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THE JUST-IN-TIME OPERATING PHILOSOPHY:

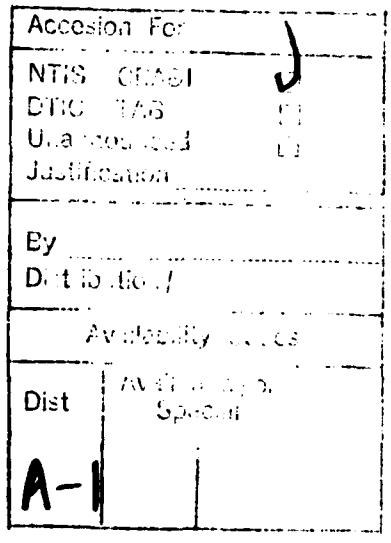
IMPLICATIONS FOR WORKERS AND WORK TEAMS

A Dissertation

by

KEVIN PATRICK GRANT

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of



DOCTOR OF PHILOSOPHY

December 1990

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THE JUST-IN-TIME OPERATING PHILOSOPHY: IMPLICATIONS FOR WORKERS AND WORK TEAMS

A Dissertation

by

KEVIN PATRICK GRANT

Approved as to style and content by:

R. E. Shannon
(Chair of Committee)

Leland Blank
(Member)

James K. Hennigan
(Member)

August W. Smith
(Member)

G. K. Bennett
(Head of Department)

December 1990

ABSTRACT

The Just-In-Time Operating Philosophy: Implications for Workers and Work Teams. (December 1990)

Kevin Patrick Grant, B.S., USAF Academy;
M.S., Air Force Institute of Technology
Chair of Advisory Committee: Dr. Robert E. Shannon

The Just-In-Time (JIT) operating philosophy has been adopted by many American companies during the last decade. As American companies have adopted JIT it has become very clear that the involvement and commitment of the work force is vital to the success of the JIT philosophy. This research effort was conducted in an electronics assembly plant which relies on work teams as the primary vehicle for employee involvement. The objective of this research was to examine the implications which the JIT operating philosophy holds for workers and work teams.

First, this research examined worker perceptions of the JIT operating environment. Several aspects of the work environment were studied to include: equity of workload, control of work pace, comfort with work pace, sources of motivation and equity of rewards. The only significant change in worker perceptions concerned the adequacy and equity of rewards. This study determined that worker satisfaction with a reward system based on team performance rather than individual performance eroded

somewhat over the course of this study.

Second, this research investigated the development of work team characteristics as the teams transitioned to the JIT operating environment. Several team characteristics were studied to include: capacity to collaborate, inclination to collaborate, communication effectiveness, priority consonance, and participation in decision making. Only team capacity to collaborate as measured by team flexibility improved during the course of this study. The improvement is attributed to an informal cross-training program which was implemented by the company.

Third, this study examined the link between team characteristics and team performance. The results indicate that team collaboration was positively related to schedule performance and labor efficiency. Further, priority consonance and participation in decision making were also positively related to schedule performance. Finally, team flexibility was positively related to product quality.

DEDICATION

I offer this work as my prayer of thanksgiving
for the many blessings I have received from you, O Lord.
Amen.

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There are many people who contributed their time and efforts to help me conduct this research effort. I would like to extend special thanks to my Committee Chairman Dr. Robert Shannon, whose door was always open, and whose help and guidance was always forthcoming. I would also like to thank all those who participated on my graduate committee: Dr. Leland Blank, Dr. James Hennigan, Dr. Bill Smith and Dr. Janis Stout. Without exception, the members of my committee took an active interest in my research efforts, and provided me with valuable suggestions and insights. I am very grateful.

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The acknowledgement of those individuals who supported me in this effort would not be complete if I did not recognize the personal support I received from my wife and my family. My heart felt thanks goes to each of you.

Finally, I would like to thank the pioneers at WordPerfect Corporation, Borland, IBM, Hewlett Packard, and any others who have participated in the revolution which has so significantly improved the process of writing a dissertation. What a difference they have made!

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CHAPTER I

INTRODUCTION

In recent years, many companies in the United States have adopted the Just-In-Time (JIT) operating philosophy. A 1987 study conducted by Coopers and Lybrand, titled "Made in America, A Survey of Manufacturing's Future," determined that nearly 25 percent of American companies had already implemented many aspects of the JIT philosophy. The study also projected that by 1992, more than 55 percent of American companies would be operating with JIT [1]. Only one year before the Coopers and Lybrand study, Waller estimated that as few as 10 percent of American companies were currently using the JIT operating philosophy [2]. These estimates suggest that many American companies have recently adopted JIT and that the trend is likely to continue in the years ahead.

As American companies have adopted JIT it has become very clear that the involvement and commitment of the work force is vital to the success of the JIT philosophy. Adair-Heeley declares, "the involvement of people at all

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levels of an organization is paramount in a successful Just-In-Time (JIT) implementation" [3]. Clark observes that frequently the difference between companies which experience success with JIT and those which have encountered failure "appears to be the extent to which all employees are involved in JIT implementation and operation" [4]. Also, Sepehri asserts that "all companies with success in implementing JIT production have used some sort of mechanism for company wide employee participation and involvement" [5].

As Sepehri indicates, there are a variety of mechanisms available to secure employee involvement in the JIT effort. Some examples of the vehicles available include employee participation in small group improvement activities (quality circles) [4], suggestion programs [6], Scanlon plans and Quality of Work Life (QWL) programs [7]. Additionally, Adair-Heeley identifies effective work teams as a mechanism by which this involvement occurs [3].

It is very important to note that each of these mechanisms has been implemented in companies which were not using JIT. The JIT philosophy has not created mechanisms for employee involvement. Rather, the JIT philosophy has underscored the importance of employee involvement, and illuminated the benefits which can be realized by actively including the work force in the on-going and continuous effort to eliminate waste.

This study will focus on JIT implementation in a manufacturing environment which relies on work teams as the primary vehicle for employee involvement. The work team is certainly not a new concept; teams were used to perform work even thousands of years before the Great Pyramid was built [8]. Poza and Markus assert [9]:

> It would be hard to find anyone at all conversant with business who has not heard or read about the startling improvements in productivity and quality of worklife to be gained by restructuring blue collar jobs in ways that permit incumbents to work in teams and give them more discretion, greater interaction with their co-workers, and responsibility for a large work area... .

The obvious benefits of work teams have resulted in the pervasive use of work teams in American industry. Given the widespread use of work teams, and the rapid increase in the adoption of JIT through the 1980s, it is inevitable that many companies will face the challenge of converting their work teams to the JIT operating philosophy. Unfortunately, while work teams and JIT have both received considerable academic attention, there is very little research concerning the impact that a JIT implementation effort has on a company which is already using work teams. This study addresses the implementation of JIT in a manufacturing environment which relies on work teams to accomplish the production effort.

Purpose of Study

This dissertation examines how JIT impacts the work

force. Further, this research effort investigates the transition of industrial work teams from a traditional manufacturing environment to a Just-In-Time manufacturing environment.

Specifically, this research includes three detailed studies. The first study addresses worker-perceived changes in the work environment as a result of implementation of the JIT operating philosophy. This study considers several factors to include the following: sources of worker motivation, perceived equity of rewards, perceived equity of workload distribution, perceived responsibility for work pace, and comfort with the work pace. The second study examines the transition of work teams to the JIT manufacturing environment. This study addresses the development of collaboration, flexibility, communication, and ownership within work teams. Finally, the third study determines if team performance is related to team abilities to collaborate, communicate and assume responsibility for their work effort.

Importance of Study

Work teams are widely used throughout industry. JIT is rapidly being adopted by American companies. How does the traditional work team transition to operating in a JIT environment? What skills or practices must a work team develop to embrace the JIT philosophy? How is team

performance affected by the development of these JIT related team skills? How do team members, the primary work force, perceive the changes to their work environment when the company transitions to the JIT philosophy? These are important questions which have not been answered through formal research. This study addresses these questions. The results of this study will provide industrial managers with insight into the nature of team transition to a JIT environment and will identify those skills which work teams must develop as they adopt the JIT philosophy. The study also reports some strategies which may be used to facilitate the development of JIT-related team skills and identifies the changes in team performance to be expected from the development of these team skills. Finally, the study presents worker perceptions regarding several aspects of the work environment which are affected by the implementation of the JIT philosophy. These perceptions can be used to guide the successful implementation of JIT in a work team manufacturing environment.

Presentation of Study

This study is presented in six chapters. This first chapter presents a brief introduction to the research effort. Chapter II provides a review of the literature. This literature review first describes the many changes to

the work environment which result from implementation of the JIT philosophy. The literature review then addresses the transition of industrial work teams to the JIT philosophy as well as actions which can be taken by companies and team advisors to facilitate the transition.

Chapters III, IV and V each present a separate study. These three studies were performed simultaneously in the same manufacturing facility. Moreover, each of these studies focused on the experiences of the same employees. The distinction between each study is based on the objectives of the study and the issues addressed by the research. Chapter III examines worker perceptions of the JIT operating environment. Chapter IV investigates the transition of work teams to the JIT philosophy. And Chapter V explores the relationship between the development of team characteristics and team performance in a JIT operating environment. Each of these three chapters presents the methodology, results and discussion associated with the specific study presented in the chapter.

A summary of the research effort is provided in Chapter VI, "Summary and Conclusions." This chapter emphasizes the important findings of the study. It also highlights the conclusions which are of the greatest interest to industrial managers. Finally, this chapter recommends additional research which should be performed

to further equip industrial managers to face the challenges of today's dynamic and competitive manufacturing environment.

CHAPTER II

LITERATURE REVIEW

This chapter presents a review of the literature which establishes the foundation for the study of work team transition to the JIT operating environment. It is presented in two parts. First, the discussion describes the many changes to the work environment which result from implementation of the JIT philosophy. This discussion will emphasize those changes which directly impact the work force. Second, the discussion will address the transition of industrial work teams to the JIT environment.

JIT Results in Changes for the Work Force

The literature indicates there are many changes the work force will experience as a result of the change to a JIT environment. This section will address the many changes indicated by the literature. It will describe how the change to just-in-time places more responsibility directly on the work force. It will also address several additional changes such as increased flexibility, and changes to: work flow and work pace; performance measurement systems and rewards; labor-management

relations; labor utilization and retention; communication on the plant floor; and finally, mechanisms for employee involvement.

Increased Responsibility

The switch to the JIT operating philosophy will increase the scope of responsibilities for the work force. In a JIT system, it is essential that workers maintain the disciplined flow of work through the plant. This requirement results in increased interdependence between work stations and imposes the need for workers to remain responsive. Consequently, JIT workers become responsible for preventive maintenance, routine cleaning of equipment and work areas, material control and scheduling [10], [11], [12]. These activities all contribute to maintaining the state of readiness which is essential to respond to the demands of the work flow.

The transition to JIT also places increased emphasis on product quality. In an effort to bolster quality in a JIT environment, workers become personally responsible for reworking the defective parts they produce [13]. They are also encouraged to actively expose any quality problems which might arise. This responsibility can place the authority to shut down the production line squarely on the worker [14]. JIT workers are also encouraged to inspect their work as it is performed in an effort to reduce

rework or scrap [13]. Clearly, the emphasis on product quality in a JIT system demands constant vigilance and responsiveness from the JIT worker.

Finally, the JIT philosophy demands a focus on continual improvement. This focus makes the worker responsible for perpetual personal and process improvement. The workers must participate in problem solving activities and constantly seek to reduce cycle times, eliminate waste and improve operations [4]. They must also learn new analytical and interpersonal skills to help them become more effective as problem solvers and agents of change [15].

Increased Flexibility

The transition to JIT not only increases the scope of a particular job, but it also requires workers to develop skills in a variety of functions [5], [16], [17]. The JIT philosophy maintains that items are not produced until they are needed. Consequently, the JIT system will give rise to idle workers and machines. The solution to the problem is to develop flexible workers who are able to perform several functions, and thereby dedicate their efforts where they are needed most [11], [18]. In a JIT factory, workers will need to move from job to job, rather than remaining at a single station to produce a stockpile of a single part [19].

The benefits accrued from flexible workers include lower inventories, a lower scrap rate and less rework [19]. Also, the flexible worker is able to cover for absent coworkers and supplement the labor pool when labor shortages occur [20]. Several additional advantages are available when the flexible worker is developed through job rotation. First, the rotation leads to fresh starts and reduced muscular fatigue. The result is a safer and more attentive work force. Second, the rotation process cultivates increased conversation between the rotating workers which results in improved human relationships. Third, since each worker performs each of the functions in the shop, he or she is better able to internalize all the goals of the shop, including safety, quality and production quantity. Finally, rotation allows the workers to take a fresh look at the process. This fresh look yields many ideas which may improve the processes in the shop [21].

The shift to increased flexibility results in several changes for the worker beyond simple cross-training. Some companies consolidate job classifications [22]. Some companies reduce the number of pay grades, as well [20]. Another strategy often employed is to link promotions to increased levels of flexibility attained by the worker [22]. Finally, increased flexibility will require a significant increase in the knowledge base of the worker

[22].

Work Pace and Work Flow

At the root of the changes in work pace and work flow is one of the most fundamental concepts of the JIT philosophy: "provide exactly what is needed when it is needed" [23]. Or as Schonberger states: "The idea is to provide subassemblies just in time to go into final assemblies, fabricated parts just in time to go into subassemblies, and purchased materials just in time to go into fabricated parts" [19]. A major implication of this concept is that "it is just as important that no one is ahead of schedule as that no one lags behind" [13]. In a JIT environment, there is no work-in-process inventory to absorb the variability of work pace that exists in traditional production facilities [13]. Consequently, attention to work pace is more critical in a JIT environment.

There are many ramifications of this concept which impact the workers directly. First, the workers must pay closer attention to their personal progress, as well as the progress of the stations downstream. Second, they may need to adjust to a system equipped with warning signals designed to regulate flow [17]. They will also have to adjust to interruptions in the work flow, which will occur more frequently as the workers become more involved with

solving problems and taking responsibility for the quality of their work [14]. Finally, in some companies, employee evaluations are linked to how closely production quantities match requirements without generating excess inventory or waste [24].

Performance Measurement and Reward Systems

"Performance measurements are a key driver of organization behavior" [1]. Consequently, it is important to an organization which switches to the JIT philosophy to ensure that performance measures are driving their organization in the right direction. The most commonly used measures in a JIT environment include product quality, schedule performance and inventory investment [25]. Also, there is increased emphasis on group performance over individual performance [20], [26]. In general, JIT measures tend to be fairly simple and designed to provide a basis for continual improvement [25], [27].

One aspect common to both the new and the traditional measures is that both provide a basis for rewards. It is this aspect of the new performance measurement systems which will most directly affect the workers. The literature provides several examples of new rewards systems implemented to cultivate the JIT philosophy in the work force. At Northern Telecom salary increases were

linked to increased flexibility [28]. A second example involves a British automotive firm which replaced individual piecework schemes with group bonuses tied to defect-free production. Finally, a third example is provided by another British automotive company which based group bonuses on company revenue [20]. In all cases, the companies rewarded desired performance, which is critical in a JIT environment "because there are so many changes in how people do things" [29].

Labor-Management Relations

Another arena affected by the transition to JIT is the nature of labor-management relations. The JIT philosophy requires more cooperation between labor and management [30]. In a JIT environment, restrictive work rules must be relaxed to facilitate flexible operations [19]. Further, highly specialized workers become flexible, multi-skilled workers. This means strictly specified job descriptions must yield to new broader classifications [13], [14], [29]. Incentive agreements based on piece rates must change in recognition of the JIT manufacturing philosophy which maintains that the right amount is better than the most [14]. Labor will need to recognize that productivity improvements may lead to excess capacity. Management will need to accept responsibility for retraining displaced employees [30].

Many of the existing patterns of interaction will need to yield to the new philosophy.

The transition to JIT can also impact the balance of power and control between management and labor. Without buffer stocks, each station becomes dependent on the prior work station. This dependency gives the worker the power to create pervasive disruptions to the manufacturing process. The worker's power is also enhanced because it is difficult to replace the flexible multi-skilled JIT worker with workers from outside the organization. On the other hand, worker actions become very visible when there are no work-in-process inventories to hide mistakes. Management can readily observe the worker who has failed to produce the proper amount at the right time. And while the flexible worker is more difficult to replace from outside the organization, there will always be many capable replacements within the ranks of the existing work force. High visibility and internal substitutability weaken the power of the worker [31]. These factors intervene to create a delicate balance of power between management and the work force.

Plant Capacity and Employee Retention

The primary emphasis of JIT is to eliminate waste. The efforts dedicated to reducing waste and improving productivity can ultimately result in an excess capacity.

Even the reduction in work-in-process inventories can give rise to anxieties and cause the work force to wonder if they will run out of work and be laid off [32]. Managers in JIT companies must determine how to handle the people who are no longer required due to the productivity improvements which result from JIT [10], [33].

While the literature does not provide clear cut solutions to this dilemma, several writers have provided relevant insights. First, management must undergo an attitudinal change to recognize the need for employee stability [18]. Second, managers must demonstrate concern for the jobs of the employees [29]. Finally, "employees should be given help to understand that JIT is not designed to eliminate their jobs, but enhance them through increased involvement and participation" [4].

One solution presented in the literature is based on the Japanese practices associated with lifetime employment. Essentially, the policy involves the establishment of a small core force. To augment this core, a secondary force consisting of subcontractors or part-time employees is hired. The existence of this secondary force allows management to protect the core force from adverse fluctuations in demand. Layoffs and shortened work weeks are only allowed to impact the secondary force [26]. This policy thus helps management to "foster motivation and loyalty among the core work

force on whom they are principally reliant" [26].

Communication Patterns and Content

The transition to the JIT philosophy will be accompanied by changes in the nature of communication throughout the organization. "JIT requires a modification of the existing patterns of communication to provide more information processing capacity and decentralization of the decision making process" [34]. This modification of communication patterns occurs at all levels of the organization. At the worker level, high visibility and immediate communication work together to reduce defects and avoid the production of large lots of low quality parts or assemblies [19]. Also, the progress of each station must be communicated to those workers whose pace depends upon it. When work teams are implemented in conjunction with JIT, the entire communication horizon broadens as the workers establish relations with their teammates [35]. At the organizational level, management typically shares more performance related information with the workers as they assume more responsibility for the manufacturing process. The JIT philosophy relies on the workers to solve problems, and management must share the information the work force needs to effectively improve operations [36].

Employee Involvement

For many companies, employee involvement in the implementation and operation of JIT has been critical to the success of the JIT philosophy [3], [4], [5], [37]. There are many practical reasons underlying the importance of worker involvement. First, the workers are most directly involved with the manufacturing process. This first hand exposure to the process gives the workers opportunities to identify improvements and solve problems [38]. Also, employee involvement encourages possibly hundreds of workers to generate ideas to help the company obtain and maintain the competitive edge, rather than relying solely on the contributions of a few managers [29]. For these reasons, one of the major changes to affect the work force when an organization adopts the JIT philosophy is an increase in employee involvement in all aspects of production.

There are several mechanisms which have been successfully used by companies to increase employee involvement in the production process. Quality control circles, which are also known as quality circles or small group improvement activities, are frequently used to secure worker involvement in JIT [5], [39]. Typically, these formal groups of volunteers are trained in problem solving techniques, such as Pareto analysis, fishbone charts and brainstorming. They meet regularly in a

structured fashion to solve problems [4], [5], [7], [12]. A second important vehicle for employee involvement which is compatible with JIT is cellular manufacturing. A group technology cell is typically a grouping of equipment and workers which operates in a fairly autonomous fashion to produce a limited number of components [18]. Cellular manufacturing works well in conjunction with JIT because it provides the workers greater responsibility, participation, ownership and more interesting work [40]. Employee suggestion programs are a third method frequently used to cultivate worker involvement in a JIT environment. Suggestion programs have all the objectives of quality circles, and additionally seek to improve the product design [7]. Additionally, the suggestion programs attempt to increase worker motivation through cash rewards and increased participation [7]. Companies have also increased employee involvement through the use of Scanlon plans, Quality of Work Life (QWL) programs, and informally by directly soliciting worker inputs into management decisions which will impact the work force [39].

One of the most important mechanisms used to increase employee involvement in JIT environments is the work team [3], [28]. There are several attributes which characterize work teams in a JIT environment. First, these work teams will typically be multifunctional. This attribute follows from the requirement for flexibility in

the work force [39]. Second, JIT work teams must be collaborative. A truly collaborative effort on the part of a work team can have an important impact on team performance [41]. Third, JIT work teams need to be communicative. Team work requires open communication among workers and management as well as cooperation between them [4]. Finally, JIT teams must assume ownership of their manufacturing process. This means teams must become involved in decision making and problem solving [41], [42]. It also implies that teams must exercise control over team resources and develop a system of priorities to deal with the many activities competing for team member attention in a JIT environment.

Summary of Changes

This section has described many changes to the work environment which directly affect the workers of a company which transitions to JIT. These changes include: increased responsibilities, increased skill requirements, changes to work pace, new performance measures and rewards systems, changes to relations between labor and management, revised retention policies, new communication practices, and increased levels of employee involvement. This section concluded with a discussion of the characteristics of work teams in a JIT environment. The next section will discuss several strategies reported in

the literature to transition work teams to the JIT philosophy.

Work Team Transition to the JIT Environment

For organizations which are operating with work teams, the literature suggests there are a number of strategies available to companies to transition their work teams to the JIT philosophy. The following discussion will present three broad approaches to accomplish this transition: formal education and training, team facilitation and natural evolution.

Work Team Transition Through Formal Training

Several writers have addressed the need for general education and training for all employees who will be working in a JIT environment. Baer says the first step must be to teach all employees the philosophy behind JIT. He further suggests that these instructional programs be structured in an interactive fashion, so that managers can obtain employee inputs regarding the design of the JIT system [30].

Adair-Heeley identifies four segments of education which she maintains are essential for building JIT teams. The first segment provides employees the basic concepts and techniques behind JIT so that employees can develop a basic understanding of the process. The second segment demonstrates the benefits the workers can expect to

receive from the JIT process, as well as the personal impacts which the JIT implementation will have on the workers. In the third segment, team members participate in exercises designed to develop skills related to goal setting, risk taking, decision making and problem solving. Finally, the team facilitators receive training to develop the skills necessary to facilitate team building in the JIT environment [43].

Clark also agrees that education related to implementation of JIT is essential for all workers. However, Clark stresses that the primary worker responsibilities in the JIT environment focus on JIT operation and process refinement. Consequently, he suggests that worker education should concentrate on operation and process refinement. Clark maintains that all workers should have a basic understanding of the following: the role of inventory in a JIT operation, performance measurement, group technology cell principles, and pull system design and operation. Additionally, the work force should be equipped with interpersonal communication skills, statistical process control skills, and other basic industrial engineering skills [4].

Several additional writers have also recommended specific training needs. Crosby submits that education programs should be instituted to cross-train JIT workers. He also asserts that teamwork training should be included

in the training program [13]. Fuller and Brown suggest that management should equip their workers with communication and analytic skills as they combine diverse organizational groups into production teams with common goals and objectives [15]. And based on experiences with technician teams at Raychem, Wenzel writes that workers should receive additional training for problem solving, decision making, group dynamics and presentation skills [28].

Work Team Transition Through Facilitation

Facilitative management can also be used to successfully support the transition of work teams to the JIT environment and to develop the JIT related skills needed by JIT work teams [44]. The facilitative approach does not mean that managers should relinquish all authority for decision making or control; rather managers should share power and accept input from the work force. By earning respect, rather than demanding it, managers can foster the worker involvement needed to develop effective teams [44].

Heard agrees the successful development of groups in a JIT environment depends upon management attitudes and styles. She identifies several characteristics of supportive management which help to foster successful small groups in a JIT environment. These characteristics

include respect for workers; trust; commitment to the JIT operation, product quality and training; open communication; supportive policies and procedures; a willingness to share responsibility and authority; and finally, a focus on rewarding team results [18].

Likewise, Landvater stresses that team building is "more than just putting people together in a room with one another" [29]. He reports the successful companies develop good working teams by providing workers with exposure, skilled group leadership and problem solving experience. He also notes these techniques are not unique to JIT environments, but can also prove useful in traditional organizations [29].

In some instances, the transition of managers from sole decision maker to facilitator has proven to be difficult. Adair-Heeley indicates the transition is particularly difficult if the managers have not been properly prepared through education [42]. Landvater echoes this position based on his experiences with JIT implementation. "Some companies have had situations where the supervisor was unable to give up the traditional role, and saw himself as the sole source of good ideas" [29]. Landvater's solution to the problem is to provide education for skilled group leadership [29].

Work Team Transition Through Natural Evolution

While management support may be crucial to the development of effective work teams, "it is important that teams not depend on management, but that they develop their own identities to get their particular task done" [44]. Moreover, over-management of a team may actually perpetuate a team's reliance on management rather than creating the maturity desired in a JIT environment [44]. Team maturity is important to effective operation in a JIT environment. The literature suggests that as teams mature, they will accept greater responsibility for their own development. Guest relates the observations of a manager at the Cummins Engine Company, who indicated the amount of time members spend on training "depends on the maturity of the team. A mature team trains itself" [45]. Otherwise, the managers must conduct the training.

The more teams work together, the more they develop their ability to work effectively as units. As the work force comes to believe they have an influence over operations, they take responsibility for recognizing trouble signs and solving problems. "Teambuilding is taking place as problems are being solved" [41]. Adair-Heeley also shares this premise. She asserts, "Teams become empowered to solve their own problems as they feel that their influence will make a difference" [42].

Finally, Turnbull suggests that work teams in a JIT

environment will also increase their motivation directly through experience with the team process. He suggests, "the manufacturing modules will create a complete working environment in which employee motivation arises naturally through the team organisation itself and from the creation of shared working goals and production objectives" [26].

CHAPTER III

WORKER PERCEPTION OF JIT ENVIRONMENT

The literature review has shown that adoption of the JIT operating philosophy can result in many changes for the work force. These changes affect many aspects of the work environment to include work flow, work pace, labor utilization, labor relations, and performance measurement/ reward systems. This study investigated the workers' perception of changes which occur as a result of the implementation of the JIT operating philosophy.

Methodology

The following discussion presents the objective of this study, a description of the research environment in which the study was performed, and a description of the research methods and statistical tools used to conduct the study.

Objective of Study

The purpose of this study was to determine if the workers perceived changes in their work climate after adoption of the JIT philosophy. This analysis addressed several aspects of the work climate to include the following: equity of workload, control of work pace,

comfort with work pace, sources of motivation and equity of rewards.

Design Classification

This study was conducted as a longitudinal field study at the Westinghouse Electronic Assembly Plant in College Station, Texas. While the field study methodology precludes the use of strict controls and leads to results which may not be readily generalized, it is conducive to performance of a detailed analysis which examines the behavior of many subjects over an extended period of observation. Consequently, this method yields insights into the work environment and the transition to the JIT philosophy which would not be obtained by other more controlled methods.

This study was conducted in two parts. The first part examined worker perceptions of the work environment prior to JIT implementation. The second part was conducted approximately six months later to examine the worker perceptions after the transition to the JIT work environment.

Research Environment

Since this study was performed at a single facility, it is important to characterize aspects of the research environment so that readers can appropriately apply the results obtained.

Faced with the pressures of a highly competitive market, Westinghouse adopted JIT in an effort to reduce cycle time and bolster production [46]. During the first six months of the implementation program, Westinghouse realized significant improvements in its manufacturing operations. The cycle time for printed wiring assemblies decreased from 11 weeks to 3.5 weeks. Work-in-process decreased from 1800 printed wiring assemblies to 750. During this same period of time, the company experienced an 18 percent improvement in productivity as measured by direct labor hours per printed wiring assembly [47]. These improvements are largely the result of the Westinghouse JIT effort.

The literature indicated that JIT is not implemented overnight, rather it is implemented in stages over an extended period of time. This has certainly been the case at Westinghouse. Westinghouse started the JIT program with a single team in the surface mount assembly area in August, 1989. After this prototype effort was determined to be successful, a second team was brought into the system in September, and then three more in early October, 1989. It must be noted however, that during the course of this study, only one manufacturing area (flatpack) was operating under the JIT philosophy. The inspection and test areas, which process the printed wiring assemblies subsequent to assembly, continued to operate under

traditional manufacturing principles. Ultimately, plant management plans to extend JIT to several additional areas within the production facility.

The Westinghouse electronics assembly plant is a captive manufacturing house which receives kitted material from a Westinghouse facility in Baltimore. The kitting requirements are determined using an MRP II system. The JIT pilot program was conducted in the surface mount assembly area. This part of the plant builds printed wiring assemblies. The completed assemblies are then shipped back to Baltimore, where they are installed in electronics components. The work performed in the plant can be characterized as low volume - high mix. More than 715 different board styles are assembled at the facility.

The Westinghouse JIT program emphasized the use of a pull system of production. However, the pull was accomplished through the use of level scheduling techniques rather than the more typical "Kanban" signal system. Quality was certainly emphasized at all levels of the Westinghouse organization, both before and after the transition to JIT. During the course of this study, Westinghouse made no changes to the plant layout to accommodate the implementation of JIT; though implementation plans include eventual changes to the layout to facilitate the flow of material and product through the assembly process. Supplier involvement was

not addressed in the Westinghouse program since this facility is a captive manufacturing house.

Employee involvement was stressed throughout the JIT implementation effort. The workers were organized into multifunctional teams, and the company initiated an informal cross-training program to develop worker skills at the variety of functions performed on each team. The workers were also encouraged to participate in efforts to identify improvements which would generate cost savings. The workers remained responsible for the cleanliness of their work areas and preventive maintenance on the assembly robots, however there was not an increased emphasis on these additional responsibilities associated with the transition to JIT in this plant.

Research Sample

Sixty workers were assigned to the five multifunctional work teams which participated in the JIT program. Of the 60 JIT participants, 57 completed the surveys administered at the beginning of the study. Fifty-two workers participated in the survey conducted after the transition to the JIT philosophy. The difference in the number of respondents was primarily due to a slight reduction in the size of the work force which resulted from a company furlough program.

Survey Instrument

A written survey titled "The Organizational Climate Survey" was prepared to determine if employee perceptions of the organizational climate changed after implementation of the JIT operating philosophy. This survey was administered to each participant twice. The survey was first administered at the beginning of the JIT program to elicit employee perceptions of the organizational climate before the JIT philosophy was implemented. The participants answered the same questions again six to seven months after the teams adopted JIT. The questions in these surveys addressed the following issues: equity of workload, sources of motivation, equity of rewards, control of work pace, and employee comfort with work pace. A copy of this survey instrument is provided in Appendix A.

Prior to the administration of the surveys, the team advisors participated in a detailed review of the survey instruments to ensure that all the questions were clear, used a shared vocabulary, and provided adequate alternatives. All of the changes suggested by the team advisors were incorporated into the survey instruments. When possible, the surveys were administered to all the members of each team simultaneously. To administer the surveys, a proctor read each question to the team and explained the format of the response structures. The team

members then answered the particular question. The proctor waited for most of the team to complete each question before moving to the next question. Time was provided at the end of the survey for all team members to complete any remaining questions. Also, a sample survey was displayed using an overhead projector to help clarify the format of the response structures.

Statistical Analysis

This analysis used 2 x c contingency tables as the primary statistical tool. The first row of the table was associated with responses describing the work climate before the implementation of JIT. The second row was associated with responses describing the work climate six to seven months after the implementation of JIT. There were "c" columns in each table representing the "c" possible responses to each of the questions analyzed. A chi square test was conducted to determine if a statistically significant shift occurred in the proportion of respondents selecting various responses to the questions in the survey. For each test, α=.10 was selected as the level of significance.

Results

The following discussion presents the results of this study. Specifically, this discussion identifies each of the hypotheses tested, presents the results of the

statistical tests associated with each hypothesis, and where appropriate provides a brief discussion of the results obtained. A detailed summary of the statistical tests performed in support of this analysis is presented in Appendix B. The summaries in Appendix B also provide the questions and response structures which correspond to the figures presented in this chapter.

Sources of Motivation

Hypotheses

The following hypotheses were tested to determine if the sources of worker motivation were affected by adoption of the JIT philosophy.

1. Team performance will become a more important source of motivation after the team members have adopted the JIT philosophy.

2. Team approval will become a more important source of motivation after the team members have adopted the JIT philosophy.

Results

The chi square test for difference in proportions indicates there was not a significant change in the distribution of ranks assigned to either of these sources of worker motivation (α=.10). The rank most frequently assigned to the importance of meeting monthly productivity and quality goals was third from a list of 9 motivators,

both before and six months after the implementation of JIT (Figure 1). The apparently large percentage of respondents shown as ranking this motivation source 5-9th is the cumulative percentage of respondents who ranked this motivation source fifth, sixth, seventh, eighth or ninth.

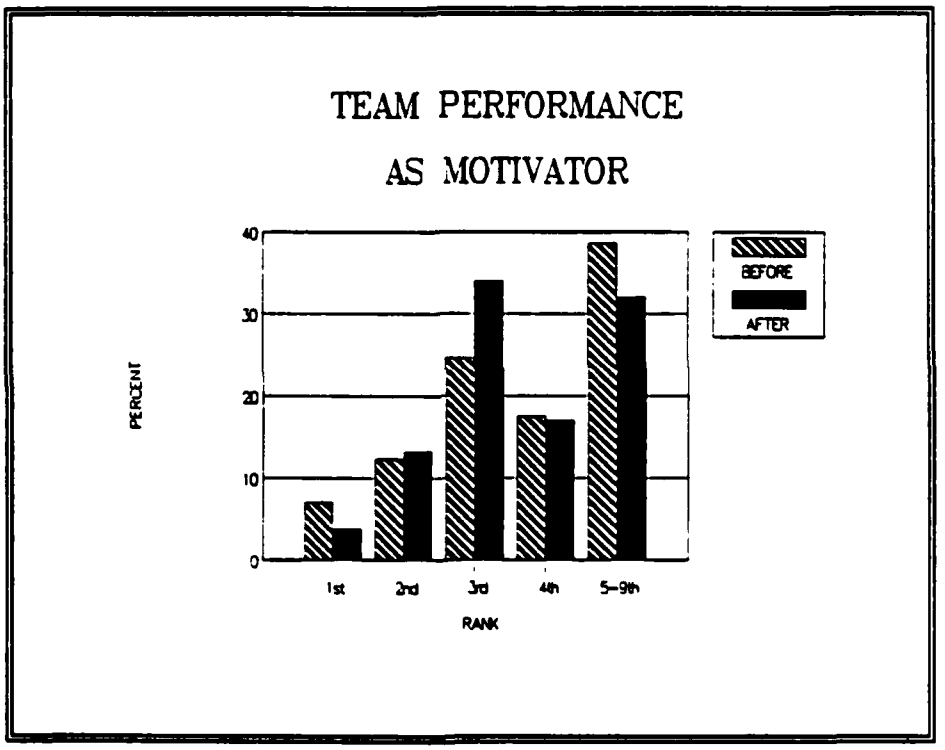

Fig. 1. Team performance as motivator.

Likewise, team approval as a source of motivation was most frequently ranked second, both before and after JIT. These results are presented in Figure 2. Again, the last column represents the percentage of respondents who ranked this source as fifth or higher.

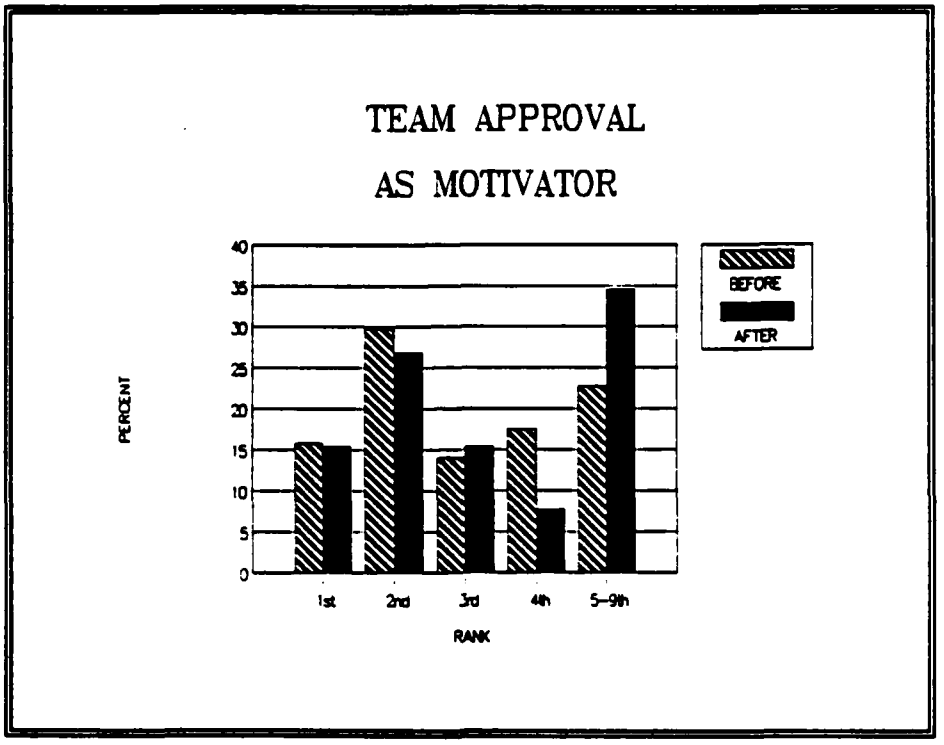

Fig. 2. Team approval as motivator.

Discussion

It is not surprising that there was little change in the ranks assigned to these two sources of motivation. The hypothesis presumed that team-oriented sources of motivation would become more important to the teams after implementation of JIT. This may well be the case in companies that initiate a team program at the same time they implement JIT. In this case, the company had emphasized team performance long before implementing JIT. The change which occurred when JIT was implemented was that teams previously formed along functional lines became multifunctional. Perhaps a more important conclusion is that the implementation of JIT did not appear to erode the

motivational importance associated with team performance and approval. These items were generally ranked as more important than other motivation sources such as advancement, recognition, rewards, team advisor approval, and company success.

Finally, it is interesting to note that, despite the emphasis the company placed on team performance and plant success, the single most important source of motivation for the workers was their personal pride in their work. This was the case even several years after Westinghouse implemented a program to boost quality through team work. It was also the case after six months of working with the JIT philosophy.

Equity and Acceptance of Reward System

Hypothesis

There will be increased worker acceptance of a reward system based on team performance rather than individual performance after the workers adopt the JIT philosophy.

Results

The chi square test for difference of proportions indicates there was a statistically significant change ($p<.1$) in the proportion of respondents who selected each of the five available responses. These results are presented in Figure 3.

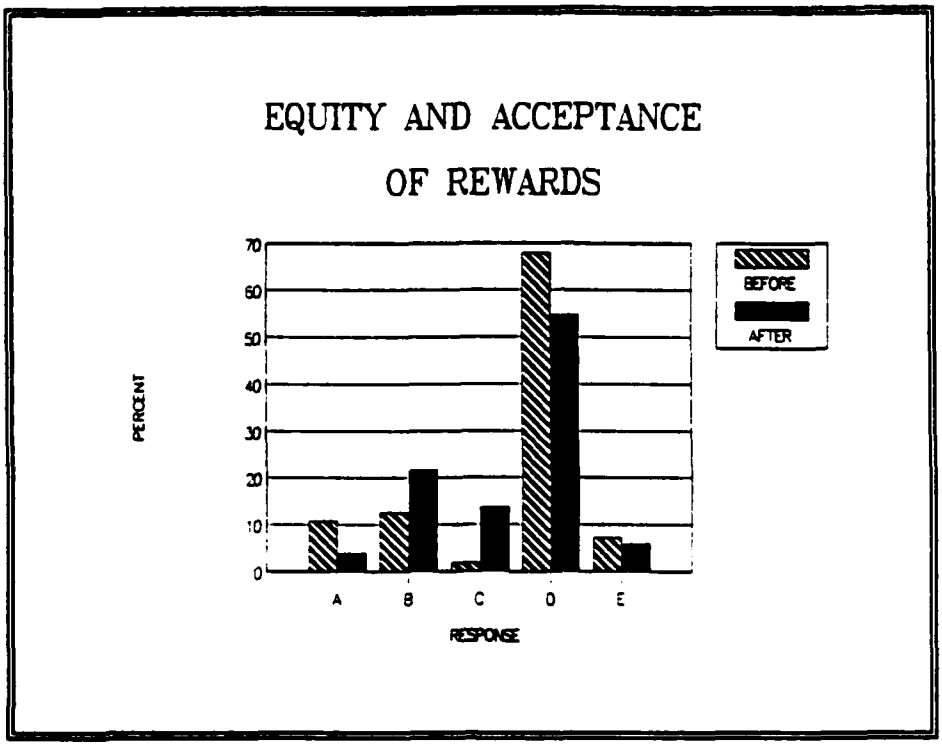

Fig. 3. Equity and acceptance of rewards.

Discussion

Figure 3 provides some insight regarding the changes in worker perceptions concerning the equity of rewards for a job well done. Response D stated that the company recognized team performance over personal performance and that was "O.K." with the worker. Prior to JIT, 68 percent of the workers indicated their satisfaction with the team based reward system. Six months after JIT, this acceptance had eroded to 55 percent. Additionally, there was a marked increase from approximately two percent to nearly 14 percent of the respondents who indicated that the company sometimes recognizes personal performance, but not enough (response c.). These results seem to suggest

that the percent of the work force which is satisfied with the reward system has decreased since the company adopted JIT.

Equity of Workload

Hypothesis

The workers will perceive the workload to be more equitably distributed between team members after the implementation of the JIT philosophy.

Results

This study indicates there was not a statistically significant change (α=.1) in worker perceptions regarding the equity of workload distribution as a result of JIT implementation.

Discussion

Although the change in proportion of workers selecting each response is not statistically significant, there are two noteworthy trends. First, the percentage of respondents who indicated that the work is distributed very evenly, more than doubled from 14 percent to over 29 percent (response A). Likewise, 65 percent of the workers indicated that the work was spread evenly before JIT, but that some of the workers had a little more to do than others (response B). After JIT, the percent of respondents indicating a slight inequity in workload had decreased to 47 percent. These results suggest there is

greater equity of workload distribution now that all team members are encouraged to collaborate; and now that the work is assigned on a team basis, rather than individually (see Figure 4).

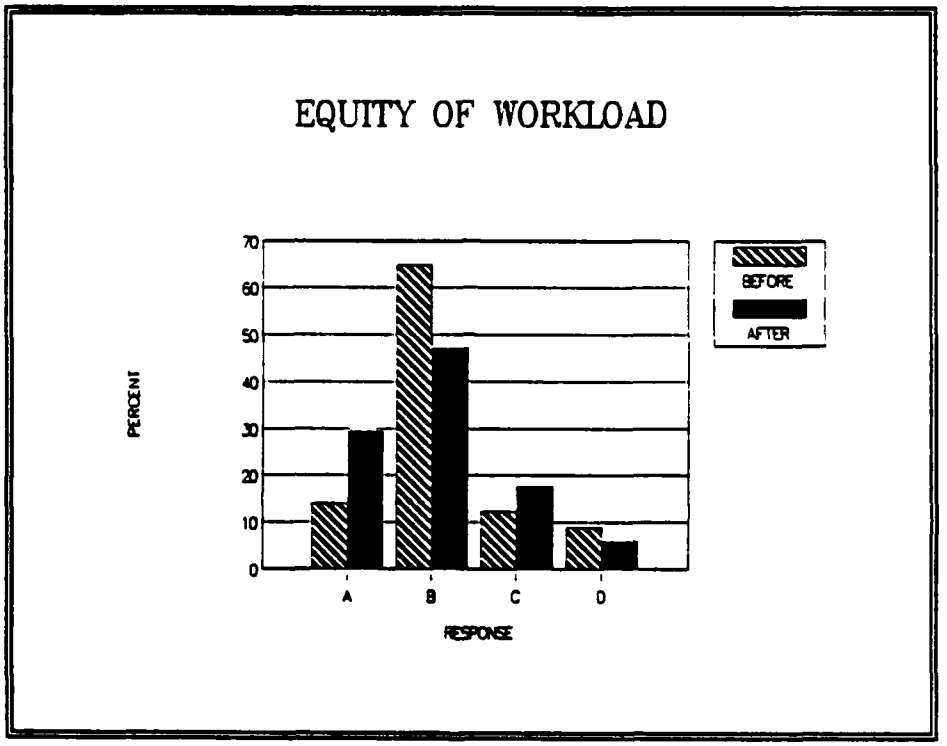

Fig. 4. Equity of workload.

Responsibility for Work Pace

Hypothesis

The employees will perceive they play a reduced role in setting their work pace after implementation of the JIT philosophy.

Results

There was not a statistically significant shift in the ranks assigned to each of the possible pace setting

alternatives (α=.1). The individual workers indicated they played the primary role in setting their own work pace before JIT as well as after JIT.

Discussion

This result is contrary to the philosophy of JIT manufacturing operations. With JIT, the expectation is that the progress of the downstream station becomes largely responsible for the amount of work that must be performed by each worker, as well as when that work should be performed. There are two factors prevalent in this manufacturing environment which may explain this apparently inconsistent result. First, this JIT system does not rely on a Kanban system to communicate requirements for the flow of product through the manufacturing system. Rather, the company controls product flow through level scheduling. Consequently, the progress of downstream stations is not readily visible to the workers, nor does it directly play a role in the pace of their work.

A second factor which accounts for the large role that the workers play in setting their own pace is the process time associated with each task. Most of the workers are unable to solder two complete boards in a single day; nor does the demand require that each assembly technician solder two boards a day. Consequently, most technicians determine whether they work quickly to

complete a single board, so they can move on to other collaborative efforts; or whether they will remain occupied by a single board all day. So, despite the transition to JIT, the workers at this plant remain largely in control of their own work pace. The literature suggests this result is much less likely in a JIT operation which involves highly repetitive tasks or relies on Kanban signal systems.

Comfort With Work Pace

Hypothesis

The workers will be more comfortable with the work pace after the transition to the JIT philosophy.

Results

There was no significant change in worker comfort with the work pace as a result of JIT implementation (α=.1) In fact, the proportion of respondents selecting each response after JIT is virtually identical to the proportions before JIT. These results are provided in Figure 5.

Discussion

This hypothesis was based on the presumption that workers would be more comfortable with the work pace after they changed from a philosophy of manufacturing as much as possible - as fast as possible; to a philosophy of manufacturing the correct quantity at the correct time.

Over 75 percent of the workers indicated it was real easy (response A), or pretty easy (response B) to keep up with the workload both before and after implementation of the JIT program (see Figure 5).

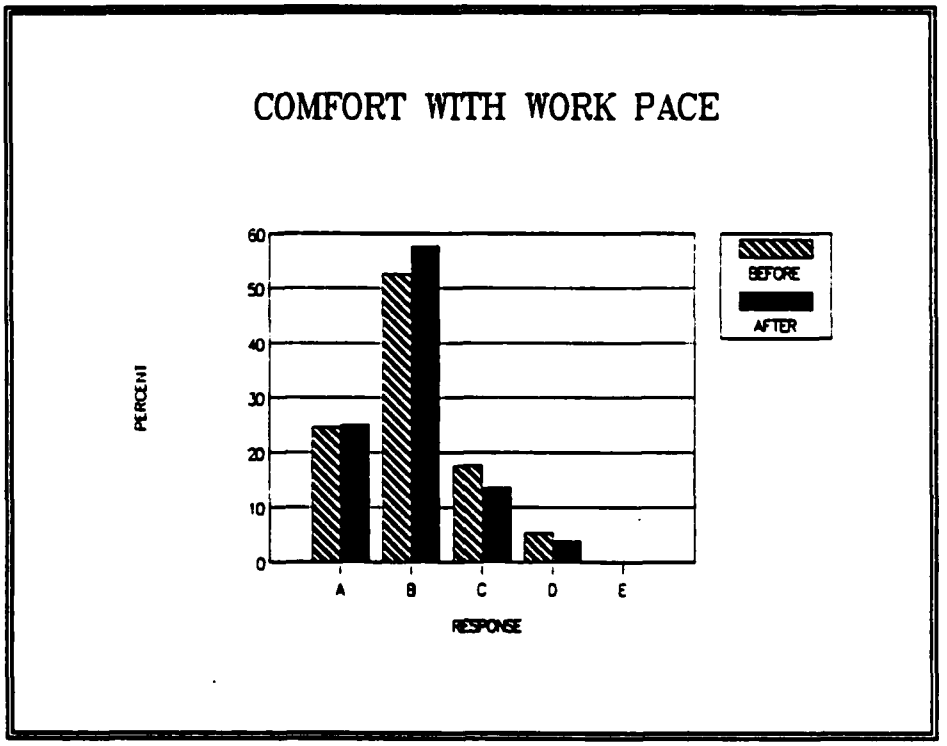

Fig. 5. Comfort with work pace.

This finding is a logical result, given the role the workers play in setting their own work pace. It is interesting to note that several workers expressed anxiety concerning their ability to keep up with the pace of the JIT program prior to its implementation. This result should allay the concerns of those workers at this facility who will begin JIT in the future.

Conflict Resolution

Hypothesis

The workers will play a greater role in resolving their personal disputes after the transition to the JIT philosophy.

Results

There was no change in the methods used by workers to resolve conflicts as a result of JIT implementation. The chi square test for difference of proportions indicates there is not a statistically significant change in the proportion of respondents selecting each of the alternative responses (α=.1).

Discussion

After implementation of JIT, nearly 60 percent of the workers indicated they usually settle interpersonal disagreements between themselves (response B). This compares to 57 percent who selected this response before JIT. A slight shift occurred in the percentage of team members who indicated the team advisor intervened to help resolve interpersonal conflicts. The percentage of respondents reporting help from the team advisor decreased from 13 percent before JIT, to less than eight percent after JIT. While these results do not indicate an increased worker role in conflict resolution, they do suggest that JIT did not weaken the interpersonal skills developed by team members while working under the team

concept. These results are presented in Figure 6.

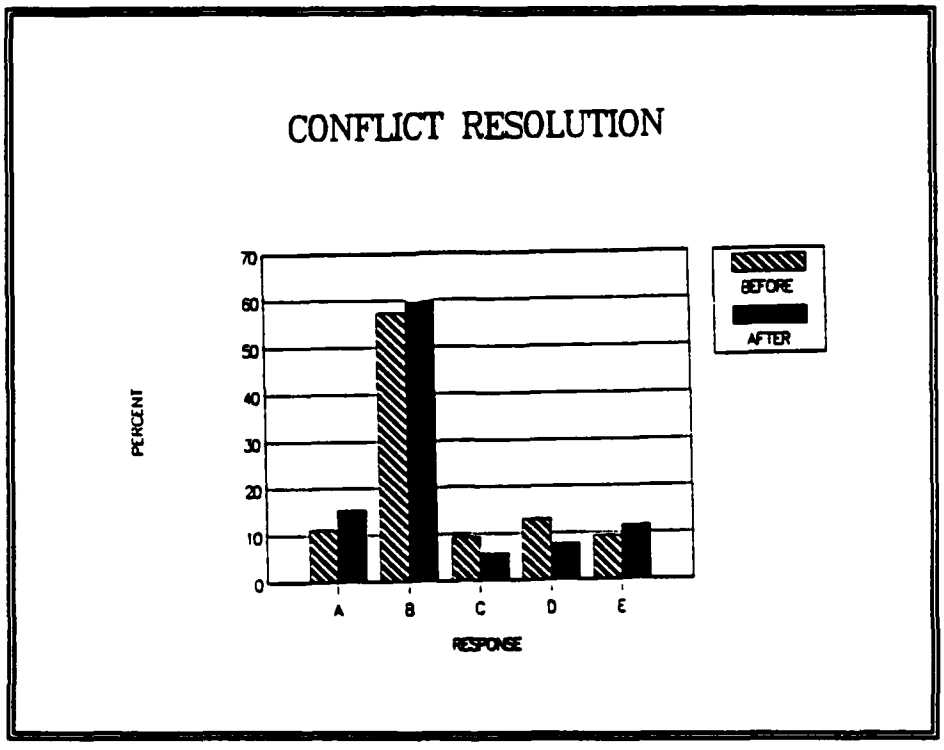

Fig. 6. Conflict resolution.

Communication Responsiveness

Hypothesis

The workers will receive answers to work related questions more quickly after the transition to the JIT philosophy.

Results

The chi square test revealed there was no change in the amount of time workers indicated it took to obtain answers to work related questions (α=.1).

Discussion

Over 80 percent of the workers receive answers to their questions very quickly (response B); or quickly, stopping work for just a short period of time (response C). Over 73 percent of the workers indicated this level of communication responsiveness before JIT. Further, the short delays associated with obtaining answers appear to be more a function of proximity to the team advisors, than a function of the JIT philosophy.

CHAPTER IV

WORK TEAM TRANSITION TO THE JIT ENVIRONMENT

The literature indicates that work teams are a popular mechanism used by companies to involve workers in a JIT environment. Additionally, the literature suggests JIT work teams should be multifunctional, collaborative and communicative. They must also participate in decision making and exercise control over manufacturing resources and activities. This second study examines the development of work teams which are in the process of adopting the JIT philosophy.

Methodology

The following discussion presents the methodology used to study work team transition to the JIT environment. The discussion will identify the objective of the study, describe the research environment, and relate the specific methods used to collect and analyze the data. Finally, the discussion will provide a detailed explanation of the measures used in this study.

Objective of Study

The objective of this study was to examine the transition of work teams to the JIT environment. This

study focused on the development of team capacity and inclination to collaborate, collaboration, communication effectiveness, priority consonance and team participation in decision making.

Research Environment

The team concept was not new to Westinghouse. The team concept was implemented when the plant first opened its doors in 1983. However, when the company adopted the JIT philosophy, the structure of the teams was changed. Prior to JIT, the teams were organized horizontally, by function. Then, when Westinghouse started to implement JIT, the work force in the surface mount assembly area was reorganized into five multifunctional work teams.

Research Sample

The study involved the five multifunctional assembly teams which fabricate printed wiring assemblies in the surface mount assembly area. Each of the five teams consisted of 12 members at the start of this study. Gradually, the size of the teams decreased to approximately 10 members per team through attrition. A team advisor was assigned to each team to facilitate their work effort. The team advisor, however, was not a team member. These teams included hardware assembly technicians, robotic assembly technicians and handsolder technicians. In addition to their work duties, some team

members also performed additional duties as team officers. Each team had a production officer, a quality officer and a budget officer. The study included all the teams in the facility which were involved with the JIT program.

There are many similarities between the teams which served as de facto experimental controls. All five teams assembled the same styles of boards; were located in the same area within the plant; had access to the same resources; and were governed by the same organizational policies. Additionally, all five teams were required to produce the same quantity of output, according to the same production schedule. Essentially, the primary differences between the teams were based on the personalities of the team members and their team advisors; and the strategies they independently selected to accomplish their assigned work.

Research Methods

Observations

The first method used to collect data in this study was nonparticipatory observation of the work teams during team meetings and at their work stations. The discussions during these team meetings dealt specifically with team strategies to implement the JIT system. The issues discussed during these meetings were documented and used to support this study.

Survey Instrument

The "Team Characteristic Survey" was designed to characterize each of the teams at specific points in time. Consequently, this survey was administered three times during the study period. This survey addressed the following issues: collaboration, flexibility, work priorities, the importance of various information items, communication effectiveness, communication sources, and decision making roles. This survey was prepared, reviewed and administered in the same fashion as the "Organizational Climate Survey," described in chapter III. The primary difference is that the "Organizational Climate Survey" was administered at the beginning and end of the study period, rather than at intermediate intervals during the course of the study. The "Team Characteristic Survey" is presented in Appendix C.

Structured Interviews

Structured interviews were used primarily to document the strategies used by the team advisors to orient their teams to the JIT philosophy and then to facilitate team development through the course of this study. In addition to the structured interviews, each team advisor was provided a log to record actions taken during the course of this study. The action logs provided the team advisors a vehicle to report their strategies as well as any actions taken to facilitate the improvement of their teams

in the areas of flexibility, collaboration, communication, priority setting and decision making.

Data Collection Activities

Figure 7 presents a schedule of the data collection activities which supported this study.

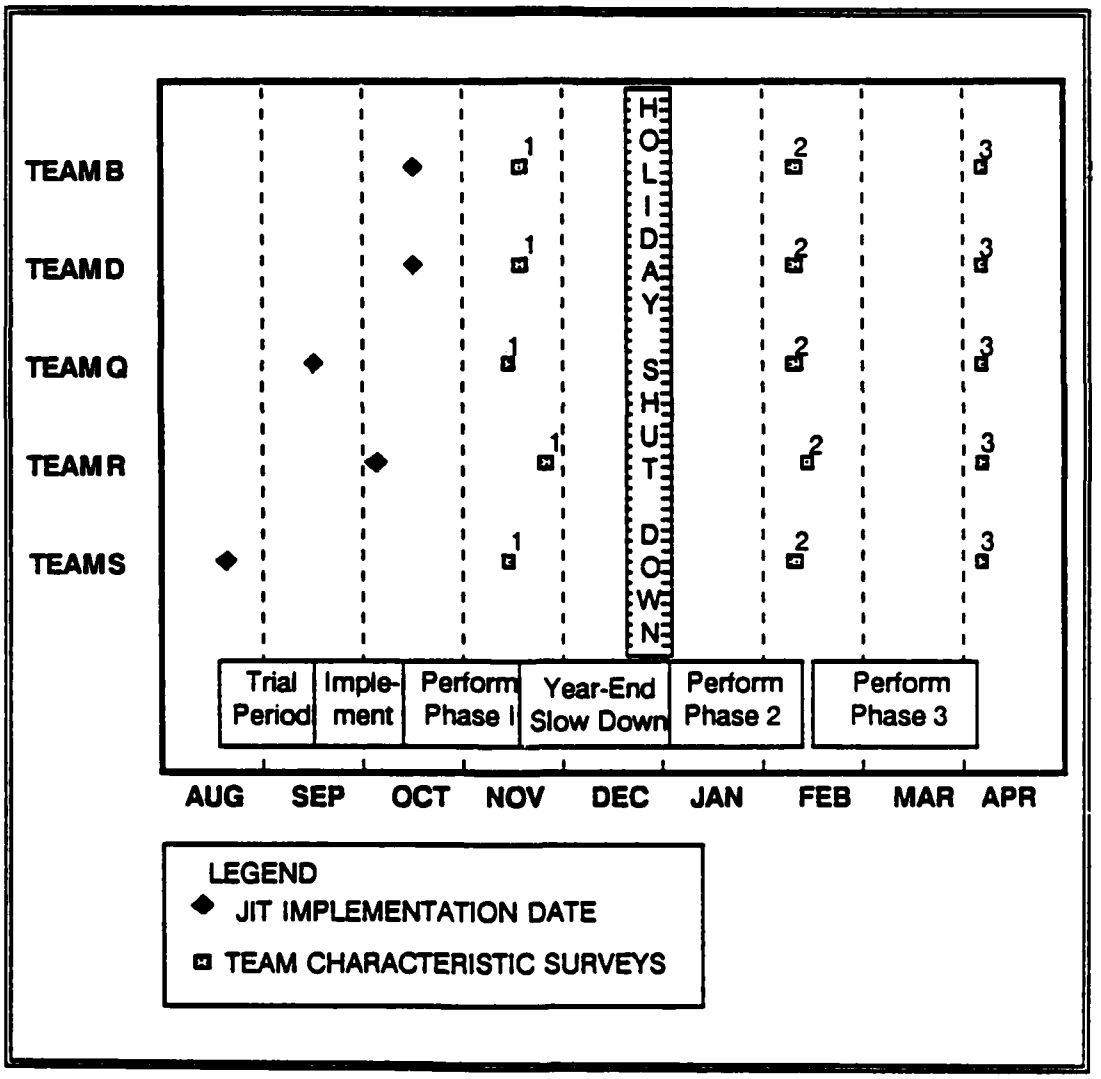

Fig. 7. Data collection activities.

As indicated in Figure 7, there are six periods of time relevant to this study. The first period is the trial

period. During this period all five teams received orientation training concerning the JIT program. Team S began the prototype implementation on August 21, 1989. The second period is the implementation period. During this period the remaining four teams adopted JIT. The study includes three development phases, each of which were six weeks in length. The "Team Characteristic Surveys" were administered at the end of each development phase. Therefore, each team took the "Team Characteristic Survey" three times over the course of the study. The fourth period was the year-end slow down. This six week period included the Thanksgiving holiday as well as the holiday shutdown at the end of December. Additionally, production quotas were reduced significantly during this period. Finally, many workers took leave during this period. These irregularities would have compromised the validity of any data collected during this period. Consequently, this period was not included in the study.

Measures of Team Development

Capacity to Collaborate

Fundamental to the JIT philosophy is the concept that workers must be capable of performing many functions. This capacity to collaborate enables the workers to remain productive even after they have completed their personal production requirements. A worker's capacity to

collaborate is a function of two primary factors. The first factor is flexibility. The worker must have the requisite skills to perform the various functions on the team. Second, the worker must have time available to collaborate. Indices were developed to characterize each of these two factors.

1. Team flexibility index. The team flexibility index measures the extent to which all team members could perform the various functions on the team. There were four primary functions which various team members performed on a regular basis: hardware assembly, robotic assembly, handbuilding and handsoldering of printed wiring assemblies. To determine the team flexibility index, all team members were asked to describe their proficiency at each of these functions using the following ordinal scale:

a) I can perform all parts of this job very well,

b) I can perform most parts of this job well,

c) I can do some parts of this job to standard, and

d) I can not perform this function.

Three points were assessed for response a), two points for response b), and 1 point for response c). The team flexibility index is the arithmetic sum of all proficiency points assessed divided by the total points possible.

2. Team help opportunities index. The team help opportunities index measured opportunities for

collaborative effort. The team members were asked to report the number of times they finished early during the ten work days preceding the survey. The workers must have finished their personal work with at least 30 minutes remaining in the work day, before the early finish qualified as an opportunity for collaborative effort. The help opportunities index is simply the total number of help opportunities reported by all team members over a ten day sample period.

Inclination to Collaborate

Team collaboration requires that team members not only possess the capacity to collaborate, they must also be willing to collaborate. Developing a valid measure of inclination to collaborate was difficult because this is not a readily measurable construct. For this reason, two separate measures were developed to characterize a team's inclination to collaborate.

1. Collaboration index 1. The first collaboration index is based on team member descriptions of their teammates' willingness to help them personally. The team members were asked to assign each of their teammates to one of 10 collaborative behavior profiles (See Appendix D). Collaboration index 1 was calculated based on the percent of team members assigned to each profile and a weight assigned to each profile which characterized the collaborative nature of the behavior described. If the

behavior provided collaboration where help was needed most, the weighting factor was two. If the behavior was collaborative, but not necessarily directed to where help was needed most, the weighting factor was one. If the behavior was not collaborative, the weighting factor was zero. Finally, If the behavior actually interfered with collaboration, the weighting factor was -1.

Table I below illustrates the calculation of collaboration index 1. The actual behavior profiles and associated weighting factors are presented in Appendix D.

TABLE I
CALCULATION OF COLLABORATION INDEX 1

A Collaborative Behavior Profile	B Percent Assigned ÷ 100	C Weighting Factor (-1,0,1,2)	D Contribution (B x C)
profile 1	.21	1	.21
profile 2	.13	2	.26
...	...	...	...
profile 10	.07	-1	-.07
		Total	Σ 10 rows

2. Collaboration index 2. The second collaboration index was based on team member descriptions of their teammates' willingness to help others on the team, in general. This second measure acknowledged that some workers may be more willing to help certain teammates than

others. The difference in inclination to collaborate may be due to factors such as proximity or friendship, or may be a function of their relative competence at the different team functions.

To generate collaboration index 2, each team member was asked to assign all teammates to one of five profiles. The profiles described worker behavior subsequent to completion of their personal daily work (See Appendix E). Two of the five descriptions characterized collaborative behavior. Collaboration index 2 is simply the percent of the team which was assigned to either of the two collaborative descriptions.

Effective Communication

The second focus of team development was team communication. The premise supporting this element of team development is that as the JIT philosophy leads to greater collaboration between team members it will also lead to improved communication between team members. Communication is essential to the successful interaction and collaboration of a multifunctional work group.

1. Communication effectiveness index. The communication effectiveness index measures how effectively the team members received information which was important to them. Each team member was asked to rate the importance of 21 information items (See Appendix F). The respondents were provided the following ordinal scale to

be used in assessing the importance of the various information items. The number in parenthesis following each rating is the number of points associated with that response.

a) This information is of little or no value to me. (1)

b) I am somewhat interested in this information. (2)

c) It is helpful for me to receive this information. (3)

d) It is important for me to receive this information. (4)

e) It is absolutely essential for me to receive this information. (5)

The 21 information items evaluated by the team members were developed through observations of several team meetings, observations of team work practices and informal interviews of the team advisors.

After the team members rated the importance of the 21 information items, they were asked to indicate how effectively each of the same 21 items were communicated using the following scale. The number in parenthesis following each rating description is the number of points associated with that response.

a) I never receive this information in a complete form when I need it. (1)

b) I rarely receive this information when I need it. This information is frequently incomplete or late. (2)

c) I often receive this information when I need it; but sometimes the information is incomplete or too late. (3)

d) I usually receive this information completely, when I need it. (4)

e) I always receive this information completely, when I need it. (5)

The first step to calculate the communication effectiveness index was to determine which information items were important to each team at the time they took the survey. The median scores were calculated for each of the 21 information items rated. Those items with a median score of 4 or above were identified as important items. The median scores for communication effectiveness were then calculated for each of the important information items. The communication effectiveness index is simply the sum of the median communication effectiveness scores for the important information items divided by the total possible communication effectiveness score (5 x the number of important items).

Priority Consonance

Successful operation in a JIT environment often requires workers to accept greater responsibility for the quality of their efforts, the efficient utilization of production resources, and for continual improvement of the production process. The increased scope of activities imposes a requirement for work teams to develop a systematic approach to assign priorities to the many

activities at hand. Consequently, this study developed an index to measure the extent to which the teams developed a unified, cohesive approach to accomplish their work.

1. Team priority consonance index. This index measures the degree to which team members shared the same priorities for work activities. The team members were asked to assign ranks to 13 alternative activities to be conducted when they finished their personal work for the day. That is, they assessed the activity they would perform first - a rank of "1"; the activity they would do second - a rank of "2"; and so forth. The complete list of alternative activities is provided in Appendix G. The team priority consonance index is the arithmetic average of all possible pairwise correlation coefficients.

Team Decision Making

The JIT philosophy emphasizes the importance of team involvement in decision making and problem solving. This study included a measure designed to determine the role team members played in making decisions concerning the performance of work and control of resources in the manufacturing setting.

Team decision making index. The team decision making index measured the degree to which the team was involved in making decisions related to work efforts and policies. Team members were asked to describe the role they played in making each of 21 sample work decisions (See Appendix

H). The respondents selected the best description of the role they played from the following options:

a) I am or can be the primary decision maker.

b) I have my say in this decision, along with other teammates. We decide together.

c) I can make inputs to this decision, but a team officer makes the decision.

d) I can make inputs to the decision, but the team advisor makes the decision.

e) The team advisor or higher management makes the decision. I am told the decision.

For each team, the mode response was calculated for each of the 21 sample decisions. The team decision making index is simply the number of decisions for which the mode response was option a, b or c. If the team reported responsibility for all 21 decisions, the team decision making index would be 21.

Statistical Analysis

The two factor analysis of variance (ANOVA) model was used to test all the hypotheses examined in this study. In each case the team development measure of interest served as the response variable. There were five blocks used in each analysis, one for each of the five teams. There were three treatments which correspond to the three different times that the team development surveys were administered. Tukey's test was used to determine which treatments were different in each case that the two factor

ANOVA indicated there was a statistically significant difference between treatment means ($\alpha = .05$). The statistical tests conducted in support of this study were performed using SAS. SAS is a registered software product of the SAS Institute Incorporated. A summary of the statistical tests conducted in support of this study is presented in Appendix I.

Results

This study addressed the development of those team skills or characteristics which are expected of teams operating in a JIT manufacturing environment. The following discussion will present the hypotheses tested, the statistical results, and any relevant conclusions which can be drawn from the results.

Capacity to Collaborate

Hypothesis

Work teams will improve their capacity to collaborate on team tasks as they transition to the JIT philosophy.

Results

1. Team flexibility. Team flexibility improved over the course of this study. The mean team flexibility index increased from .604 in November to .679 in early April. This increase is statistically significant ($p = .0403$).

2. Opportunity for collaboration. The second measure of team capacity to collaborate, the help

opportunities index, showed no improvement over the course of the study. In fact, the mean of the team help opportunities index decreased during each study interval. The use of this measure of team capacity to collaborate was based on the rationale that in order for team members to collaborate, they would not only need to possess the skills, as measured by the team flexibility index, but they would also need to have time available to collaborate. The shortcoming of this measure is that it is directly influenced by many factors beyond the control of the team such as absenteeism, a company furlough program, the initiation of new programs in the plant, and increases in product demand. Consequently, this measure did not prove to be an effective measure of a team characteristic.

Discussion

Of primary interest to managers is an understanding of how the company obtained the improved team flexibility. Westinghouse did not implement a formal cross-training program. Nor did Westinghouse adopt a "pay for skills" program to encourage cross-training. In this facility, cross-training was strongly encouraged by the team advisors. When the teams did not respond through their own initiative, the team advisors scheduled selected team members to work at new functions. Figure 8 shows the pattern of increase for team flexibility.

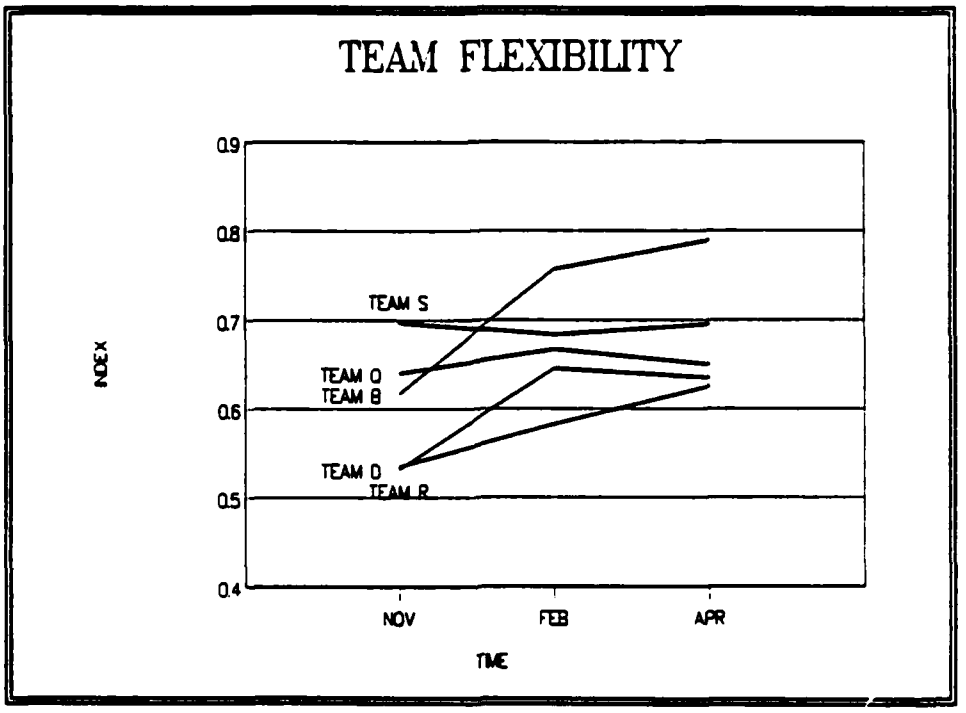

Fig. 8. Team flexibility.

It is apparent that most of the increases in flexibility occurred between the first and second survey events. There are a number of factors which may be responsible. First, the time between the first and second survey events was nearly 3 months, whereas the time between the second and third survey events was only six weeks. One could expect a greater change simply due to the difference in the length of the intervals. In addition to this factor, the first interval also includes the 6 weeks at the end of the year when the plant experienced a slow down. This period of reduced production provided team members more opportunities to cross-train. Finally, during the last interval, an increase in absenteeism due to a company

furlough program combined with the addition of a new program in the facility to reduce the opportunities for elective cross-training.

Team Inclination to Collaborate

Hypothesis

Work teams will increase their inclination to collaborate on team tasks as they transition to the JIT philosophy.

Results

1. Personal collaboration. The analysis of variance conducted using collaboration index 1 determined that team members did not increase their inclination to collaborate during this study.

2. General collaboration. The two factor analysis of variance conducted with collaboration index 2 also revealed that inclination to collaborate did not improve over the course of the study. It is also worth noting that a separate analysis was performed to determine if the two collaboration indices were correlated. This analysis determined that there was a relatively high degree of correlation between the two indices ($r=.78$).

Discussion

Despite the lack of any indication that teams improved their inclination to collaborate, there is still merit to reporting strategies used by the team advisors to

cultivate collaboration on their teams. There were actually several actions taken by the team advisors during the course of this study. In one instance, team seating assignments were rearranged to mitigate the adverse consequences that resulted when cliques formed on a team. In another instance, the team advisor isolated two team members in a room to resolve personal differences which were interfering with progress on the work floor. There were also instances when team advisors moved a team member to another team to reduce personality conflicts. The lack of improvement does not necessarily indicate that the strategies employed were not effective. It is possible that the inclination to collaborate would have declined were it not for the actions taken by the team advisors. Rather, the results suggest that cultivating team inclination to collaborate demands increased attention and facilitation. Further, most of the actions taken seem to be oriented towards resolving problems. Perhaps, the next step is to move from reducing the frequency of negative situations to increasing the prevalence of positive situations.

Team Communication Effectiveness

Hypothesis

Work teams will more effectively communicate important information as they transition to the JIT

philosophy.

Results

The two factor analysis of variance determined that the teams did not significantly improve the effectiveness of their communication. Rather, the communication effectiveness indices remained relatively constant in the range between .75 and .85. These results are presented in Figure 9.

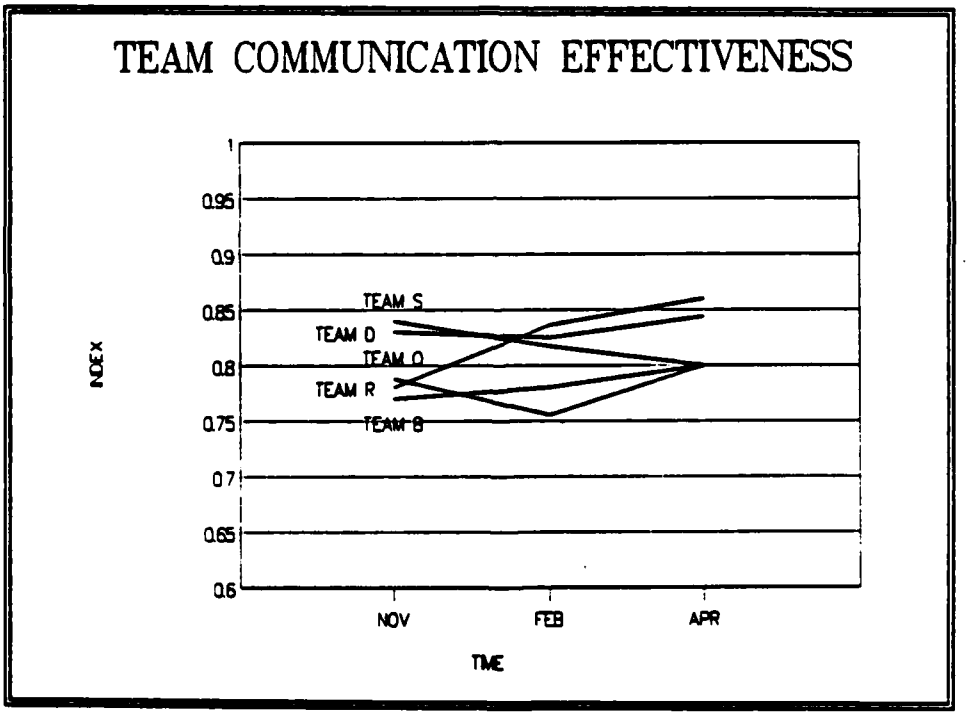

Fig. 9. Team communication effectiveness.

Discussion

Further analysis suggests that the lack of improvement in this team skill may be due to the relatively high standard of communication effectiveness which characterized the teams from the start of the study.

If the team members indicated they received a preponderance of important information items frequently, but sometimes the information was late or incomplete, the team index would be around .6. The cluster of indices around .8 indicates that all 5 teams report they usually received the information items they considered important in a complete form and in a timely fashion.

There are several strategies which have been used by the team advisors and plant managers to facilitate effective communication. At an organizational level, the plant manager convened two meetings of the entire plant during this study, to explain company policies and programs. Also, plant management arranged the presentation of a JIT videotape for all employees involved in the program to explain the mechanics of the pull system of production.

At the team level there were many mechanisms, both formal and informal, in place to provide the workers the information they needed. Each team had a bulletin board. The team advisors posted team performance charts and graphs weekly. Team advisors also called team meetings on an "as needed" basis. During the course of this study, formal team meetings were called for several reasons including the following: to resolve interpersonal conflicts, to celebrate excellent team performance, to establish strategies for sharing work, to provide

employees a forum to identify cost saving opportunities, and to explain new work programs and company policies. More importantly, the team advisors encouraged their teams to call their own informal team meetings on the manufacturing floor. While all team advisors encouraged spontaneous team meetings, some of the teams called informal meetings more frequently than others. Based on observation and interviews, this practice is one which seems to explain the improvement experienced by Team R through the course of the study.

On an interpersonal level, the team advisors encouraged team members to address interpersonal problems directly, rather than relying on the team advisor to function as an intermediary. While there appear to be many benefits associated with this policy, in some instances this approach caused high levels of frustration in the work teams. During interviews of employees, some expressed anxiety concerning the difficulty of confronting a worker who was not pulling his or her share of the load. These employees explained that such a confrontation would lead to hostility rather than improvement. They preferred retaining some degree of harmony with an inequitable work load over sitting next to an angry and hostile teammate. These employees further indicated the team advisors should retain responsibility for monitoring individual productivity and administering discipline when

appropriate.

Finally, it should also be noted that teams developed different patterns of communication. Some teams relied very heavily on a team officer to communicate information. Other teams relied on less formal patterns, obtaining important information from teammates without official responsibilities. The results of this study suggest that in either case, the teams all reported receiving important information completely and in a timely fashion.

Priority Consonance

Hypothesis

Work teams will develop a higher degree of consensus regarding the priority of alternative work activities as they transition to the JIT philosophy.

Results

The study results do not indicate a statistically significant increase in priority consonance (α=.05).

Discussion

Although priority consonance did not provide significant statistical results, there are several useful lessons which can be learned from individual team experiences. As is evident in Figure 10, "team priority consonance," four of the five teams reflected a higher degree of priority consonance at the time of the third survey than at the time of the first.

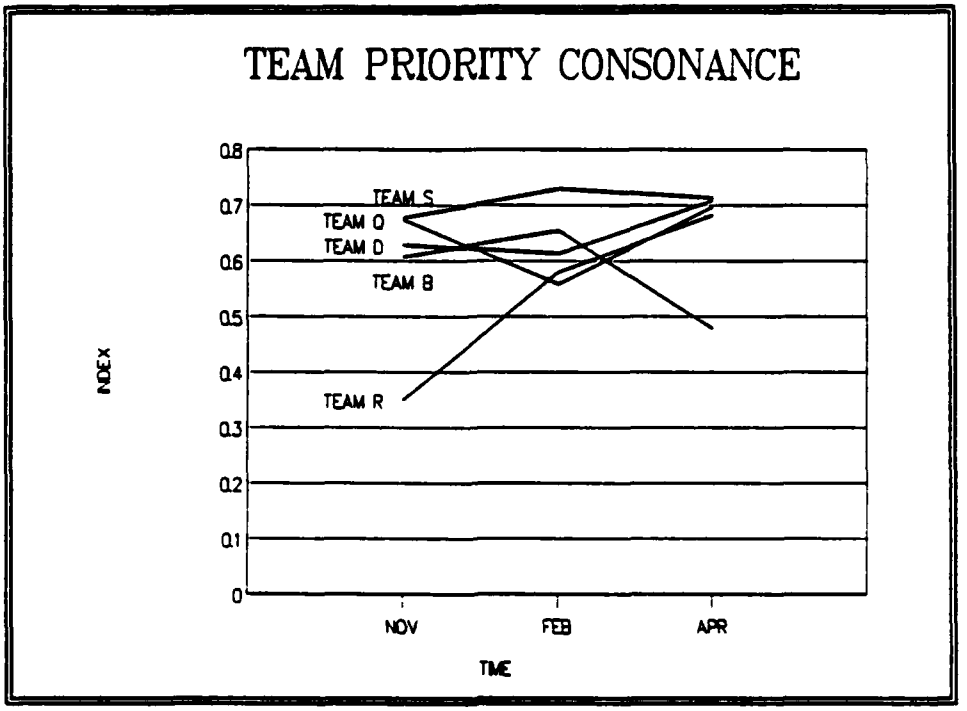

Fig. 10. Team priority consonance.

A variety of approaches were used by the team advisors to influence team priority setting. One strategy used by the advisor for team D was to provide the team a written priority list which was placed at each work station. This checklist summarized the priority scheme which the team developed during team meetings prior to implementation of JIT. The team advisors' role was to facilitate the development of the initial priority scheme, and then to distribute the results of the discussion in written form to the team members. It is interesting to note that a dispute occurred during the first week the priority list was used. The misunderstanding was based on a lack of specificity in the priority list. Some workers

interpreted "complete rework" to mean their personal rework, that is the rework of circuit boards for which they were personally responsible. Others interpreted "complete rework" to mean any defective circuit board requiring rework, regardless of who was initially responsible for it. This controversy resulted in a heated debate during a team meeting. The team advisor resolved the conflict by helping the team to reach a consensus on responsibility for rework and updated the written priority list accordingly.

An entirely different approach was used with team R. With this team, the team advisor left the determination of priorities entirely up to the initiative of the team. The result was a very low degree of priority consonance during the early stages of the JIT implementation effort. Interviews conducted in conjunction with the first survey indicated that many members of team R were frustrated with the lack of direction they received. Further, they indicated that they were working under the same philosophy they used prior to the JIT program. Their priorities emphasized personal activities over team activities. For example, cleaning their personal work areas was rated as the third most important priority, above completing team rework or helping whoever was furthest behind to complete their boards. Eventually, however, the team frustration developed into action. The team production officer called

some informal team meetings and together the team took greater control of their work process. The results of this increased ownership were reflected not only in the priority consonance index, which increased from .350 to .682; but also in both of the collaboration indices. Collaboration index 1 increased from .558 to 1.009. Collaboration index 2 increased from .462 to .908, which proved to be the highest team score obtained in this study.

A third approach which ultimately resulted in higher priority consonance was evident in the experience of team S. In this case, the team advisor moved a strong personality from team D to team S. While on team D this worker was productive, but did not fit the "team personality" that had developed. Once on team S, the new member was quickly selected by the team to be the production officer. This team adopted a strict protocol of consulting the production officer every time a member encountered an opportunity to begin a new task. Over time, the experienced production officer emerged as a true leader on the team. The consistency of her priorities helped the team to develop and practice the evolving team priority system. The dramatic improvement for this team is evident in Figure 10.

Team Decision Making

Hypothesis

Work teams will become responsible for making more decisions regarding the performance of their work and the control of manufacturing resources as they transition to the JIT philosophy.

Results

This index measured the breadth of decision making responsibility which is delegated to, or assumed by, the teams. The statistical analysis indicates that teams did not possess responsibility for significantly more decisions six months after JIT implementation than they did at the beginning.

Discussion

There are several factors which account for the lack of change in the decision making index. First, there are some decisions which management will rarely yield to the work force, despite interest in cultivating team ownership. For example, decisions concerning permission to work overtime, or required production quantities remained the prerogative of management throughout the course of this study.

Another factor which accounts for the lack of change is that teams possessed fairly wide latitude for decision making from the start of the JIT program. All five teams consistently reported possessing the primary decision

making responsibility for the following decisions: which activities to perform next, how to improve the sharing of work, how to cover for an absent employee, how fast they needed to work, which team members would work various board styles, which team members would assemble the hand built boards, and who would serve as the team production officer. Most of these decisions are directly related to the performance of work, and the consistent reporting of team responsibility for these decisions demonstrates that teams played a major role in making work related decisions from the start of the JIT implementation effort.

It is also important to investigate and, where possible, draw conclusions regarding those decision making roles which did appear to change over the course of the study. Some of the changes seem directly tied to team advisor interventions which were aimed at solving team problems. For example, the team D advisor assigned specific seating positions in an attempt to mitigate the adverse consequences which were resulting from the formation of cliques. Consequently, team D identified the team advisor as the primary decision maker for team seating. After the team advisor relaxed the seating policy, the team resumed the primary decision making role regarding team seating assignments. When the team B advisor intervened to resolve the interpersonal conflicts on team B, the team identified the team advisor as the

primary decision maker regarding resolution of team conflicts. Team B then reported that the responsibility for decisions concerning team conflict reverted back to the team in the subsequent period of observation.

Finally, some of the variability seems due to ambiguity over where the responsibility really lies, rather than as a result of purposeful change. This conclusion is based on the observation that the teams provided inconsistent results for some decisions. That is, many of the team members may have identified the team advisor as the primary decision maker at the same time that several teammates identified team members as primarily responsible for the decision. Examples of decisions where the teams seem uncertain of their role include the following: how the team will cross-train, who will back up the robot technicians when they are absent, who will cross-train, and what authority does the production officer possess. Some of this ambiguity is understandable, in that a formal cross-training program was never implemented. In the early stages cross-training was encouraged. When encouragement did not yield results, specific cross-training assignments were made. Then, the team workloads increased when production requirements increased and the furlough program resulted in absent team members. Cross-training received less emphasis because the teams were too busy trying to meet production

requirements.

It is also easy to understand the uncertainty regarding the role of the production officers. There was no formal role prescribed. The role of the production officer seemed to be largely a function of team advisor discretion, production officer leadership skills and initiative, and team cohesiveness. These factors contributed to uncertainty about who decided what authority the production officers possessed.

CHAPTER V

TEAM PERFORMANCE IN A JIT ENVIRONMENT

The previous chapter examined the development of team characteristics as work teams embarked upon the transition to operating in a JIT environment. This chapter takes the next important step and examines the link between team characteristics and team performance in a JIT operating environment.

Methodology

The following discussion presents the methodology used to conduct this study. Since this study of work team performance was conducted in concert with the previous study of work team transition, many aspects of the methodology will be the same. Consequently, this discussion will emphasize those aspects of the methodology which are different. The objective of this study, as well as the data collection and analysis methods used are presented in the discussion which follows.

Objective of Study

The purpose of this study was to determine if team performance is related to the development of JIT related team characteristics such as flexibility, collaboration,

communication effectiveness, priority consonance and team decision making.

Research Sample

This study included the same five multifunctional assembly teams which participated in the previous study of work team transition to the JIT operating environment. In addition to measuring the development of these five teams as they adopted the JIT philosophy, this study also measured the performance of the five teams during the same transition period.

It should also be noted that one of the five teams worked on experimental board styles during the last performance period of the study. Several factors related to the manufacture of the experimental boards made this team's performance during the last period atypical. First, the quantity of experimental boards required of this team was different than the quantity of standard boards required of the remaining teams during this period. Also, the nature of the work on the experimental boards involved a learning curve and an increased likelihood of defects. For these reasons, only the performance results of the four teams which worked standard boards were collected for the final performance period.

Research Methods

Survey Instrument

The "Team Characteristic Survey" which was used in the previous study was designed to characterize each of teams at specific points in time. The survey addressed the following issues: collaboration, flexibility, work priorities, the importance of various information items, communication effectiveness, communication sources, and decision-making roles. The results of this survey were also used in the study of team performance.

Performance Data

Team performance data were also collected during this study. These data are resident in the Westinghouse manufacturing data base. The specific information collected included the following: the weekly schedule of boards required from each team, the weekly number of boards completed by each team, the weekly percent of boards which passed initial inspection for each team, and the number of elapsed hours worked by each team each week.

Data Collection Activities

Figure 11 presents a schedule of the data collection activities which supported this study. As indicated in Figure 11, there are six periods of time relevant to this study.

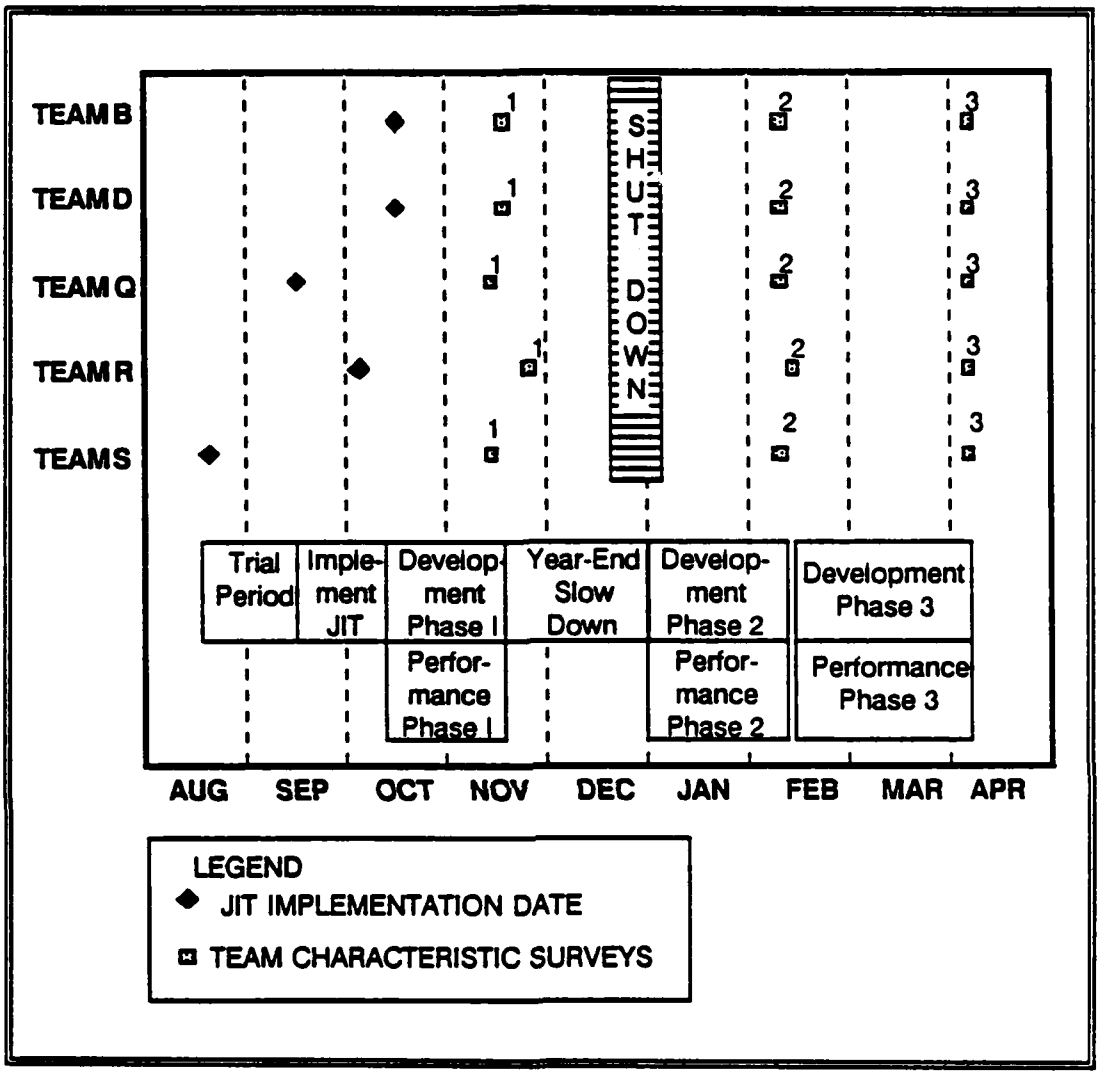

Fig. 11. Concurrence of development and performance.

The first period is the trial period. During this period all five teams received orientation training concerning the JIT program. The second period is the implementation period. The third, fifth and sixth periods are labelled as both development phases and performance phases. These phases were six weeks in length. Team performance data was collected throughout each performance phase. A six week period was selected to better characterize the

sustained performance of the teams over time, and to mitigate the adverse impact of weekly fluctuations. The "Team Characteristic Surveys" were administered at the end of each performance phase. The link between team development and team performance was investigated by associating the "Team Characteristic Survey" results with the results of the performance period immediately prior.

Measures of Team Performance

The measures of team performance selected for use in this study reflect the JIT philosophy. The data used to calculate these measures were obtained from the company manufacturing data base.

Performance-to-Schedule

In a JIT environment, the objective is not to produce as much as possible, but rather to produce the exact amount needed, when it is needed [10], [13], [24]. For this reason, performance-to-schedule has frequently been used as a measure of team performance in a JIT environment. In this study, performance-to-schedule (Y1) was calculated as follows:

$$Y1 = 1 - \left| \frac{\text{qty. scheduled - qty. produced}}{\text{quantity scheduled}} \right| \qquad (1)$$

This value was calculated on a weekly basis. The team performance-to-schedule value for the six week performance

period is the mean of the weekly values obtained for each week in the period.

Quality of Work

The second team performance measure used in this study related to the quality of the work team's product. Specifically, the measure used was the percent of product that passed initial inspection the first time. This performance measure (Y2) was calculated as follows:

$$Y2 = \frac{\text{\# of boards that pass}}{\text{\# of boards inspected}} \times 100 \qquad (2)$$

The percent first pass yield is normally calculated on a weekly basis. For this study, the percent first pass yield was calculated by dividing the total number of boards that passed initial inspection for the entire six week performance period, by the total number of boards inspected during the entire performance period.

Labor Efficiency

The third team performance measure used in this analysis was labor efficiency. A measure of individual labor efficiency would not be valid in a JIT environment which encourages a worker to be idle rather than produce ahead of schedule. However, a team labor efficiency measure remains valid because it represents the advantage realized when idle workers collaborate with busy teammates. Specifically, team labor efficiency (Y3) is calculated as follows:

$$Y3 = \frac{\text{elapsed hours of work}}{\text{number of boards produced}} \quad (3)$$

This measure was based on weekly results, but calculated for the entire performance period. The labor efficiency measure for the six week performance period was simply the sum of the weekly elapsed hours of work for each of the six weeks in the performance period divided by the number of boards manufactured during the performance period.

Statistical Analysis

The analysis of covariance model was used to analyze all hypotheses tested in this study. In each case, a single team performance measure was used as the response variable in the model. Two class variables were used to account for the variability between teams, and between times the "Team Characteristic Surveys" were administered. Finally, a single team development measure served as the covariate. To determine if there was a positive relationship between the performance measure and team characteristic measure included in each model, a test for the significance of the regression coefficient (β_1) was conducted. For each test, α=.10 was selected as the level of significance. The statistical tests conducted in support of this study were performed using SAS. SAS is a registered software product of the SAS Institute Incorporated.

Results

This study examined the vital link between team characteristics and team performance. This is a crucial element of this research, for the strength of this relationship serves as a primary justification for efforts directed to improve team skills. The following discussion will present the hypotheses tested in this study as well as the statistical results and any relevant discussion. A summary of the statistical tests performed in support of this analysis is provided in Appendix J.

Capacity to Collaborate and Team Performance

Hypothesis

There is a positive relationship between team capacity to collaborate and team performance.

Results

1. Team flexibility. This analysis determined there is a statistically significant positive relationship between team flexibility and the quality of the product that is manufactured (p=.0415).

The team flexibility index did not have a statistically significant positive relationship with either of the remaining team performance measures; namely, performance-to-schedule or labor efficiency.

2. Team help opportunities. The team "help opportunities index" was not positively related with any

of the measures of team performance (α=.10).

Discussion

1. Team flexibility. The significance of the positive relationship between team flexibility and quality could very likely indicate that as team members develop their skills at the variety of functions performed by the team, the quality of the work product will improve. It must be stressed, however, that it is also possible that the positive relationship is more a function of team member skills at their primary functions, than it is a function of the breadth of their skills. This is because the team flexibility index includes both of these components. Regardless, this result is significant and strongly suggests that worker skill levels are associated with the quality of their product.

2. Team help opportunities. As described in the previous chapter, one of the problems associated with this measure was that it was influenced by many factors which were not specifically related to the team. These factors included: the company furlough program; the introduction of new programs and the learning curves associated with new board styles; and finally, changes in levels of product demand.

Inclination to Collaborate and Team Performance

Hypothesis

There is a positive relationship between a team's inclination to collaborate and team performance.

Results

The results of this analysis were very significant, not only statistically, but also in terms of the implications they portend for team development. Both collaboration index 1 and collaboration index 2 were positively related to team performance-to-schedule ($p=.0852$ and $p=.0223$ respectively). Additionally, both collaboration index 1 and collaboration index 2 were positively related to team labor efficiency ($p=.0284$ and $p=.0904$ respectively). Neither index was positively related with team quality performance ($\alpha=.10$).

Discussion

These results suggest that inclination to collaborate, or a "collaborative spirit" is associated with the two aspects of team performance which represent the quantity of work performed. In the case of performance-to-schedule, it is a matter of producing the correct quantity at the correct time. Labor efficiency measures the human effort used to produce the quantity of output required of the team. The positive relationship between the collaboration indices and quantity based team performance measures suggests the better the teams work

together, the more efficiently they complete the work required of them, and the better they are able to coordinate their efforts to produce the scheduled quantity of output.

This finding yields important implications for the team advisors involved in this study. It suggests that efforts directed to cultivate a collaborative spirit within their teams will likely result in more efficient production, which more consistently yields the desired quantities of circuit boards.

Communication Effectiveness and Team Performance

Hypothesis

There is a positive relationship between a team's communication effectiveness and team performance.

Results

The communication effectiveness index was not positively related with any of the measures of team performance (α=.10).

Discussion

As was mentioned in the previous chapter, all five teams reported that important information items were received completely and in a timely fashion. It would be interesting to determine if any of the team performance measures declined when the communication effectiveness index declined to an unsatisfactory level. In this study,

all teams communicated effectively throughout the period of observation. Consequently, this study can not adequately examine the relationship between communication effectiveness and team performance.

Priority Consonance and Team Performance

Hypothesis

There is a positive relationship between priority consonance and team performance.

Results

The results of this study indicate that, for the most part, there is not a positive relationship between priority consonance and team performance (α=.10). The exception occurs upon examination of schedule performance. Priority consonance is positively related to performance-to-schedule. The p-value for the significance of the regression coefficient is .0907.

Discussion

These results suggest that as teams develop shared priorities they are better able to conduct their manufacturing activities in a cohesive fashion and hence deliver the scheduled production quantity more consistently. It should be emphasized that while significant at α=.1, the relationship between priority consonance and performance-to-schedule is not conclusive.

Team Decision Making

Hypothesis

There is a positive relationship between the extent to which work teams are involved in making decisions concerning their work and the performance of the work teams.

Results

The results of this study indicate that, for the most part, there is not a statistically significant relationship between team decision making and team performance (α=.10). The only relationship which is significant is between team decision making and performance-to-schedule. The regression coefficient associated with the team decision making index is positively related to schedule performance (p=.0547).

Discussion

These results suggest that as work teams play a greater role in decision making they are better able to control their production efforts. This increased involvement and control appears to help teams execute their required activities in accordance with the production schedule.

Summary of Significant Results

The significant findings of this analysis are presented in Table II, "Summary of Significant Results."

TABLE II
SUMMARY OF SIGNIFICANT RESULTS

Performance Measure	Team Characteristic	p value
Performance-to-schedule	Collaboration 1	.0852
	Collaboration 2	.0223
	Priority Consonance	.0907
	Decision Making	.0547
Labor Efficiency	Collaboration 1	.0284
	Collaboration 2	.0904
Quality	Flexibility	.0415

CHAPTER VI

SUMMARY AND CONCLUSIONS

This final chapter will summarize the major findings of the study. It will also identify the limitations of this research and recommend further research which may help industrial managers in today's competitive environment to bridge the gap between innovative approaches to manufacturing such as Just-In-Time and their work force.

Summary of Findings

Worker Perception of the JIT Operating Environment

The first study conducted in this research effort examined worker perceptions of the operating environment before and after JIT. The only significant change in worker perceptions concerned the adequacy and equity of rewards. This study determined that worker satisfaction with a reward system based on team performance rather than individual performance eroded somewhat, over the course of this study. Additionally, more workers indicated they were not adequately recognized for their personal performance after the switch to JIT. This is an important finding because the shift from individual performance

measurement and rewards to group measurement and rewards is a common feature of many JIT implementation efforts. These results suggest that workers are not always comfortable with the change. Further, intuition suggests the more productive workers are more likely to suffer from the subordination of individual recognition to team recognition. This finding reveals a challenge which will face many organizations which adopt JIT. It also raises questions about the long term impact of dissatisfaction with the equity of rewards, especially if the dissatisfaction is on the part of the most productive workers.

There were no significant changes in worker perceptions regarding several additional aspects of the operational climate. The other factors examined included the following: sources of worker motivation, equity of workload, responsibility for work pace, comfort with work pace, responsibility for conflict resolution, and the responsiveness of the communication network. These results may in part be due to the fact that the company has relied on industrial work teams since the plant opened in 1983. From this perspective, any lack of change in worker perceptions may well indicate that JIT has not undermined the benefits accrued by the company through their efforts to develop effective work teams.

Work Team Development of JIT Characteristics

The second study examined the development of team characteristics as the teams transitioned to the JIT environment. This study addressed team capacity to collaborate, team inclination to collaborate, team communication effectiveness, priority consonance and team decision making. Of these characteristics, only te .n capacity to collaborate, as measured by team flexibility, improved significantly over the course of the study. Team flexibility reflected how well each of the team members performed each of the tasks assigned to the team. An informal cross-training program was implemented early during the transition process. Team flexibility improved most during this period, suggesting that the cross-training was successful.

While the link between cross-training and a multi-skilled work force is readily apparent, it is more difficult to ascertain strategies to improve the less tangible characteristics of the team, such as inclination to collaborate, or ownership of the manufacturing process. The strategies employed by the team advisors to facilitate improvement in these areas were primarily oriented toward problem solving. The team advisors intervened to settle disputes between quarreling team members. In a few instances, they reassigned workers to a different team where they were more compatible. They also intervened to

change seating arrangements when it appeared that cliques were interfering with team cohesiveness. These actions seemed to help solve the problems in the short term, but it is unclear whether these actions ultimately improved team characteristics such as inclination to collaborate. Indeed, in some cases the interventions were viewed by the teams as a loss of team responsibility for decision making.

Work Team Characteristics and Team Performance

The final study examined the link between team characteristics and team performance. There were several significant findings which resulted from this analysis. Performance-to-schedule was a performance measure based on how well the team produced the exact quantity scheduled. This study determined that inclination to collaborate was positively related to performance-to-schedule. This finding suggests that cohesive teams that work together are more likely to produce the proper amount of product. Both measures of team ownership; namely priority consonance and team decision making, were also positively related to performance-to-schedule. These results suggest that higher levels of discipline and involvement also lead to improved schedule performance. These results are consistent with the premise that collaboration, participation and organization contribute to successful

adoption of the JIT philosophy which stresses the importance of producing the proper quantity at the proper time.

This study also investigated the association between team characteristics and labor efficiency. Again, both measures of team inclination to collaborate were positively related to labor efficiency. This result is also consistent with intuition. If the faster workers are more inclined to help others when they finish their personal work, it is reasonable to expect it will take less time for the team to complete all the work required. There was not a significant relationship between any other team characteristics and labor efficiency.

Finally, this study examined the relationship between team characteristics and the quality of the work performed. The only characteristic which was positively related to quality performance was team flexibility. This team characteristic represents the degree of skill which each worker possesses at each function, as well as the breadth of functions which the individual can perform. It is possible that the breadth of worker skills was responsible for this result. It is more likely; however, that higher worker skill levels are chiefly responsible for the positive relationship between the team flexibility index and the quality of work.

Limitations of Study

As in any research effort, there were several factors which impacted this study and may consequently limit the broad application of these results. The following paragraphs will identify several of these factors.

One shortcoming of this research effort results from the difficulties of performing research in a real production facility, producing real components to satisfy real demand, in an effort to obtain a real profit. In all cases, production requirements and schedules took precedence over research objectives, as well they should. Fortunately, these constraints did not alter the objectives of this research or the methods of analysis. There were, however, impacts to the research schedule. For example, reduced production requirements and high absenteeism during the end of year slow down in November and December meant that results obtained during that period were not representative. Consequently, data collection activities were suspended during the holidays and resumed immediately afterwards. This necessary suspension of data collection activities represents a lost opportunity to characterize the progress the teams made during this period. Also, Team Q began working on a new program during the final performance period. This team was actually performing work on experimental board styles, rather than the standard board styles which the remaining

teams manufactured during this same period. Since the performance results obtained for this team were no longer comparable to the remaining teams, this team was not included in the analysis of team performance for the final period of the study.

A second shortcoming of this research stems from the nature of the JIT implementation in the facility used for this study. This facility did not rely on the use of a Kanban system to communicate production requirements between stations. Additionally, JIT was only implemented in part of the manufacturing operation. Both of these factors impact the manner in which work is pulled through the system. These factors may also impact the extent to which workers feel control over their work pace, as well as their comfort with the work pace. Also, it can be concluded that these aspects of the Westinghouse JIT system may have made the change to JIT much less pervasive and also less conspicuous. For these reasons, it will be difficult to the apply the results of this study to a JIT operation which is implemented in a more complete and dramatic fashion.

A third shortcoming of this study is drawn from the nature of the work performed in the Westinghouse facility. The workers who participated in this study manufacture printed wiring assemblies. These assembly technicians may work on only one or two boards per day. Consequently,

they retained significant control of their work pace. This aspect of the research environment makes it difficult to generalize the results to a highly repetitive manufacturing process.

Recommended Further Study

This study has provided insight regarding worker perceptions of the impact JIT can have on the operational climate. It has also suggested that in many respects, team performance in a JIT environment is related to the development of key team characteristics. Finally, this study has described efforts to develop those team characteristics which are most important to successful operation in a JIT environment. Despite this progress in understanding the relationship between JIT and work teams in industrial settings, there remains considerable research to be performed. The following section will describe some additional research which should be performed to provide industrial managers better insight concerning the impact which JIT will have on people throughout their organizations.

As in most case studies, one of the major limitations of this study arises from how readily the results can be generalized to other companies. Additional research should be performed to determine if the relationships between team characteristics and team performance can be

validated in another setting. If research efforts can conclusively establish this link, then industrial managers can justify efforts dedicated to the development of team characteristics with a reasonable expectation their efforts will yield tangible and meaningful results.

This study was performed in a plant which implemented JIT practices in only one part of the plant. Further, the nature of the circuit board assembly tasks allows workers wide latitude in setting their personal work pace. A study similar to this study should be performed in a JIT plant with highly repetitive operations to determine if certain team characteristics are more important to successful operations in alternative settings. The recommended study should also focus on issues related to the operational climate such as responsibility for pace and comfort with pace.

This study indicated that worker satisfaction with the equity of team rewards eroded after the transition to JIT. Also, more workers indicated they did not receive adequate recognition after the switch to JIT. Finally, the most important source of worker motivation both before and after JIT was the workers' personal pride in their work. These results suggest that, despite the emphasis that team systems place on thinking and working like a team, workers care most about their personal performance. This result was obtained even when the performance

measurement and reward systems were designed to foster team work. Additional research should be performed to determine if performance measurement and reward systems in a JIT environment should necessarily be limited to the team level, as the literature suggests; or if there are still benefits to be realized through the use of individual measurements and rewards. Should the "most valuable player" on each team be recognized? What are the most effective mechanisms to provide individuals recognition without undermining the importance of team performance? These are valid questions which should be answered through further study.

The long term aspects of the JIT philosophy were not addressed in the present study. This study focused on the implementation and initial transition to the JIT philosophy. Additional research is necessary to determine how the team characteristics evolve in the long run. There are also several additional questions which should be addressed. Will the most productive workers grow tired of carrying the burden for the team? Will team members develop the ability to discipline fellow team members? How will the role of the team advisors evolve over the long run? What are effective means to "renew" teams after the novelty of the innovation subsides? Again, the answers to these questions would be very helpful for today's industrial managers.

Finally, this study determined that schedule performance and labor efficiency were both positively related to the teams' willingness to collaborate. Unfortunately, this study failed to validate specific strategies which can be used to truly facilitate development of this team characteristic. Further research should be performed to validate specific methods of cultivating and sustaining team willingness to collaborate. This future effort must also ensure that the actions identified are validated in an industrial setting.

Clearly, there are many unanswered questions which remain for future research. Hopefully, this study has provided both the foundation and the motivation for continued research. Today's industrial manager faces many challenges. Research directed to help the industrial manager bridge the gap between rapidly advancing technology and the people involved in the work place is vital to the success of industrial operations, especially in the dynamic and competitive environment which currently prevails.

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APPENDICES

APPENDIX A

ORGANIZATIONAL CLIMATE SURVEY

12. When you need an answer to a question to perform your function, how quickly do you usually get the answer? (check best answer)

_____ immediately, I don't miss a beat.

_____ very quickly, no interruption in work, I may slow down a little.

_____ quickly, I stop work, but only for a short period of time.

_____ slowly, I must stop work for 5 - 15 minutes to find the information.

_____ very slowly, I must stop work for more than 15 minutes.

13. When you have a disagreement with a fellow team member, how do you usually solve the conflict? (check one)

_____ the disagreement usually fades away as time passes.

_____ we usually settle the disagreement between ourselves.

_____ we usually settle the disagreement with the help of another team member.

_____ we usually settle the disagreement with the help of the team advisor.

_____ most disagreements are never settled.

14. How difficult is it for you to keep up with your workload? (check one)

_____ real easy, I always get all of my work done.

_____ pretty easy, I almost always finish all my work.

_____ not so easy, I occasionally do not finish all my work. (3-4 times per month)

_____ pretty hard, I frequently do not finish all my work. (more than once per week)

_____ real hard, I almost never finish all of my work.

15. How would you rate your team performance as a productive team which produces quality work? (check one)

_____ the best team in the plant.

_____ the second best team in the plant.

_____ we are in the top half.

_____ we are not in the top half, but we're not the worst.

_____ we are one of the worst teams.

16. Please rank the following based on how big a role they play in setting your work pace. (Place a "1" next to the description which plays the biggest role in setting your work pace. Place a "2" next to the description which plays the second biggest role and so forth.

_____ we all set the pace together, as a group.

_____ the team advisor sets the pace.

_____ the fastest worker sets the pace.

_____ the slowest worker sets the pace.

_____ the most senior worker sets the pace.

_____ the loudest, bossiest worker sets the pace.

_____ top management sets the pace.

_____ I set my own pace.

17. How well does the company reward you for a job well done. (check one)

_____ the company always recognizes my personal accomplishments.

_____ the company usually recognizes my personal performance.

_____ the company sometimes recognizes my personal performance, but not enough.

_____ the company recognizes team performance over personal performance and thats O.K. with me.

_____ the company recognizes team performance over personal performance and so I get recognized less than I deserve.

18. Please rank the following based on how much they influence your willingness to work hard. (Place a "1" next to the description which influences you most. Place a "2" next to the description which influences you second most, and so forth.)

_____ My personal pride in my work.

_____ I want to do my part for the team, and not let them down.

_____ I want to help and please the team advisor.

_____ I want to help EAP be the best in our industry.

_____ I want my team to meet our monthly quality and productivity goals.

_____ I want my team to be recognized as the outstanding monthly goal achiever, because it feels good to know we did the best.

_____ I want my team to be recognized as the outstanding monthly goal achiever, so we will earn the floating banner, have our team name permanently placed on the Q-YES plaque, and get our team picture in the "News and Views."

_____ I believe my hard work will lead to my advancement within the plant.

_____ I want to be personally recognized for my performance.

19. How evenly is the work distributed on your team. (check one)

_____ very evenly, all work loads on the team are the same.

_____ pretty evenly, but some have to do a little more than others.

_____ the work is not evenly spread and some team members have it worse than others, but the work distribution helps team productivity.

_____ the work is not evenly spread, some team members have it worse than others, and this hurts team performance.

APPENDIX B

STATISTICAL SUMMARY FOR CHAPTER III

The following notes are provided to facilitate the use of this appendix.

1. The test statistic (T) was calculated using the following formula:

$$T = \frac{1}{\frac{n_1}{N}\left(1-\frac{n_1}{N}\right)} \left(\sum_{j=1}^{c} \frac{O_{1j}^2}{C_j} - \frac{n_1^2}{N} \right)$$

The values in this formula are taken from the contingency tables as follows:

RESPONSE	A	B	C	D	E	TOTAL
BEFORE	O_{11}	O_{12}	.	.	.	n_1
AFTER	O_{21}	.	.	.	.	n_2
	C_1	.	.	.	C_5	N

2. The critical values for those contingency tables with five columns are taken from the chi-square distribution with four degrees of freedom.

$T_{critical}$ (α=.05) = 9.488 $T_{critical}$ (α=.10) = 7.779

3. The critical values for those contingency tables with four columns are taken from the chi-square distribution with three degrees of freedom.

$T_{critical}$ (α=.05) = 7.815 $T_{critical}$ (α=.10) = 6.251

4. This following source was used to determine the formula for the test statistic as well as the critical values:

Conover, W. J., Practical Nonparametric Statistics 2ed., New York: John Wiley and Sons, 1980.

ANALYSIS OF TEAM PERFORMANCE AS MOTIVATOR

QUESTION: PLEASE RANK THE FOLLOWING BASED ON HOW MUCH THEY INFLUENCE YOUR WILLINGNESS TO WORK HARD.

THE RESPONDENTS WERE GIVEN A LIST OF 9 POSSIBLE MOTIVATORS INCLUDING: PRIDE IN WORK, DESIRE TO PLEASE SUPERVISOR, ADVANCEMENT, RECOGNITION, ETC.

FOR THIS ANALYSIS, WE ARE INTERESTED IN THE RELATIVE RANKING ASSIGNED TO THE FOLLOWING MOTIVATOR:

I WANT MY TEAM TO MEET OUR MONTHLY QUALITY AND PRODUCTIVITY GOALS.

A: RANKED THIS ITEM AS MOST IMPORTANT MOTIVATOR

B: RANKED THIS ITEM SECOND

C: RANKED THIS ITEM THIRD

D: RANKED THIS ITEM FOURTH

E: RANKED THIS ITEM FIFTH OR LOWER

RESPONSE:	A	B	C	D	E	TOTAL
BEFORE	4	7	14	10	22	57
AFTER	2	7	18	9	17	53
TOTALS	6	14	32	19	39	110
	0.132	0.005	0.208	0.001	0.082	
	4.005					
T=	1.717					

CONCLUSION: FAIL TO REJECT THE NULL HYPOTHESIS THAT THE PROPORTION OF RESPONDENTS SELECTING EACH RANKING BEFORE JIT IS THE SAME AS THE PROPORTION OF RESPONDENTS SELECTING EACH RANKING SIX MONTHS AFTER JIT.

THIS MEANS THERE HAS NOT BEEN A CHANGE IN THE IMPORTANCE OF TEAM PERFORMANCE AND GOAL ATTAINMENT AS A SOURCE OF MOTIVATION FOR THE WORKERS.

PERCENTAGE TABLE:

RESPONSE:	A	B	C	D	E
BEFORE	0.070	0.123	0.246	0.175	0.386
AFTER	0.038	0.132	0.340	0.170	0.321

ANALYSIS OF TEAM APPROVAL AS MOTIVATOR

QUESTION: PLEASE RANK THE FOLLOWING BASED ON HOW MUCH THEY INFLUENCE YOUR WILLINGNESS TO WORK HARD.

THE RESPONDENTS WERE GIVEN A LIST OF 9 POSSIBLE MOTIVATORS INCLUDING: PRIDE IN WORK, DESIRE TO PLEASE SUPERVISOR, ADVANCEMENT, RECOGNITION, ETC.

FOR THIS ANALYSIS, WE ARE INTERESTED IN THE RELATIVE RANKING ASSIGNED TO THE FOLLOWING MOTIVATOR:

I WANT TO DO MY PART FOR THE TEAM, AND NOT LET THEM DOWN.

A: RANKED THIS ITEM AS MOST IMPORTANT MOTIVATOR

B: RANKED THIS ITEM SECOND

C: RANKED THIS ITEM THIRD

D: RANKED THIS ITEM FOURTH

E: RANKED THIS ITEM FIFTH OR LOWER

RESPONSE:	A	B	C	D	E	TOTAL
BEFORE	9	17	8	10	13	57
AFTER	8	14	8	4	18	52
TOTALS	17	31	16	14	31	109
	0.001	0.020	0.008	0.513	0.333	
	4.008					
T=	3.505					

CONCLUSION: FAIL TO REJECT THE NULL HYPOTHESIS THAT THE PROPORTION OF RESPONDENTS SELECTING EACH RANKING BEFORE JIT IS THE SAME AS THE PROPORTION OF RESPONDENTS SELECTING EACH RANKING SIX MONTHS AFTER JIT.

THIS MEANS THERE HAS NOT BEEN A CHANGE IN THE IMPORTANCE OF TEAM APPROVAL AS A MOTIVATOR FOR WORKERS.

PERCENTAGE TABLE:

RESPONSE:	A	B	C	D	E
BEFORE	0.158	0.298	0.140	0.175	0.228
AFTER	0.154	0.269	0.154	0.077	0.346

ANALYSIS OF REWARD EQUITY

QUESTION: HOW WELL DOES THE COMPANY REWARD YOU FOR A JOB WELL DONE?

A: THE COMPANY ALWAYS RECOGNIZES MY PERSONAL ACCOMPLISHMENTS.

B: THE COMPANY USUALLY RECOGNIZES MY PERSONAL PERFORMANCE.

C: THE COMPANY SOMETIMES RECOGNIZES MY PERSONAL PERFORMANCE, BUT NOT ENOUGH.

D: THE COMPANY RECOGNIZES TEAM PERFORMANCE OVER PERSONAL PERFORMANCE, AND THAT'S O.K. WITH ME.

E: THE COMPANY RECOGNIZES TEAM PERFORMANCE OVER PERSONAL PERFORMANCE AND SO I GET RECOGNIZED LESS THAN I DESERVE.

RESPONSE:	A	B	C	D	E	TOTAL
BEFORE	6	7	1	38	4	56
AFTER	2	11	7	28	3	51
TOTALS	8	18	8	66	7	107
	0.411	0.326	1.270	0.181	0.016	
	4.009					
T=	8.833					

CONCLUSION: REJECT THE NULL HYPOTHESIS THAT THE PROPORTION OF RESPONDENTS SELECTING EACH RESPONSE BEFORE JIT IS THE SAME AS THE PROPORTION OF RESPONDENTS SELECTING EACH RESPONSE SIX MONTHS AFTER JIT.

THIS MEANS THERE HAS BEEN A CHANGE IN EMPLOYEE PERCEPTIONS CONCERNING THE EQUITY OF REWARDS

PERCENTAGE TABLE:

RESPONSE:	A	B	C	D	E
BEFORE	0.107	0.125	0.018	0.679	0.071
AFTER	0.039	0.216	0.137	0.549	0.059

ANALYSIS OF EQUITY OF WORKLOAD DISTRIBUTION

QUESTION: HOW EVENLY IS THE WORK DISTRIBUTED ON YOUR TEAM?

A: VERY EVENLY, ALL WORK LOADS ON THE TEAM ARE THE SAME.

B: PRETTY EVENLY, BUT SOME HAVE TO DO A LITTLE MORE THAN OTHERS.

C: THE WORK IS NOT EVENLY SPREAD AND SOME TEAM MEMBERS HAVE IT WORSE THAN OTHERS, BUT THE WORK DISTRIBUTION HELPS TEAM PRODUCTIVITY.

D: THE WORK IS NOT EVENLY SPREAD, SOME TEAM MEMBERS HAVE IT WORSE THAN OTHERS, AND THIS HURTS TEAM PERFORMANCE.

RESPONSE:	A	B	C	D	TOTAL
BEFORE	8	37	7	5	57
AFTER	15	24	9	3	51
TOTALS	23	61	16	8	108
	0.745	0.379	0.130	0.076	
	4.012				
T=	5.334				

CONCLUSION: FAIL TO REJECT THE NULL HYPOTHESIS THAT THE PROPORTION OF RESPONDENTS SELECTING EACH RESPONSE BEFORE JIT IS THE SAME AS THE PROPORTION OF RESPONDENTS SELECTING EACH RESPONSE SIX MONTHS AFTER JIT.

THIS MEANS THERE HAS NOT BEEN A CHANGE IN EMPLOYEE PERCEPTION CONCERNING THE EQUITY OF WORKLOAD DISTRIBUTION AS A RESULT OF JIT IMPLEMENTATION.

PERCENTAGE TABLE:

RESPONSE:	A	B	C	D
BEFORE	0.140	0.649	0.123	0.088
AFTER	0.294	0.471	0.176	0.059

ANALYSIS OF INDIVIDUAL ROLE IN SETTING WORK PACE

QUESTION: PLEASE RANK THE FOLLOWING BASED ON HOW BIG A ROLE THEY PLAY IN SETTING YOUR WORK PACE.

THE RESPONDENTS WERE GIVEN A LIST OF 8 POSSIBLE PACE SETTERS INCLUDING: THE TEAM AS A GROUP, TOP MANAGEMENT, THE TEAM ADVISOR, THE FASTEST WORKER, ETC.

FOR THIS ANALYSIS, WE ARE INTERESTED IN THE RELATIVE RANKING ASSIGNED TO THE FOLLOWING PACE SETTER:

I SET MY OWN PACE.

A: RANKED THIS ITEM AS MOST IMPORTANT PACE SETTER

B: RANKED THIS ITEM SECOND

C: RANKED THIS ITEM THIRD

D: RANKED THIS ITEM FOURTH

E: RANKED THIS ITEM FIFTH OR LOWER

RESPONSE:	A	B	C	D	E	TOTAL
BEFORE	19	14	7	9	7	56
AFTER	23	10	2	5	12	52
TOTALS	42	24	9	14	19	108
	0.184	0.101	0.605	0.216	0.428	
	4.005					
T=	6.144					

CONCLUSION: FAIL TO REJECT THE NULL HYPOTHESIS THAT THE PROPORTION OF RESPONDENTS SELECTING EACH RANKING BEFORE JIT IS THE SAME AS THE PROPORTION OF RESPONDENTS SELECTING EACH RANKING SIX MONTHS AFTER JIT.

THIS MEANS THERE HAS NOT BEEN A CHANGE IN THE ROLE EACH PERSON PLAYS IN SETTING THEIR OWN PACE AS A RESULT OF JIT IMPLEMENTATION.

PERCENTAGE TABLE:

RESPONSE:	A	B	C	D	E
BEFORE	0.339	0.250	0.125	0.161	0.125
AFTER	0.442	0.192	0.038	0.096	0.231

ANALYSIS OF TEAM ROLE IN SETTING WORK PACE

QUESTION: PLEASE RANK THE FOLLOWING BASED ON HOW BIG A ROLE THEY PLAY IN SETTING YOUR WORK PACE.

THE RESPONDENTS WERE GIVEN A LIST OF 8 POSSIBLE PACE SETTERS INCLUDING: THE TEAM AS A GROUP, TOP MANAGEMENT, THE TEAM ADVISOR, THE FASTEST WORKER, ETC.

FOR THIS ANALYSIS, WE ARE INTERESTED IN THE RELATIVE RANKING ASSIGNED TO THE FOLLOWING PACE SETTER:

WE ALL SET THE PACE TOGETHER, AS A GROUP.

A: RANKED THIS ITEM AS MOST IMPORTANT PACE SETTER

B: RANKED THIS ITEM SECOND

C: RANKED THIS ITEM THIRD

D: RANKED THIS ITEM FOURTH

E: RANKED THIS ITEM FIFTH OR LOWER

RESPONSE:	A	B	C	D	E	TOTAL
BEFORE	7	13	10	8	18	56
AFTER	13	9	9	10	11	52
TOTALS	20	22	19	18	29	108
	0.568	0.115	0.001	0.099	0.303	
	4.005					
T=	4.350					

CONCLUSION: FAIL TO REJECT THE NULL HYPOTHESIS THAT THE PROPORTION OF RESPONDENTS SELECTING EACH RANKING BEFORE JIT IS THE SAME AS THE PROPORTION OF RESPONDENTS SELECTING EACH RANKING SIX MONTHS AFTER JIT.

THIS MEANS THERE HAS NOT BEEN A CHANGE IN THE IMPORTANCE OF THE TEAM IN SETTING THE WORK PACE AS A RESULT OF JIT IMPLEMENTATION.

PERCENTAGE TABLE:

RESPONSE:	A	B	C	D	E
BEFORE	0.125	0.232	0.179	0.143	0.321
AFTER	0.250	0.173	0.173	0.192	0.212

ANALYSIS OF COMFORT WITH WORK PACE

QUESTION: HOW DIFFICULT IS IT FOR YOU TO KEEP UP WITH YOUR WORKLOAD?

A: REAL EASY, I ALWAYS GET ALL OF MY WORK DONE.

B: PRETTY EASY, I ALMOST ALWAYS FINISH ALL OF MY WORK.

C: NOT SO EASY, I OCCASIONALLY DO NOT FINISH ALL OF MY WORK (3-4 TIMES PER MONTH).

D: PRETTY HARD, I FREQUENTLY DO NOT FINISH ALL OF MY WORK (MORE THAN ONCE PER WEEK).

E: REAL HARD, I ALMOST NEVER FINISH ALL OF MY WORK.

RESPONSE:	A	B	C	D	E	TOTAL
BEFORE	14	30	10	3	0	57
AFTER	13	30	7	2	0	52
TOTALS	27	60	17	5	0	109
	0.001	0.032	0.072	0.030	0.000	
	4.008					
T=	0.538					

CONCLUSION: FAIL TO REJECT THE NULL HYPOTHESIS THAT THE PROPORTION OF RESPONDENTS SELECTING EACH RESPONSE BEFORE JIT IS THE SAME AS THE PROPORTION OF RESPONDENTS SELECTING EACH RESPONSE SIX MONTHS AFTER JIT.

THIS MEANS THERE HAS NOT BEEN A CHANGE IN EMPLOYEE COMFORT WITH THE WORK PACE SINCE JIT WAS IMPLEMENTED

PERCENTAGE TABLE:

RESPONSE:	A	B	C	D	E
BEFORE	0.246	0.526	0.175	0.053	0.000
AFTER	0.250	0.577	0.135	0.038	0.000

ANALYSIS OF TEAM ESTEEM

QUESTION: HOW WOULD YOU RATE YOUR TEAM PERFORMANCE AS A PRODUCTIVE TEAM WHICH PRODUCES QUALITY WORK?

A: BEST TEAM IN PLANT

B: SECOND BEST TEAM IN PLANT

C: WE ARE IN TOP HALF

D: WE ARE NOT IN TOP HALF, BUT WE'RE NOT THE WORST

E: WE ARE ONE OF THE WORST TEAMS

RESPONSE:	A	B	C	D	E	TOTAL
BEFORE	15	4	10	14	13	56
AFTER	15	4	23	8	1	51
TOTALS	30	8	33	22	14	107
	0.016	0.004	1.602	0.281	2.299	
	4.009					
T=	16.846					

CONCLUSION: REJECT THE NULL HYPOTHESIS THAT THE PROPORTION OF RESPONDENTS SELECTING EACH RESPONSE BEFORE JIT IS THE SAME AS THE PROPORTION OF RESPONDENTS SELECTING EACH RESPONSE SIX MONTHS AFTER JIT.

THIS MEANS THERE HAS BEEN A CHANGE IN EMPLOYEE PERCEPTIONS CONCERNING ESTEEM FOR THEIR TEAMS

PERCENTAGE TABLE:

RESPONSE:	A	B	C	D	E
BEFORE	0.268	0.071	0.179	0.250	0.232
AFTER	0.294	0.078	0.451	0.157	0.020

ANALYSIS OF CONFLICT RESOLUTION

QUESTION: WHEN YOU HAVE A DISAGREEMENT WITH A FELLOW TEAM MEMBER, HOW DO YOU USUALLY SOLVE THE CONFLICT?

A: THE DISAGREEMENT USUALLY FADES AWAY AS TIME PASSES.

B: WE USUALLY SETTLE THE DISAGREEMENT BETWEEN OURSELVES.

C: WE USUALLY SETTLE THE DISAGREEMENT WITH THE HELP OF ANOTHER TEAM MEMBER.

D: WE USUALLY SETTLE THE DISAGREEMENT WITH THE HELP OF THE TEAM ADVISOR.

E: MOST DISAGREEMENTS ARE NEVER SETTLED.

RESPONSE:	A	B	C	D	E	TOTAL
BEFORE	6	31	5	7	5	54
AFTER	8	31	3	4	6	52
TOTALS	14	62	8	11	11	106
	0.092	0.006	0.107	0.177	0.033	
	4.001					
T=	1.658					

CONCLUSION: FAIL TO REJECT THE NULL HYPOTHESIS THAT THE PROPORTION OF RESPONDENTS SELECTING EACH RESPONSE BEFORE JIT IS THE SAME AS THE PROPORTION OF RESPONDENTS SELECTING EACH RESPONSE SIX MONTHS AFTER JIT.

THIS MEANS THERE HAS NOT BEEN A CHANGE IN IN THE MANNER EMPLOYEES RESOLVE TEAM CONFLICTS.

PERCENTAGE TABLE:

RESPONSE:	A	B	C	D	E
BEFORE	0.111	0.574	0.093	0.130	0.093
AFTER	0.154	0.596	0.058	0.077	0.115

ANALYSIS OF COMMUNICATION RESPONSIVENESS

QUESTION: WHEN YOU NEED AN ANSWER TO A QUESTION TO PERFORM YOUR FUNCTION, HOW QUICKLY DO YOU USUALLY GET THE ANSWER?

A: IMMEDIATELY, I DON'T MISS A BEAT.

B: VERY QUICKLY, NO INTERRUPTION IN WORK, I MAY SLOW DOWN A LITTLE.

C: QUICKLY, I STOP WORK, BUT ONLY FOR A SHORT PERIOD OF TIME.

D: SLOWLY, I MUST STOP WORK FOR 5 - 15 MINUTES TO FIND THE INFORMATION.

E: VERY SLOWLY, I MUST STOP WORK FOR MORE THAN 15 MINUTES.

RESPONSE:	A	B	C	D	E	TOTAL
BEFORE	2	13	28	11	3	57
AFTER	0	17	25	8	2	52
TOTALS	2	30	53	19	5	109
	0.455	0.241	0.002	0.060	0.030	
	4.008					
T=	3.154					

CONCLUSION: FAIL TO REJECT THE NULL HYPOTHESIS THAT THE PROPORTION OF RESPONDENTS SELECTING EACH RESPONSE BEFORE JIT IS THE SAME AS THE PROPORTION OF RESPONDENTS SELECTING EACH RESPONSE SIX MONTHS AFTER JIT.

THIS MEANS THERE HAS NOT BEEN A CHANGE IN HOW QUICKLY EMPLOYEES REPORT THEY RECEIVE ANSWERS TO JOB RELATED QUESTIONS.

PERCENTAGE TABLE:

RESPONSE:	A	B	C	D	E
BEFORE	0.035	0.228	0.491	0.193	0.053
AFTER	0.000	0.327	0.481	0.154	0.038

APPENDIX C

TEAM CHARACTERISTIC SURVEY

1. How often do your teammates offer to help <u>you</u> finish your work. Please consider <u>all</u> of your teammates when you answer this question. Please assign <u>each</u> of your teammates to one of the following descriptions. Place the total number of teammates who fit the description on the line next to the appropriate description. The total of the numbers at the left should equal the total number of your teammates. It may help to read all of the descriptions before deciding which best describe your teammates.

_____ A. How many of your teammates can you <u>always</u> count on to offer you help <u>first</u>, in the event they finish their work early?

_____ B. How many of your teammates can you <u>usually</u> count on to offer you help <u>first</u>, in the event they finish their work early?

_____ C. How many of your teammates <u>usually</u> offer you help when they finish early, <u>but only after</u> they offer help to others on the team whom they like better.

_____ D. How many of your teammates will <u>usually</u> offer you help when they finish early, <u>but only after</u> offering help to others who are further behind?

_____ E. How many of your teammates will <u>usually</u> offer you help when they finish early, <u>but only after</u> checking with the production officer?

_____ F. How many of your teammates frequently slow down their pace so they will not finish early?

_____ G. How many of your teammates will not offer to help you because you have asked them not to offer you help? If you need help you will let the production officer know.

_____ H. How many of your teammates can not offer to help you because they are not yet able to perform your function properly?

_____ I. How many of your teammates do not offer to help you because you don't get along well?

_____ J. How many of your teammates do not offer to help you because they are slow workers who rarely finish early?

_____ K. How many of your teammates do not fit any of the descriptions above?

** Remember the total of the numbers next to A through K above should equal the number of teammates you have (11).

2. Teammates may treat others differently than they treat you. How often do your teammates offer to help <u>others</u> on the team finish their work. Please consider <u>all</u> of your teammates when you answer this question. Please assign <u>each</u> of your teammates to one of the following descriptions. Place the total number of teammates who fit the description on the line next to the appropriate description. The total of the numbers at the left should equal the total number of your teammates. It may help to read all of the descriptions before deciding which best describe your teammates.

_____ A. In general, how many of your teammates will <u>always</u> help others on the team when they finish early?

_____ B. In general, how many of your teammates will <u>usually</u> help others on the team when they finish early?

_____ C. In general, how many of your teammates often finish early, but spend the extra time taking care of personal affairs.

_____ D. In general, how many of your teammates rarely finish early?

_____ E. How many of your teammates do not fit any of the descriptions above?

** Remember the total of the numbers next to A through E above should equal the number of teammates you have (11).

3. How many days have you finished early in the last 10 working days? Please try your best to remember. Include only those days when you finished with more than 30 minutes left in the work day.

_____

4. How many days have you worked on team activities after finishing early, in the last 10 working days. Please try your best to remember.

_____

5. Please rate how well you can perform each of the following functions. Please score your ability using the following scale:

4 points	I can perform all parts of this job very well
3 points	I can perform most parts of this job well
2 points	I can do some parts of this job to standard
1 points	I can not perform this function

_____ Hardware _____ Inspection _____ Handbuild

_____ Robot _____ ICT _____ Assembly _____ Jumpers

6. When you finish early, what do you do next? Please rank the following activities in the order you would do, or have done them. Place a "1" next to the activity you would do first. A "2" next to the activity you would do second, and so forth. Please rank all activities.

_____ A. Clean my work area

_____ B. Check with the production officer to see who needs help

_____ C. Check with the team advisor to see who needs help

_____ D. Complete my personal rework

_____ E. Complete team rework

_____ F. Help my friends on the team to complete their boards

_____ G. Help whoever is furthest behind to complete their boards

_____ H. Take care of office duties

_____ I. Check to see if other teams need help

_____ J. Learn other functions on the team which I do not know yet

_____ K. Check team bulletin board to see what additional work I can do.

_____ L. I do nothing.

_____ M. I intentionally don't finish early, so I won't have to do any additional work.

_____ N. other _____

7. Sometimes it does not make sense to start additional work when there is just too little time left in the day. How much time must there be remaining in the day before it is worth your while to start an additional task? (Please circle 1 answer)

15 minutes 30 minutes 45 minutes 1 hour

1½ hours 2 hours

8. How important is it for you to know the information described below? Please use the following scale to identify how important it is for you to know the information described in the list below?

1. This information is of little or no value to me.
2. I am somewhat interested in this information.
3. It is helpful to me to receive this information.
4. It is important for me to receive this information.
5. It is absolutely essential for me to receive this information.

Information (Importance)

_____ A. Notice that there is a defective component on a team board I am helping build.

_____ B. Why a board I worked has failed inspection.

_____ C. Who on the team might need help when I'm done.

_____ D. How my friends are doing today.

_____ E. A word of congratulations for a job well done.

_____ F. The teams' quality performance for the past week.

_____ G. Who else has worked on a board that I'm sharing.

_____ H. What kind of board(s) I will work on tomorrow.

_____ I. When my teammates are going to be absent.

_____ J. What kind of boards we will work on next week.

_____ K. How profitable EAP was last quarter.

_____ L. Why a board I am reworking failed inspection.

_____ M. What I can do better, or how I can improve.

_____ N. Is someone on the team mad at me?

_____ O. What I should do when I finish my work for the day.

_____ P. How well the team is doing on today's work.

_____ Q. When the next team meeting will occur.

_____ R. What my teammates are currently working on.

_____ S. How busy my teammates are today.

_____ T. What team work remains once I've finished my work.

_____ U. Which other teams might need help when I'm done.

9. Do you get the information you need, when you need it? Please use the following scale to describe the completeness and timeliness of the information you receive.

1. I never receive this information in a complete form when I need it.
2. I rarely receive this information when I need it. This information is frequently incomplete or late.
3. I often receive this information when I need it; but sometimes the information is incomplete or too late.
4. I usually receive this information completely, when I need it.
5. I always receive this information completely, when I need it.

Information (Timely and Complete)

_____ A. Notice that there is a defective component on a team board I am helping build.
_____ B. Why a board I worked has failed inspection.
_____ C. Who on the team might need help when I'm done.
_____ D. How my friends are doing today.
_____ E. A word of congratulations for a job well done.
_____ F. The teams' quality performance for the past week.
_____ G. Who else has worked on a board that I'm sharing.
_____ H. What kind of board(s) I will work on tomorrow.
_____ I. When my teammates are going to be absent.
_____ J. What kind of boards we will work on next week.
_____ K. How profitable EAP was last quarter.
_____ L. Why a board I am reworking failed inspection.
_____ M. What I can do better, or how I can improve.
_____ N. Is someone on the team mad at me?
_____ O. What I should do when I finish my work for the day.
_____ P. How well the team is doing on today's work.
_____ Q. When the next team meeting will occur.
_____ R. What my teammates are currently working on.
_____ S. How busy my teammates are today.
_____ T. What team work remains once I've finished my work.
_____ U. Which other teams might need help when I'm done.

10. How do you get the information you need? Please use the following scale to identify the primary source of the information described below.

1. A teammate.
2. My team advisor.
3. A team officer (production, quality, etc.).
4. From a graph, chart or note posted on the team board. (or team advisors grease board)
5. From discussion at team meetings.
6. From upper management.
7. From someone on another team.

Information (Primary Source)

_____ A. Notice that there is a defective component on a team board I am helping build.

_____ B. Why a board I worked has failed inspection.

_____ C. Who on the team might need help when I'm done.

_____ D. How my friends are doing today.

_____ E. A word of congratulations for a job well done.

_____ F. The teams' quality performance for the past week.

_____ G. Who else has worked on a board that I'm sharing.

_____ H. What kind of board(s) I will work on tomorrow.

_____ I. When my teammates are going to be absent.

_____ J. What kind of boards we will work on next week.

_____ K. How profitable EAP was last quarter.

_____ L. Why a board I am reworking failed inspection.

_____ M. What I can do better, or how I can improve.

_____ N. Is someone on the team mad at me?

_____ O. What I should do when I finish my work for the day.

_____ P. How well the team is doing on today's work.

_____ Q. When the next team meeting will occur.

_____ R. What my teammates are currently working on.

_____ S. How busy my teammates are today.

_____ T. What team work remains once I've finished my work.

_____ U. Which other teams might need help when I'm done.

11. There are many decisions which you encounter regularly as you perform your work. Please use the following scale to describe the role <u>you personally</u> play in making the decisions described below.

1. I am or can be the primary decision maker.
2. I have my say in this decision, along with other teammates. We decide together.
3. I can make inputs to this decision, but a team officer (production, quality, etc.) makes the decision.
4. I can make inputs to the decision, but the team advisor makes the decision.
5. The team advisor or higher management makes the decision. I am told the decision.

<u>Decisions</u>

_____ A. Where I sit to perform my work.

_____ B. What work I do when I finish <u>my</u> work for the day.

_____ C. When we will have the next team meeting.

_____ D. How we solve team conflicts or disagreements.

_____ E. How we pass on important work related information.

_____ F. How we might improve the way we share work on the team.

_____ G. How we cover for an absent team member.

_____ H. What we can do to improve team productivity or quality.

_____ I. What quantity of work materials we should have available, such as kim-wipes, solder, and so forth.

_____ J. Whether or not I can work overtime.

_____ K. How many boards the team must complete each day.

_____ L. How fast I need to work today.

_____ M. Who will work which board styles today.

_____ N. Who will be responsible for team rework?

_____ O. Who will assemble the hand builds?

_____ P. How will the team assemble the two extra boards each day?

_____ Q. How we will cross train for other functions on the team?

_____ R. Who will back up our hardware assembly technician or robot assembly technician when they are absent?

_____ S. Who will be the production officer?

_____ T. What decisions can the production officer make?

_____ U. Who will cross train for other functions on the team.

APPENDIX D

COLLABORATIVE BEHAVIOR PROFILES

[ ] = Weighting Factor

_____ A. How many of your teammates can you **always** count on to offer you help **first**, in the event they finish their work early? [1]

_____ B. How many of your teammates can you **usually** count on to offer you help **first**, in the event they finish their work early? [1]

_____ C. How many of your teammates **usually** offer you help when they finish early, **but only after** they offer help to others on the team whom they like better. [1]

_____ D. How many of your teammates will **usually** offer you help when they finish early, **but only after** offering help to others who are further behind? [2]

_____ E. How many of your teammates will **usually** offer you help when they finish early, **but only after** checking with the production officer? [2]

_____ F. How many of your teammates frequently slow down their pace so they will not finish early? [-1]

_____ G. How many of your teammates will not offer to help you because you have asked them not to offer you help? If you need help you will let the production officer know. [0]

_____ H. How many of your teammates can not offer to help you because they are not yet able to perform your function properly? [0]

_____ I. How many of your teammates do not offer to help you because you don't get along well? [-1]

_____ J. How many of your teammates do not offer to help you because they are slow workers who rarely finish early? [0]

APPENDIX E

GENERAL DESCRIPTIONS OF COLLABORATIVE BEHAVIOR

_____ A. In general, how many of your teammates will **always** help others on the team when they finish early?

_____ B. In general, how many of your teammates will **usually** help others on the team when they finish early?

_____ C. In general, how many of your teammates often finish early, but spend the extra time taking care of personal affairs.

_____ D. In general, how many of your teammates rarely finish early?

_____ E. How many of your teammates do not fit any of the descriptions above?

APPENDIX F

INFORMATION ITEMS

_____ A. Notice that there is a defective component on a team board I am helping build.

_____ B. Why a board I worked has failed inspection.

_____ C. Who on the team might need help when I'm done.

_____ D. How my friends are doing today.

_____ E. A word of congratulations for a job well done.

_____ F. The teams' quality performance for the past week.

_____ G. Who else has worked on a board that I'm sharing.

_____ H. What kind of board(s) I will work on tomorrow.

_____ I. When my teammates are going to be absent.

_____ J. What kind of boards we will work on next week.

_____ K. How profitable EAP was last quarter.

_____ L. Why a board I am reworking failed inspection.

_____ M. What I can do better, or how I can improve.

_____ N. Is someone on the team mad at me?

_____ O. What I should do when I finish my work for the day.

_____ P. How well the team is doing on today's work.

_____ Q. When the next team meeting will occur.

_____ R. What my teammates are currently working on.

_____ S. How busy my teammates are today.

APPENDIX F - INFORMATION ITEMS (CONT.)

_____ T. What team work remains once I've finished my work.

_____ U. Which other teams might need help when I'm done.

APPENDIX G

DECISIONS

_____ A. Where I sit to perform my work.

_____ B. What work I do when I finish my work for the day.

_____ C. When we will have the next team meeting.

_____ D. How we solve team conflicts or disagreements.

_____ E. How we pass on important work related information.

_____ F. How we might improve the way we share work on the team.

_____ G. How we cover for an absent team member.

_____ H. What we can do to improve team productivity or quality.

_____ I. What quantity of work materials we should have available, such as kim-wipes, solder, and so forth.

_____ J. Whether or not I can work overtime.

_____ K. How many boards the team must complete each day.

_____ L. How fast I need to work today.

_____ M. Who will work which board styles today.

_____ N. Who will be responsible for team rework?

_____ O. Who will assemble the hand builds?

_____ P. How will the team assemble the two extra boards each day?

_____ Q. How we will cross train for other functions on the team?

APPENDIX G - DECISIONS (CONT.)

_____ R. Who will back up our hardware assembly technician or robot assembly technician when they are absent?

_____ S. Who will be the production officer?

_____ T. What decisions can the production officer make?

_____ U. Who will cross train for other functions on the team.

APPENDIX H

ALTERNATIVE ACTIONS UPON FINISHING EARLY

A. Clean my work area

B. Check with the production officer to see who needs help

C. Check with the team advisor to see who needs help

D. Complete my personal rework

E. Complete team rework

F. Help my friends on the team to complete their boards

G. Help whoever is furthest behind to complete their boards

H. Take care of office duties

I. Check to see if other teams need help

J. Learn other functions on the team which I do not know yet

K. Check team bulletin board to see what additional work I can do.

L. I do nothing.

M. I intentionally don't finish early, so I won't have to do any additional work.

APPENDIX I

STATISTICAL SUMMARY FOR CHAPTER IV

The following notes are provided to facilitate the use of this appendix.

1. The model statement presents the two-factor ANOVA model used to determine if the team characteristics were equal each of the three survey times. The hypothesis tested in this analysis is that the treatment means are equal. Rejection of the null hypothesis indicates the treatment means are not equal, and hence at least one treatment mean is different from the other two.

2. The data presented was obtained from the "Team Characteristic Survey."

3. The results presented were obtained using @SAS. The value reflected as PR > F which corresponds to Treatments represents the probability of committing a type I error and incorrectly concluding there is a difference between the treatments when, in fact, there is not.

4. The conclusion statement summarizes the statistical result for the hypothesis tested.

ANALYSIS OF TEAM FLEXIBILITY

MODEL: $y_{ij} = \mu + \tau_i + \gamma_j + \epsilon_{ij}$

where: y = team flexibility index
μ = overall mean
τ = treatment effect (survey time)
γ = block effect (teams)
ϵ = random error component

DATA: TEAM FLEXIBILITY

	TREATMENTS		
BLOCKS	T1	T2	T3
B	0.617	0.757	0.790
D	0.532	0.645	0.635
Q	0.640	0.667	0.650
R	0.535	0.583	0.625
S	0.697	0.683	0.695

RESULTS:

ANOVA:

SOURCE	DF	F VALUE	PR > F
Blocks	4	6.28	0.0138
Treatments	2	4.93	0.0403

AFTER ANOVA (TUKEYS): ALPHA=.05

T1 MEAN: 0.6042
T2 MEAN: 0.6670
T3 MEAN: 0.6790
MINIMUM SIGNIFICANT DIFFERENCE: 0.07314

*THESE RESULTS OBTAINED USING @SAS

CONCLUSION:

THERE IS A STATISTICALLY SIGNIFICANT TREATMENT EFFECT. TREATMENT 3 IS SIGNIFICANTLY DIFFERENT FROM TREATMENT 1. THESE RESULTS INDICATE THAT TEAM FLEXIBILITY IMPROVED OVER THE COURSE OF THIS STUDY.

ANALYSIS OF HELP OPPORTUNITIES

MODEL: $y_{ij} = \mu + \tau_i + \gamma_j + \epsilon_{ij}$

where: y = help opportunities index
μ = overall mean
τ = treatment effect (survey time)
γ = block effect (teams)
ϵ = random error component

DATA: HELP OPPORTUNITIES

	TREATMENTS		
BLOCKS	T1	T2	T3
B	54	8	32
D	42	53	54
Q	84	58	21
R	20	18	20
S	60	45	25

RESULTS:

ANOVA:

SOURCE	DF	F VALUE	PR > F
Blocks	4	1.93	0.1995
Treatments	2	1.97	0.2019

AFTER ANOVA: N/A

*THESE RESULTS OBTAINED USING @SAS

CONCLUSION:

THERE IS NOT A STATISTICALLY SIGNIFICANT TREATMENT EFFECT. THIS MEANS WE CAN NOT CONCLUDE THAT HELP OPPORTUNITIES CHANGED OVER THE COURSE OF THIS STUDY.

ANALYSIS OF COLLABORATION INDEX 1

MODEL: $y_{ij} = \mu + \tau_i + \gamma_j + \epsilon_{ij}$

where: y = collaboration index 1
μ = overall mean
τ = treatment effect (survey time)
γ = block effect (teams)
ϵ = random error component

DATA: COLLABORATION INDEX 1

	TREATMENTS		
BLOCKS	T1	T2	T3
B	0.774	0.699	0.769
D	0.953	0.779	0.753
Q	1.030	1.025	1.153
R	0.558	1.123	1.009
S	1.230	1.616	1.486

RESULTS:

ANOVA:

SOURCE	DF	F VALUE	PR > F
Blocks	4	7.82	0.0072
Treatments	2	1.00	0.4089

AFTER ANOVA: N/A

*THESE RESULTS OBTAINED USING @SAS

CONCLUSION:

THERE IS NOT A STATISTICALLY SIGNIFICANT TREATMENT EFFECT. THIS MEANS WE CAN NOT CONCLUDE THAT COLLABORATION INDEX 1 CHANGED OVER THE COURSE OF THIS STUDY.

ANALYSIS OF COLLABORATION INDEX 2

MODEL: $y_{ij} = \mu + \tau_i + \gamma_j + \epsilon_{ij}$

where: y = collaboration index 2
μ = overall mean
τ = treatment effect (survey time)
γ = block effect (teams)
ϵ = random error component

DATA: COLLABORATION INDEX 2

	TREATMENTS		
BLOCKS	T1	T2	T3
B	0.681	0.596	0.638
D	0.595	0.558	0.620
Q	0.814	0.808	0.696
R	0.462	0.876	0.908
S	0.849	0.835	0.897

RESULTS:

ANOVA:

SOURCE	DF	F VALUE	PR > F
Blocks	4	2.21	0.1576
Treatments	2	0.44	0.6573

AFTER ANOVA: N/A

*THESE RESULTS OBTAINED USING @SAS

CONCLUSION:

THERE IS NOT A STATISTICALLY SIGNIFICANT TREATMENT EFFECT. THIS MEANS WE CAN NOT CONCLUDE THAT COLLABORATION INDEX 2 CHANGED OVER THE COURSE OF THIS STUDY.

ANALYSIS OF COMMUNICATION EFFECTIVENESS

MODEL: $y_{ij} = \mu + \tau_i + \gamma_j + \epsilon_{ij}$

where: y = communication effectiveness index
μ = overall mean
τ = treatment effect (survey time)
γ = block effect (teams)
ϵ = random error component

DATA: COMMUNICATION EFFECTIVENESS

	TREATMENTS		
BLOCKS	T1	T2	T3
B	0.770	0.780	0.800
D	0.830	0.825	0.844
Q	0.788	0.755	0.800
R	0.780	0.836	0.860
S	0.840	0.817	0.800

RESULTS:

ANOVA:

SOURCE	DF	F VALUE	PR > F
Blocks	4	3.01	0.0866
Treatments	2	0.98	0.4153

AFTER ANOVA: N/A

*THESE RESULTS OBTAINED USING @SAS

CONCLUSION:

THERE IS NOT A STATISTICALLY SIGNIFICANT TREATMENT EFFECT. THIS MEANS WE CAN NOT CONCLUDE THAT COMM. EFFECTIVENESS CHANGED OVER THE COURSE OF THIS STUDY.

ANALYSIS OF PRIORITY CONSONANCE

MODEL: $y_{ij} = \mu + \tau_i + \gamma_j + \epsilon_{ij}$

where: y = priority consonance index
μ = overall mean
τ = treatment effect (survey time)
γ = block effect (teams)
ϵ = random error component

DATA: PRIORITY CONSONANCE

	TREATMENTS		
BLOCKS	T1	T2	T3
B	0.607	0.655	0.479
D	0.629	0.614	0.709
Q	0.674	0.559	0.697
R	0.350	0.580	0.682
S	0.678	0.730	0.713

RESULTS:

ANOVA:

SOURCE	DF	F VALUE	PR > F
Blocks	4	1.30	0.3469
Treatments	2	0.59	0.5771

AFTER ANOVA: N/A

*THESE RESULTS OBTAINED USING @SAS

CONCLUSION:

THERE IS NOT A STATISTICALLY SIGNIFICANT TREATMENT EFFECT. THIS MEANS WE CAN NOT CONCLUDE THAT PRIORITY CONSONANCE CHANGED OVER THE COURSE OF THIS STUDY.

ANALYSIS OF DECISION MAKING

MODEL: $y_{ij} = \mu + \tau_i + \gamma_j + \epsilon_{ij}$

where: y = team decision making index
μ = overall mean
τ = treatment effect (survey time)
γ = block effect (teams)
ϵ = random error component

DATA: DECISION MAKING

	TREATMENTS		
BLOCKS	T1	T2	T3
B	16.0	12.5	13.0
D	14.0	14.0	14.0
Q	15.5	13.5	16.0
R	16.0	17.0	16.5
S	14.5	14.0	15.0

RESULTS:

ANOVA:

SOURCE	DF	F VALUE	PR > F
Blocks	4	3.05	0.0842
Treatments	2	1.17	0.3594

AFTER ANOVA: N/A

*THESE RESULTS OBTAINED USING @SAS

CONCLUSION:

THERE IS NOT A STATISTICALLY SIGNIFICANT TREATMENT EFFECT. THIS MEANS WE CAN NOT CONCLUDE THAT DECISION MAKING CHANGED OVER THE COURSE OF THIS STUDY.

APPENDIX J

STATISTICAL SUMMARY FOR CHAPTER V

The following notes are provided to facilitate the use of this appendix.

1. The model statement presents the two-factor analysis of covariance model used to determine if the performance measure tested is related to the team characteristic specified in the model. The hypotheses tested in this analysis is that the regression coefficient is equal to zero. Rejection of this null hypothesis indicates the performance measure is related to the team characteristic.

2. The data presented was obtained from two sources. The performance data was obtained from the Westinghouse production data base. The team characteristic data was obtained from the "Team Characteristic Survey."

3. The results presented were obtained using @SAS. The value reflected as PR > F which corresponds to the team characteristic represents the probability of committing a type I error and incorrectly concluding the performance measure is related to the team characteristic when, in fact, it is not.

4. The conclusion statement summarizes the statistical result for the hypothesis tested.

PERFORMANCE-TO-SCHEDULE AS FUNCTION OF TEAM FLEXIBILITY

MODEL: $y_{ij} = \mu + \tau_i + \gamma_j + \beta(x_{ij} - \bar{x}_{..}) + \epsilon_{ij}$

where: y = observed performance-to-schedule
μ = overall mean
τ = effect of team
γ = effect of survey time
β = regression coefficient
x = observed team flexibility index
ϵ = random error component

DATA:

PERFORMANCE -TO-SCHEDULE	TEAM	TIME	FLEXIBILITY
0.960	B	1	0.617
0.979	D	1	0.532
0.955	Q	1	0.640
0.835	R	1	0.535
0.931	S	1	0.697
0.870	B	2	0.757
0.978	D	2	0.645
0.956	Q	2	0.667
0.911	R	2	0.583
0.941	S	2	0.683
0.858	B	3	0.790
0.933	D	3	0.635
0.973	R	3	0.625
0.969	S	3	0.695

RESULTS:

	F VALUE	PR > F	
MODEL	0.87	0.5748	
VARIABLES			
TEAM	1.32	0.3627	
TIME	0.59	0.5825	
FLEX.	1.54	0.2607	B1= -0.5677

STD. ERR. OF EST.: 0.4572

*THESE RESULTS OBTAINED USING @SAS

CONCLUSION:

THERE IS NOT A STATISTICALLY SIGNIFICANT RELATIONSHIP BETWEEN TEAM FLEXIBILITY AND PERFORMANCE-TO-SCHEDULE.

PERFORMANCE-TO-SCHEDULE AS FUNCTION OF HELP OPPORTUNITIES

MODEL: $y_{ij} = \mu + \tau_i + \gamma_j + \beta(x_{ij} - \bar{x}_{..}) + \epsilon_{ij}$

where: y = observed performance-to-schedule
μ = overall mean
τ = effect of team
γ = effect of survey time
β = regression coefficient
x = observed help opportunities index
ϵ = random error component

DATA:

PERFORMANCE -TO-SCHEDULE	TEAM	TIME	HELP OPPORTUNITIES
0.960	B	1	54
0.979	D	1	42
0.955	Q	1	84
0.835	R	1	20
0.931	S	1	60
0.870	B	2	8
0.978	D	2	53
0.956	Q	2	58
0.911	R	2	18
0.941	S	2	45
0.858	B	3	32
0.933	D	3	54
0.973	R	3	20
0.969	S	3	25

RESULTS:

	F VALUE	PR > F		
MODEL	0.60	0.7413		
VARIABLES				
TEAM	0.34	0.8409		
TIME	0.10	0.9089		
HELP	0.35	0.5736	B1=	0.0008

STD. ERR. OF EST.: 0.0013

*THESE RESULTS OBTAINED USING @SAS

CONCLUSION:

THERE IS NOT A STATISTICALLY SIGNIFICANT RELATIONSHIP BETWEEN HELP OPPORTUNITIES AND PERFORMANCE-TO-SCHEDULE.

PERFORMANCE-TO-SCHEDULE AS FUNCTION OF COLLABORATION INDEX 1

MODEL: $y_{ij} = \mu + \tau_i + \gamma_j + \beta(x_{ij} - \bar{x}_{..}) + \epsilon_{ij}$

where: y = observed performance-to-schedule
μ = overall mean
τ = effect of team
γ = effect of survey time
β = regression coefficient
x = observed collaboration index 1
ϵ = random error component

DATA:

PERFORMANCE -TO-SCHEDULE	TEAM	TIME	COLLAB1
0.960	B	1	0.774
0.979	D	1	0.953
0.955	Q	1	1.030
0.835	R	1	0.558
0.931	S	1	1.230
0.870	B	2	0.699
0.978	D	2	0.779
0.956	Q	2	1.025
0.911	R	2	1.123
0.941	S	2	1.616
0.858	B	3	0.769
0.933	D	3	0.753
0.973	R	3	1.009
0.969	S	3	1.486

RESULTS:

	F VALUE	PR > F		
MODEL	1.49	0.3215		
VARIABLES				
TEAM	1.75	0.2575		
TIME	0.40	0.6891		
COLLAB1	4.24	0.0852	B1=	0.1786

STD. ERR. OF EST.: 0.0867

*THESE RESULTS OBTAINED USING @SAS

CONCLUSION:

THERE IS A STATISTICALLY SIGNIFICANT POSITIVE RELATIONSHIP BETWEEN COLLABORATION INDEX 1 AND PERFORMANCE-TO-SCHEDULE.

PERFORMANCE-TO-SCHEDULE AS FUNCTION OF COLLABORATION INDEX 2

MODEL: $y_{ij} = \mu + \tau_i + \gamma_j + \beta(x_{ij} - \bar{x}_{..}) + \epsilon_{ij}$

where: y = observed performance-to-schedule
μ = overall mean
τ = effect of team
γ = effect of survey time
β = regression coefficient
x = observed collaboration index 2
ϵ = random error component

DATA:

PERFORMANCE -TO-SCHEDULE	TEAM	TIME	COLLAB2
0.960	B	1	0.681
0.979	D	1	0.595
0.955	Q	1	0.814
0.835	R	1	0.462
0.931	S	1	0.849
0.870	B	2	0.596
0.978	D	2	0.558
0.956	Q	2	0.808
0.911	R	2	0.876
0.941	S	2	0.835
0.858	B	3	0.638
0.933	D	3	0.620
0.973	R	3	0.908
0.969	S	3	0.897

RESULTS:

	F VALUE	PR > F		
MODEL	2.66	0.1267		
VARIABLES				
TEAM	3.32	0.0923		
TIME	0.64	0.5597		
COLLAB2	9.36	0.0223	B1=	0.3209

STD. ERR. OF EST.: 0.1049

*THESE RESULTS OBTAINED USING @SAS

CONCLUSION:

THERE IS A STATISTICALLY SIGNIFICANT POSITIVE RELATIONSHIP BETWEEN COLLABORATION INDEX 2 AND PERFORMANCE-TO-SCHEDULE.

PERFORMANCE-TO-SCHEDULE AS FUNCTION OF COMMUNICATION EFFECTIVENESS

MODEL: $y_{ij} = \mu + \tau_i + \gamma_j + \beta(x_{ij} - \bar{x}_{..}) + \epsilon_{ij}$

where: y = observed performance-to-schedule
μ = overall mean
τ = effect of team
γ = effect of survey time
β = regression coefficient
x = observed communication effectiveness index
ϵ = random error component

DATA:

PERFORMANCE -TO-SCHEDULE	TEAM	TIME	COMMUNICATION EFFECTIVENESS
0.960	B	1	0.770
0.979	D	1	0.830
0.955	Q	1	0.788
0.835	R	1	0.780
0.931	S	1	0.840
0.870	B	2	0.780
0.978	D	2	0.825
0.956	Q	2	0.755
0.911	R	2	0.836
0.941	S	2	0.817
0.858	B	3	0.800
0.933	D	3	0.844
0.973	R	3	0.860
0.969	S	3	0.800

RESULTS:

	F VALUE	PR > F		
MODEL	0.64	0.7140		
VARIABLES				
TEAM	0.90	0.5211		
TIME	0.00	0.9983		
COMM.	0.54	0.4918	B1=	0.5582

STD. ERR. OF EST.: 0.7626

*THESE RESULTS OBTAINED USING @SAS

CONCLUSION:

THERE IS NOT A STATISTICALLY SIGNIFICANT RELATIONSHIP BETWEEN COMM. EFFECTIVENESS AND PERFORMANCE-TO-SCHEDULE.

PERFORMANCE-TO-SCHEDULE AS FUNCTION OF PRIORITY CONSONANCE

MODEL: $Y_{ij} = \mu + \tau_i + \gamma_j + \beta(x_{ij} - \bar{x}_{..}) + \epsilon_{ij}$

where: y = observed performance-to-schedule
μ = overall mean
τ = effect of team
γ = effect of survey time
β = regression coefficient
x = observed priority consonance index
ϵ = random error component

DATA:

PERFORMANCE -TO-SCHEDULE	TEAM	TIME	PRIORITY CONSONANCE
0.960	B	1	0.607
0.979	D	1	0.629
0.955	Q	1	0.674
0.835	R	1	0.350
0.931	S	1	0.678
0.870	B	2	0.655
0.978	D	2	0.614
0.956	Q	2	0.559
0.911	R	2	0.580
0.941	S	2	0.730
0.858	B	3	0.479
0.933	D	3	0.709
0.973	R	3	0.682
0.969	S	3	0.713

RESULTS:

	F VALUE	PR > F		
MODEL	1.45	0.3341		
VARIABLES				
TEAM	0.64	0.6546		
TIME	0.12	0.8876		
PRIOR.	4.05	0.0907	B1=	0.3006

STD. ERR. OF EST.: 0.1493

*THESE RESULTS OBTAINED USING @SAS

CONCLUSION:

THERE IS A STATISTICALLY SIGNIFICANT POSITIVE RELATIONSHIP BETWEEN PRIORITY CONSONANCE AND PERFORMANCE-TO-SCHEDULE.

PERFORMANCE-TO-SCHEDULE AS FUNCTION OF DECISION MAKING

MODEL: $y_{ij} = \mu + \tau_i + \gamma_j + \beta(x_{ij} - \bar{x}_{..}) + \epsilon_{ij}$

where: y = observed performance-to-schedule
μ = overall mean
τ = effect of team
γ = effect of survey time
β = regression coefficient
x = observed team decision making index
ϵ = random error component

DATA:

PERFORMANCE -TO-SCHEDULE	TEAM	TIME	DECISION MAKING
0.960	B	1	16.0
0.979	D	1	14.0
0.955	Q	1	15.5
0.835	R	1	16.0
0.931	S	1	14.5
0.870	B	2	12.5
0.978	D	2	14.0
0.956	Q	2	13.5
0.911	R	2	17.0
0.941	S	2	14.0
0.858	B	3	13.0
0.933	D	3	14.0
0.973	R	3	16.5
0.969	S	3	15.0

RESULTS:

	F VALUE	PR > F		
MODEL	1.82	0.2421		
VARIABLES				
TEAM	3.06	0.1074		
TIME	0.77	0.5044		
DEC. MAK.	5.67	0.0547	B1=	0.0336

STD. ERR. OF EST.: 0.0141

*THESE RESULTS OBTAINED USING @SAS

CONCLUSION:

THERE IS A STATISTICALLY SIGNIFICANT POSITIVE RELATIONSHIP BETWEEN DECISION MAKING AND PERFORMANCE-TO-SCHEDULE.

QUALITY AS A FUNCTION OF TEAM FLEXIBILITY

MODEL: $y_{ij} = \mu + \tau_i + \gamma_j + \beta(x_{ij} - \bar{x}_{..}) + \epsilon_{ij}$

where: y = observed quality
μ = overall mean
τ = effect of team
γ = effect of survey time
β = regression coefficient
x = observed team flexibility index
ϵ = random error component

DATA:

QUALITY	TEAM	TIME	FLEXIBILITY
0.973	B	1	0.617
0.947	D	1	0.532
0.974	Q	1	0.640
0.950	R	1	0.535
0.963	S	1	0.697
0.990	B	2	0.757
0.953	D	2	0.645
0.971	Q	2	0.667
0.947	R	2	0.583
0.960	S	2	0.683
0.983	B	3	0.790
0.928	D	3	0.635
0.948	R	3	0.625
0.951	S	3	0.695

RESULTS:

	F VALUE	PR > F		
MODEL	16.19	0.0017		
VARIABLES				
TEAM	6.45	0.0230		
TIME	6.00	0.0371		
FLEX.	6.68	0.0415	B1=	0.1348

STD. ERR. OF EST.: 0.0521

*THESE RESULTS OBTAINED USING @SAS

CONCLUSION:

THERE IS A STATISTICALLY SIGNIFICANT POSITIVE RELATIONSHIP BETWEEN TEAM FLEXIBILITY AND QUALITY OF PRODUCT.

QUALITY AS A FUNCTION OF HELP OPPORTUNITIES

MODEL: $y_{ij} = \mu + \tau_i + \gamma_j + \beta(x_{ij} - \bar{x}_{..}) + \epsilon_{ij}$

where: y = observed quality
μ = overall mean
τ = effect of team
γ = effect of survey time
β = regression coefficient
x = observed help opportunities index
ϵ = random error component

DATA:

QUALITY	TEAM	TIME	HELP OPPORTUNITIES
0.973	B	1	54
0.947	D	1	42
0.974	Q	1	84
0.950	R	1	20
0.963	S	1	60
0.990	B	2	8
0.953	D	2	53
0.971	Q	2	58
0.947	R	2	18
0.960	S	2	45
0.983	B	3	32
0.928	D	3	54
0.948	R	3	20
0.951	S	3	25

RESULTS:

	F VALUE	PR > F	
MODEL	7.74	0.0118	
VARIABLES			
TEAM	12.22	0.0048	
TIME	1.57	0.2828	
HELP	0.40	0.5518	B1= -0.0001

STD. ERR. OF EST.: 0.0002

*THESE RESULTS OBTAINED USING @SAS

CONCLUSION:

THERE IS NOT A STATISTICALLY SIGNIFICANT RELATIONSHIP BETWEEN HELP OPPORTUNITIES AND QUALITY OF PRODUCT.

QUALITY AS A FUNCTION OF COLLABORATION INDEX 1

MODEL: $y_{ij} = \mu + \tau_i + \gamma_j + \beta(x_{ij} - \bar{x}_{..}) + \epsilon_{ij}$

where: y = observed quality
μ = overall mean
τ = effect of team
γ = effect of survey time
β = regression coefficient
x = observed collaboration index 1
ϵ = random error component

DATA:

QUALITY	TEAM	TIME	COLLAB1
0.973	B	1	0.774
0.947	D	1	0.953
0.974	Q	1	1.030
0.950	R	1	0.558
0.963	S	1	1.230
0.990	B	2	0.699
0.953	D	2	0.779
0.971	Q	2	1.025
0.947	R	2	1.123
0.960	S	2	1.616
0.983	B	3	0.769
0.928	D	3	0.753
0.948	R	3	1.009
0.951	S	3	1.486

RESULTS:

	F VALUE	PR > F	
MODEL	7.44	0.0130	
VARIABLES			
TEAM	11.53	0.0056	
TIME	1.50	0.2966	
COLLAB1	0.17	0.6949	B1= -0.0068

STD. ERR. OF EST.: 0.0165

*THESE RESULTS OBTAINED USING @SAS

CONCLUSION:

THERE IS NOT A STATISTICALLY SIGNIFICANT RELATIONSHIP BETWEEN COLLABORATION INDEX 1 AND QUALITY OF PRODUCT.

QUALITY AS A FUNCTION OF COLLABORATION INDEX 2

MODEL: $y_{ij} = \mu + \tau_i + \gamma_j + \beta(x_{ij} - \bar{x}_{..}) + \epsilon_{ij}$

where: y = observed quality
μ = overall mean
τ = effect of team
γ = effect of survey time
β = regression coefficient
x = observed collaboration index 2
ϵ = random error component

DATA:

QUALITY	TEAM	TIME	COLLAB2
0.973	B	1	0.681
0.947	D	1	0.595
0.974	Q	1	0.814
0.950	R	1	0.462
0.963	S	1	0.849
0.990	B	2	0.596
0.953	D	2	0.558
0.971	Q	2	0.808
0.947	R	2	0.876
0.960	S	2	0.835
0.983	B	3	0.638
0.928	D	3	0.620
0.948	R	3	0.908
0.951	S	3	0.897

RESULTS:

	F VALUE	PR > F	
MODEL	7.47	0.0129	
VARIABLES			
TEAM	11.79	0.0053	
TIME	1.18	0.3684	
COLLAB2	0.20	0.6729	B1= -0.0108

STD. ERR. OF EST.: 0.0244

*THESE RESULTS OBTAINED USING @SAS

CONCLUSION:

THERE IS NOT A STATISTICALLY SIGNIFICANT RELATIONSHIP BETWEEN COLLABORATION INDEX 2 AND QUALITY OF PRODUCT.

QUALITY AS A FUNCTION OF COMMUNICATION EFFECTIVENESS

MODEL: $y_{ij} = \mu + \tau_i + \gamma_j + \beta(x_{ij} - \bar{x}_{..}) + \epsilon_{ij}$

where: y = observed quality
μ = overall mean
τ = effect of team
γ = effect of survey time
β = regression coefficient
x = observed communication effectiveness index
ϵ = random error component

DATA:

QUALITY	TEAM	TIME	COMMUNICATION EFFECTIVENESS
0.973	B	1	0.770
0.947	D	1	0.830
0.974	Q	1	0.788
0.950	R	1	0.780
0.963	S	1	0.840
0.990	B	2	0.780
0.953	D	2	0.825
0.971	Q	2	0.755
0.947	R	2	0.836
0.960	S	2	0.817
0.983	B	3	0.800
0.928	D	3	0.844
0.948	R	3	0.860
0.951	S	3	0.800

RESULTS:

	F VALUE	PR > F		
MODEL	7.86	0.0113		
VARIABLES				
TEAM	7.17	0.0180		
TIME	1.78	0.2465		
COMM.	0.49	0.5114	B1=	0.079

STD. ERR. OF EST.: 0.1132

*THESE RESULTS OBTAINED USING @SAS

CONCLUSION:

THERE IS NOT A STATISTICALLY SIGNIFICANT RELATIONSHIP BETWEEN COMMUNICATION EFFECTIVENESS AND QUALITY OF PRODUCT

QUALITY AS A FUNCTION OF PRIORITY CONSONANCE

MODEL: $Y_{ij} = \mu + \tau_i + \gamma_j + \beta(x_{ij} - \bar{x}_{..}) + \epsilon_{ij}$

where: y = observed quality
μ = overall mean
τ = effect of team
γ = effect of survey time
β = regression coefficient
x = observed priority consonance index
ϵ = random error component

DATA:

QUALITY	TEAM	TIME	PRIORITY CONSONANCE
0.973	B	1	0.607
0.947	D	1	0.629
0.974	Q	1	0.674
0.950	R	1	0.350
0.963	S	1	0.678
0.990	B	2	0.655
0.953	D	2	0.614
0.971	Q	2	0.559
0.947	R	2	0.580
0.960	S	2	0.730
0.983	B	3	0.479
0.928	D	3	0.709
0.948	R	3	0.682
0.951	S	3	0.713

RESULTS:

	F VALUE	PR > F	
MODEL	7.42	0.0131	
VARIABLES			
TEAM	11.51	0.0056	
TIME	1.35	0.3276	
PRIOR.	0.16	0.7045	B1= -0.0112

STD. ERR. OF EST.: 0.0282

*THESE RESULTS OBTAINED USING @SAS

CONCLUSION:

THERE IS NOT A STATISTICALLY SIGNIFICANT RELATIONSHIP BETWEEN PRIORITY CONSONANCE AND QUALITY OF PRODUCT.

QUALITY AS A FUNCTION OF DECISION MAKING

MODEL: $y_{ij} = \mu + \tau_i + \gamma_j + \beta(x_{ij} - \bar{x}_{..}) + \epsilon_{ij}$

where: y = observed quality
μ = overall mean
τ = effect of team
γ = effect of survey time
β = regression coefficient
x = observed team decision making index
ϵ = random error component

DATA:

QUALITY	TEAM	TIME	DECISION MAKING
0.973	B	1	16.0
0.947	D	1	14.0
0.974	Q	1	15.5
0.950	R	1	16.0
0.963	S	1	14.5
0.990	B	2	12.5
0.953	D	2	14.0
0.971	Q	2	13.5
0.947	R	2	17.0
0.960	S	2	14.0
0.983	B	3	13.0
0.928	D	3	14.0
0.948	R	3	16.5
0.951	S	3	15.0

RESULTS:

	F VALUE	PR > F	
MODEL	10.60	0.0052	
VARIABLES			
TEAM	13.27	0.0039	
TIME	2.04	0.2106	
DEC. MAK.	2.52	0.1633	B1= -0.0038

STD. ERR. OF EST.: 0.0024

*THESE RESULTS OBTAINED USING @SAS

CONCLUSION:

THERE IS NOT A STATISTICALLY SIGNIFICANT RELATIONSHIP BETWEEN DECISION MAKING AND QUALITY OF PRODUCT.

LABOR EFFICIENCY AS A FUNCTION OF TEAM FLEXIBILITY

MODEL: $y_{ij} = \mu + \tau_i + \gamma_j + \beta(x_{ij} - \bar{x}_{..}) + \epsilon_{ij}$

where: y = observed labor efficiency
μ = overall mean
τ = effect of team
γ = effect of survey time
β = regression coefficient
x = observed team flexibility index
ϵ = random error component

DATA:

LABOR EFFICIENCY	TEAM	TIME	FLEXIBILITY
9.039	B	1	0.617
8.870	D	1	0.532
9.360	Q	1	0.640
10.170	R	1	0.535
9.620	S	1	0.697
8.860	B	2	0.757
9.130	D	2	0.645
9.350	Q	2	0.667
9.690	R	2	0.583
9.500	S	2	0.683
7.990	B	3	0.790
8.130	D	3	0.635
9.030	R	3	0.625
8.680	S	3	0.695

RESULTS:

	F VALUE	PR > F		
MODEL	25.86	0.0004		
VARIABLES				
TEAM	17.64	0.0018		
TIME	30.85	0.0007		
FLEX.	0.10	0.7628	B1=	0.4627

STD. ERR. OF EST.: 1.4647

*THESE RESULTS OBTAINED USING @SAS

CONCLUSION:

THERE IS NOT A STATISTICALLY SIGNIFICANT RELATIONSHIP BETWEEN TEAM FLEXIBILITY AND LABOR EFFICIENCY.

LABOR EFFICIENCY AS A FUNCTION OF HELP C.'ORTUNITIES

MODEL: $y_{ij} = \mu + \tau_i + \gamma_j + \beta(x_{ij} - \bar{x}_{..}) + \epsilon_{ij}$

where: y = observed labor efficiency
μ = overall mean
τ = effect of team
γ = effect of survey time
β = regression coefficient
x = observed help opportunities index
ϵ = random error component

DATA:

LABOR EFFICIENCY	TEAM	TIME	HELP OPPORTUNITIES
9.039	B	1	54
8.870	D	1	42
9.360	Q	1	84
10.170	R	1	20
9.620	S	1	60
8.860	B	2	8
9.130	D	2	53
9.350	Q	2	58
9.690	R	2	18
9.500	S	2	45
7.990	B	3	32
8.130	D	3	54
9.030	R	3	20
8.680	S	3	25

RESULTS:

	F VALUE	PR > F		
MODEL	26.31	0.0004		
VARIABLES				
TEAM	19.41	0.0014		
TIME	43.04	0.0003		
HELP	0.20	0.6692	B1=	0.0018

STD. ERR. OF EST.: 0.0040

*THESE RESULTS OBTAINED USING @SAS

CONCLUSION:

THERE IS NOT A STATISTICALLY SIGNIFICANT RELATIONSHIP BETWEEN HELP OPPORTUNITIES AND LABOR EFFICIENCY.

LABOR EFFICIENCY AS A FUNCTION OF COLLABORATION INDEX 1

MODEL: $y_{ij} = \mu + \tau_i + \gamma_j + \beta(x_{ij} - \bar{x}_{..}) + \epsilon_{ij}$

where: y = observed labor efficiency
μ = overall mean
τ = effect of team
γ = effect of survey time
β = regression coefficient
x = observed collaboration index 1
ϵ = random error component

DATA:

LABOR EFFICIENCY	TEAM	TIME	COLLAB1
9.039	B	1	0.774
8.870	D	1	0.953
9.360	Q	1	1.030
10.170	R	1	0.558
9.620	S	1	1.230
8.860	B	2	0.699
9.130	D	2	0.779
9.350	Q	2	1.025
9.690	R	2	1.123
9.500	S	2	1.616
7.990	B	3	0.769
8.130	D	3	0.753
9.030	R	3	1.009
8.680	S	3	1.486

RESULTS:

	F VALUE	PR > F	
MODEL	61.50	0.0001	
VARIABLES			
TEAM	46.36	0.0001	
TIME	98.01	0.0001	
COLLAB1	8.24	0.0284	B1= -0.6084

STD. ERR. OF EST.: 0.2120

*THESE RESULTS OBTAINED USING @SAS

CONCLUSION:

THERE IS A STATISTICALLY SIGNIFICANT NEGATIVE RELATIONSHIP BETWEEN COLLABORATION INDEX 1 AND HOURS PER BOARD.

LABOR EFFICIENCY AS A FUNCTION OF COLLABORATION INDEX 2

MODEL: $y_{ij} = \mu + \tau_i + \gamma_j + \beta(x_{ij} - \bar{x}_{..}) + \epsilon_{ij}$

where: y = observed labor efficiency
μ = overall mean
τ = effect of team
γ = effect of survey time
β = regression coefficient
x = observed collaboration index 2
ϵ = random error component

DATA:

LABOR EFFICIENCY	TEAM	TIME	COLLAB2
9.039	B	1	0.681
8.870	D	1	0.595
9.360	Q	1	0.814
10.170	R	1	0.462
9.620	S	1	0.849
8.860	B	2	0.596
9.130	D	2	0.558
9.350	Q	2	0.808
9.690	R	2	0.876
9.500	S	2	0.835
7.990	B	3	0.638
8.130	D	3	0.620
9.030	R	3	0.908
8.680	S	3	0.897

RESULTS:

	F VALUE	PR > F	
MODEL	43.24	0.0001	
VARIABLES			
TEAM	29.85	0.0004	
TIME	54.30	0.0001	
COLLAB2	4.07	0.0904	B1= -0.7527

STD. ERR. OF EST.: 0.3733

*THESE RESULTS OBTAINED USING @SAS

CONCLUSION:

THERE IS A STATISTICALLY SIGNIFICANT NEGATIVE RELATIONSHIP BETWEEN COLLABORATION INDEX 2 AND HOURS PER BOARD.

LABOR EFFICIENCY AS A FUNCTION OF COMMUNICATION EFFECTIVENESS

MODEL: $y_{ij} = \mu + \tau_i + \gamma_j + \beta(x_{ij} - \bar{\bar{x}}_{..}) + \epsilon_{ij}$

where: y = observed labor efficiency
μ = overall mean
τ = effect of team
γ = effect of survey time
β = regression coefficient
x = observed communication effectiveness index
ϵ = random error component

DATA:

LABOR EFFICIENCY	TEAM	TIME	COMMUNICATION EFFECTIVENESS
9.039	B	1	0.770
8.870	D	1	0.830
9.360	Q	1	0.788
10.170	R	1	0.780
9.620	S	1	0.840
8.860	B	2	0.780
9.130	D	2	0.825
9.350	Q	2	0.755
9.690	R	2	0.836
9.500	S	2	0.817
7.990	B	3	0.800
8.130	D	3	0.844
9.030	R	3	0.860
8.680	S	3	0.800

RESULTS:

	F VALUE	PR > F	
MODEL	36.10	0.0002	
VARIABLES			
TEAM	28.57	0.0005	
TIME	48.92	0.0002	
COMM.	2.44	0.1695	B1= -3.0189

STD. ERR. OF EST.: 1.9336

*THESE RESULTS OBTAINED USING @SAS

CONCLUSION:

THERE IS NOT A STATISTICALLY SIGNIFICANT RELATIONSHIP BETWEEN COMMUNICATION EFFECTIVENESS AND LABOR EFFICIENCY.

LABOR EFFICIENCY AS A FUNCTION OF PRIORITY CONSONANCE

MODEL: $y_{ij} = \mu + \tau_i + \gamma_j + \beta(x_{ij} - \bar{x}_{..}) + \epsilon_{ij}$

where: y = observed labor efficiency
μ = overall mean
τ = effect of team
γ = effect of survey time
β = regression coefficient
x = observed priority consonance index
ϵ = random error component

DATA:

LABOR EFFICIENCY	TEAM	TIME	PRIORITY CONSONANCE
9.039	B	1	0.607
8.870	D	1	0.629
9.360	Q	1	0.674
10.170	R	1	0.350
9.620	S	1	0.678
8.860	B	2	0.655
9.130	D	2	0.614
9.350	Q	2	0.559
9.690	R	2	0.580
9.500	S	2	0.730
7.990	B	3	0.479
8.130	D	3	0.709
9.030	R	3	0.682
8.680	S	3	0.713

RESULTS:

	F VALUE	PR > F	
MODEL	31.01	0.0003	
VARIABLES			
TEAM	24.07	0.0008	
TIME	48.28	0.0002	
PRIOR.	1.27	0.3021	B1= -0.5707

STD. ERR. OF EST.: 0.5057

*THESE RESULTS OBTAINED USING @SAS

CONCLUSION:

THERE IS NOT A STATISTICALLY SIGNIFICANT RELATIONSHIP BETWEEN PRIORITY CONSONANCE AND LABOR EFFICIENCY.

LABOR EFFICIENCY AS A FUNCTION OF DECISION MAKING

MODEL: $y_{ij} = \mu + \tau_i + \gamma_j + \beta(x_{ij} - \bar{x}_{..}) + \epsilon_{ij}$

where: y = observed labor efficiency
μ = overall mean
τ = effect of team
γ = effect of survey time
β = regression coefficient
x = observed team decision making index
ϵ = random error component

DATA:

LABOR EFFICIENCY	TEAM	TIME	DECISION MAKING
9.039	B	1	16.0
8.870	D	1	14.0
9.360	Q	1	15.5
10.170	R	1	16.0
9.620	S	1	14.5
8.860	B	2	12.5
9.130	D	2	14.0
9.350	Q	2	13.5
9.690	R	2	17.0
9.500	S	2	14.0
7.990	B	3	13.0
8.130	D	3	14.0
9.030	R	3	16.5
8.680	S	3	15.0

RESULTS:

	F VALUE	PR > F	
MODEL	25.63	0.0005	
VARIABLES			
TEAM	10.06	0.0079	
TIME	44.65	0.0002	
DEC. MAK.	0.05	0.8374	B1= -0.0121

STD. ERR. OF EST.: 0.0565

*THESE RESULTS OBTAINED USING @SAS

CONCLUSION:

THERE IS NOT A STATISTICALLY SIGNIFICANT RELATIONSHIP BETWEEN DECISION MAKING AND LABOR EFFICIENCY.

VITA

KEVIN PATRICK GRANT

14206 Golden Woods, San Antonio, Texas 78249

Education

DEC 90 Ph.D., Industrial Engineering, Texas A & M University.

SEP 83 M.S., Systems Management, Air Force Institute of Technology.

MAY 80 B.S., Management, United States Air Force Academy.

Professional Experience

OCT 83 - JUL 87 **Program Manager**, Aeromedical/Casualty System Program Office, Human Systems Division, Air Force Systems Command. Responsible for acquisition management of the Survivable Collective Protection System - Medical (SCPS-M); a wartime emergency medical shelter.

MAY 81 - JUN 82 **Project Manager**, A-10 System Program Office, Aeronautical Systems Division, Air Force Systems Command. Responsible for the analysis and correction of operational deficiencies associated with the electrical, hydraulic and lighting systems of the A-10 aircraft.

JUL 80 - MAY 81 **Configuration Management Officer**, A-10 System Program Office, Aeronautical Systems Division, Air Force Systems Command (July 1980 - May 1981). Responsible for management and control of all engineering changes to the A-10 gun, ammunition and ammunition loading system.