenging.
8. In this organization, there is a lively and active flow of ideas.
9. My supervisor clearly sets overall goals for me.
10. There is much emphasis in this organization on doing things the way we have always done them.
11. I have sufficient time to do my project(s).
12. I feel considerable pressure to meet someone else's specifications in how I do my work.
13. Overall, this organization is effective.
14. Overall, the people in this organization have a shared "vision" of where we are going and what we are trying to do.
15. There is a feeling of trust among the people I work with most closely.
16. People in this organization are very concerned about protecting their territory.
17. There are too many distractions from project work in this organization.
18. New ideas are encouraged in this organization.
19. Within my work group, we challenge each other's ideas in a constructive way.
20. There is destructive competition within this organization.
21. My supervisor has poor interpersonal skills.
22. Performance evaluation in this organization is fair.
23. I do not have the freedom to decide what project(s) I am going to do.
24. There are many political problems in this organization.
25. People in my work group are open to new ideas.
26. The facilities I need for my work are readily available to me.

27. My supervisor serves as a good work model.
28. In this organization, top management expects that people will do creative work.
29. In my work group, people are willing to help each other.
30. Procedures and structures are too formal in this organization.
31. There are unrealistic expectations for what people can achieve in this organization.
32. Generally, I can get the resources I need for my work.
33. My supervisor's expectations for my project(s) are unclear.
34. People are quite concerned about negative criticism of their work in this organization.
35. People are recognized for creative work in this organization.
36. The tasks in my work call out the best in me.
37. My supervisor plans poorly.
38. The organization has an urgent need for successful completion of the work I am now doing.
39. People in this organization feel pressure to produce anything acceptable, even if quality is lacking.
40. There is an open atmosphere in this organization.
41. There is a good blend of skills in my work group.
42. Ideas are judged fairly in this organization.
43. Top management does not want to take risks in this organization.
44. In my daily work environment, I feel a sense of control over my own work and my own ideas.
45. Failure is acceptable in this organization, if the effort on the project was good.
46. The budget for my project(s) is generally adequate.
47. My area of this organization is creative.
48. My area of this organization is productive.
49. People are encouraged to solve problems creatively in this organization.
50. People are rewarded for creative work in this organization.
51. My supervisor supports my work group within the organization.
52. Overall, my current work environment is conducive to my own creativity.

53. I feel challenged by the work I am currently doing.
54. My area of this organization is effective.
55. A great deal of creativity is called for in my daily work.
56. People in this organization can express unusual ideas without the fear of being called stupid.
57. I can get all the data I need to carry out my project(s) successfully.
58. The people in my work group are committed to our work.
59. My supervisor does not communicate well with our work group.
60. I get constructive feedback about my work.
61. This organization has a good mechanism for encouraging and developing creative ideas.
62. People are encouraged to take risks in this organization.
63. I have trouble getting the materials I need to do my work.
64. I feel that top management is enthusiastic about my project(s).
65. Overall, this organization is productive.
66. People are too critical of new ideas in this organization.
67. There is free and open communication within my work group.
68. My supervisor shows confidence in our work group.
69. Overall, my current work environment is conducive to the creativity of my work group.
70. I feel a sense of time pressure in my work.
71. Overall, this organization is efficient.
72. My supervisor values individual contributions to projects.
73. My supervisor is open to new ideas.
74. My area of this organization is efficient.
75. The information I need for my work is easily obtainable.
76. I believe that I am currently very creative in my work.
77. Other areas of the organization hinder my project(s).
78. Destructive criticism is a problem in this organization.

