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LEAN MANUFACTURING - AN INTEGRATED SOCIO-TECHNICAL SYSTEMS APPROACH TO WORK DESIGN

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LEAN MANUFACTURING - AN INTEGRATED SOCIO-TECHNICAL SYSTEMS APPROACH TO WORK DESIGN

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ABSTRACT

Over the years, the manufacturing industry has witnessed a number of work design practices, based on different principles, which have significantly shaped the nature of work and have affected employees' behavior and performance. This study compares the socio-technical systems (STS) principles and lean production (LP) principles in to explore the potential for synergistic integration between the two. They are categorized according to the common overarching goals of these principles, and through a process of theoretical rationalization, these categories are operationalized into the work design practices of middle management support, social practices usage, and technical practices usage.

A model of work design is proposed to test the relationships between these work practices and to understand their effect on employees' quality of work life and performance. The effect of task interdependence is also examined since teams are the basic unit of analysis in STS and LP approaches to work design. This model is tested with a cross-sectional survey research in which team leaders in manufacturing plants in the United States were the key respondents.

Statistical analyses of survey data yielded three key findings. Middle management support has a positive direct and indirect effect on improved employee performance, a positive direct effect on social practices usage, and a positive indirect effect on technical practices usage and on employees' quality of work life. Social practices usage has a total positive direct effect on technical practices usage, and a positive indirect effect on employees' quality of work life and their performance. Technical practices usage has a direct effect on both quality of work life and employee performance.

This study provides empirical support for the definition of lean production posited by Shah and Ward (2007). Results indicate that middle management is crucial for the implementation and sustainability of a lean system because it offers the support necessary for the usage of social and technical practices. Applications for manufacturing organizations and suggestions for future research are presented.

Keywords: Lean principles, work design practice, socio-technical systems principles, quality of work life, employee performance, task interdependence, manufacturing

DEDICATION

This dissertation is lovingly dedicated to my parents and grandparents:

Iqbal Z Raja, Dad	late Zainuddin A Raja, Dadaji
late Munira I Raja, Mom	Batul Z Raja, Dadima

It was their encouragement, love, and sacrifices that enabled me to achieve this goal.

Raat jitni bhi sangeen hogi,
Subah utni hi rangeen hogi.
Raat bhar ka mehman hai yeh andhera,
Kiske roke ruka hai savera.

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CHAPTER 1. INTRODUCTION

Over the years, organizations have witnessed a number of work-design practices based on different principles. These design practices have significantly shaped the nature of work (Ohno, 1988; Cherns, 1976; Trist & Bamforth, 1951; Taylor, 1947; Taylor, 1911) and have affected employees' behavior and performance within an organization (Conti et.al., 2006; Liker, 2004; Bruno & Jordan, 2002; Waterson et.al., 2002 Jones, 2000; Babson, 1993). Prominent among them are the 'Tayloristic or Fordistic' practices based on scientific management principles (Taylor, 1947, 1911), the 'holistic open systems' practices based on the socio-technical systems (STS) principles (Hyer et.al., 1999; Taylor & Felten, 1993; Cherns, 1987, 1976), and the lean production (LP) practices based on the principles of the Toyota Production System (Shah & Ward, 2007; Dennis, 2007; Liker, 2004; Womack and Jones, 1996).

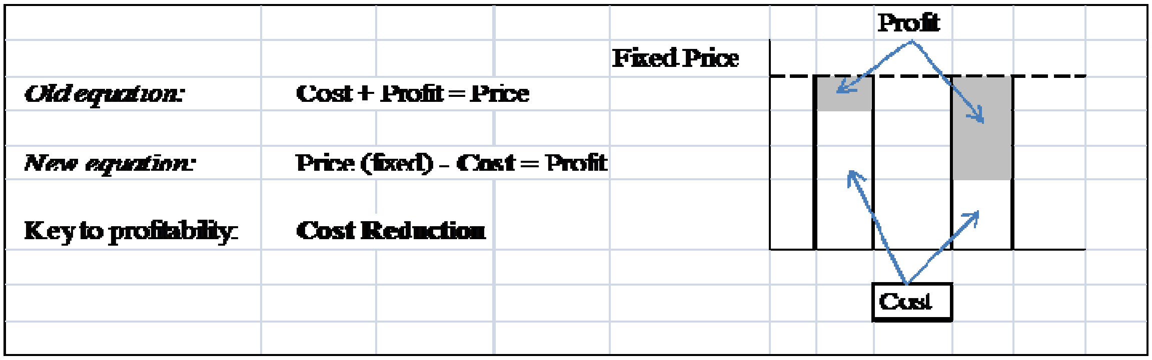
This study provides a clear comparison between the STS and LP approaches to work design practice and explores the potential for synergistic integration between the two. Specific work practices are identified from theoretical arguments in STS and LP literature to develop an integrated model of work design practice that is grounded in both approaches. Furthermore, the model developed in this study is an attempt to build a theory on lean production, which is based on the definition of lean provided by Shah & Ward (2007). To validate the theory, this model is then examined empirically to evaluate how these practices affect employees' performance and their quality of work life in an organization.

1.1. Background of work design practices

The Fordist-Tayloristic practice developed in the 1920's broke away from the then popular craftsmanship approach to manufacturing. This work design practice optimized the way in which work tasks were performed in manufacturing to improve productivity. Taylor (1911) proposed four principles in his book, *The Principles of Scientific Management*, which formed the basis of this work design practice. The first principle focused on replacing rule-of-thumb work methods with methods based on a scientific study of the tasks. The second principle emphasizes the need to scientifically select, train, and develop workers, rather than leave them to train themselves. The third principle focused on the cooperation of managers with their workers to ensure that the scientifically developed methods were being followed. Finally, the fourth principle referred to the execution of work, wherein the managers apply scientific management principles to plan the work and the workers actually perform the tasks. These principles described the application of the scientific method to the management of workers. The Fordist-Tayloristic practice created a clear delineation of authority and responsibility by separating planning from operations, which resulted in improved productivity (Forza, 1996).

The socio-technical systems (STS) approach developed in the 1950's at the Tavistock Institute of Human Relations provided a form of work design practice very different from the traditional 'Tayloristic' approach (Trist & Bamforth, 1951, Trist, 1981). It proposed the introduction of autonomous work groups as the basic unit of organizational design and emphasized the unity of preparation, execution, and control at the lowest possible level in an organization (Hyer et.al., 1999). The STS approach emphasized the joint optimization of the social and technical systems of an organization by providing a conceptual framework and methodology to enhance the overall systems performance (Emery, 1959, Cherns, 1976, 1987). This approach was purpose-oriented and addressed the whole system instead of the problem-oriented or solution-oriented approach of 'Taylorism', which addressed only part of the system (Taylor & Felten, 1993; Taylor & Asadorian, 1985).

The origins of the LP system can be traced to the Toyota Production System (TPS) at Toyota Motor Company (Shah & Ward, 2007; Holweg, 2007), which implemented the concepts of just-in-time (JIT) and 'autonomation'. JIT emphasized low cost production through the elimination of waste in the system (Monden, 1993; Ohno, 1988), whereas 'autonomation' – automation with a human touch – recognized workers' diligence and ability; and therefore, entrusted them with greater responsibility and authority (Sugimori et.al., 1977). The LP approach came to be known as 'doing more with less' – less time, less space, less human effort, less machinery (Womack and Jones, 1996; Womack et.al., 1990). As shown in Figure 1.1, this approach focused on achieving higher profitability by reduction costs, rather than the traditional approach of increasing price to increase profitability (Dennis, 2007). LP approaches advocate the latter to improve profits, thereby giving customers better quality products at for the same prices.



Adopted from Dennis (2007)
Figure 1.1. Key to profitability using a lean approach.

Each of the three approaches discussed above have a distinct influence on the organizational work design. However, a deeper look reveals that STS and LP approaches have more in common with each other as opposed to the Fordist-Tayloristic approach to work design. Table 1.1 illustrates the focus of STS and LP approaches, and the Fordist-Tayloristic approach on organizational changes, management role changes, and employee role changes within an organization.

Table 1.1 A comparison of the STS/LP and Tayloristic approaches to work design practice

	STS / LP approach to work design	**Tayloristic approach to work design**
Organizational Change	1. Open systems thinking 2. Product focus 3. Semi-autonomous groups; teams 4. Long term focus 5. Quality and quantity	1. Closed systems thinking 2. Task focus 3. Individual 4. Short term focus 5. Quantity
Management Role Change	1. Participative and collaborative 2. Empower employees 3. Encourage innovation	1. Directive and competitive 2. Command and conquer 3. Risk averse
Employee Role Change	1. Informed 2. Assertive 3. Multi-functional skill-set 4. Empowered	1. Uninformed 2. Passive 3. Single skill-set 4. Dependent

Adapted from Taylor & Felten (1993)

Organizational Change

In an integrated STS and LP approach to work design, work practices are developed as an 'open system[1]' and are based on a holistic view, which is grounded in systems theory (Von Bertalanffy, 1950). The boundaries of work practices are defined in terms of the product focus; hence facilitating a systems thinking approach. Semi-autonomous groups and teamwork is promoted in these approaches (Liker, 2004; Trist, 1981). Finally, the organizations implementing the integrated STS and LP approach to work design have a long term focus and recognize both quantity and quality as measures for products being manufactured.

On the other hand, work practices developed based on the traditional Fordist-Tayloristic approach to work design are developed as a 'closed system', wherein the focus is only on the technical component of organizational work design. The boundaries of work practices are based on the task that is to be performed (Dankbaar, 1997; Taylor, 1911). The unit of control is the individual workers (Taylor, 1911). Finally, the organizations implementing the Fordist-Tayloristic approach to work design have a short term focus and only recognize the performance of employees in terms of quantity produced.

[1] A system that spontaneously reorganizes towards states of greater heterogeneity and complexity and achieve a steady state at a level where they can still do work (Bertalanffy, 1950)

Management role change

In an STS/LP approach to work design, the management role is more participative and collaborative. Managers require employees to participate in decision making on issues that affect their work. They act as facilitators to collaborate with employees on how best to implement the chosen decisions. Managers empower employees to innovate and improve existing processes (Spear & Bowen, 1999; Lawler et.al., 1995; Huber & Brown, 1991; Ohno, 1988).

On the other hand, work practices developed based on the Tayloristic approach is directive and competitive. Managers do not involve employees in decision making, instead provide them with instructions. Managers tend to be competitive since they are always trying to achieve one's departmental goals, even if it means compromising the overall company goals. Managers like to have control over the decision making and are risk averse (Dankbaar, 1997; Taylor, 1911).

Employee role change

In an STS/LP approach to work design, employees are well informed about their organization in terms of its social, technical and environmental components. They are encouraged to be assertive and learn multiple skills so that they can perform multiple tasks in the future (Closs et.al., 2008; Dennis, 2007; Huber & Brown, 1991). Most importantly, the employees are empowered to make design and process changes if it helps in both product and process improvements respectively (Ohno, 1988; Lawler et.al., 1995).

On the other hand, work practices developed based on a Fordist-Tayloristic approach to work design, the employees are uninformed, passive, and possess only a single skill-set. They are mostly dependent on management to provide them with details on how to perform their job (Briscoe, 1980; Taylor, 1911).

1.2. Research questions

The broad objective of this study is to provide a clear comparison between the STS and LP approaches to work design and to explore the potential for synergistic integration of work practices based on these two approaches. More specifically, this study aims to identify specific work practices from theoretical arguments based on STS and lean principles. A model of work design is then proposed to test the relationship between the identified practices and to understand the effect of those practices on the employees' performance and their quality of work life.

1.1.1. Research question 1

This research question is conceptualized based on the definition of lean production proposed by Shah and Ward (2007). They defined lean as "an integrated socio-technical system whose main objective is to eliminate waste by concurrently reducing supplier, customer and internal variability". The key word in this definition, "integrated socio-technical system," provides an answer to the question raised by Dankbaar (1997) **–** can STS be subsumed under the lean production approach? However, apart from this definition, there is no research, empirical or anecdotal, that provides an explanation of how these two different approaches (i.e. lean and STS) can be combined together in terms of an integrated work design.

At best, studies by Niepce and Molleman (1998) and Dankbaar (1997) evaluated lean production against the STS design principles proposed by Cherns (1987). The results of this comparison showed irreconcilable differences between the two approaches. A study by Manz and Stewart (1997) provided a theoretical model which addressed the potential for synergistic integration of the STS and lean practices to attain organizational flexibility and stability. However, they conclude that "a clear understanding of the theoretical principles underlying both STS and TQM can help researchers focus more on the integration of these two important approaches" (pg. 68). This study identifies work practices based on the approach used by Liu et.al. (2006). Thus the research question: **What work practices integrate the socio-technical systems and lean production approaches to organizational work design within manufacturing?**

1.1.2. Research question 2

Critics of LP argue that lean is not any different from the Tayloristic approach (Bruno & Jordan, 2002; Dankbaar, 1997; Berggren, 1994; Babson, 1993). They refer to LP as "High-Fordism" (Dohse et.al., 1985), "Neo-Taylorism" (Dankbaar, 1997), or "mean production" (Babson, 1993). In fact, according to most critics, LP has revamped, intensified, or maintained some of the defining elements of Taylorism, and has lead to a lower quality of work life (Parker, 2003; Dankbaar, 1997). For example, the multiple tasks are variations of similar simple jobs with shorter training requirements, representing multi-tasking rather than multi-skilling (Delbridge et.al., 2001). Employee participation in decision making is suggested to be very limited (Berggren, 1994). Team working environment, portrayed as being positive by advocates, has been argued by critics to exploit peer pressure to facilitate the process of intensification (Bruno & Jordon, 2002, Babson, 1993).

On the contrary, proponents of the STS approach argue that optimization of the social elements (human interaction) with the technical elements (processes, technology) within an organization can lead to humanization of working conditions and improve the quality of work life for employees (Hyer et.al., 1999; Applebaum, 1997; Trist & Bamforth, 1951). Thus, if LP and STS approaches have two different perceived outcomes, it is important to understand the effects of the integrated work design on the quality of work life of employees. Thus the research question: **What are the effects of the identified organizational work practices on employees' quality of work life?**

1.1.3. **Research question 3**

Proponents of LP have touted unanimously that implementing lean practices has usually resulted in improved employee performance regarding quality, delivery reliability, productivity, and cost (Narasimhan et.al., 2006; Shah and Ward, 2003; McLachlin, 1997; Sohal, 1996; Katayama & Bennet, 1996; Krafcik, 1988). Critics of STS, on the other hand, have doubts about the sustainability of employee performance when using the STS approach (Kuipers et.al., 2004; Womack et.al., 1990; Womack & Jones, 1996). Since there are concerns about performance outputs between LP and STS approaches, it is important to understand what effect the integrated work practices have on employee performance. Thus the research question: **What are the effects of the identified organizational work practices on employee performance?**

1.1.4. **Research question 4**

The increased use of work groups (teams) in the STS and LP approaches to work design requires that greater importance be given to the design and implementation of the appropriate level of task interdependence (Wageman, 1995; Saavendra et.al., 1993; Thompson, 1967). More specifically, since the focus on work performance in organizations has shifted from individuals to teams (Liker, 2004; Shah and Ward, 2003; Sohal & Egglestone, 1994), it is imperative that managers consider task interdependency when evaluating employee productivity (Treville and Antonakis, 2006; Seibert et.al, 2004; Kozlowski and Bell, 2003). To this end, this study will assess the effect of task interdependence on the relationship between empowerment and employee performance. Thus the research question: **How does task interdependence affect employee performance?**

1.3. Structure of the dissertation

The remainder of this dissertation is organized as follows. Chapter two provides a literature review of three different research streams that are pertinent to the formulation of the research model. The bulk of this chapter consists of an extensive review of STS and lean literature. Organizational behavior and design literature is used to identify work practices that affect quality of work life and employee performance. Specifically, it focuses on the following work practices are discussed: middle management support, employee involvement, employee empowerment, and task interdependence. Operations management literature is used to identify and describe commonly used technical practices. Human resource management literature is used to review the quality of work life outcome.

Chapter three provides the theoretical arguments for the conceptualization of the research model. It contains the research model, which illustrates the relationships between the identified work practices and the two outcomes (i.e. employee performance and quality of work life). Lastly, a rationale for each hypothesis in this research model is provided.

Chapter four includes the research design, with details of the qualitative and quantitative procedures and methods used to test the research model. More specifically, it contains information on the unit of analysis, key informant, target sample frame, sample size, and the method for survey administration. In addition, this chapter also contains the description of measures for constructs used in the research model.

Chapter five contains the results of the data analyses. More specifically, it contains the description of the respondent sample, assessment of the constructs measurement properties (i.e. construct validity, reliability, descriptive statistics) and issues related to potential problems due to common method bias. In addition, this chapter also contains the assessment of the structural model and the results of the hypotheses tested in the model.

Finally, chapter six contains a summary of this dissertation. More specifically, it contains the key findings from the data analyses, the contribution of this study to academics and practitioners. Finally, it also contains the limitations and directions for future research, and the concluding thoughts of the author.

CHAPTER 2. LITERATURE REVIEW

2.1. Socio-technical systems

2.1.1. Origins of socio-technical systems

The socio-technical systems (STS) approach to organizational work design was developed in the early fifties at the Tavistock Institute of Human Relations in United Kingdom, as a result of the labor unrest and the disappointing productivity in the British coal mines (Dankbaar, 1997; Trist & Bamforth, 1951). The goal of this approach was to propose a work design that achieved two values: the humanization of the workplace by redesigning of jobs, and the democratization of the workplace to enhance organizational performance (Emery, 1959). The STS approach immediately found home in Europe, as there was a lack of 'quality of working life' value at the time, and the labor and management were always in adversarial modes.

Different groups in Europe became interested in this new approach for different reasons. As the region's manufacturing industry rebuilt and expanded after World War II, companies were faced with severe labor problems (e.g. difficulty obtaining and retaining staff). The engineers and technologists were presented with new design options which involved development of flexible and friendly production systems. Ergonomists started investigating the man-machine interaction. These fertile conditions allowed for the research, development and propagation of the STS approach to work design.

The STS approach to work design permeated several European countries during the early sixties and seventies. In Norway, as the result of a three-phased program for the implementation of STS, a law on working conditions was established that gave workers the right to demand jobs based on the STS principles of good work practice. Sweden followed suit and enacted a law that democratized working life. The French government introduced legislation requiring employers to demonstrate how they had improved working conditions and how they proposed to improve them further. A program for humanization of work was introduced by the German ministry of labor and of science and technology that emphasized the development of standards and minimum requirements for machines and workplaces, the development of technologies to meet human requirements, and models of organization of work based on the STS analysis used in Britain and Norway (for more details see Mumford, 2006).

In the seventies, the decline in U.S. productivity due to unsatisfied employees in the seventies aroused interest in the STS approach to organizational design (Mumford, 2006). Government and private foundations funded organizations such as the Center for Quality of Working Life, Work in America Institute, and American Productivity Center to foster labor-management cooperation in organizational change, and to conduct research on national policies and issues related to quality of work life (Taylor & Felten, 1993). In addition to these organizations, many industries experimented with this approach to improve their continuous processes; the results of which were mixed (Taylor & Felten, 1993).

Socio-technical systems provide a conceptual framework for the identification and management of human factors in technical environments (Trist, 1981; Trist & Bamforth, 1951), and a methodology for the redesign of work practices in an organization to enable more effective integration of human and technological resources

(Cherns, 1979, 1987; Cleggs, 2000). The STS approach emphasizes the autonomous work groups as the basic unit of organizational design and highlights the unity of preparation, execution, and control at the lowest possible level in an organization. An extensive review of organizational design literature reveals that the STS approach has never been operationally defined (Walker et.al., 2008). At best, it has been described as a holistic ‘open systems’ approach to organizational work design (Emery, 1959; Bertalanffy, 1950).

Researchers have taken two approaches to explaining STS. One set of researchers has described STS as an aggregation of interacting parts in an organization - social subsystem, technical subsystem, and environmental subsystem (Trist & Bamforth, 1951; Emery, 1959; Taylor & Felten, 1993). The other set of researchers has described STS as a set of principles (Davis, 66; Cherns, 1976, 1987; Clegg, 2000). The “interacting parts” description provides insight into ‘what’ elements of work design that make up the social subsystem and the technical subsystem. As a set of principles, STS provides insight into ‘how’ an organization achieves synergy between its technical and social systems.

2.1.2. STS as an aggregation of interacting parts

Various work models based on the STS approach consider that organizations are made up of three components: social subsystem, technical subsystem, and environmental subsystem. As seen in Table 2.1, the social subsystem encompasses individuals’ aptitudes, attitudes, beliefs, and relationships, both within and between groups (Carayon, 2006; Shani et.al., 1992; Pasmore, 1988). The technical subsystem encompasses how things get done. More specifically, it consists of tools, techniques, devices, artifacts, methods, configurations, procedures, technology, and knowledge used by the individuals in an organization to acquire inputs, and transform inputs into outputs (Wilson, 2000; Smith & Carayon, 1995; Shani et.al, 1992). The environmental subsystem consists of several subsystems (Pasmore, 1988). It frames and balances the social and technical subsystem interfaces with various internal and external stake holders, such as internal politics, physical environment, organizational conditions, customers, competitors, government, regulators, and societal and cultural pressures.

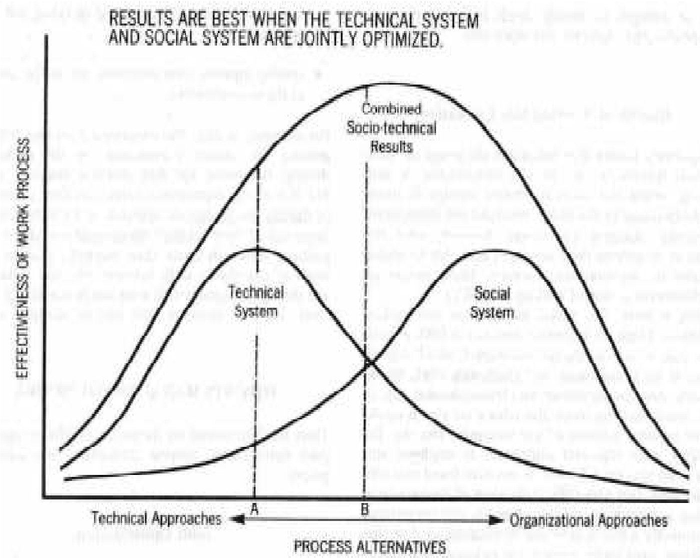
Table 2.1 Work models based on the STS approach

Authors	Components of STS		
	Social Subsystem	Technical Subsystem	Environmental Subsystem
Wilson, 2000 People interact with…..	• Other people (cooperative interaction) • Remote agents (temporal and spatial interaction) • Supply chain (logistical interaction)	• Task • Hardware and software (interface interaction) • Structure, policy, and roles (organizational interaction)	• Environment (setting interaction) • Society, finance, and politics (contextual interdependence)
Smith & Carayon, 1995 Individuals interact with…	• People	• Task • Tools/technology	• Physical environment • Organizational conditions
Hendrick & Kleiner, 2001	• Personnel sub-system	• Technological subsystem • Task and organizational design	• Internal and external environment
Rasmussen, 2000	• Staff involved in planning work • Management plans operations and supplies resources	• Productive processes and work performed by operator	• Company interacting with various regulations • Government
Moray, 2000	• Individual behavior • Team and group behavior	• Physical devices and physical ergonomics	• Organizational and management behavior • Legal and regulatory rules • Societal and cultural pressures

Adapted from Carayon (2006)

Mutual causality. It is seen that the social and the technical subsystems are mutually independent with respect to their origins. The social subsystem follows the principles of human sciences (e.g. sociology & psychology), while the technical subsystem follows the laws of natural sciences (e.g. chemistry, physics & mathematics) (Baba & Mejabi, 1997). However, according to Trist (1981), the two systems are correlated, in that one needs the other for the transformation of an input into an output. Thus, while the systems are causally independent, they are interdependent in action.

Joint optimization. The proponents of the STS approach to work design believe that the overall performance of the system depend not on the optimization of a single subsystem, but rather the joint optimization of the social with the technical subsystems within the context of the given environmental subsystem (Baba & Mejabi, 1997, Taylor & Felton, 1993; Taylor & Asadorian, 1985; Carayon, 2006). Figure 2.1 illustrates this concept of joint optimization. The combined optimum value for the integrated socio-technical system is greater than the individual optimum value of each system taken separately.



Adopted from Taylor and Asadorian (1985)

Figure 2.1. Joint optimization of the STS approach

2.1.3. **STS as a set of principles**

In order to design a work system which jointly optimizes the social and technical subsystem within an organization, researchers articulated the STS approach to organizational work design through a set of principles (Cherns, 1976, 1987; Trist, 1981; Clegg, 2000). Cherns (1976) compiled a set of nine principles based on the concepts distilled from the early work of researchers at the Tavistock Institute of Human Relations (Trist & Bamforth, 1951; Emery, 1959, Emery & Trist, 1972) to facilitate in work design based on the STS approach. In order to incorporate the changes in the business climate over time, Cherns amongst others (Trist, 1981; Clegg, 2000) revisited the principles articulated to facilitate the joint optimization of the social and technical subsystem within an organization. These researchers believed that a new or revised set of principles was needed to reflect the STS approach to work design due to the effect of globalization, newer technologies, and newer breed of workers.

Trist (1981) extended the earlier work of Cherns by providing clarity for STS principles according to the level of implementation (e.g. work system, organizational, or societal). Clegg (2000) explicitly provides principles that capture the design issues based on these different levels of implementation. The meta-principles provide a systemic worldview for design considerations, the content-principles focuses on specific aspects of the content of the new system, and finally the process-principles emphasize an overall process of design.

Cherns (1987) revised his earlier set of principles by including two new principles (power and authority, and transitional organizations), while removing one (design and human values). He suggested that this latter principle underpins all of the other principles and hence needed to be dropped. The principle of power and authority was added to make sure that top management does not misuse information or take charge of a situation remotely; instead, they should provide people at the forefront with not only access to pertinent resources, but also with the authority to command them. The principle of transitional organization emphasizes that members of the design team are engaged in the process of change within an organization.

2.1.3.1. **STS principles based on the works of Cherns**

Compatibility. This principle emphasizes that the systems design process should be consistent with the goals of the design (Cherns 1976, 1987). The design process should involve employee participation; and more importantly, the responsibility for planning and designing of the system should rests with the people who manage and use it (Hyer et.al., 1999). Being a participatory process, conflicts will arise as it is difficult to satisfy all aspects of the design objectives. These conflicts can be resolved through consensus, wherein each participating member provides rationale and assumptions to either support their point of view or refute someone else's. The degree of compatibility between the process and the desired outcome achieved through the participation of employees determines how well the other principles are implemented.

Minimum critical specification. This principle deals with specifying the ends but not the means while undertaking a task. This principle has two aspects. Firstly, specify no more than what is absolutely essential. Secondly, identify only what is essential and critical to the successful completion of the task (Cherns, 1976, 1987). In other words, determine '*what*' has to be done, and then '*how to do it*' should be left to the individuals or the team performing the task. This approach encourages employees to use their creativity and previous experiences to adapt to circumstances (Huber & Brown, 1991; Beglund & Karltun, 2007). Once the performance criteria are set, much of the detailed design should be determined by the employees who complete the task (Hyer et.al., 1999).

Variance control. This principle suggests that the unexpected deviations from the standard operation procedures, plans, or routines should be controlled as close as possible at its point of origin (Cherns, 1987). Cherns re-named this principle from its earlier name 'sociotechnical criterion' to incorporate and bring to surface the inefficiencies in an organizations' method of controlling key variances, and also lay emphasis on how to improve it. Variances result from the inability of employees to either identify the cause of the variance or correct the cause. Hence work systems should be designed such that errors can be identified, controlled and corrected before they are fed downstream (Closs et.al., 2008; Hyer et.al., 1999). For example, quality need not be inspected in a product; it needs to be built into the product (Huber & Brown, 1999).

Boundary location. This principle states that boundaries, be they structural or just an artificial demarcation, should be determined based on a logical process criterion (Hyer et.al., 1999; Huber & Brown, 1991; Cherns, 1987). The boundary location should be determined such that it does not impede the sharing of information, knowledge and learning within an organization. The boundaries should not be drawn in the middle of a process; rather they should encompass tasks that are temporally, sequentially, and technically related to each other (Carayon, 2006; Hyer et.al., 1999). In other words, the structures should fit the process and not vice versa (Clegg, 2000).

Information flow. This principle refers to the flow of work related information to individuals who need it most to complete their task(s) (Cherns, 1987; Hyer et.al., 1999). Information flows should allow for three basic purposes: (1) controlling - help monitor the behavior of workers; (2) recording - provide management with comprehensive and detailed information of various operations within the plant/department/work unit; and (3) actionability – provides a feedback mechanism to control for variances (Huber & Brown, 1991). Depending on its purpose, information flow should be directed towards those who need it first and to be able to act on it (Cherns, 1987).

Power and Authority. This principle refers to the ability of employees to access and exercise authority over resources in order to carry out their responsibilities (Cherns, 1987). In addition to authority and power, this principle also focuses on the issue of ownership of responsibilities and accountability of actions. Employees are made responsible for completing a task successfully, while also being held accounTable for the appropriate use of the resources to complete the task (Closs et.al., 2008).

Multi-functionality. This principle refers to the practice of developing worker skills through training so that they could be made responsible for multiple task(s) within their unit (Cherns 1976, 1987). The workers are not seen as expendable and functional redundancy can be reduced by having multiple task allocation. Organizations in fast changing markets needing product and process flexibility focus on the multi-functionality of their workforce (Huber & Brown, 1991; Closs et.al., 2008). "*mechanistic*' organizations would achieve flexibility by hiring specialists and experts, while '*organic*' organizations would achieve flexibility through training employees to be able to perform multi-tasks (Cherns (1987).

Support congruence. This principle refers to the social support structure that should be designed to reinforce the behaviors which the organization structure is designed to elicit (Cherns, 1976, 1987). Social support structures such as reward systems, the selection process, training policies, conflict resolution mechanisms etc should be consistent with the objectives that govern the design of the work system (Hyer et.al., 1999). As newer systems and subsystems assimilate into older pre-existing ones, the process of change can be made smooth for employees by having the appropriate support structures (Closs et.al., 2008).

Transitional Organizations. This principle refers to the transitional process of redesigning an organization from an older traditional system to a newer philosophy of management that is based on socio-technical systems using design teams (Cherns, 1987). The design team and its processes are viewed as vehicles of transition and it is important that the design team and the processes therein involved in the change, do embody the values of socio-technical systems principles (Closs et.al., 2008). The period of transition requires a lot of planning and design. More importantly, one must be careful that 'experts' do not exclude users of the system while designing and implementing it. This could lead to loss of a vital learning opportunity for users who end up using the new system.

Incompletion. This principle refers to the efforts made to examine, critique, and improve a system the moment it is implemented. Systems design is an iterative process. That is, there is no such thing as a final design (Cherns, 1987). At the end we are back at the beginning. There is no state of equilibrium. Stability is desired, but the organization must continue to review and revise its design to reflect the appropriate changes due to the changing environment (Huber & Brown, 1991, Closs et.al., 2008). There is always a better way of doing things. Everyone must be able to appreciate that the design is never finished – it is always incomplete.

2.1.3.2. **STS principles – based on the works of Clegg**

Design is systemic. This principle states that there are certain interdependencies between the social and technical subsystem that may not be apparent when designing a new system. There may be unintended consequences in the social and/or technical subsystem for systems design change initiatives in an organization. According to Clegg (2000), “some of the consequences may only become obvious when the system is in operation.”

Values and mindset are central to design. This principle focuses on the notion that system designers should consider employees as assets (and not costs), while technologies (and techniques) are the tools to support employees in completing their task(s). Designers should create a system that seeks out an appropriate balance between human and technological activities. According to Clegg (2000), employees should not be designed out of the system as soon it is technologically feasible; and a command and control approach should not be adopted to manage them when it is not possible to design them out of the system. Instead, one must challenge the existing status quo by asking questions such as: “why are we using technology to undertake this task?”, “What are the roles of human in this system?”, “what alternative ways are there of configuring the work?”

Design involves making choices. This principle emphasizes that choices exists on all dimensions in the design of a sociotechnical system (Klein, 1994) and that they are not necessarily independent of each other. For example, a decision choice made in the technical subsystem may influence the social subsystem and vice versa. Being dependent does not mean that these choices are deterministic. A choice is one area does not fully determine a choice in another. According to Clegg (2000), “choices constrain (but do not determine) other choices”.

Decision should reflect the needs of the business, its users and their managers. This principle insists on evaluating a system in terms of how well it meets the current needs of the users, the managers and most importantly the business. Business needs may change over time as a result of changes in the market place and changes in the strategic direction. Users and managers need may change over time as they develop new needs and sometimes they may not even know what they want. According to Clegg (2000), a system that focuses on the needs of the business, the managers and its users' has a better a performance than companies that do not.

Design is an extended social process. This principle states that systems design is not a '*one-off*' thing that has a definite ending. The process of systems design continues beyond its implementation and throughout its use. People, who use, maintain, evaluate, and upgrade the system, continuously interpret it, amend it, massage it, make adjustments as they see fit, and eventually (re-)configure it to accomplish their task(s). This principle also brings out the social nature of the design process, in which various stakeholders (internal to an organization) help shape and moderate design choices over time. According to Clegg (2000), "different people will interpret the system in different ways, and there needs to be structures and mechanisms through which views can be aired, recognized, and recorded."

Design is socially shaped. This principle is an extension of the above principle. It makes explicit that design is shaped by a range of social partners over time. In the earlier principle, the stakeholders referred to people within an organization (i.e internal stakeholders), however in this principle stakeholders could be external to the organization. In addition to external stakeholders, systems design could be shaped due to the following: fad and fashion of the time, pursuit to lead, or respond to market and competitive pressures, and government mandates.

Design is contingent. This principle acknowledges that design choices are subject to contexts and do not have universal applicability. There is no '*one best way*'. System designers must consider under what circumstances, systems design would improve overall performance before designing and implementing a new system.

Core processes should be integrated. This principle emphasizes the importance of designing integrated core processes. The boundaries of the core processes should be based on logical process criterion before considerations of how they will be managed, controlled, and supported (Cherns, 1976, 1987). Structure fits the process, and not vice versa (Clegg, 2000).

Design entails multiple task allocations between and amongst humans and machines. This principle focuses on identifying the contingencies under which the following forms of work organizations are optimal: task allocation amongst humans, task allocation between hardware and software, and task allocation between humans and machines. System designers should conduct a feasibility study to determine which form of work organization fits in a given situation. They should calculate the cost of automation, find out the health and safety implications of allocating decisions, and determine the characteristics of the task itself before implementing a particular form of work organization.

System components should be congruent. This principle emphasizes on the set of working arrangements that are needed to be congruent with the goals of the new system and its practices. The working arrangements not only include the social support structure (e.g., payment and reward system, selection system, work measurement system, performance assessment system) but it also considers the technical support structure (e.g., information and control system). According to Clegg, these working arrangements do not necessarily influence the outcomes of the new system, but that the new system could get assimilated into the older system and its set of working arrangements.

Systems should be simple and make problems visible. This principle focuses on the concerns regarding the ease of use, ease of understanding, and learnability of a new system. Systems should not only be designed such that they are simple to explain and communicate, but also are very powerful in their effects. This principle also suggests that once a problem is detected, resources should be allocated immediately to resolve the quality issue.

Problems should be controlled at source. This principle states that any deviations from the ideal state should be controlled at its point of origin (Cherns, 1976, 1987). According to Clegg, the need to control problems at their source, allows for people to take control over problems they face. They learn to perform better through exerting control and by anticipating and solving problems.

The means of undertaking tasks should be flexibly specified. This principle emphasizes instructions that are given to the employees to perform a certain task. Specify no more than that which is absolutely essential. According to Clegg (2000), “whilst the ends should be agreed and specified, the means should not”.

Design practice is itself a sociotechnical system. This principle states that design teams that undertake design projects should themselves be designed in accordance to the STS principles. The design process itself is subjected to both social and technical changes.

Systems and their design should be owned by their managers and users. This principle emphasizes the relationship between the notion of ownership and appropriation of a new system within an organization. It is found that different forms of expertise are involved at different stages, undertaking different activities while designing and implementing a new system. According to Clegg (2000) the performance of the new system is best when the same person is responsible for the design, implementation, and use.

Evaluation is an essential aspect of design. This principle refers to the concept of systematically evaluating a new system against the original goals it was supposed to achieve. The evaluation should encompass a wide range of social, technical, operational and financial criteria. More importantly, evaluations should be viewed as an opportunity for learning Clegg (2000).

Design involves multidisciplinary education. This principle focuses on the relationship between the effectiveness of a new system design with the amount of knowledge possessed by the team that designed it. The effectiveness of a new system is only as good as the knowledge possessed by the team designing it (i.e. a team having partial knowledge will design a system that is only partially effective). Multi-disciplinary education allows members of a team to educate each other in the complexities of designs, and also foster creative and innovative solutions by providing a multi-disciplinary understanding of design need.

Resources and support are required for design. This principle refers to the investment in resources to design a new system. Resources include elements from both, the social (e.g., time, effort, knowledge, expertise and skills of employees) and the technical (e.g., method, tools, techniques, design structures and mechanisms) subsystem within an organization. According to Clegg (2000), resources related to time and expertise become crucial when they are invested in the design of a new system which is owned and appropriated by the people who will use and manage it.

System design involves political processes. This principle highlights the need to recognize the political nature of change. Various stakeholders of a given system are always concerned over its design and implementation, management and use, and evaluation changes. According to Clegg (2000), “different perspectives on change should be respected and need to be addressed”. In addition, certain mechanisms are put in place to handle the debate on the different perspectives of change.

2.1.4. **Comparison between Cherns’ (1987) and Cleggs’ (2000) STS principles**

Based on an extensive review of the STS literature, works of Cherns (1976, 1987) and Clegg (2000) stand out as they provide a comprehensive set of principles for designing and implementing organizational work design systems based on the joint optimization of the social and technical subsystems within an organization. These principles can be applied at both strategic and operational levels in an organization (Hyer et.al., 1999; Berglund & Karltun, 2007; Closs et.al., 2008). However a careful examination of Cherns (1987) and Clegg (2000) set of design principles reveal that these principles are in no way blueprints or design rules for strict adherence for the development of a socio-technical system. Instead these principles are for the most part, prescriptive and are offered as a checklist for work system design.

Table 2.2 Theoretical comparison of STS principles based on works of Cherns (1987) and Clegg (2000)

Design Principles	Clegg (2000)					
Cherns (1987)	P#	Meta-Principles	P#	Content-Principles	P#	Process-Principles
Compatibility: The process of designing a system must be compatible with the goals of the design	1 3 7	*Design is systemic* *Design involves making choices* *Design in contingent*	9	*Design entails multiple task allocations between and amongst humans and machines*	16 15	*Evaluation is an important aspect of design* *Systems and their design should be owned by their managers and users*
Minimal critical specification: In the design of jobs, specify no more than what is absolutely essential **Variance Control:** Work is designed to control variation (deviation from the ideal) as close as possible to its source		-	*11* *12* *13*	*Systems should be simple and make problems visible* *Problems should be controlled at source* *The means of undertaking tasks should be flexibly specified*		-
Boundary condition: This should be determined based on logical process critereon Information flow - Work related information flows to one who needs it most to complete their task(s)		-	*8*	*Core processes should be integrated*		-
Power and Authority: Ability of employees to access and exercise authority over pertinent resource (technical & Social) to carry out responsibilities	2	*Values and mindsets are central to design*		-	*18*	*Resources and support are required for design*

Support Congruence: Social support structures such as reward systems, selection process, training policies, conflict resolution mechanisms, work measurement and performance assessment is designed to re-inforce behaviors which the organization structure is designed to elicit		-	*10*	*System component should be congruent*		-
Transitional organization: Involve people who use the system to re-configure the old system into a newer more effective and user friendly system	*5* *6*	*Design is an extended social process* *Design is socially shaped*		-	*14*	*Design practice is itself a sociotechnical system*
Incompletion: Examine, critique and improve the system the moment it is implemented	*4*	*Design should reflect the needs of the business, its users and their managers*		-		-
Multi-functionality: Workers are made responsible for multiple tasks within their unit		-		-		-
-		-		-	*17* *19*	*Design involves multidisciplinary education* *Systems design involves political processes*

Table 2.2 demonstrates how Clegg's (2000) set of meta-principles, content-principles, and process-principles for organizational design are not free standing. These principles can be associated with Cherns' (1987) set of ten design principles. Cherns principle of compatibility is associated with the following meta-, content-, and process-principles suggested by Clegg: design is systemic, design involves making choices, design is contingent, design entails multiple task allocations between and amongst humans and machines, evaluation is an essential aspect of design, and system and their design should be owned by their managers and users. Cherns principle of power and authority is associated with the following meta- and process- principle suggested by Clegg: values and mindsets are central to design and resources and support are required for design. Cherns principle of support congruence and information flow is associated with Clegg's content principle, system component should be congruent. Cherns principle of incompletion is associated with Clegg's meta-principle of design should reflect the needs of the business, its users and their managers. Cherns principle of transitional organizations is associated with the following meta- and process principles suggested by Clegg: Design is an extended social process, design is socially shaped, and design practice is itself a sociotechnical system. Cherns principle of boundary location is associated with Clegg's content principle of core processes should be integrated. Cherns principle of minimum critical specification and variance control is associated with the following content principles suggested by Clegg: systems should be simple and make problems visible, problems should be controlled at source, and the means of undertaking task should be flexibly satisfied. Clegg's process principle of design involving multidisciplinary education and systems design involves political process is not explicitly mentioned in Cherns set of 10 design principles.

2.2. Lean production perspective

2.2.1. Origins of lean production

Lean production can be traced back to the Toyota Motor Company and Toyota Production System (Holweg, 2007; Shah & Ward, 2007; Ohno, 1988). Formed out of sheer necessity rather than by intended design, Toyota Production System (TPS) evolved as an alternative to the then existing mass production system (Ohno, 1988). TPS was Toyota's response to overcome the three daunting challenges it faced after World War II: 1) catering to the needs of a domestic market which was not only small but demanded high product variety, 2) inability of the capital starved company to make huge investments in western technologies, and 3) competing with well-established foreign brands such as General Motors and Ford (Cusumano, 1985). This concept proved very successful and came to be generalized as lean production.

In an endeavor to produce large variety in small volumes, reduce costs and eliminate waste, Ohno (1988) laid the foundation of TPS by implementing 'just-in-time production' (JIT) and 'autonomation'. The concept of JIT emphasized low-cost production through the elimination of waste in the system, and the concept of autonomation – automation with a human touch – recognized the diligence and ability of the workforce by entrusting them with greater responsibility and authority. Ohno applied his 'common-sense approach' to the then existing method of mass production. He argued that production in large batches resulted in higher inventory, larger warehousing needs, tied-up capital, and most importantly, made it difficult to accommodate customer preference for product diversity (Holweg, 2007). To resolve these issues, Ohno initiated production in small batch sizes. Shingo's development of the concept of single minute exchange of dies (SMED) made it economical to produce in small batch sizes and facilitated in the implementation of the TPS.

TPS was an implicitly communicated production system which remained internal to Toyota plants until the mid-sixties. It was formally documented for the first time when Toyota rolled out the 'Kanban' system to its suppliers in Japan. The western world began noticing Toyota Motor Company in the early eighties when the International Motor Vehicle Program (IMVP) published a report stating the rising threat of Japanese automobile imports in the United States. It was during the phase-2 of the IMVP research that practitioners and academicians became aware of TPS.

Aimed at describing and measuring the gap between the western 'mass production' system and TPS, this research provided valuable insight into the manufacturing practices of TPS and found evidence that TPS outperformed the western 'mass production' systems. A study conducted by Krafcik (1986) as part of the IMVP research showed that the NUMMI plant, a joint venture between GM and Toyota, achieved a productivity level more than 50% higher than that of any other GM plant with similar technology in the U.S. In a follow-up study, Krafcik (1988) used the word "lean" instead of the IMVP terminology of "fragile" to classify companies according to their production management philosophy. Subsequently, Womack et.al., (1990) used the term "lean production" to contrast TPS with the Western "mass production" system in their book, "The Machine that Changed the World". Figure 2.2 summarizes the development and recognition of lean production.

Toyota Motor Company formally formed **1937**	Ohno Joins the automobile business and implemented the foundations of the Toyota Production System (TPS) **1948**	Toyota Motor Company split after World War II **1950**	Shingo is hired as an external consultant and develops the concept of SMED **1955**	Formal documentation of TPS when Kanban systems rolled out to suppliers **1965**
	Oil Crisis **1973**			
IMVP phase-1 research initiated **1979**	Conclusion of the IMVP research published in the book "Future of the Automobile" **1984**	IMVP phase-2 research initiated **1985**	International assembly benchmarking results presented by Krafcik **1986**	The IMVP benchmarking terminology 'fragile' was replaced by the term 'lean' **1988**
Womack et.al. wrote the book, "Machine that changed the world" and popularized the concept of TPS as "Lean production" **1980**				

Figure 2.2. Timeline depicting the origin of lean production

The 80's and 90's saw a rise in both the conceptual and empirical understanding of the TPS concept. This provided valuable insights into different aspects of lean production, especially its practices. The works of Monden (1983), Pegels (1984); Lee & Ebrahimpou (1984); Schonberger (1986), Ohno (1988), Barker (1994), and Spear & Bowen (1999) introduced the broad concept of JIT and the practices therein to the western world. Monden (1983) provided a list of JIT practices related to the shop floor activities. Pegels described aspects (practices) of TPS which were applicable to the assembly lines. Lee & Ebrahimpour described the practices needed for the implementation of JIT. Schonberger (1986) stressed many of the same shop floor practices as Monden and also included employee involvement, preventative maintenance, and quality**.** Barker described a structured method to create and evaluate a value stream map to differentiate between value and non-value added activities. Spear & Bowen (1999) decoded the DNA of the TPS and proposed a set of four rules which emphasized the usage of certain lean practices.

Empirical research on the TPS concept provided insights into its dissemination into the manufacturing sector throughout the world. The work of Voss & Robinson (1987), Suzaki (1985), and Sohal (1996) identified the JIT practices used in the UK, U.S., and Australia. Sakakibara et.al. (1993) provided a theoretical framework identifying 16 dimensions of JIT, along with a theoretically validated survey instrument. Karlsson & Ahlstrom offered a model that operationalized the different principles of lean to study change processes when implementing lean in an organization.

As shown in Table 2.3, there is no consensus on a consistent set of lean practices. There is a varying degree of frequency that each of the practices and techniques selected are considered in the studies reviewed. The practice of pull systems, production leveling, production layout, setup time reduction, and cross functionality are included most often, while that of lean accounting, Hoshin planning and empowerment are referenced least frequently in the literature. Lean production came to mean different things to different people (e.g., managers, academics, and consultants).

Table 2.3 Commonly cited lean practices and techniques in operations management literature

Practices	**Techniques**	Monden (1983)	Lee & Ebrahimpour (1984)	Pegels (1984)	Suzaki (1985)	Schonberger (1986)	Finch & Cox (1986)	Voss & Robinson (1987)	Barker (1994)	Sohal (1996)	Karlsson & Ahlstrom (1996)	Sakakibara et.al. (1997)	McLachlin (1997)	Koufterous et.al. (1998)	White et.al. (1999)	Spear & Bowen (1999)
Lean Accounting Practices	Visual management, Value stream management,		x						x							
Hoshin (kanri) planning	PDCA cycle, Nemawashi, Catchball, A3 thinking,		x									x				
Standardized work	Standard cycle times, Standard routings, Standard processing		x	x												x
Pull production	Kanban			x			x	x		x	x	x	x	x	X	
Continuous flow	Lot size reduction	x				x		x			x		x			
Heijunka – Production Leveling	Level by volume, product type, or product mix	x	x		x	x	x	x					x	x		
Production Layout	Cellular Manufacturing	x	x		x	x	x	x		x		x	x	x	x	x
Total productive maintenance	Predictive and preventative maintenance	x			x	x	x			x	x		x	x		
Setup time reduction	SMED, Rapid tool setting	x			x	x	X	x		x	x	x	x	x	x	
Zero defects	Poka Yoke			x	x			x		x	x		x			
Visual Control	Andon, 5S technique			x	x					x			x			
Continuous improvement	Go see for yourself "Genchi Genbutsu"							x			x			x		x
Cross functional work practice	Machine utilization Cross training	x	x		x	x	x	x			x	x			x	

Academicians and practitioners in the early part of the twenty first century focused their attention on providing an operational definition for lean production that would alleviate problems arising from a lack of common definition (Shah & Ward, 2007; Dennis, 2007; Narasimhan et.al., 2006; Treville & Antokanis, 2006; Bonavia & Marin, 2006; Hopp & Spearman, 2004; Liker, 2004; Shah & Ward, 2003; Womack & Jones, 1996). Researchers developed good working definitions of lean production; however, they defined lean from two different points of view. One defined lean from a philosophical approach, wherein the focus was on its principles and overarching goals (Treville & Antonakis, 2006; Narasimhan et.al., 2006; Dennis, 2007; Liker, 2004; Hopp & Spearman, 2004; Womack & Jones, 1996). The other point of view was based on a set of management practices and techniques that can be directly observed (Shah & Ward, 2003; Li et.al., 2005; Bonavia & Marin, 2006).

2.2.2. **Philosophical approach to lean**

As seen in Table 2.4, the common theme across principles identified by researchers defining lean from a philosophical approach is that of elimination of 'waste'. Hopp and Spearman (2004) bring in clarity to the term 'waste' by explicitly distinguishing between the obvious 'waste' resulting from overproduction, waiting, transportation, inappropriate processing, excess inventory, excess motion, and defects, and the less obvious 'waste' resulting due to variability. Treville and Antonakis (2006) and Narasimhan (2006) concur with Hopp and Spearman's approach to identify and eliminate waste. Treville and Antonakis also emphasize the value of respecting workers in an organization.

Table 2.4 Lean definitions based on a philosophical approach

Authors	**Definition of lean**
Hopp & Spearman (2004)	Production of goods or services is lean if it is accomplished with minimal buffering cost (i.e., inventory, capacity, and time) costs ***Principle:*** • Reduction in the buffering cost
Treville & Antonakis (2006)	Lean production is an integrated manufacturing system that is intended to maximize the capacity utilization and minimize the buffer inventories of a given operation through minimizing system variability (related to arrival rates, processing times, and process conformance to specifications) ***Principle:*** • Maximize capacity utilization • Reduce buffering cost (inventory reduction) • Respect for workers
Narasimhan et.al. (2006)	Production is lean if it is accomplished with minimal waste due to unneeded operations, inefficient operations, or excessive buffering in operations ***Principle:*** • Minimizing waste by reducing unneeded operations • Minimize excessive buffering
Dennis (2007)	Lean Production is doing more with less - less time, less space, less human effort, less machinery, less materials-while giving customers what they want ***Principle:*** • Provide customers with high quality products at low costs in short lead times • Produce the right item at the right time in the right quantity • Strive to have automation with a human intelligence

	• Standardization and stability of processes during production • Engage workers in production planning and problem solving
Liker (2004)	No definition provided…. "lean is a philosophy that is defined by a set of guiding principles (Lander & Liker, IJOP, 2007, pp 3696) ***Principle:*** • Base management decisions on a long term philosophy even at the expense of short term gains • Create continuous process flow to bring problems to the surface • Use "pull" systems to avoid overproduction • Level out the workload • Standardized tasks are the foundations for continuous improvement and employee empowerment • Use visual control so no problems are hidden • Use only reliable thoroughly tested technology that serves your people and process • Develop exceptional people and teams who will follow your company's philosophy • Respect your extended network of partners and suppliers by challenging them and helping them improve • Go and see for yourself to thoroughly understand the problem • Become a learning organization through relentless reflection and continuous improvement
Womack & Jones (1996)	Lean is defined as a five step process which consists of defining customer value, defining the value stream, making it "flow", "pulling" from the customer back, and striving for excellence ***Principle:*** • Specify value for the customer • Identify the value stream for each product • Make product flow without interruptions • Produce only what is pulled by the customers just in time • Pursue perfection by complete elimination of waste

The principles suggested by Womack and Jones (1996) are the most frequently cited list of lean principles found in the literature. However, these principles do not include an emphasis on the individuals that make up the social subsystem that facilitates the implementation and management of lean production itself. Liker (2004) extended the works of Womack and Jones (1996) by explicitly including the 'people focus' in his principles. According to Liker, an organization is 'lean' not when it uses a variety of TPS tools, but when it develops appropriate lean principles and practices them diligently. Dennis (2007) provided a set of six simplified, yet comprehensive, lean principles that stemmed from the "house of lean" (Japanese Management Association, 1980), a visual description of the TPS. These principles differ from the earlier works of Womack & Jones (1996) and Liker (2004), in that they specifically focus on shop floor practices of lean production.

2.2.3. **Practical approach to lean**

As seen in Table 2.5, researchers (Bonavia & Marin, 2006; Li et.al., 2005; Shah & Ward, 2003) have also defined lean production in terms of the management practices used to eliminate waste.

Table 2.5 Lean definitions based on a practical approach

Authors	**Definition of Lean**
Shah & Ward (2003)	Lean Production is a multidimensional approach that encompasses a wide variety of management practices that can work synergistically to create a streamlined high quality system that produces finished products at the pace of customer demand with little or no waste ***Practice:*** • Lot size reduction, continuous flow, pull production, setup time reduction (JIT bundle) • Continuous improvement, quality management (TQM bundle) • Predictive and preventative maintenance (TPM bundle) • Self directed work teams, cross functional employees(HRM bundle)
Li et.al. (2005)	The practice of eliminating waste (cost, time etc) in a manufacturing system, characterized by reduced setup times, small lot sizes, and pull production ***Practice:*** • Setup time reduction, pull production, continuous quality improvement, lot size reduction
Bonavia & Marin (2006)	Set of techniques and tools designed to increase business competitiveness by systematically eliminating all kinds of waste ***Practice:*** • Cross functional employees, quality circles • Cellular manufacturing, group technology, setup time reduction, production leveling, pull system • Total productive maintenance • Quality control, standardized work, visual control

It is worth noting that every researcher has identified a set of different practices to define lean. A study by Shah & Ward (2003) explains the multi-dimensionality of lean production by providing a comprehensive list of management practices. These practices, depending on their function, were then categorized into one of four bundles: Just-In-Time (JIT), Total Quality Management (TQM), Total Productivity Management (TPM), and Human Resource Management (HRM). Li et.al. (2005) defined lean based only on the JIT and TQM bundles. Bonavia and Marin (2006) corroborate the findings of Shah & Ward (2003), that lean production is a multi-dimensional concept and to achieve the true benefits of lean production, organizations must implement appropriate practices from all four bundles.

2.2.4. **Reconciling the philosophical and practical approaches to lean**

Lean principles provide an understanding of why things are done, and a basis for judging whether an organization's progress is consistent with those principles. However, the principles are abstract in nature; they are descriptive fundamental assumptions that are accepted as truth and used as a basis for reasoning. Practice, on the other hand, is the observable facet of principles and is conceived as activities or sets of activities that help achieve the principles (Dean & Bowen, 1994). Hence, in order to fully understand lean production, it is not only important that we understand the principles, but it is imperative that we understand the practices and techniques therein.

Shah and Ward (2007) bridged the definitional gap between the philosophical and practical approaches to lean by explicitly defining lean as both a principle and a set of practices (Table 2.6). They define lean as “an integrated socio-technical system whose main objective is to eliminate waste by concurrently reducing or minimizing supplier, customer, and internal variability". This definition allows for both the philosophical theme of reducing waste and eliminating variability, and also for the social and technical practices needed to achieve the philosophical objective.

Table 2.6 Lean production defined as a principle and a practice

Shah & Ward (2007)	Lean production is an integrated socio-technical system whose main objective is to eliminate waste by concurrently reducing or minimizing supplier, customer, and internal variability	
	Principle	Associated Practice
	Eliminate waste (obvious and not so obvious)	Minimizing supplier, customer, and internal variability

2.2.5. **Principles of lean production**

Researchers accept the fact that lean production has become a common if not an integral part of the manufacturing landscape all across the globe in the last couple of decades (Voss & Robinson, 1987; Sohal and Egglestone, 1994; Karlsson & Ahlstrom, 1996; Pannizzolo, 1998; Sanchez & Perez, 2001; Shah & Ward, 2003; Hopp & Spearman, 2004). The benefits of lean implementation are well accepted by both academicians and practitioners' alike (Krafcik, 1988; Womack et.al., 1990; Sohal, 1996; Shah & Ward, 2003; Spear, 2004; Liker, 2004; Browning & Heath, 2009). In this section we will review the most widely applied lean production principles that are instrumental in companies achieving the benefits from implementing lean production. These principles provide an understanding of why things are done, and a base for judging whether the progress made is consistent with those principles in an organization.

2.2.5.1. **Lean principles based on the works of Womack & Jones**

Womack & Jones (1996) proposed five principles which formed the early foundation of lean implementation in the western world. According to them: (1) specify value for the customer, (2) identify the value stream for each product to distinguish between value added and non value added activities, (3) make the product flow without interruptions, (4) let customer pull value from the producer, and (5) pursue perfection by complete elimination of waste. These five principles were specified at a philosophical level, and could be applied to different business contexts.

Specify value for the customer. Specifying "*value*" for the customer is a critical starting point for lean thinking. "Value" can only be defined by the customer. It is meaningful when expressed in terms of a specific product (e.g., goods or service), which meets customers' needs at a specific price and at a specific time. In a manufacturing organization, "value" added may involve any activity that increases the market form or function of the product, for which the customer is willing to pay.

Identify the value stream for each product. Organizations that recognize "value" in terms of their customer expectations need to next focus on identifying the value stream for each of their product. Value stream defined as, "specific activities required to design, order, and provide a specific product, from concept to launch, order to delivery, raw material into to finished goods into the hands of the customer" (Womack & Jones, 1996), helps distinguish the value adding activities from the non value adding activities for each product being manufactured. Three types of activities need to be evaluated while analyzing a value stream – one kind adds value, and the other two are wastes (type 1 and type 2). The value added activities are those that unambiguously create “value” for the customer. Type 1 waste, include activities that create no “value”, but are necessary to maintain operations, by assisting the operators, managers, or stake holders (inventory clerk, maintenance department, accounting department). Type 2 wastes, include activities that create absolutely no value and can be avoided (e.g. rework, scrap, waiting times).

Make the product flow without interruptions. A value stream that provides customer “value” is just not sufficient. Organizations need to focus on achieving an uninterrupted flow of material through the entire value chain. Flow is often interrupted by poor process visibility, long changeovers times, unexpected machine breakdowns or poor cooperation with suppliers. Uninterrupted product flow defined as, “a progressive achievement of tasks along the value stream so that a product proceeds from design to launch, order to delivery and raw materials into finished goods for the customer with no stoppages, scrap or backflows” (Womack & Jones, 1996) helps ensure continuous flow. In order to achieve uninterrupted product flow, Womack and Jones suggest that one should move away from the traditional large batch and queue approach to production.

Let customer pull value from the producer. Having developed a value stream which facilitates uninterrupted product flow, organizations should make sure that production matches with the pace of the customer demand. Customer demand, thus acts as a trigger mechanism for production to start. Organizations need to make sure that they produce only what the customer needs (in terms of both quantity and timing). This pull mechanism defined as, “a system of cascading production and delivery instructions from downstream to upstream in which nothing is produced by the upstream supplier until the downstream customer signals a need" (Womack & Jones, 1996) makes certain that unnecessary inventory buildup is avoided.

Pursue perfection by eliminating all kinds of "waste". Once the above principles are in place and organizations can sustain them, they should strive to maximize the value for the customer by pursuing perfection, i.e. develop routines that continuously help minimize the non value added activities (both type 1 and type 2). The pursuit of lean is a never ending process. There will always be activities that may be considered waste in the value stream.

2.2.5.2. **Lean principles based on the works of Liker**

Liker (2004) in his book, "The Toyota Way", extended the works of Womack and Jones (1996) by explicitly including the 'people focus' in his principles. He described lean production using a list of fourteen principles based on his experiences at different Toyota plants. Liker's study emphasized that using a variety of TPS tools is not considered as being lean, but it is about developing the principles that are right for the organization and diligently practicing them that makes an organization lean.

Base your management decisions on a long term philosophy, even at the expense of short term financial goals. This principle focuses on long term thinking. Managing decisions based on a long term philosophy, even at the expense of short term financial goals forms the bedrock for all other principles, as it determines the kind of decisions organizations will take in given situations. Organizations should develop a mission which creates value for its customer, employees, and the society as a whole. This way of thinking helps organizations create a constancy of purpose and hence everything the organization does is subjugated to this guiding principle.

Create continuous process flow to bring problems to the surface. This principle focuses on the elimination of waste resulting from waiting, transportation, and inappropriate processing (Shingo, 1992). Continuous flow results in the lowering of cycle time by minimizing the inter-operation time (queue and waiting) between tasks. This results in bringing to surface the inefficiencies in the system. Problems surface in a continuous flow process since there are no capacity, inventory, and time buffers to hide the inefficiencies in the process. Thus creating a continuous flow is an essential principle for organizations that want to start their journey to becoming lean.

Use "pull" systems to avoid overproduction. This principle focuses on the elimination of waste resulting from overproduction. Customer orders which initiate production form the basis for pull production. The purest form of pull production is illustrated in the previous principle of continuous flow (a.k.a one piece flow) wherein a product is manufactured only at the moment it is needed in the shortest cycle time possible. However in instances when one-piece flow is not possible because processes are too far apart or the cycle times to perform the operations vary a great deal, organizations must resort to the principle of pull, i.e. provide customer with what they need, when they need it, and in the amount they need it. Rother and Shook (1999) suggest that, "flow where you can, pull where you must".

Level out the workload (heijunka). This principle focuses on the elimination of waste resulting from the production variability (Sugimori et.al., 1977). The principle of

“Heijunka” suggest that production should be leveled in terms of both volume and product mix. This can be achieved when production is not be based on the actual flow of customer orders, but based on the total volume of orders placed in a certain time period. Thus a leveled out workload results in producing the same amount and mix each day.

Build a culture of stopping to fix problems, to get quality right the first time. This principle focuses on the elimination of waste resulting from defective parts being produced, and is the second pillar of the TPS – Jidoka (Ohno, 1988). This principle emphasizes the importance placed on the culture to stop the line in case of defective parts being produced. In case of machines, built-in devices will automatically stop the machine when it detects a problem, while in case of humans, they are given the authority to push a button or pull cords – “andon cords” which can bring a machine or an entire line to a stop. The machine or the line remains shut until the root cause of the problem has been resolved. This culture of stopping the machine/production line makes certain that defective parts are not sent downstream.

Standardize tasks are the foundations for continuous improvement and employee empowerment. This principle focuses on the elimination of waste resulting from the inappropriate processing and variability due to different work methods. Standardization of the activities (tasks), connections, and production flows, lead to flexibility, adaptability, and creativity (Spear & Bowen, 1999). Whenever a standard is specified, an implicit hypothesis is created. This hypothesis is then tested to see if it is supported. This process of testing new hypotheses eventually leads to continuous improvement. In addition the ability of employees to experiment with already set standards, leads to employee empowerment.

Use visual control so no problems are hidden. This principle focuses on the elimination of waste resulting from unnecessary motion and defective parts being produced. Visual control makes certain that the information regarding processes, equipment and inventory buildup is not only visually observable, but it is also easily accessible. This can be achieved when the visual indicators are placed close to the work areas. Being able to detect any deviations from the standards quickly results in improved productivity, reduced defects and mistakes, improves safety and most importantly facilitates communication between workers.

Use only reliable, thoroughly tested technology that serves your people and processes. This principle focuses on valuing people over technology. Adoption of a new technology must support the people, processes, and the values of the organization, and not displace or replace them. Before implementing a new technology it must be thoroughly evaluated against existing processes to determine if it does not conflict with the organization's philosophy and operating principles. If pilot proves that the new technology does not conflict with the existing processes and more importantly, it adds "value", it is quickly implemented after a process of consensus analysis involving all the stake holders affected by the new technology.

Grow leaders who thoroughly understand the work, live the philosophy, and teach it to others. This principle focuses on tapping the human potential available within the organization, i.e. growing leaders from within the organization rather than bringing them from outside. People within an organization, who thoroughly understand the culture, when chosen to be leaders provide the same constancy of purpose as their predecessors. These people make an effort to support the same culture year after year and train the subordinates to live by the same philosophy, they live by so as to create an environment for a learning organization. This results in laying the groundwork for genuine long term success.

Develop exceptional people and teams who will follow your company's philosophy. This principle also focuses on the tapping of the human potential, however in this case the human potential is obtained externally (new job applicants). After a thorough screening process, they are groomed internally through training to fit the organizations culture. Training involves developing both the individual's technical knowledge and other broad range of skill required to do the job, and his ability to work on a team. Organizations investing in people, in return get a committed worker and team player who shows up every day on time and is motivated to continually improve the process.

Respect your extended network of partners and suppliers by challenging them and helping them improve. This principle focuses on elimination of waste resulting from supplier variability. Organizations that not only respect but also help their suppliers improve by challenging them, grow together to mutually benefit in the long term. However care should be taken in indentifying a supplier. The supplier selected must prove their sincerity and commitment to the organizational goals and objectives. Once selected the supplier is not replaced except for the most egregious behavior.

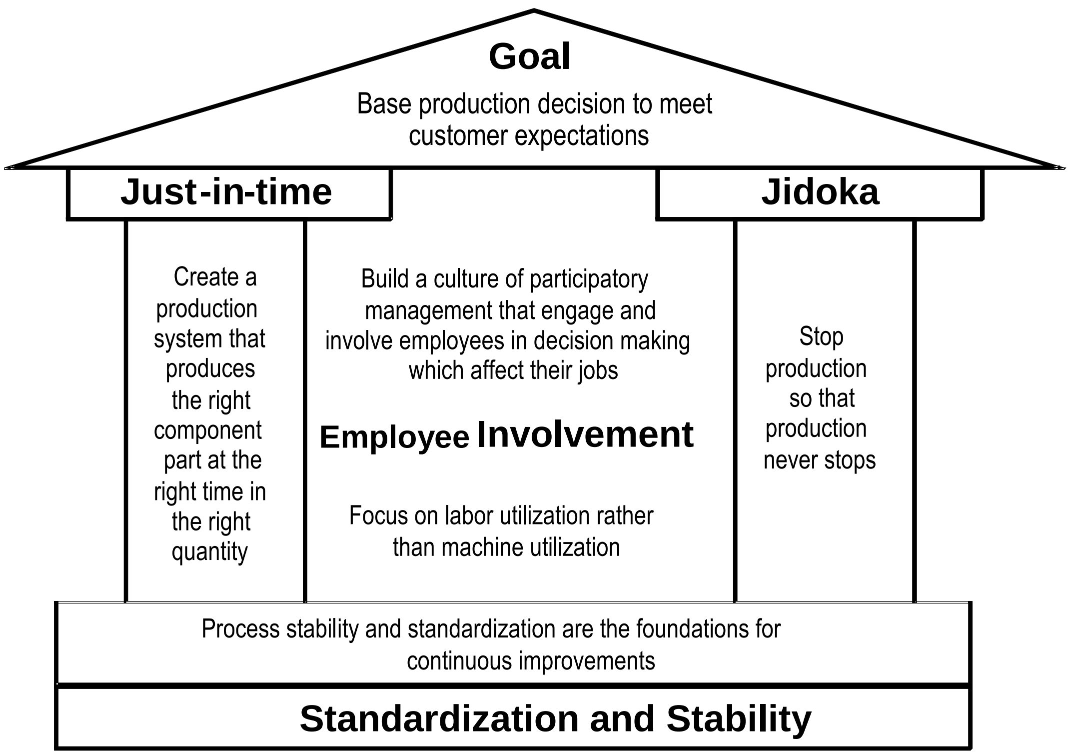
Go and see for yourself to thoroughly understand the situation. This principle emphasizes on the need to get on to the shop floor and see for one's self how work methods and work processes are executed and implemented. Individuals should think and speak based on personally verified data and information. Do not rely on others for information. The process of problem solving is best executed when one goes to the root cause of the problem by visiting the actual place (Gemba) where it occurred to resolve it.

Make decisions slowly by consensus, thoroughly considering all options, implement decisions rapidly. This principle includes an important process of "nemawashi", i.e. focus on the approach of how one arrives at a decision, let alone the quality of the decision. Decisions are made only after covering all the facts, alternatives, and consulting with the people who will be affected by the outcome of the decision. Involving a broad range of people in decision making is a tough task, however when consensus is achieved, the implementation process is quick and smoother.

Become a learning organization through relentless reflection and continuous improvement (Kaizen). This principle focuses on learning by establishing a process for continuous monitoring (Hansei) and continuous improvement (Kaizen). Learning organizations do not adopt and develop new skills, but instead, they put a second level of learning which focuses on learning how to learn new skills, knowledge and capabilities (Senge, 1990). This is achieved when organizations view errors as opportunities for learning (Spear & Bowen, 1999), take corrective actions immediately and distribute the knowledge about each experience broadly.

2.2.5.3. **Lean principles based on the "*House of Lean*"**

Dennis (2007) in his book, "Lean Production Simplified", described lean production based on the illustration of the 'house of lean production' (referred to as the 'house', hereafter). This description of lean production differs from the earlier works of Womack & Jones (1996) and Liker (2004) because it is specifically aimed at the shop floor practices of lean. As shown in Fig 2.3, the description of the different parts of the "house of lean production" can be drawn on to develop lean principles which are applicable at the shop floor level.



Adapted from Japanese Management Association (1980)

Figure 2.3. House of lean production

Base production decision to meet customer expectations. The roof of the 'house' represents the goals of an organization in terms of the quality, costs, delivery time of its products, safety of its employees, and environmental obligations. Lean production is not a complex idea; however its implementation which allows organizations to achieve high product quality at low cost, in the shortest time possible by eliminating waste and maintaining employee safety and environmental obligations requires not only time, but also money. Production decisions may involve changes in equipment and/or equipment layout, additional training for employees and more importantly a change in the management culture. Thus implementation of lean production requires planning for the long term and is always subjugated to fulfilling the needs and expectations of the customers.

Process stability and standardization are the foundations for continuous improvements. The foundation of the 'house' represents standardization and stability of the production processes within an organization. Standardization is a tool for developing, confirming, and improving the set of steps or actions of a particular task/process with clearly defined goals. Standardization of the task/process allows for repeatability of the task/process by providing clear start and end points for each process; preserving the know-how and expertise to accomplish the task; assessing the current condition to identify problems through checkpoints in the process; and providing a basis for employee training (Spear & Bowen, 1999). Process improvements within an organization cannot occur without stability. In order to achieve stability one must create standards. However, standards which are not stable are worthless. Hence stability without standardization and standardization without stability are meaningless terms. Together these terms help identify the ‘muda’ or waste in the system so that we can continually improve our processes.

Create a production system that produces the right component part at the right time in the right quantity. One of the two pillars of the ‘house’ is the concept of Just-in-time (JIT) production system. The JIT production system is designed for efficient, quality production with an emphasis on the idea of customer pull so that there is a value flow rather than material flow through the system. It is a production system which focuses on lot-less production and strives to have one unit of work-in-progress at any moment in time. The production lead times are greatly shortened by having all processes to produce the necessary parts at the necessary time and in the necessary quantity, while having only the minimum stock on hand necessary to hold the process together.

Stop production – so that production never stops. The second pillar of the ‘house’ is the concept of jidoka or autonomation (i.e. automation with a human mind). This concept reflects the idea that intelligent workers and machines can identify errors and can take quick counter measures to fix it. Jidoka lays’ a strong emphasis on defect prevention and considers it okay to stop the production line to eliminate the root causes of the defects.

Build a culture of participatory management that engage and involve employees in decision making which affect their jobs. The heart of the ‘house’ is the concept of employee involvement. Ohno very early in his career realized the importance of engaging and involving employees in the process of production planning and problem solving. He believed that employee involvement helps develop the capabilities of the employees and improves the prospect for long term success. In order to successfully handle today's rapidly changing markets and technological needs companies need to be flexible and creative. No amount of investment in technology alone will help companies achieve that flexibility and creativity, if the employees are not involved in the decision making processes.

Focus on labor utilization rather than machine utilization. The final principle is borne out of the concept of Jidoka or 'autonomation' and just-in-time production. With autonomation, there is no need for workers to stand by a machine as they are designed to stop automatically or emit signals when defects occur or the required quantity has been produced. In a just-in-time production system the machines need not be utilized as much as they would in a mass production system. In order to compensate this loss of machine utilization, organizations focus their efforts on maximizing the use of labor. Since autonomation helps separate the workers from the machines and a worker can operate more than one machine, it is reasonable for organizations to sacrifice machine utilization in lieu of labor utilization.

2.2.6. **Comparison between principles based on the works of Womack & Jones (1996), Liker (2004), and Dennis (2007)**

A careful comparison between the three different sets of principles reveals that the all of the lean principles suggested by Womack & Jones (1996) can be associated with the lean principles developed by Dennis (2007). However, not all of Liker's (2004) principles can be matched to Dennis's (2007). One possible explanation for this is that

Liker (2004) provides principles for both strategic and shop floor lean implementation, while Dennis's (2007) principles focus primarily on shop floor lean implementation. Table 2.7 details how the principles of Liker (2004) and Womack and Jones (1996) match to the six principles that Dennis (2007) conceptualized from the "House of Lean".

Table 2.7 Matching lean principles by Liker and Womack & Jones to lean principles by Dennis

	Principles based on Dennis (2007)	**Principles based on Liker (2004)**	**Principles based on Womack & Jones (1996)**
Match 1	Base production decisions to meet customer expectations	Base Management decisions on a long term philosophy, even at the expense of short term financial goals	Specify value for the customer
Match 2	Process stability and standardization are the foundations for continuous improvements	Standardized tasks are the foundations for continuous improvement and employee empowerment Become a learning organization through relentless reflection and continuous improvement	Identify the value stream for each product
Match 3	Create a production system that produces the right component part at the right time in the right quantity	Create continuous process flow to bring problems to the surface Use "pull" systems to avoid overproduction Level out the workload	Make product flow without interruptions Let customer pull value from the producer
Match 4	Stop production - so that production never stops	Build a culture of stopping to fix problems, to get quality right the first time	-
Match 5	Build a culture of participatory management that engage and involve employees in decision making which affect their jobs	Make decisions slowly by consensus, thoroughly considering all options, implement decisions rapidly Develop exceptional people and teams who will follow your company's philosophy	-
Match 6	Focus on labor utilization and not machine utilization	Use only reliable thoroughly tested technology that serves your people and processes	-
		Use visual control so no problems are hidden* Go and see for yourself to thoroughly understand the situation* Grow leaders who thoroughly understand the work, live the philosophy, and teach it to others** Respect your extended network of partners and suppliers by continually challenging them and helping them improve***	-

**   This is more of a practice than a principle*
***   This is a lean principle at the strategic level involving top level human resource management decisions*
**** This principles extends beyond the shop floor and is external to an organization*

Match 1. These principles form the bedrock for all other principles. These principles emphasize that everything one does in a lean organization should be subjugated to the needs and expectations of the customer. Production decisions or management decisions must be made after considering customers' "*value*" proposition of goods or services (Womack & Jones, 1996), even if it means to forego financial gain in the short term (Liker, 2004).

Match 2. These principles focus on the establishment of standards and continuous improvement once the standards are stable. The establishment of standards not only helps eliminate wastes resulting from inappropriate processing (Liker, 2004, Womack & Jones, 1996), but also allows for identifying the value stream for each product (Womack & Jones, 1996). Once standards are stabilized, they are explicitly stated as hypotheses, which can then be tested. The hypotheses form the basis of scientific learning and facilitate in the process of continuous improvement resulting in the elimination of waste (Liker, 2004; Womack & Jones, 1996).

Match 3. These principles emphasize value flow rather than material flow in the production system. Customer demand acts as a trigger mechanism for production to start and dictates which items need to be produced, as well as their quantity and timing, to avoid overproduction (Liker, 2004; Womack & Jones, 1996). Making product flow without interruptions (i.e. continuous flow) is the purest form of a pull system. It focuses on producing parts in the shortest cycle time possible by applying good scheduling techniques and eliminating waiting time. Thus resulting in bringing system inefficiencies come to the surface (Liker, 2004).

Match 4. These principles aim to reduce or eliminate waste resulting from the production of defective parts. A machine or production line is stopped until the root cause of the problem is resolved. This practice makes certain that defective parts are not sent downstream, and that the same problem does not recur (Liker, 2004).

Match 5. These principles stress the importance of treating employees with respect and making full use of their capabilities and potential (Ohno, 1988). The process of "nemawashi" refers to the involvement of employees in the decision making process when it affects their jobs. This process focuses on the approach to decision making rather than the outcome and quality of the decisions (Liker, 2004).

Match 6. These principles suggest that companies should value people over technology. Technology must support the people, processes, and the values of the organization, and not displace or replace them. It is important that a new technology be tested and evaluated against existing processes to determine if it conflicts with the organization's philosophy and its operating principles. If it does, then labor utilization should prevail over machine utilization.

2.3. Work design practices

2.3.1. Middle management support

There is absolute agreement amongst academicians and practitioners that any new initiative within an organization cannot be successful without the support of its top management (Ahire et.al., 1996; Anderson et.al., 1994; Flynn et.al., 1994). However in some cases, programs have failed even with this support. Amongst many possible explanations, middle management support seems to be a strong candidate (Pappas et.al., 2003; Facteau et.al., 1995; Brennan, 1991). It is middle management support that is crucial in translating the organizational policies and top management directives into practices and action.

Middle management support, similar to top management support, comes in three forms: interpersonal relations, information processing, and decision making (Mintzberg 1973). The difference is that the former views work on an operational level and has a short-term outlook, whereas top management support has a broader, more strategic focus and a long-term outlook. In addition, middle management support serves two instrumental roles of providing pertinent information to top management and executing strategies formulated by them (Hrebiniak, 1984).

Middle management, which represents the middle of an organization, is the crucial link between individual employees/teams and top management directives (Balogun, 2003; Mintzberg et.al., 2003; Likert, 1961). It connects an organization's strategic and operational levels through the process of mediation, negotiation, and interpretation activities (Balogun & Johnson, 2004). In a study by King et.al. (2001), middle management support is viewed as a catalyst that identifies, develops, and formulates operational strategies according to top management's organizational strategies, leading to improved performance.

From a change theory perspective, middle management support is crucial to initiate, create, and sustain organizational change (Oshry, 1999). Top management does not manage change; it enables middle management to understand why the change is needed, solicits input on how to achieve this change, and allows them to communicate this change to their workers (O'Toole, 1995). Top management expects middle management to provide the oversight and guidance needed to create the requisite collaboration and teamwork (Kuo-Wei, 2005) by interpreting top management objectives, managing the change, and encouraging learning throughout the organization (Mintzberg et.al., 2003; Balogun & Johnson, 2004). More importantly, middle management support is crucial in maintaining clarity of the message through a top-down hierarchy. If clarity or sincerity is compromised, the say/do gap begins to widen (Senge, 1990).

Middle management support has become recognized as a critical source to organizational success (Huy, 2001). They help support top management's organizational strategic direction by championing alternatives at the operational levels (Burgelman, 1983), synthesizing information based on internal and external events (Westley, 1990) and implement top management's strategy. Through consensus building (Rue & Byars, 2003; Pappas et.al., 2003), middle management facilitates the implemention of actions and decisions that align with the advocated vision of top management (Senge, 1990; Valentino, 2004). In a study by Kraut et.al., (1989), the most important tasks for middle management involve planning and allocating resources among different groups, coordinating interdependent groups, and managing group performance within their span of control. In the traditional organizational hierarchical structure, middle management supports the resolution of internal conflicts, ensures standards are satisfied throughout operational units, and supports hierarchical flow of information (Mintzberg et.al., 2003).

For the purpose of this study, middle management support is defined as a set of managerial activities that facilitate the provision of resources and communication of top management directives to employees to improve organizational performance.

2.3.2. Employee participation versus employee involvement

A review of organizational behavior and human resource management literature reveals that "employee involvement", "employee participation", and "participative decision making" have been used interchangeably in many instances (Lawler, 1991; Cotton, 1993; Marshall & Stohl, 1993; Glew et.al., 1995; Shadur et.al., 1999). As the latter two terms are similar, employee participation and employee involvement are distinguished further to provide clarification.

2.3.2.1. Employee participation

"Employee participation" is concerned with shared decision making in the work environment (Mitchell, 1973). Over the years, employee participation has come to mean different things to different people. As seen in Table 2.8, not only has it been conceptualized in numerous ways, but when implemented in a laboratory or organizational setting, it brings diverse outcomes based on the innumerable methodology, participation processes and forms used to measure it (Locke & Schweiger, 1979; Miller & Monge, 1986; Guzzo et.al., 1985; Cotton et.al., 1988; Leana et.al., 1990).

Table 2.8 Meta-analyses of employee participation studies

Author	**Conceptualization**		
	Context of Study	Type of Setting	Outcomes
Locke & Schweiger (1979)	Based on Methodology	Laboratory Studies	No effect on productivity and satisfaction
		Co-relational field studies	No effect on productivity, slight effect on satisfaction
		Multivariate experimental field studies	Difficult to determine of the results were due to participation
		Controlled experimental field studies	Positive effect on satisfaction, however not consistently
Miller & Monge (1986)	Based on Participation Process	Cognitive Model	Stronger relationship with productivity as opposed to satisfaction
		Affective model	Strong correlation between participation and satisfaction
		Contingency Model	No effect on productivity and satisfaction

Cotton et.al. (1988)	Based on form	Participation in work decisions Consultative participation Short term participation Informal participation Employee ownership Representative participation	Positive effect with performance and mixed effect with satisfaction Inconclusive effect with both performance and satisfaction No effect on both performance and satisfaction Positive effect with both performance and satisfaction Positive effect with both performance and satisfaction No effect on performance and satisfaction
Guzzo et.al. (1985)	Based on participation programs	Training and instruction, Goal setting Socio-technical intervention Financial compensation	Strongest positive effect on productivity improvement Positive effect on productivity, however not

		Recruitment and selection, Appraisal and feedback, Management by objectives Work re-design, Decision making techniques, Supervisory methods, Work rescheduling Kind and size of organization Multiple program implementation	statistically significant positive effect on productivity for smaller sized, governmental kinds of organization rather than larger managerial/professionally run organizations Combined effect is not as great as the simple sum of the their separate effects

Locke & Schweiger (1979) were the first researchers to take a comprehensive look at the participation management literature. They reviewed 50 studies with "satisfaction" and "productivity" as the criterion variables. Their study divided the extant literature into four general categories based on the methodology used: laboratory studies, correlational field studies, multivariate experimental field studies, and univariate (controlled) experimental field studies. While they concluded that employee participation did not relate to productivity, they did find that employee participation increased employee satisfaction in approximately 60% of their reviewed studies. Miller & Monge (1986) found fault with the classification system of Locke & Schweiger (1979), stating it was too general to provide any meaningful information on the strength of the relationship between participation, productivity and satisfaction. They criticized Locke and Schweiger's (1979) work for not attempting to detect the systemic differences in the studies that found participation to be superior as compared to those who found it inferior. In their study, Miller and Monge (1986) focused on variables, identified from the cognitive[2], affective[3] and contingency[4] models, that may have moderated the relationship between employee participation and the outcomes of satisfaction and productivity. Participation had no effect on productivity and satisfaction when using the contingency model, and there were varying degrees of positive relationship between participation and productivity and satisfaction when using the cognitive and affective models.

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[2] Concerned with the meaningful utilization of employees capabilities and views satisfaction as a by-product of the participation process (Miles and Ritchie, 1970)

[3] Concerned with the participation and consulting activities of employees to satisfy the egoistic needs so that they will be more cooperative to management decisions (Miles and Ritchie, 1970)

[4] Concerned with a variety of factors such as individuals' personality, particular decision situations, nature of relationships between individuals, job levels, individuals' values participating in organizational decision making (Vroom, 1960)

Cotton et.al. (1988) provided a classification scheme, based on the works of Dachler and Wilpert (1978), that identified the various forms of participation. More specifically, participation in work decisions, informal participation, and employee ownership had a positive effect on productivity and satisfaction. Short term participation and representative participation had no effects on productivity and satisfaction. Consultative participation offered inconclusive results. Leana et.al. (1990), however, rejected the conclusions of Cotton et.al., noting that generalization was not possible due to methodological inconsistencies within their study. The issue of questionable methodologies was also raised by Wagner and Gooding (1987), who found that studies using questionable methodologies led to stronger findings for employee participation and its relationship to productivity and satisfaction.

The divergence of outcomes for this research topic stems from a lack of consensus among researchers as to what organizational phenomena, dimension, or event should be labeled as “participation”. Many different techniques have been classified under the employee participation rubric (Glew et.al., 1995; Coye and Belohlav, 1995). There is no agreed upon definition of employee participation. Also, participative programs have varying degrees of effect on different levels within an organization. Some programs include only a few individuals or teams, whereas others may include whole plants or corporations.

In order to address the confusion surrounding the concept of employee participation, Lawler (1986) posited that researchers use a different perspective to study the concept of employee participation. He introduced the concept of employee involvement. With this conceptualization, researchers began to examine “how” employees participate in programs rather than in “what” programs they participate. That is, their focus shifted from describing the process to evaluating the underlying factors in the employee participation process.

2.3.2.2. **Employee involvement**

Employee involvement is an action-oriented organizational process characteristic that is used to manage organizational behavior (Coye & Belohlav, 1995). A review of the employee involvement literature reveals that employee involvement interventions lead to both higher productivity (Kaufman, 2003; Hanna et.al., 2000; Lawler et.al., 1995; Lawler et.al., 1992) and improved quality of work life (Huse & Cummings, 1985; Riordan et.al., 2005). Employee involvement is a bottom-up approach to management decision making, in which employees are encouraged to participate in activities aimed at defining and solving problems to improve their workplace (Shah & Ward, 2003; Ohno, 1988; Sugimori et.al., 1977).

Employee involvement is defined as an approach to manage organizational performance, in which employees have a sense of controlling their work, receive information about their work and performance, and are rewarded for their performance (Lawler et.al., 1992). The managerial practices that facilitate employee involvement consist of four critical factors:

- information sharing – degree of downward and upward flow of information;
- training – expertise and knowledge of the specific operations and organization in general;
- rewards – types of rewards and compensation used; and

- power sharing – type of power and the areas in which they are used.

For an employee involvement program to be successful, all four factors should be integrated in parallel (Frey, 1993). Lawler and Bowen (1995) assert that:

> Power without training, information, and rewards leads to poor decision making. Information and training without power leads to frustration because employees cannot use their expertise to make changes. Power, training, and information sharing without reward for performance leads to lack of motivation, because employees do not see any personal growth and retribution for their efforts. **(p. ?)**

Mohrman et.al. (1996) extended the works of Lawler and Bowen (1995) by studying the employee involvement activities at Fortune 100 companies. They noted an increasing trend to transfer employee involvement initiatives down to lower levels of the organization using the four critical factors suggested by Lawler (1986).

Information sharing practice. This factor refers to a set of activities aimed at facilitating the exchange of information about operational and administrative functions with and between employees in an organization (Riordan et.al., 2005). Information sharing occurs when employees at the lowest level in an organization have access to, are directly provided with, or are providing others with information related to their work activities (Denison, 1990; Lawler, 1986). The information shared should be accurate, relevant and timely. When both upward and downward channels of information sharing are in place, employees participate in a meaningful way and act responsibly, and they are involved in organizational processes and functions that were previously handled only by upper management (Randolph, 1995; Kouzes & Posner, 1987).

Training practice. This factor refers to a set of activities that provide specific skill sets relevant to an employee's work assignment in an organization (Sumukadas, 2005; Vandenberg et.al. 1999). Increasing organizational effectiveness depends on the skill and knowledge acquired through training (Backeberg, 1995; Senge, 1990). Without the right skills and knowledge, employees cannot do their jobs effectively (Lawler et.al., 1992, 1995). The most frequently identified training practices for employee involvement are cross training, team building, problem solving, safety, and job skills (Sumkadas, 2005; Shah and Ward, 2003; Brown et.al., 2000; Lawler et.al., 1992).

Reward practice. This factor refers to a set of activities aimed at linking rewards directly to individual performance and business results (Lawler et.al., 1995). Reward practices are used as tools to modify the behavior of employees in an organization (Sumukadas, 2005). The type of reward is not as important as the process of rewarding. The connection between rewards and performance must be visible to employees (Vandenberg et.al., 1999). Finally, rewards must be tied to behavior, be valued, and be achievable, in order to increase motivation and employee involvement (Lawler, 1986).

Power. The concept of power has been described in the literature in a number of ways. Conger & Kanungo (1988) and Bacharach & Lawler (1980) found that the perception of power was related to availability and control of information, and to access to training. Kotter (1979) and Pfeffer (1981) concluded that the perception of power was related to the locus of control. The greater the locus of control, the greater is the feeling of power. Bowen & Lawler (1992) described power as the right to make decisions that influence organizational direction and performance. For this study, power refers to the ability of employees at the lowest level in the organizational hierarchy to participate in decision making and to determine how best to implement decisions (Vandenberg et.al., 1999).

2.3.3. **Employee empowerment**

Employee empowerment has been widely recognized as a potentially effective work design practice to manage organizations (Seibert et.al., 2004; Menon, 2001; Bowen and Lawler, 1992). It is, however, very different from employee involvement. The major difference between these terms is in ‘transfer’ of decision making authority. In employee involvement programs, management retains control, whereas in employee empowerment programs the employees have, at least to some extent, more authority to control the coordination, allocation, and improvement of functions associated with their task.

A review of the empowerment literature reveals that empowerment has been classified as either structural or psychological (Seibert et.al., 2004; Mills and Ungson, 2003; Psoinos & Smithson, 2002; Randolph, 1995; Conger and Kanungo, 1988; Thomas and Velthouse, 1990; Menon, 2001). As seen in Table 2.9, structural empowerment is described in terms of the organizational structures, policies and practices that support employee empowerment (Seibert et.al., 2004; Mills & Ungson, 2003; Psoinos & Smithson, 2002; Randolph, 1995). Psychological empowerment is described in terms of the specific cognitions an individual makes about their work environment (Conger & Kanungo, 1988; Thomas & Velthouse, 1990; Menon, 2001).

Table 2.9 Perspectives on employee empowerment

	Authors	**Empowerment Definition**	**Dimensions**
Structural Empowerment	Seibert et.al. (2004)	A set of shared perceptions regarding the extent to which an organization makes use of policies, practices, and procedures to support empowerment	Information sharing, autonomy through boundaries, team accountability
	Psoinos & Smithson (2002)	The decentralization of the decision making authority by delegating power to the staff to make and implement decisions	Improvements, problem solving, quality responsibility, planning and scheduling of work, equipment maintenance and repair
	Randolph (1995)	As recognizing and releasing into the organization the power that people already have in their wealth of useful knowledge and internal motivation	Information sharing, goal setting, decision making rules, training, appraisal system, teamwork
	Mills and Ungson (2003)	The horizontal decentralization of authority by delegating the decision making prerogatives to employees, along with the discretion to act on one's own	
Psychological Empowerment	Conger and Kanungo (1988)	A process of enhancing feelings of self efficacy among organizational members through the identification of conditions that foster powerlessness and through their removal by both formal organizational practices and informal techniques of providing efficacy information	Feelings of self efficacy
	Thomas and Velthouse (1990)	Intrinsic task motivation	Impact, Competence, Meaningfulness, Choice
	Spreitzer (1995)	A motivational construct that is manifested in four cognitions: meaning, competence, self determination, impact	meaning, competence, self determination, impact
	Menon (2001)	A cognitive state of mind that is characterized by a sense of perceived control, competence and goal internalization	Perceived control, Perceived competence, Goal internalization

According to the conceptualization of Thomas and Velthouse (1990) and Spreitzer (1995), psychological empowerment is manifested as four cognitions:

Meaning. Defined as an "individual's intrinsic caring about a given task" (Thomas & Velthouse, 1990, p.674), meaning is the association of job value and purpose with the ideals and standards of the individual. A stronger association results in a more significant meaning. Tasks must be meaningful for employees to feel empowered.

Competence. Competence, defined as a "feeling of self-efficacy" (Conger & Kanungo, 1988), refers to an individual's belief in his/her capability to perform activities with skill (Gist, 1987). Wood and Bandura (1989) documented four primary ways in which self-efficacy can be instilled and strengthened:

- Mastery experiences – past successful performances increases beliefs about future capabilities;
- Modeling – effective techniques and strategies are observed and built into the repertoire of the person observing, thus enhancing the belief that they have the capability to manage future situations;
- Social persuasion – a realistic encouragement leads to greater expended efforts which results in likely successes; and
- Physiological states – Emotional arousal and tension can create both favorable and unfavorable outcomes.

Regardless of the method chosen, maximizing employees' beliefs of self-efficacy is important because without a sense of confidence in their abilities, employees feel inadequate and unempowered.

Self-determination. This cognition is defined as "an individual's sense of having a choice in initiating and regulating actions" (Deci et.al., 1989). In other words, individuals see themselves as initiators of their own behavior, free to select their desired outcomes and corresponding means to achieve them. Self-determined employees see themselves as being proactive rather than reactive (Spreitzer, 1995). They feel empowered and take ownership of their behavior because it originates from within, rather than being controlled from external sources.

Impact. Employees feel empowered when they perceive their behavior has an effect on organizational outcome. Impact refers to "the degree to which an individual can influence strategic, administrative, or operating outcomes at work" (Ashforth, 1989). A lack of impact can lead to learned helplessness (Thomas and Velthouse, 1990). This can result in reduced motivation and thus lead to a feeling of being unempowered.

Menon (2001) conceptualized empowerment on the premise that the psychological experience of power underlies the feeling of empowerment. The sociological perspective treats power as potential influence in the context of social interactions (Bacharach & Lawler, 1980), while the psychological perspective treats power as motivating factors (McClelland, 1975). Combining these perspectives, Menon (2001) conceived empowerment to manifest itself in three dimensions: power as perceived control, power as perceived competence, and power as being energized towards achieving the valued goals of an organization. These dimensions of employee empowerment are used in this study.

Perceived control. Perceived control, conceived from the sociological perspective of power, occurs in situations in which power is treated as an internal urge, or drive, to influence and control others and their work decisions (White, 1959). It reflects Thomas & Velthouse's (1990) cognitions of impact (i.e. ability to influence others to effect organizational outcomes) and self-determination (i.e. autonomy in initiation and continuation of work behaviors). For the purpose of this study, perceived control is defined as an individual's perception of autonomy in the scheduling of work, performance of work, utilization of resources, and decision making (Menon, 2001).

Perceived competence. Stemming from the psychological perspective of power, perceived competence is essential for the feeling of empowerment. An individual believes that s/he can successfully meet routine task demands and any non-routine challenges that might arise in the course of work (Menon, 2001). Perceived competence occurs in a situation in which power is treated as a motivation factor that boasts one's feeling of self-efficacy to meet given situational demands (Wood and Bandura, 1989). This belief of self-efficacy reflects Thomas and Velthouse's (1990) cognition of competence. For the purpose of this study, perceived competence is defined as an individual's self-efficacy and confidence with regards to role demands.

Goal internalization. Also grounded in the psychological perspective of power, goal internalization is the energizing aspect of the psychological experience of empowerment. It occurs in a situation in which power is treated as a motivating factor to energize and strengthen one's belief and action in the attainment of a mission or a valued cause. This commitment in belief and action reflects Thomas and Velthouse's cognition of meaning. For the purpose of this study, goal internalization is defined as an individual's belief in the goals of the organization and his/her readiness to act on its behalf (Menon, 2001).

2.3.4. Task interdependence

A review of organizational design and behavior literature reveals that interdependence has been described in different forms: resource interdependence, task interdependence, goal interdependence, and reward and feedback interdependence (Wageman, 1995; Mitchell and Silver, 1990; Saavendra et.al., 1993; Wageman and Baker, 1997; Hardin, 1968). In a more recent study, Barrick et.al. (2007) suggested that interdependence can be categorized into two types. Structural interdependence is based on the nature of the task or the technological requirements (Thompson, 1967). Psychological interdependence is based on the social demand to work together in order to achieve collective outcomes (e.g. goals and rewards) (Wageman, 1995).

Task interdependence is an important structural variable in organizational behavior theories, especially those that focus on organizational design. Kiggundu (1983) characterized task interdependence as being either initiated or received. Initiated task interdependence occurs when an individual influences someone else's task performance, whereas received task interdependence occurs when an individual is influenced by someone else's task performance. Thompson (1967) and Saavendra et.al. (1993) used the exchange of information and resources to categorize task interdependence as pooled, sequential, or reciprocal.

Pooled task interdependence. Team members make a contribution to group output without the need for direct interaction with other work group members. Typically, members in the team have similar roles and do similar tasks. For example, the overall output of a team making widgets in the drilling department is dependent on the individual outputs of each member working on the same operation, but on different machines without any direct interaction with each other.

Sequential task interdependence. A team member must act on a particular operation before other members of the team can act on it to complete the remaining operations needed to complete the whole task. Typically, members in the team have different roles, performing different tasks in a pre-determined order (work sequence is unidirectional). Most importantly, no one member completes the entire operation. For example, the overall output of a team manufacturing shirts is dependent on the output of each member working on the different operations (i.e. cutting, stitching, labeling, and packaging) in a pre-determined sequence on different machines with direct interaction with each other.

Reciprocal task interdependence. When the scope of an operation is too large, team members must work simultaneously to complete it. One team member's output becomes another member's input and vice versa. Generally team members have different roles and often are specialists in performing specific tasks. Work sequence is bi-directional and time-lagged. For example, in a search and rescue operation, team members communicate location, status, and other vital information to coordinate their efforts and complete the operation.

In organizational work design, task interdependence can vary along a continuum from none (e.g. an individual task executed by one person who has all resources necessary to complete it) to high (e.g. a collective task whose successful completion depends on the input of multiple individuals). For the purpose of this study, task interdependence is defined as the degree to which members within a work unit work closely with each other and share material and expertise in order to complete a task.

2.3.5. **Technical practices**

The common themes across lean definitions in the previous section suggest that the most important objective of lean production is the elimination of 'waste' and reduction of variability. In this section we will review the most commonly used practices[5], both in the literature and in the industry that help in achieving the objectives of elimination of 'waste' and reduction of variability on the shop floor. Table 2.10 provides a summary of those technical practices that help eliminate the seven classical forms of waste and reduce the variability due to processing time and customer demands.

[5] Practices are the observable facets of principles. They are conceived as activities or a set of activities (Dean & Bowen, 1994) since principles are too general and abstract for empirical research

Table 2.10 Lean practices associated with types of waste

Associated lean practices	Type of Waste								
	Overproduction Making more than is required by the next process	**Waiting** Idle time created when waiting	**Transportation** Movement of materials or people around a plant that does not add value to the product	**Inappropriate processing** Any effort that adds no value to the product	**Unnecessary inventory** Any supply in excess through the manufacturing process	**Unnecessary motion** Movement of people or equipment around a plant that does not add value to the product	**Defective parts** Inspection and repair of materials in inventory	**Untapped human potential** Waste of not utilizing people to the best of their unique abilities	**Variability** Waste that is created by buffering for inventory, capacity, and time
Standardized work				x					x
Pull production	x	x		x	x				x
Continuous flow		x	x	x					
Production smoothing "Heijunka"			x						x
Production layout			x			x			
Total productive maintenance		x							x
Setup time reduction	x				x				
Zero defects	x				x		x		
Visual control							x		
Kaizen /Continuous improvement								x	
5-S						x			

2.3.5.1. **Standardized work**

Standardized work defined as, “a set of formal, written work instructions for each process” (Hill, 2010), lead to work that is highly specified as to its content, sequence, timing, and outcome (Spear & Bowen, 1999; Lee & Ebrahimpour, 1984). Standardized work practices help in eliminating waste resulting from inappropriate processing (e.g., overproduction and transportation) and achieving process stability by minimizing the variability (e.g., inventory buffering) during production (Hill, 2010). It not only facilitates in the organizational learning wherein the know-how and expertise is preserved, but also assists in auditing, problem solving and improvements as standard work provides the baseline against which processes can be measured against.

2.3.5.2. **Pull production**

In the classical JIT view, pull production is a practice that determines what should be ordered, how much should be ordered, and when it should be ordered based on customer demands. Hopp & Spearman’s (2004) definition of pull production distinguish between pull and traditional push systems. Pull production defined as, “a practice that explicitly limits the amount of work-in-process in a system” help manage material movement in the system by a mechanism which triggers production at one work station based on the current demand at the next work station (Voss & Robinson, 1987). Pull production helps minimizing the waste resulting from overproduction (e.g., larger inventory and work-in-progress, longer cycle times).

2.3.5.3. **Continuous flow**

Continuous flow is the ultimate goal of lean production. It is defined as, "a practice that support the production and movement of small batches through a series of processing steps with minimal inventory and almost no waiting between steps" (Hill, 2010). This practice helps eliminate the waste resulting from waiting (e.g., longer cycle times), and inappropriate processing (e.g., transportation).

2.3.5.4. **Production leveling "Heijunka"**

Production leveling (a.k.a production smoothing, Heijunka) is defined as, "a practice of distributing production volume and mix evenly over time" (Dennis, 2007). Instead of running large batches of one of model after another, it is advised to run small batches of many models over short periods of time. This practice results in producing the same mix of products during each period (McLachlin, 1997). When achieved, this practice will help minimize the production variability by eliminating the unnecessary expediting, checking, and reworks (Suzaki, 1985).

2.3.5.5. **Cellular manufacturing**

A production layout refers to an "approach to organizing the physical configuration of a facility based on the sequence of steps required to build a particular product" (Hill, 2010). Lean operations support a physical layout of the production facility that facilitates a one-piece process flow which is streamlined (Voss & Robinson, 1987; Lee & Ebrahimpour, 1894). Cellular manufacturing is one such process in which equipment and workstations are arranged in a sequence that supports a smooth flow of materials and components through the process with minimum transport or delay (Suzaki, 1985). This practice helps eliminate the waste resulting from transportation and unnecessary motion of men, machinery and material (Suzaki, 1985).

2.3.5.6. **Total productive maintenance**

Total productive maintenance is defined as, "a practice that ensures uninterrupted and efficient use of equipment(s) through machine operator involvement" (Dennis, 2007). Machine operators dedicate a portion of their day to both inspection and planned equipment maintenance activities (Shah & Ward, 2007; White et.al., 1999). The machine operators can identify and repair minor equipment problems to avoid future major problems. This practice helps eliminate the waste due to waiting (e.g. longer cycle times) and reduce production variability by making sure that there are no machine/equipment breakdowns.

2.3.5.7. **Setup time reduction**

Setup time reduction is defined as, "a practice that reduces, simplifies, and or eliminates the work required in changing over a machine's setup time from one component to the next component" (Finch & Cox, 1986). Changeovers are done in minutes rather than hours (Shingo, 1983). Setup time reduction practices included separating internal setups from external setups, and more importantly converting internal setups into external setups wherever possible (Monden, 1983). Reduction in the setup times helped eliminate waste due to overproduction (e.g. larger inventory) by facilitating in the production of smaller batch sizes (Voss & Robinson, 1987).

2.3.5.8. **Zero defects**

Zero defects defined as, “a practice that is aimed at improving quality and promoting error free production through employee empowerment” was developed by Shingo (1983) in an effort to extend the concept of ‘Jidoka’. Sugimori et.al. (1977) in his description of the JIT production system emphasized that workers were prevented from taking non standard methods to keep the system from running. These procedures usually resulted in accidents, troubles and or defects. Suzaki (1985) emphasized prevention of defects rather than relying on inspection to detect them. This method put a check on the transfer of any defective parts to the subsequent process. The ability to check for defects at the source and stopping of the line to fix the problem resulted in the elimination of inspection at the end of the line, and there was neither need for re-work nor any material wastage (Stewart & Grout, 2001).

2.3.5.9. **Visual control**

It is a system that is designed to create a visual workplace wherein the work environment is self explaining, self ordering, and self improving. Any out-of-standard situation is immediately obvious and employees can take corrective action (s). Hill (2010) defined visual control as, “a set of practices that is aimed to design systems that have simple indicators and metrics that can be seen and understood almost immediately”. This practice helps in the elimination of waste resulting from overproduction, unnecessary inventory, and defective parts being produced (e.g. re-work).

2.3.5.10. **Kaizen / continuous improvement**

In order to sustain quality products and processes, organizations are always looking out for ways to improve (Koufterous et.al.1998; Spear & Bowen, 1999; Hopp & Spearman, 2004). Kaizen is defined as, "a practice that continuously strives to make incremental improvements through worker involvement on an ongoing basis" (Hill, 2010). Achieving leanness in production is not a one-off effort, it is rather a journey. Koufterous et.al. (1998) and Hopp & Spearman (2004) focus on continuous improvement efforts as a means to achieve high levels of pull production through reducing defects and eliminating the variability in the system while Spear and Bowen talk about how continuous improvement efforts can be conducted in a scientific method under the guidance of a teacher.

2.3.5.11. **5-S**

5-S is a lean manufacturing practice that helps organizations sort, set in order, shine, standardize, and sustain productive work environments. The first sub-practice, "*Sort*" focuses on separating the necessary from the unnecessary and getting rid of the unnecessary items. This is done through a visual method called as "red tagging". A red tag is placed on all items that are not required to complete a job in a given work area. The second sub-practice, "*Set in order*" focuses on organizing the work area by making sure that everything has a place and everything is in its place. The third sub-practice, "*Shine*" focuses on keeping the work area clean and shining. The fourth sub-practice, "*Standardize*" focuses on standardizing the best work practices once established in each work areas. The fifth sub-practice, *"Sustain"* emphasizes on the importance of sustaining the new standards once they are implemented and achieved.

2.4. Quality of work life

An extensive review of the organizational behavior literature reveals that there is no consensus on the definition and operationalization of the term "quality of work life" (QWL) (Rethinam and Ismail, 2008; Martel & Dupuis, 2006; Lewchuk et.al., 2001; Sirgy, 2001; Loscocco & Roshelle, 1991; Nadler & Lawler (1983); Levine, 1983; Kohl and Shooler, 1982). According to the early works of Nadler and Lawler (1983), QWL was described using six definitions: (1) as a variable, (2) as an approach, (3) as a set of methods, (4) as an ideology, (5) as everything, and (6) as nothing. As a variable, QWL was measured as the individuals' overall outcome of a job (Levine, 1983). As an approach, QWL was defined as a program to improve cooperation between management and the union to improve outcomes for both the individual and the organization (Lewchuk et.al., 2001; Lippitt, 1978). As a set of methods, QWL was described as a variety of organizational change levers such as work redesign, participation in decision making, gainsharing, and team building (Martel and Dupius, 2006; Glaser, 1980). As an ideology, QWL was defined in terms of the nature of the work and the worker's relationship to the organization. This definition not only included the methods to achieve QWL, but also elaborated on why those methods were desirable, moral, and obligatory. The last two definitions refer to QWL as a global concept; it was perceived as a panacea for coping with grievance problems, quality problems, low productivity rates and just about everything else.

Table 2.11 Quality of work life definitions

Author	Definition	Operationalization	
		Dispositional approach	**Structural approach**
Glaser (1980)	(none, only description)		
		breaking down traditional status barriers between management and production personnel, internally motivated,	Organizational commitment, competency development, challenging work, growth opportunities,
Nadler & Lawler (1983)	QWL is defined as a way of thinking about people, work, and organization		
		Idea of participation in organizational problem solving and decision making, reward systems,	Basic nature of work itself, physical work environment
Levine (1983)	QWL is defined in terms of those aspects of work which make a difference to individuals		
		Social satisfaction needs, self esteem, equitable promotions, non work life balance	Variety in daily job routines, work challenges

Lau & May (1998)	QWL is defined as favorable conditions and environments of a workplace that supports and promotes employee satisfaction by providing employees with rewards, job security, and growth opportunities		
		Rewards, job security	Growth opportunities
Sirgy et.al. (2001)	QWL is defined as employee satisfaction with a variety of needs through resources, activities, and outcomes stemming from participation in the work place		
		Satisfaction of health and safety needs, satisfaction of economic and family needs, satisfaction of social needs, satisfaction of aesthetic needs, satisfaction of knowledge needs, satisfaction of actualization needs, satisfaction of esteem needs	
Martel & Dupius, 2006	QWL at a given time is defined as the condition experienced by the individual in his or her dynamic pursuit of his/her hierarchically organized goals within work domain …..		
		Participation in decision making affecting one's own work, Autonomy in performance of duties, effectiveness at work, Feeling of belonging, Emotive	Time to perform duties, Fit between skills and type of work, Diversity of duties, Physical requirement needed to perform the duties, Work

		power, competitiveness, relationship with colleagues, supervisor, and employer, Income and Income security, Clarity of role, Allocation of work during absence of other employees	environment, Equipment and tools needed for work facilities, Company policies concerning leave for family reasons, Possibility of advancement, Transfer, Work schedules,
Rethinam & Ismail (2008)	QWL is defined as the effectiveness of the work environment that transmit to the meaningful organizational and personal needs in shaping the values of the employees that support and promote health and well being, job security, job satisfaction, competency development and balance between work and non-work life		
		Job security, Job satisfaction, Work and non-work life balance	Health and well being, competency development

The different definitions and their operationalization can be categorized into two broad categories: the dispositional approach and the structural approach (Kerce and Booth-Kewley, 1993; Lawler, 1982). As shown in Table 2.11, in the dispositional approach, QWL definitions are subjective. They are defined as a variable, which focuses on the individual's reaction to work and their personal consequences of their work experience (Nadler & Lawler, 1983). These definitions are then operationalized based on individuals' culture and values (Sirgy et.al., 2001; Daniels, 2000). This approach assumes that individuals may be predisposed to certain work attitudes and values (Staw et.al., 1986) and that these attitudes and values can differ based on age, gender, culture, and education. According to the structural approach, QWL definitions are objective. They are defined as an approach or method, which focuses on the process by which the outcomes for both the individual and the organization can be improved (Loscocco & Roschelle, 1991; Nadler & Lawler, 1983). These definitions are then operationalized based on situational attributes, such as characteristics associated with an individuals' job (Nadler & Lawler, 1983; Levine, 1983).

A review of the definitions and their operationalization indicates that QWL is a multi-dimensional construct made up of a number of interrelated factors that need careful consideration to conceptualize and measure. In a study by Lau and May (1998), they acknowledge that these factors need not be universal or eternal. The choice of the factors included in a study depends on the intended context of each administration.

For the purpose of this study, QWL is defined as the condition experienced by individuals that result from the effectiveness of their work environment (Martel &

Dupius, 2006; Rethinam & Ismail, 2008). The factors included in this study are: (1) physical context, (2) psychosocial context, (3) job satisfaction, and (4) job security. The physical context is defined as the organization's physical environment that is likely to influence the workers safety and health (Rethinam & Ismail, 2008; Martel & Dupius, 2006; Brown et.al., 2000; Nadler & Lawler, 1983). The psychosocial context is defined as the individuals' quality of social interaction with other employees in the organization (Martel & Dupius, 2006; Sirgy et.al., 2001; Levine, 1983). Job satisfaction is defined as the appraisal and feeling one has towards their job (Rethinam & Ismail, 2008; Sirgy et.al., 2001). Job security is defined as the ability of the organization to provide stable full-time employment, regardless of changes in the environment (Rethinam & Ismail, 2008; Sirgy et.al., 2001; Lau & May, 1998).

2.5. Employee performance

A review of the operations management, human resources, and organizational behavior literature reveal that researchers have proposed a wide variety of measures for employee performance. The selection of these measures is based on the following characteristics: relevance to objectives, ability to assess performance accurately; simplicity of data collection and calculation; and impact on operational productivity (Seibert et.al., 2004; Motowidlo et.al., 1997; Globerson & Riggs, 1989). The common employee performance measures in operations management are based on the evaluation of operational actions such as output quantity, quality of output, timeliness, dependability, and flexibility (Spangenberrg & Theron, 2004; Ahmad & Schroeder, 2003;

Globerson & Riggs, 1989). The most widely used employee performance measures in human resources and organizational behavior literature is based on behaviors which are under individuals' control, and which contribute to, or detract from, individual, departmental, and/or organizational goal attainment (Parker, 2007; Campbell et.al., 1993). Employee performance based on these individual behaviors can be measured as either task or contextual performance.

Task performance is operationalized in one of two ways. It is measured as performance based on task knowledge, which is measured as the individuals perceived competence cognition. More specifically, it is individuals' knowledge of facts and principles related to their function(s) in the organization, and includes knowledge of procedures, heuristics, and rules for processing information and making decisions about matters related to their function(s). Task performance can also be measured as performance based on task skill. Here, performance is measured in terms of individuals' ability to use their skills and relevant technical knowledge to perform the necessary actions, quickly, smoothly, and without error (Seibert et.al., 2004; Motowidlo et.al., 1997).

Contextual performance is also operationalized in one of two ways. It is measured as performance based on contextual knowledge, which refers to carrying out actions known to be effective for handling situations that call for help and coordination with others. More specifically, this is done by following organizational rules and procedures, and by endorsing, supporting, and defending organizational objectives. Contextual performance is also measured as performance based on contextual skill. Employee performance is measured in terms of individuals' ability to use their skills and relevant technical knowledge to carry out actions known to be effective for handling situations that call for help and to coordinate with others; following organizational rules and procedures; endorsing, supporting, and defending organizational objectives. (Seibert et.al., 2004; Motowidlo et.al., 1997).

CHAPTER 3. RESEARCH MODEL AND HYPOTHESES

This chapter provides the theoretical arguments used to conceptualize the framework for the research model. This framework is used to evaluate whether lean production, defined as an integrated socio-technical system, enhances employee productivity and quality of work life. Following the research model are the hypotheses tested in this study.

3.1. Conceptualization of the research model

The review of the LP and STS literature revealed a link between organizational work practices and the principles of LP and STS. This section establishes the theoretical rationale for the research model. Table 3.1 details how specific work practices are associated with LP and STS principles.

Table 3.1 Work practices associated with LP and STS principles

Work Practice	STS Principles Adopted from Cherns (1976, 1987)	Lean Principles Adapted from the "House of Lean" (2007)
Management Support Middle Management Support	**Compatibility:** *The process of designing a system should be consistent with the goals of the design*	**Production decisions based on meeting customer expectations:** *Identify and address the critical production needs*
Employee Involvement Information sharing practices Training practices Rewards practices	**Information flow**: *Flow of work related information to individuals who need it most* **Support Congruence:** *Social support structures such as reward systems, selection process, training policies, conflict resolution mechanisms designed to re-inforce behaviors which the organization structures is designed to elicit* **Multi-functionality** *Work design should avoid highly fractionalized jobs; individuals should be trained to perform a range of tasks* **Transitional organizations** *Involve the design team to transition into new systems based on the STS approach*	**Participatory management:** *Build a culture that engage and involve employees in decision making on decisions which affect their jobs/tasks* **Labor utilization** *Cross train workers so that they can perform multiple task(s)*
Employee Empowerment	**Minimal critical specification** *In the design of jobs, specify no more than what*	**Stop production** *Employees stop the production line to prevent defective parts from being transferred to the*

Perceived Control Perceived Competence Goal Internalization	*is absolutely essential* **Power and Authority** *Ability of employees to access and exercise authority over resources to carry out responsibilities*	*subsequent process*
Technical practices Standardized work Pull production Continuous flow production Production leveling Setup time reduction Total preventative maintenance Zero defects Visual control Kaizen 5-S Cellular Manufacturing	**Variance control** *Work should be designed to control variances (deviations from the ideal place) as close to their sources as possible* **Incompletion** *Examine, critique, and improve the system the moment it is implemented*	**Process stability and standardization are the foundations for continuous improvement** *Continuous improvement processes through which employees identify and then eliminate the 'waste' in the system* **Just-in-time production** *Focus on customer pull so that there is value flow rather than material flow*
Task Interdependence*	**Boundary location** *Boundaries should be determined based on logical process criterion*	**-**

* Is a work factor and not a work practice

3.1.1. **Middle management support**

Defined as a “set of managerial practices that facilitate in the implementation of top management directives by providing resources and interpreting the top management directives to employees to accomplish their task(s)” (Ramus & Steger, 2000), middle management support is associated with the STS principle of compatibility and the LP principle of Hoshin planning. Compatibility emphasizes the congruence between a systems design and an organization’s long term objectives (Cherns, 1987). Planning for and designing of the system should be the responsibility of the people who manage and use it (Hyer et.al., 1999). The LP principle of ‘*Hoshin kanri*’ (a.k.a Hoshin planning) refers to a process used to identify and address the critical business needs of an organization by aligning company resources to achieve the organization’s long term objective(s) (Dennis, 2007). Though it is top management who uses Hoshin planning to develop a road map that has a starting point and a destination (i.e. long term objectives), and also a plan for getting there (i.e. systems design), it is middle management support that determines the plan’s success or failure.

The successful implementation of top management directives depends on how well middle management manages daily operational activities, interprets the change for themselves and their teams, and most importantly, communicates the interpretation to their teams, in an endeavor to achieve the top management’s vision (Balogun & Johnson, 2004; O’Toole, 1995). Compatibility between the top management’s vision and its execution can occur only if middle management supports the change and facilitates in consensus building within their teams. This helps to align teams’ actions and decisions with top management's vision, thus increasing the likelihood of achieving that vision (Rue & Byars, 2003).

3.1.2. **Employee involvement practice**

The work practice of employee involvement is defined as an approach that emphasizes participatory organizational and management systems that involves employees in production planning, problem solving, and decision making activities aimed at the success of an organization (Lawler et.al., 1995). It is associated with the STS principles of information flow, support congruence, multi-functionality, and transitional organizations, and the LP principles of participatory management and labor utilization.

The information flow principle states that work related information should be provided to individuals to complete their task(s). This information can be used by individuals for the purposes of controlling, monitoring, record keeping, and action taking, and should be directed towards those who need to act on it (Cherns, 1987). The principle of support congruence states that organizations should provide for social support structures such as appropriate reward systems and training opportunities in order to reinforce the behaviors that the organization wants to elicit from its employees. The principle of multi-functionality states that workers should be cross trained so that, when the need arises, they can be made responsible for multiple tasks within the department. The principle of transitional organizations states that design teams should involve existing employees in the planning and design stage when transitioning into a newer structure.

The LP principle of participatory management states that employees should be engaged and involved in the process of production planning, execution, and problem solving at all times (Ohno, 1988). Involving employees not only helps to develop their capabilities but also to improve the organization's chances of success in the long term. The principle of labor utilization states that employees need not stand in front of an automated machine to monitor its operations; instead, employees should be trained to perform multiple tasks so that their time and capability is well utilized (Ohno, 1988).

Thus, employee involvement is a process characteristic of the job that allows employees to participate in decision making that affects their jobs and in the designing of new systems. Employees must be provided with timely and accurate work related information in order to have meaningful and responsible participation. They are also encouraged to participate by receiving appropriate support that reinforces behaviors the organization wants to elicit at the time. Finally, organizations that focus on labor utilization provide employees with multi-functional training so that they can be actively involved in organizational activities while being able to perform a wide range of tasks.

3.1.3. **Employee empowerment practice**

The work practice of employee empowerment is defined as an "individuals' cognitive state of mind which is characterized by a sense of perceived control, perceived competence, and goal internalization" (Menon, 2001). It is associated with the STS principle of minimal critical specification and authority, and the LP principle of stopping production so that production never stops.

The STS principle of minimal critical specification states that management should specify as little as possible about how jobs should be performed, so as to leave room for employees to use their creativity (Hyer et.al., 1999). However, one must first identify only what is essential and critical to the successful completion of the task(s), and only that which is essential should be specified to the employees (Cherns, 1976; 1987). The STS principle of authority states that employees should have the ability to access and exercise power over resources in order to carry out their responsibilities (Cherns, 1987). Employees are also made accountable for completing their task(s) with the appropriate use of resources that they have access to and authority over (Closs et.al., 2008).

The LP practice of ‘stop production’ states that competent and well trained workers using ‘autonomated’ machines are given the power to push a button or pull a chord that can stop the entire production line when they first identify defects or any variation from the standards. The line continues to remain shut down until the root cause of the defect is resolved.

Thus, employee empowerment is a process in which competent, self motivated and committed individuals expend high levels of effort, initiative, and persistence in accomplishing their task(s). Organizations promote empowerment by designing jobs such that employees are provided with no more information than what is absolutely essential. The information provided is usually essential and critical to the successful completion of the task(s). Employees at lower levels in the organization are given the control of and access to resources to carry out their job responsibilities. They also have the authority to stop a production line when a defective part is produced and not allow it to be moved to the subsequent process until the root cause of the defect is corrected.

3.1.4. **Technical practices**

Technical practices include eleven commonly used practices that aim to continuously eliminate all kinds of 'waste' by minimizing internal variability during production (Shah & Ward, 2003; Hopp & Spearman, 2004). These practices are representative of three bundles – just-in-time (JIT), total preventative maintenance (TPM), and total quality management (TQM) – that were classified by Shah and Ward (2003). The JIT bundle includes the practices of pull production, continuous flow, production leveling, and setup time reduction. The TPM bundle includes total productive maintenance practices. TQM bundle includes the practices of standardized work, kaizen, zero defects, 5-S and visual control. The technical practices are associated with the STS principles of variance control and incompletion, and the LP principles of continuous improvement through stability and standardization and the principle of just-in-time.

The principle of variance control states that any unexpected deviations in the output conformance should be controlled as close as possible to its point of origin (Cherns, 1987). The work system should be designed such that it facilitates in the identification, controlling and most importantly correcting the source of the error, so that defective parts are not fed downstream (Closs et.al., 2008). The principle of incompletion states that there is no such thing as a final design (Cherns, 1987). Systems design is an iterative process. Stability is desired, but the organization must continue to review and revise its design to reflect the appropriate changes to cope with the changing environment (Closs et.al., 2008; Huber & Brown, 1991).

The principle of stability and standardization states that in order to achieve stability one must create standards (Dennis, 2007). Stability can be achieved when the workplace supports management through organization and standardization, to be able to correct any deviations from the standard condition. In addition, machine operators' ability to perform the basic equipment maintenance task(s) such as inspection, cleaning, lubricating, and tightening of loose parts reduces machine breakdowns, minor machine stoppages, minor and hidden machine failures, and improves operational stability (Dennis, 2007). Standard are set in place through standardized work procedures. This allows for repeatability by providing clear start and end points for each task(s) or processes.

The principle of pull systems states that a work center must produce the right component at the right time in the right quantity for the subsequent work center. For example, the pull production practice eliminates the over production and reduction in the work-in-process inventory, the continuous flow practices, set-up time reduction practices, and production leveling practices aim to reduce the unnecessary delays in flow times by elimination of unnecessary wait times. These JIT practices help in creating a pull system which produces the right components at the right time in the right quantity. The standardized work practices eliminate variances by standardizing work in terms of its content, sequence, timing and outcome (Spear & Bowen, 1999). The total productive maintenance practice maximizes equipment effectiveness and provides production stability by preventing unexpected equipment breakdown. These TQM and TPM practices help achieve stable and standardized production process. Zero defects and visual management practices reduce (or eliminate) defective parts from being sent to subsequent operations in the production process by sending a signal to stop production until the root cause of the problem is resolved. These TQM practices facilitate the process of variance control by detect and possibly rectifying any deviations from the ideal. Kaizen practices help examine critique and continually improve processes the moment they are implemented. This TQM practice reflects the notion that although standardization and stability are desired, they are not the end all. Organizations continually strive to review and revise its processes to adapt to the changing environment.

3.1.5. **Task interdependence**

Task interdependence is considered an important structural variable in organization design literature. It is defined as the "degree to which members within a work unit need to work closely with each other, share material, and expertise in order to complete the given task" (Cummings, 1978). This structural variable is associated with the STS principle of boundary location.

The principle of boundary location states that organizational boundaries should be determined based on a logical process criterion, and not how it is supposed to be managed. Structure should fit the process and not vice versa (Cleggs, 2000; Huber & Brown, 1991). It is essential that the boundaries should be such that it does not impede the sharing of information, knowledge and learning (Cherns, 1987). Boundaries which impede either the sharing of information, knowledge, learning and/or resources lead to interdependence. This interdependence could be caused by the manner in which employee roles, skills and resources are differentiated and distributed within the organization.

In the literature, degree and type of interdependence is categorized as either structural (Saavendra et.al., 1993; Thompson, 1967) or psychological (McGrath et.al., 2000; Wageman, 1995). Psychological interdependence, consists of goal interdependence (manner in which goals are defined), reward and feedback interdependence (manner in which performance is rewarded and feedback is given), are overlooked in making a direct association with the STS principle of boundary location because even though these begin with task requirements of work, they extend into the social demand to work together to achieve collective outcomes such as goals and rewards (McGrath et.al., 2000). In this study, we will focus on the structural type of interdependence.

3.2. Research model

The recent research on lean manufacturing suggests that lean is an integrated social-technical system which encompasses a wide variety of management practices (i.e. JIT, TQM, TPM & HRM practices) that work synergistically to create a streamlined high quality system (Shah & Ward, 2003; 2007). The social subsystem comprises of employees and encompasses their aptitudes, attitudes, beliefs, and their relationships both within and between groups (Shani et.al., 1992; Pasmore, 1988; Emery, 1959). The technical subsystem focuses on how things get done and consists of consists of tools, techniques, procedures, and technology used by employees in an organization to acquire inputs, and transform inputs into outputs (Hupp & Polak, 1995; Shani et.al, 1992; Emery, 1959). Figure 3.1 presents a theoretical model of an integrated lean production system. This model operationalized the integration of the lean and STS principles. More specifically, the model presented shows the relationship between the specific work design practice and how it affects the quality of work life and employee performance.

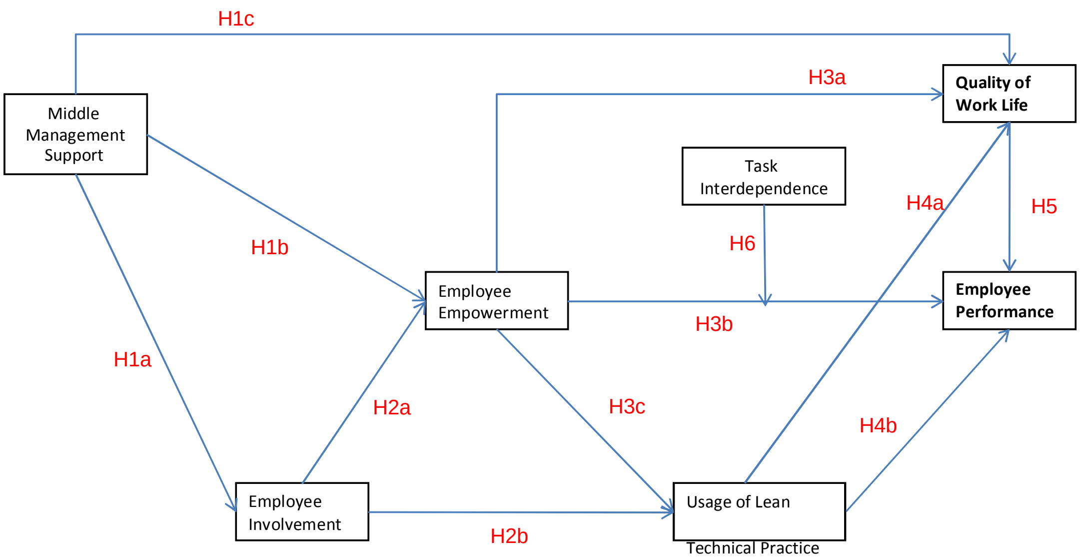

Figure 3.1. Research model for lean work practice

In figure 3.1, the middle management support construct influences the implementation of the three employee involvement practices considered in this study – information sharing practice, reward practices, and training practices (Huy, 2001; O'Crevy, 1998; Lawler et.al., 1995; Fisher, 1986). Employees can find themselves being involved when the middle managers facilitate the information sharing practices by acting as a conduit of communication between them and senior management (Mintzberg et.al., 2003; Block, 2002; O'Toole, 1995). Middle managers, who by the virtue of their unique position in the organizational hierarchy are closer to frontline employees than the senior managers, can facilitate in building a consensus between employees to support senior managements' organizational strategic directions (Rue & Byars, 2003; Floyd & Wooldridge, 1992). Middle managers can improve employee involvement initiatives by providing employees appropriate training practices since they are in a better position to know where and what their problems are on a day-to-day basis (Huy, 2001; Facteau et.al., 1995). Middle managers can sustain the employee involvement initiative when performance measures and reward practices are not in conflict with each other (Lawler et.al., 1995). Middle managers attention to these contextual dynamics would determine the success of any employee involvement initiative. Thus it is suggested that:

H1a: Middle management support is positively related to the employee involvement practices

In figure 3.1, the middle management support construct creates and fosters a work environment within an organization which promotes employees' psychological empowerment in terms of their feeling of perceived control, perceived competence and goal internalization (Menon, 2001; Klagge, 1998; Hut & Molleman, 1998). Employees feel empowered when middle managers enhance their feeling of perceived control by delegating responsibility, promoting participation, and providing information and resources (Kirkman & Rosen, 1999). Middle managers can create an environment which not only allow for employees' to be able to make a difference in their day-to-day work outcomes, but also have the choice in making decisions about their actions at work (Spreitzer, 1995). Perceived competence of employees can be strengthened when middle managers actually use/implement their ideas and suggestions in the workplace. This makes the employees feel more confident in their abilities and capabilities to perform activities with skill (Spreitzer, 1995; Guzzo et.al., 1993). Middle managers formulate and articulate the valued cause, objective or a vision for the future of the organization, which helps frontline employees to judge them in relation to their own individual ideals and standards (Spreitzer, 1995). In doing so, middle managers help align employees work goals to the organizations' goals and objectives by inspiring, energizing, and communicating the high performance expectations of the management for them (Guzzo et.al., 1993; Burns, 1978). Thus it is suggested:

H1b: Middle management support is positively related to employee empowerment

As shown in figure 3.1, middle management support construct influences the effectiveness of the four dimensions of quality of work life considered in this study – physical context, social context, job security, and job satisfaction. Middle managers can influence the employees' physical context, more specifically, the safety and health issues by making sure that physical work environment has all material elements needed for employees to perform their work and non-work related activities without any safety or health related inhibitions (Martel & Dupuis, 2006). The social interactions at work can be increased when middle managers organize team building activities (e.g. regular team get-together, family picnics, meetings to discuss individuals work related issues in a group, etc). Organization changes such as downsizing and outsourcing have adverse effects on employee loyalty, moral, motivation and job security. Since middle managers are closer to the daily operations than senior managers, they can conceive, suggest, and set in motion new ideas that the top managers may not have thought of (Huy, 2001), which may result in sustaining or even creating of new jobs to implement and execute those new ideas. In addition, middle managers could help foster an environment in the work place which could be perceived by employees as interesting and stimulating (Rethinam & Ismail, 2008). Thus it is suggested:

H1c: Middle management support is positively related to the quality of work life of employees

As shown in figure 3.1, employee involvement practices contribute to the success of the lean work design framework by supporting the process of employee empowerment (Bowen and Lawler, 1992; Thomas & Velthouse, 1990). Empowerment can be achieved when employees at the lowest hierarchical level have access to the "right mix" of information (about processes, quality, customer feedback and organizational policies and procedures), training (regarding all aspects related to work and work safety), and rewards (tied to organizational results and ones' own job performance). The information provides a framework on which employees can make sense of the organizations goals and objectives. They can then base their behavior and actions in a meaningful manner in work activities beyond their immediate job duties (Lawler et.al., 1992). Training not only allows employees to perform their jobs effectively and gives them a feeling of competence (Lawler et.al., 1992), but in addition with the "right mix" of information it also enables them to comprehend, and contribute by making appropriate decisions about their work, thereby giving them a feeling of perceived control. Rewards which are tied to employees' behavior and performance always motivate them to perform better and get involved. Thus it is suggested:

H2a: Employee involvement practices are positively related to employee empowerment

As shown in figure 3.1, employee involvement practices contribute to the success of organizational performance by promoting the usage of the specific technical practices – standardized work, pull production, continuous flow production, production leveling, setup time reduction, total preventative maintenance, zero defects, and visual control. Organizations that promote employee involvement by providing information sharing systems, appropriate and timely training, and awarding rewards which are linked to individual/group and/or business performance can certainly motivate employees to use certain technical practices (Sumukadas, 2005; Pun et.al., 2001; McLachlin, 1997; Lawler et.al., 1992). Information sharing practices that provide accurate, timely, and relevant information encourage employees to use the visual control practice (e.g. Andon, 5-S) as a means to reduce and/or eliminate quality defects (Suzaki, 1985), pull production practice as a means to reduce over-production of unwanted parts (Koufterous et.al., 1998), continuous flow practices to reduce and/or eliminate the long wait and queue times (Shah & Ward, 2003; Voss & Robinson, 1987), and production leveling practices to reduce lead time, work-in-process inventory and stress, due to uneven workload for employees (Shah & Ward, 2003; Koufterous et.al., 1998; Voss & Robinson, 1987). Training practices provide opportunities for employees to build competencies in their jobs by learning how to interpret and execute the standardized process instructions (Shah & Ward, 2003; Spear

& Bowen, 1999), practice setup time reduction techniques (Shah & Ward, 2003; Sakakibara et.al., 1997; Voss & Robinson, 1987), perform machine maintenance to reduce machine downtime (Shah & Ward, 2003; Koufterous et.al., 1998; Voss & Robinson, 1987), and identify and eliminate sources of quality defects in operations (Voss & Robinson, 1987). Reward practices foster an environment in an organization which motivates employees to perform better than their previous ways by using the technical practice of kaizen and continuous improvement (Shah & Ward, 2003; Koufterous et.al., 1998; Voss & Robinson, 1987). Thus it is suggested:

H2b: Employee involvement practices are positively related to the usage of technical practices

As shown in figure 3.1, employee empowerment can influence the four dimensions of quality of work life considered in this study – physical context, social context, job security, and job satisfaction. Organizations that encourage employee empowerment by enhancing their feeling of perceived control, perceived competence, and goal internalization will usually see an increased workforce commitment and humanization of the workplace. This in turn, results in improved quality of work life (Barling et.al., 2003; Podsakoff et.al., 1997; Cohen et.al., 1997).

The quality of work life based on the physical context (i.e. work place safety and health issues) can be safer and healthier when employees feel that they are in control of their physical work environment (Barling et.al., 2003; Brown et.al., 2000). Empowered employees can influence work unit outcomes by taking ownership of the process (Spreitzer, 1995; Ashforth, 1989), thereby making it safer, cleaner, and healthier for them to work in. The quality of work life based on the social context (i.e. quality of social interaction with colleagues at work) can be improved when competent employees interact with co-workers to offer work related expertise and feedback, and share power and authority to complete a task (Liden et.al., 2000). Organizational changes such as downsizing, rightsizing, and outsourcing have adversely affected perceived job security. The quality of work life based on the perception of job insecurity can be reduced if not completely eliminated when employees feel a sense of perceived competence. Being competent at one's job makes an employee a valuable asset to the company and most likely he will be able to keep his job longer. The quality of work life based on the job satisfaction can be enhanced when employees feel a sense of goal internalization (Treville & Antonakis, 2006; Liden et.al., 2000). Employees are satisfied when they feel that the work they are doing is not only meaningful, but also challenging which may provide opportunities for recognition in the future. Thus it is suggested:

H3a: Employee empowerment is positively related to the quality of work life

Organizations that encourage employee empowerment by enhancing employees feeling of perceived control, perceived competence, and goal internalization are expected to see higher levels of employee performance than organizations that do not (Sigler & Pearson, 2000; Spreitzer, 1995). Employees who believe that they can have an impact on their work through autonomous initiation and regulation of their own behavior, have the necessary skills to do the job, and most importantly consider what they do at work to be meaningful show a higher level of performance than ones that do not. Employees' ability to control and/or influence decisions that affect their work area can lead to improvement in work quality. Employees' competence in addition to the control can lead to an increased productivity and dependability to meet given goals. The above outcomes are only possible if the employee intrinsically cares about the task(s) at work. Thus it is suggested:

H3b: Employee empowerment is positively related to improvement in employee performance

As shown in figure 3.1, employee empowerment contributes to the success of quality management programs in an organization by supporting the application of specific technical practices considered in this study: standardization practice, pull production practice, continuous flow practice, production leveling practice, setup time reduction practice, total preventative maintenance practice, zero defects, visual control practice, and continuous improvement practice. Empowered employees use either a single technical practice or a combination of several technical practices to make improvement in product and process design, participate in problem solving activities, manage quality control responsibilities, maintain production levels, and schedule equipment maintenance (Psoinos & Smithson, 2002; Powell 1995). Organizations that encourage employee empowerment by enhancing their feeling of perceived control, perceived competence, and goal internalization will usually see an increased usage of technical practices.

Employees' feeling of perceived control promotes the usage of certain technical practices: pull production practice, zero defects, and visual control. Empowered workers have the authority to stop the production line when defective parts are produced and keep it shut down until the root cause of the error is identified and counter measures are put in place (i.e. zero defects). Employees who work downstream, control inventory in the system by requesting goods as and when they are needed from employees upstream (i.e. pull production). Empowered employees have the authority to sort and discard materials used on the shop floor; in addition, they can set protocols for signboards, walkways, and protective clothing needed on the shop floor, and they can maintain a clean, organized workplace (i.e. visual control).

Employees' feeling of perceived competence promotes the usage of certain technical practices: setup time reduction and total preventative maintenance. Empowered workers have the appropriate training to reduce the set up times required when changing from one operation to the next through practice and making special fixtures that convert internal setups to external setups (i.e. setup time reduction). Empowered employees have the training to perform basic equipment maintenance work such as inspection, cleaning, lubricating, and tightening of machine components (i.e. total preventative maintenance).

Employees' feeling of goal internalization promotes the usage of technical practices. Empowered employees who not only ascribe to the organizations goals/objectives, but also are ready to act on its behalf are likely to use technical practices. To eliminate waste by maintaining and improving the production flow, empowered employees will engage in continuous flow practice, pull production practice, production leveling and setup time reduction practice (Shah & Ward, 2003). To sustain and improve product and process quality, empowered employees implement work standardization practice, zero defects, visual control practice, and continuous improvement practices (Shah & Ward, 2003). To maximize equipment effectiveness, empowered employees use total preventative maintenance practices (Shah & Ward, 2003). Thus it is suggested:

H3c: Employee empowerment is positively related to the usage of technical practices

As shown in figure 3.1, technical practices are expected to improve employees' performance through the systemic usage of techniques and tools in managing the production flow activities, continuous improvement activities, and equipment maintenance activities (Shah & Ward, 2003; Spear & Bowen, 1999; Koufterous, 1998; Sakakibara et.al., 1993; Voss & Robinson, 1987; Suzaki, 1985; Sugimori et.al., 1977). While some studies (Parker, 2003; Bruno & Jordan, 2002; Babson, 1993) suggest that technical practices are not directly related to employee performance, other studies (Lander & Liker, 2007; Shah & Ward, 2003, Suzaki, 1985) find evidence that the technical practices have a significant impact on employee performance by managing the production flow activities, continuous improvement activities, and equipment maintenance activities. Production flow practices (such as continuous flow practice, pull production practice, production leveling, and setup time reduction practices) improve employee performance by facilitating the continuous reduction and eventual elimination of all forms of waste, more specifically, the waste resulting from high work-in-progress inventory and the waste resulting from unnecessary delays in flow time (Ohno, 1988).

Continuous improvement practices (such as standardization practice, zero defects, visual control practices, and kaizen practices) improve employee performance by increasing productivity and decreasing the quality defects in the production process (Grout & Stewart, 2001; Spear & Bowen, 1999). The equipment maintenance practices (such as planned, predictive, and preventative maintenance practices) improve employee performance by facilitating in the maintenance of equipment(s) efficiency and effectiveness and prevent any unplanned downtime, which may result in increased flow times and reduced productivity and dependability (Sakakibara, 1997; Finch & Cox, 1986). Thus it is suggested:

H4a: Technical practices usage is positively related to the improvement in employee performance

As shown in figure 3.1, technical practices are expected to improve employees' quality of work life through the systemic usage of techniques and tools to facilitate in the improvement and maintenance of safety and health issues in one's workplace, allow for team building opportunities, development of one's personal skill, and achievement of a feeling of job satisfaction (Rethinam & Ismail, 2008; Martel & Dupius, 2006; Sirgy et.al., 2001; Brown et.al., 2000; Lau & May, 1998; Nadler & Lawler, 1983; Levine, 1983). Technical practices such as 5-S and visual control help make the physical work environment safer. These practices promote safety by making sure tools, raw materials, and component parts are in its place and that the work environment is self explaining, and self improving through visual cues. Technical practices such as pull production, continuous flow production, and kaizen activities promote opportunities for social interaction with colleagues at work. These practices support social interaction as team members are required to communicate and coordinate their actions and task(s) with each other. Technical practices such as zero defects, kaizen, and total productive maintenance can lead to a feeling of job satisfaction. The practice of zero defects and total productive maintenance, which empowers employees to take corrective action to make sure they have error free production, could result in a feeling of satisfaction for a job well done. The ability to participate in kaizen activities to resolve issues that have caused strife at work could also result in a feeling of job satisfaction. In today's work environment very few companies can promise job security to their employees. However, employees that adopt and routinely apply the technical practices in their daily work task(s) are more likely not to be fired as opposed to employees that do not. Thus it is suggested:

H4b: Technical practices usage is positively related to the employee quality of work life

As shown in figure 3.1, employees' quality of work life is expected to influences employee performance through the provision of a safer and cleaner physical work environment, opportunities to socially interact with colleagues, assurance of job security, and a feeling of job satisfaction (Phusavat et.al., 2009; Lau & May, 1998). A safer and cleaner physical work environment reduces workplace related injuries, injury costs, and days lost and helps improve employee productivity (Brown, 1996). Employees that do not feel safe in their jobs are most likely to not do their jobs well (Das et.al., 2008). Collegiality and social interactions at work can help improve employees' relations with each others at work so that they can collectively contribute to the accomplishment of organizational objectives/goals by improving their own performance (Briscoe, 1980). The assurance of job security is an important determinant of employee health, employee turnover, and employee commitment. Healthier employees, who are committed to the organization will perform better than employees who remain absent (due to illness, stress etc) and are not as committed to the goals/objectives of the organization. While a study conducted by Page & Wiseman, (1993) suggest that job satisfaction is not directly related to employee performance, other studies (Vallario, 1997; Osterman, 1995) suggest that improvements in employee performance can be achieved when the employees are committed and satisfied. Thus it is suggested:

H5: Quality of work life is positively related to the improvement in employee performance

As shown in figure 3.1, task interdependence alters the course and consequences of employee empowerment in an organization (Somech et.al., 2009; Barrick et.al., 2007; Bacharach et.al., 2006; Langfred, 2005). As tasks become highly interdependent, the need for employees to interact and coordinate with each other increases (Wageman, 1995). This creates an opportunity for conflicts, which then result in lower employee performance (Wilmont & Hocker, 2001; Guzzo & Shea, 1992). However as tasks become less interdependent, employees work relatively independently of one another, without the need to interact and coordinate with each other frequently. This results in improved employee performance. Thus it is suggested:

H6: Task interdependence moderates the relationship between employee empowerment and improvement in employee performance.

CHAPTER 4. RESEARCH METHODOLOGY

This chapter details the methods used to conduct research that aims to develop a model for lean work practice that explains the inter-relationships between middle management support, employee involvement, employee empowerment, technical practices, and task interdependence with employee productivity and quality of work life. The research design (i.e. unit of analysis, key respondent, target sample frame, sample size, and survey administration) is explained first. The next section provides the measurement items, along with a discussion of their underlying structure. The last section contains the methods used for measurement and structural validation.

4.1. Research design

4.1.1. Unit of analysis

The unit of analysis in this study is a 'team'. The respondents were asked to answer the survey items with respect to their teams within the department. For the purpose of this study, a team is defined as a group (more than two) of people associated together at work or in an activity wherein each person has a distinct role (Bamforth, Griffin, 2008).

4.1.2. Key respondent

For this study, survey respondents included floor supervisors, manufacturing supervisors, production supervisors, and team leaders. By virtue of their hierarchical position within their companies, these individuals were the most informed respondents.

They possessed sufficient understanding of middle management support for employee involvement and empowerment initiatives, and direct knowledge of the extent to which their shop floor employees were involved and empowered.

Key respondents in this study were also potentially aware of the quality of work life of their employees, as they interact with them closely on a daily basis. Interviews with operation managers confirmed this selection, as they agreed that supervisors of shop floor employees would be the most informed respondents for this kind of study. Triangulation of performance data is achieved by administering the survey to both supervisors/team leaders and their reporting manager (i.e. the operations manager) within the department.

4.1.3. **Target sample frame**

The population of interest in this study includes all manufacturing organizations in the United States that can be identified with SIC codes 311 through 339. Since the purpose of this study is to develop a model for lean work practice, the sample frame was comprised of manufacturing plants in the United States having a minimum of fifty employees. This threshold was chosen based on preliminary interviews with academic experts in the field and with plant managers. Both groups agreed that a plant with less than 50 employees most likely would not possess the organizational structure necessary for testing the research model.

The target sample frame was selected from three sources:

1. Manufacturing plants with more than 50 employees were randomly selected from the directory of the Association of Manufacturing Excellence (AME).

2. An online business directory called Jigsaw was used to identify and select additional manufacturing plants within the United States.
3. Personal contacts and references from Clemson University faculty and alumni were also used to identify and select manufacturing plants in the United States.

4.1.4. **Sample size**

To make sure that the statistical tests performed in this study will detect an effect in the sample size when, in fact, a true effect exists in the population, the sample size has to be adequate (Cohen, 1988). A review of the operations literature revealed that there is no consensus on the exact number of responses needed for studies applying the SEM technique for testing a structural model (Schumacker and Lomax, 2004; Mitchell, 1993). According to Shah and Goldstein (2006), in a review of articles in the Journal of Operations Management, sample size should be: 1) a minimum of 200, as a rule of thumb, or 2) based on the number of observed variables, number of parameters to be estimated, and adequate statistical power desired. Hence, a sample size of at least 200 responses was required for this study, in order to ensure that a true effect would be detected within the population.

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4.1.5. **Pilot study administration**

The pilot survey was administered online using Zoomerang[6], a national market research firm (www.zoomerang.com). This firm sent out the survey to its online panel which fit with the key respondent profile and the sample target frame described earlier (Sections 4.1.2 - 4.1.3). In order to gain better control over the target frame and ensure that respondents answering the survey were the most well-informed individuals about the survey items, the following screening questions were included in the survey:

- Which industry best represents your organization's major product from the list provided?
- How many employees work at your plant?
- Please indicate the job that best describes your position in the organization?
- Do you work in manufacturing?
- How many years have you worked with this organization?
- Do you directly supervise shop floor employees / machine operators?

4.1.6. **Final survey administration**

For the final survey, a comprehensive list of 1300 potential respondents was compiled from the AME directory, Jigsaw – online sales directory, and personal contacts and references. This list contained individual's names, their company names, e-mail ids, and their job title. The final survey was administered to this list using the total design methodology for e-mail surveys procedure suggested by Dillman's (2000).

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[6] Zoomerang is a market research firm that has over 3 million members in its research panel. These members are profiled across 500 attributes. Individuals that belong to this research panel have double opted into the panel to participate in surveys. Double opt-in implies that the panelists sign up and are given the opportunity to withdraw from the panel, ensuring that they do want to participate. Panelists are provided with incentive points for each survey that they complete. Respondent quality in Zoomerang is maintained and fraudulent behavior is curbed by monitoring the survey taking time and response pattern for individual respondents.

Four rounds of e-mail correspondence were carried out with the potential respondents. The first contact was made in the form of a brief e-mail asking potential respondents if they would like to participate in the research study. Immediately following their acceptance, an e-mail with the cover letter and the link to the online survey was sent in a reply e-mail. One week later, a second contact was made through e-mail which contained the same link to the online survey. Approximately, two weeks after sending the survey link, a reminder e-mail (third contact) including the online survey link again was sent to those who agreed to participate in the study, but had not yet completed the survey. The fourth and final contact was made with respondents who did not respond to any of the former contacts.

An indirect approach was also used to increase the response rate of the most informed respondents. An initial contact was made first with the managers who were associated with manufacturing in a plant. The titles sought for the purpose of this study were operations manager, production manager, continuous improvement manager, and manufacturing manager. These respondents received the link to the online survey, and were asked to forward the link to one supervisor/team leader who directly reported to them. The confidentiality of supervisor responses was maintained as their managers were not given access to their responses.

4.2. Construct measurement

The measures for the constructs used in the study have either been adopted from existing scales or newly created. An iterative process of pre-testing and pilot testing was used to improve the measurement properties of existing scales as suggested by Malhotra and Grover (1998). For the construction of new measures and their associated scales, the two stage scale development approach (figure 4.1) suggested by Menor and Roth (2006) was used. The measurement properties of constructs were then assessed in terms of dimensionality, reliability and validity (Churchill, 1979).

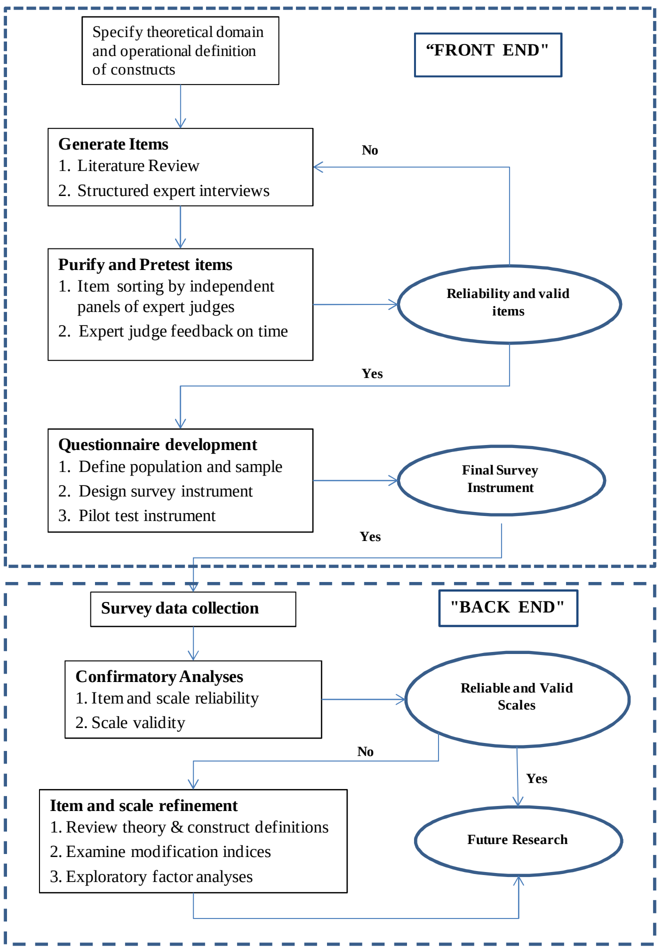

Figure 4.1. Scale development approach (adopted from Menor and Roth, 2006)

This section describes the following:

1. The item sorting approach used to purify and pre-test items;

2. The measurement items used for the constructs in the research model;
3. The control variables used in the study; and
4. The approach to modeling and measuring the constructs.

4.2.1. **Item to construct sorting**

As shown in Figure 4.1, the construct definition and its multi-item scales were subject to rigorous empirical scrutiny to establish their reliability and validity. Based on an initial review of the literature, the theoretical domain and operational definitions were identified for the constructs and their factors. Survey items were generated for the study based on adaption of existing measurement items and creation of new items.

Measurement items were purified and pretested through several rounds of item sorting exercises. The preliminary survey instrument was administered to undergraduate, full-time MBA, executive MBA, and Ph.D. students in the operations management program at Clemson University. It consisted of a definition for each construct used in the study, and a randomized listing of all the measurement items. For each item sorting round, students were asked to match each measurement item to the construct definition that they deemed to be most appropriate. Each round of item sorting produced independent samples of judgment-based, nominal data which was used to assess the inter-rater reliability and substantive validity of the measurement items. In order to include an item in the final survey, the raw inter-rater agreement percentages, along with Cohen's k value, must be greater than 0.65, as suggested by Moore and Benbasat (1991).

To improve the face validity of these measurement items, interviews with experts (e.g. operations managers, supervisors, and machine operators) in the field were conducted. An expert identified in this study was one that has the appropriate knowledge, experience, and motivation to evaluate the following: relevance of the constructs of the study to practice, degree to which each item captured its constructs, and degree of difficulty to rate the selected measurement items. The identified experts were most informed about recognizing the relationships between the work practices chosen in this study. Based on the interviews with these experts, several items in the initial questionnaire were revised to improve readability and to provide better coverage of the construct content.

4.2.2. **Measurement items**

This section provides the definition and measurement items used for each construct in the research model. Middle management support, task interdependence, and employee performance were measured as first order constructs. Employee involvement, employee empowerment, technical practice, and quality of work life were measured as second order constructs, having multiple first order factors.

4.2.2.1. **Middle management support**

Middle management support is defined as a set of managerial practices that facilitate in the implementation of top management directives by providing resources and interpreting the top management directives to employees to accomplish their task(s) (Ramus & Steger, 2000). The measures were adapted from Ramus and Steger (2002) and from Schlesinger and Oshry (1984). These items are shown below:

- MMS1 - My manager spends time with me to explain my job priorities

- MMS2 - My manager provides me with the necessary resources to accomplish my tasks effectively
- MMS3 - My manager facilitates in the implementation of quality improvements in this department
- MMS4 - My manager provides me with the necessary resources to improve product quality

4.2.2.2. **Employee involvement**

Employee involvement is defined as an approach that emphasizes participatory organizational and management systems that involves employees in production planning, problem solving, and decision making activities aimed at the success of an organization (Lawler et.al., 1995). This practice consists of three factors – information sharing, reward, and training practices. The definitions and the measures of these factors are provided below.

Information sharing practice. Information sharing practice is defined as a set of activities aimed at facilitating the exchange of information about operational and administrative functions with and between employees in an organization (Riordan et.al, 2005). Adapted from Riordan et.al. (2005), Denison, (1990), and Lawler et.al. (1995), the items used in the study are as follows:

- IS1 - Information regarding company policies and procedures is shared with my team members
- IS2 - My team members receive regular feedback about their work quality
- IS3 - My team members' productivity details are shared with them on a regular basis
- IS4 - My team members are kept informed when something important occurs in the department
- IS5 - My team members share information about their work processes with each other
- IS6 - My team members share information regarding best practices with each other
- IS7 - My team members share their productivity data with each other

- IS8 - My team members share their frequency of machine breakdown with each other

Reward practice. Reward practice is defined as a set of activities aimed at linking rewards directly to individual performance and business results (Lawler et.al., 1995). The items were adapted from Lawler (1986) and Vandenberg (1996). The items are shown as below:

- R1 - My team members are rewarded with bonuses when this plant performs well
- R2 - My team members receive recognition / praise when they help achieve the goals (objectives) set for this department
- R3 - My team members are rewarded when they make an extra effort to improve overall performance of this department
- R4 - My team members receive a letter or a certificate of appreciation when they perform well
- R5 - My team members are rewarded when they learn additional skills related to their work

Training practice. Training practice is defined as a set of activities aimed at providing training for specific skill-sets relevant to one's work assignment in an organization (Sumukadas, 2005). The items were adopted from Sumukadas (2005) and are shown as below:

- T1 - My team members are provided with training in specific job skills needed to do their job
- T2 - My team members are provided with training to perform multiple tasks in this department
- T3 - My team members are provided with training to improve their ability to work as a team
- T4 - My team members are provided with training in problem solving skills related to their work
- T5 - My team members are provided with training in quality improvement skills related to their work area

4.2.2.3. **Employee empowerment**

Employee empowerment is described as the specific cognitions an individual has about their work environment. It is measured as the experience of power in terms of three dimensions - perceived control, perceived competence, and goal internalization (Menon, 2001). The definitions and the measures of these dimensions are provided below.

Perceived control. Perceived control is defined as an individual's perception of autonomy in the scheduling of work, performance of work, utilization of resources, and decision making (Menon, 2001). The items were adapted from Kanter (1983), Menon (2000), and Keltmer et.al (2003). The items are shown below:

- PCTRL1 - My team member influence process changes that affect their work
- PCTRL2 - My team members influence changes in their work methods
- PCTRL3 - My team members influence the way in which tasks are completed in their work area
- PCTRL4 - My team members influence decisions about issues that affect their work

Perceived competence. Perceived competence is defined as an individual's self-efficacy and confidence with regards to role demands (Menon, 2001). The items were adapted from Conger and Kanungo (1987) and Menon (2001). These items are:

- PC1 - My team members are confident that they can do their job well
- PC2 - My team members demonstrate competence in meeting their job tasks
- PC3 - My team members have the capabilities to meet their job demands
- PC4 - My team members have the ability to perform their jobs effectively

Goal internalization. Goal internalization is defined as an individual's belief in the goals of the organization and his/her readiness to act on its behalf (Menon, 2001). The items were adapted from Menon (2001). These items are:

- GI1 - Working towards the goals (objectives) of this department is important to my team members
- GI2 - My team members are enthusiastic and ready to act towards achieving the goals (objectives) of this department
- GI3 - My team members are inspired by the goals (objectives) of this department
- GI4 - My team members are willing to help this department achieve its goals (objectives)
- GI5 - Achieving this department's goals (objectives) is meaningful to my team members

4.2.2.4. **Quality of work life**

Quality of work life is defined as the condition experienced by individuals that result from the effectiveness of their work environment (Martel & Dupius, 2006; Rethinam & Ismail, 2008). It is a multidimensional construct. This study focuses on four dimensions - physical context, social context, job security, and job satisfaction (Cammann et.al., 1983). The definitions and the measures of these dimensions are provided below.

Physical context. Physical context is defined as the organization's physical environment that is likely to influence the workers safety and health (Rethinam & Ismail, 2008; Martel & Dupius, 2006; Brown et.al., 2000; Nadler & Lawler, 1983). The items are adapted from Brown et.al. (2000) and Martel and Dupius (2006). These items are:

- PHYC1 - The quality of air, lighting, and noise in my work area is satisfactory
- PHYC2 - Safety protocols are enforced to prevent accidents in this department
- PHYC3 - Health issues are considered when designing / changing the way tasks are accomplished in this department

- PHYC4 - Eating areas within the plant are clean and hygienic
- PHYC5 - Restrooms within the plant are clean and hygienic

Social context. Social context is defined as the quality of social interaction with other employees in the organization (Martel & Dupius, 2006; Sirgy et.al., 2001; Levine, 1983). These items were adapted from Sirgy et.al. (2001) and Martel & Dupius (2006). These items are:

- SC1 - My team members can always count on each other for support at work
- SC2 - My team members have a good relationship with each other at work
- SC3 - My team members are always willing to help each other when needed at work
- SC4 - My team members are friendly with each other at work
- SC5 - My team members can talk frankly about their job with each other at work

Job satisfaction. Job satisfaction is defined as the appraisal and feeling one has towards their job. The items were adapted from Bacharach et.al.(1991) and Rethinam and Ismail (2008). The items are:

- JSAT1 - My team members enjoy coming to work everyday
- JSAT2 - My team members are satisfied with their job
- JSAT3 - My team members enjoy performing their daily job activities
- JSAT4 - My team members have very few complaints about their job

Job security. Job security is defined as the ability of the organization to provide stable full time employment regardless of the changes in the environment. The items are adapted from Rethinam and Ismail (2008). The items are:

- JS1 - My team members do not worry about losing their job
- JS2 - My team members have job security within this organization
- JS3 - My team members have job stability within this organization
- JS4 - My team members' jobs have not been affected by layoffs in this plant
- JS5 - My team members' job will not be affected by a recession

4.2.2.5. **Task interdependency**

Task interdependency is defined as the degree to which members within a work unit work closely with each other and share material and expertise in order to complete a task (Saavendra et.al., 1993; Thompson, 1967). The items were adapted from Saavendra et.al., (1993) and are shown as below:

- TI1 - My team members work in groups to get the job done in this department
- TI2 - My team members rely on each other to get the job done
- TI3 - My team members frequently have to coordinate their efforts with each other to complete their jobs in this department
- TI4 - My team members work in groups to get the job done in this department

4.2.2.6. **Technical practices**

Technical practices are defined as a set of practices aimed at eliminating waste and reducing buffers (i.e. capacity, inventory, and lead time) by minimizing internal variability during production (Shah & Ward, 2007; Hopp & Spearman, 2004). These practices are operationalized using ten indicators that were identified as the common technical practices from an extensive review of the quality management literature, and from interviews with operations managers at the AME conference (Kentucky, 2009). The measures for these eleven indicators were adopted from Hill (2000). The definitions and measures of these indicators are provided below.

Standardized work. Standardized work is defined as a set of discrete set of formal, written work instructions for each process (Spear & Bowen, 1998). The items are:

- SP1 - My employees use well documented standardized operating procedures to complete their task
- SP2 - My employees receive standardized process instructions

Pull production. Pull production is defined as a practice that explicitly limits the amount of work-in-process in the system (Hill, 2010). The items are:

- PP1 - My team members authorize and control production by using kanban cards, squares, containers, or space allocations
- PP2 - Production at one work station is initiated according to the demand at the next work station

Continuous flow. Continuous flow production is defined a practice of producing and moving small batches (ideally, lot size of one) through a series of processing steps with minimal inventory and almost no waiting between steps (Hill, 2010). The items are:

- CFP1 - My team members move materials in small batches through the production process with almost no waiting at work stations
- CFP2 - There is low waiting (queue) times observed for material flow through the production process

Production leveling. Production leveling is defined as a practice of distribution of production volume and mix evenly over time (Hill, 2010). The items are:

- PL1 - My team members work on a schedule in which the production volume and mix are evenly distributed over time
- PL2 - Production schedules are level and stable

Cellular Manufacturing. Cellular manufacturing is defined as a practice in which equipment and workstations are arranged in a sequence that allows for continuous and smooth movement of material to produce products from start to finish in a single process flow, while incurring minimal transportation, waiting, or delays (Hill, 2010). The items are:

- CM1 - Workstations are arranged in a sequence to reduce transportation and delay of materials through the production process
- CM2 - Groups of machines are dedicated to processing parts that require similar sequence of operations

Total Productive Maintenance. Total productive maintenance is defined as a practice that ensures uninterrupted and efficient use of equipments through operator involvement (Hill, 2010). The items are:

- TPM1 - My team members dedicate a portion of each day to equipment inspection / maintenance activities
- TPM2 - Machine operators in this department can identify and repair minor equipment problems

Setup time reduction. Setup time reduction is defined as a practice that reduces, simplifies, and or eliminates the work required in changing over machine setup from one item to the next item (Hill, 2010). The items are:

- STR1 - My team members develop special tooling (fixtures) to reduce setup times
- STR2 - My employees prepare the set-up for the next operation while working on the current operation

Zero Defects. The practice of Zero Defects is defined as a technique that improves quality and promotes error free production through employee empowerment (Hill, 2010). The items are:

- ZD1 - My team members eliminate the root cause of problems when quality defects occur in their work areas
- ZD2 - My employees stop the machine (line) when they identify defective parts from being produced

Visual control. Visual control is defined as a visual design system that has simple indicators and metrics that can be seen and understood almost immediately (Hill, 2010). The items are:

- VC1 - My team members visually display the production status for current operations at their work stations
- VC2 - Warning lights on (or near) a machine display the current status of that machine

Kaizen/continuous improvement. Kaizen is defined as a practice that continuously strives to make incremental improvements through employee involvement (Caffyn, 2001). The items are:

- K1 - My team members initiate continuous improvement activities in their work area on a regular basis
- K2 - Continuous improvement efforts are an ongoing process in this department

5-S. 5-S refers to a practice that helps organizations simplify, clean and sustain a productive work environment (Hill, 2000). The items are:

- 5-S1 - My team members maintain a clean and well-ordered work place using "5-S" practices
- 5-S2 - My employees return tools and materials to their designated places once they are used

4.2.2.7. **Employee performance**

Employee performance is defined as an appraisal process in which the management evaluates employees on how well they do their jobs compared with a set of standards determined by the department / organization (Motowidlo et.al., 1997; Globerson & Riggs, 1989). The measures were adapted from Ahmad and Schroeder (2003), and Motowildo et.al. (1997).

- EP1 - My team members' abilities to deliver work output on time has improved over the past three years
- EP2 - My team members' productivity has improved over the past three years
- EP3 - My team members absenteeism has decreased over the past three years
- EP4 - My team members' work quality has improved over the past three years
- EP5 - My team members' overall performance has improved over the past three years
- EP6 - My team members' dependability in meeting this department's goals (objectives) has improved over the past three years

4.2.3. **Control variables**

A review of the operations literature suggest that size of plant, age of plant, union representation and production process (i.e. job shop, batch shop, assembly line, continuous flow production) should be included as controls for measuring employee performance and quality of work life (Conti et.al., 2006; Shah & Ward, 2003; Cooney, 2002). Hence, in this study, questions were included in the survey to control for these four variables. The control variables were operationalized as follows:

- Size of the plant – How many employees work at your plant?
- Age of the plant – How many years ago did this plant open for production?
- Union representation – Approximately what percentage of this plant's employees are represented by a union?
- Production process – Please select the operation process of your major product at your plant?

4.2.4. **Construct identification and measurement**

When using structural equation modeling, the underlying structure of the constructs must be conceptualized before proceeding to their measurement (Howell et.al., 2007). More specifically, the nature and direction of relationships between the constructs and their indicators needs to be clarified. Indicators can either be reflective or formative (Edwards & Bagozzi 2000). Reflective indicators represent reflections, or manifestations, of a construct (Bollen 1989), while formative indicators form, or produce, their associated construct (Fornell and Bookstein 1982).

According to Jarvis et al. (2003), constructs can be classified as formative or reflective, based on the answers to the following four questions:

- What is the direction of causality between constructs and indicators?

- Are the indicators interchangeable?
- Is there any covariation amongst the indicators?
- Does the nomological net of the construct indicators differ?

Table 4.1 Criteria to determine the structure (e.g. reflective, formative) of the constructs

	Reflective Scale	Formative Scale
Direction of causality		
• Do indicators define the characteristics of the construct?	No	Yes
• Do changes in the indicator cause changes in the construct?	No	Yes
• Do changes in the construct cause changes in the indicators?	Yes	No
Interchangeability of indicators		
• Do the indicators share a common theme?	Yes	No
• Does dropping an indicator alter the conceptual domain of the construct?	No	Yes
Co-variation amongst indicators		
• Does a change in one of the indicators also associated with a change in other indicators?	Yes	No
Nomological net		
• Do the indicators have the same antecedents and consequences?	Yes	No

Based on the assessment of the conceptual structure of constructs, the investigation of the causal relationships between indicators and constructs, and the analysis of previous studies that measured similar constructs, the research model developed for this study is comprised of all reflective constructs except for technical practice, which is modeled as a formative construct.

Standard statistical procedures – Factor analysis and internal consistency reliabilities – were used to validate indicators of reflective constructs (i.e. middle management support, employee involvement, employee empowerment, task interdependence, quality of work life, and employee performance). Guidelines for measuring the formative construct (i.e. technical practice), however, are not as straightforward. According to Diamantopoulos and Winklhofer (2001), successful index construction for formative constructs relies on four critical issues:

- Content specification - The domain of content the index is supposed to capture (Bagozzi, 1994);
- Indicator specification - The indicators must cover the entire scope of the latent variable;
- Indicator collinearity - Care should be taken that the maximum variance inflation factor for the indicators used in the study should be below the cut-off threshold of 10 (Kleinbaum et.al., 1988); and
- External validity - use different dimensions to develop an index.

Failing to include any one of the eleven dimensions of technical practice would change the composition of the formative construct. The conventional guidelines regarding clarity, length, directionality, lack of ambiguity and avoidance of jargons are also followed (DeVellis, 1991). An issue particular to formative indicators is that of multicollinearity. Care is taken that the maximum variance inflation factor for the indicators used in the study should be below the cut-off threshold of 10 (Kleinbaum et.al., 1988). The criterion of external validity is necessary to ensure that the ten dimensions relate to the construct (technical practice).

External validity is achieved through one of three procedures, as proposed by Diamantopoulos and Winklhofer (2001). One procedure involves the usage of a global item that summarizes the essence of the construct that the index purports to measure. The second procedure involves the usage of some reflective indicators to assess the validity of the proposed dimensions that form the formative construct. The third procedure emphasizes the linkage of the formative construct with other reflective constructs with which it would be expected to be linked (e.g., antecedents and/or consequences) to assess the validity of the formative construct. In this study, the two latter procedures were used to validate the formative construct of technical practice.

First, the validation of the technical practice construct was done by assessing its relationship to the ten dimensions as a set. This takes into account the interrelationships of the ten dimensions that aim to eliminate waste and reduce variability. Two reflective indicators were included in the study to help estimate a multiple indicator and multiple causes (MIMIC) model (Hauser & Goldberger, 1971; Joreskog & Goldberger, 1975) for the validation of the technical practice construct. Specifically, the reflective indicators are:

- My employees use lean practices on a regular basis in this department, and
- There is a strong commitment to using lean practices at all levels in this department.

These indicators represented the usage of and commitment to lean practices at all levels within an organization, and they are necessary for the model identification purpose (Bollen, 1989). Finally, if the overall model fit (e.g., CFI, RMSEA and χ^2) of the MIMIC model is acceptable, then there is enough support for the inclusion of the set of ten dimensions that form the technical practice construct.

The second procedure focused on the nomological aspect of the model to validate the construct of technical practice. This approach is useful when certain dimensions have been eliminated from the original construct. According to Diamantopoulos and Winklhofer (2001), this type of validation requires that: 1) information is gathered for at least one construct other than the one captured by the formative construct, 2) this other construct is measured by means of reflective indicators, and 3) a theoretical relationship can be postulated between the constructs. Hence, in the research model, the formative construct of technical practice was linked to the constructs of quality of work life and employee performance, which were measured by reflective indicators.

4.3. Data validation

Several steps were taken to analyze the data within the framework of the research model. After cleaning the data, the analysis was done in two phases. Figure 4.2 shows the procedures for measurement and structural validation.

Measurement Validity

1. Non Response Bias
    a. Early v/s late respondents
2. Common Method Bias
    a. Harman one factor test
    b. Marker variable
    c. Method factor
3. Triangulation
4. Unidimensionality
5. Reliability
    a. Internal consistency
6. Constructvalidity
    a. Convergent validity
    b. Discriminant validity

Structural Validity

1. Hypothesis testing
    a. Direct effects
    b. Interaction effect
    c. Indirect effects

Figure 4.2 Data validation plan

4.3.1. **Initial data cleaning**

Little's MCAR (missing completely at random) test (Little and Rubin, 1987) was conducted to check if the missing values in the data were occurring completely at random (i.e. missing values on variable X are not related to missing values on variable Y). Since there were values missing completely at random, they were imputed using the direct maximum likelihood method with the expectation maximization algorithm (Byrne, 2006; Allison, 2003). The data set with the imputed values was then evaluated for possible outliers with univariate and multivariate analyses. If the observed data fell within $\pm 3\ \sigma$, there was no evidence of univariate outliers. Eliminate outliers if the observation is greater than $\pm 3\sigma$ (Cohen et.al., 2003). Next check for multi-variate outliers using the Mahalanobis distance method (Cohen et.al., 2003). After the removal of all multivariate outliers, Mardia's (1970) normalized estimate was calculated to determine the extent of normality of the data. This test assessed the degree of kurtosis in the data. When the sample is very large and multivariately normal, a large Mardia's coefficient value reflects significant positive kurtosis and large negative values reflect significant negative kurtosis (Byrne 2006). According to Bentler (2005), values greater than 5.0 indicated that the data was not normally distributed.

4.3.2. **Measurement validation**

This section contains the details of the tests that will be conducted to validate the measurement model. First and foremost, the data was cleaned and univariate and multivariate descriptive statistics were obtained. More specifically, the data was checked for missing values, and the type of distribution for all item level responses was identified.

Next, the authenticity of the source of the data was evaluated. This was done by checking for non-response bias. Once the data and its sources were assessed, a confirmatory factor analysis (CFA) was conducted to validate the factors used in the study. Then the measurement properties (i.e., dimensionality, factor loading, reliability, validity, and model fit) of the constructs were assessed (Menor & Roth, 2006). This was followed by a check for any common method bias. Finally, tests were conducted to check for agreement of responses between multiple raters surveyed in the study.

4.3.2.1. **Non-response bias**

Non-response bias refers to the difference in the outcome variables between those who answered the survey and those who did not (Armstrong and Overton, 1977). The greatest concern for an empirical researcher is their dependence on individuals participating in a study. Low response rates are always a concern; not only do they result in a smaller sample size, but they also can undermine the generalizability of the data collected and lead to incorrect conclusions that are not generalizable to the entire population (Rogelberg & Stanton, 2007; Rogelberg & Luong, 1998).

To assess the potential of non-response bias, late respondents were used as a proxy for non respondents (Armstrong and Overton, 1977). Early and late respondents were identified based on the dates the responses were received. More specifically, the middle point of the data collection time frame was used as a cutoff point for differentiating between early and late respondents. A Chi-square test was performed on the control variables (i.e., size of plant, age of plant, unionization, and production process) for the early and late respondents. A significance difference between the means of the two groups indicates that there is response bias between early and late responders.

4.3.2.2. **Common method bias**

Common method bias refers to the variance that is attributable to the measurement method rather than to the construct of interest (Lindell & Whitney, 2001; Bagozzi & Yi, 1991; Buckley et. al., 1990). It results in a systemic measurement error that has serious confounding influence on empirical results. This bias yields potentially misleading conclusions, as it can inflate or deflate the observed relationship between a predictor and criterion variable (Lindell & Whitney, 2001; Cote & Buckley, 1988; Campbell & Fiske, 1959). In other words, common method bias may cause alternative explanations for the observed relationships between the constructs of interest (Williams

& Brown 1994; Bagozzi & Yi, 1991; Feldman & Lynch 1988). In this study the problem of common method bias is reduced, if not eliminated, by implementing several procedural and statistical recommendations set forth by Podsakoff et.al. (2003).

Procedural approaches based on the design of the study. There are four methods by which the design of this study eliminated and/or minimize the common method biases. First, anonymity of respondents was maintained throughout the survey administration and data collection process. Second, survey respondents were informed that there is no right or wrong answer, thereby reducing their evaluation apprehension, and their likelihood to edit their responses to be more socially desirable, lenient, acquiescent, or consistent with how they think the researcher wants them to respond.

The other two procedural approaches to eliminate and/or reduce common method bias involve the measurement items. The items were carefully constructed and tested with both academicians and practitioners for their simplicity, readability and content coverage. Randomizing the items in the survey eliminated any biases from priming effects, item-context induced mood states, and any other biases related to the question context or item embeddedness.

Usage of statistical controls. In addition to these procedural remedies, three statistical controls were also employed to reduce any potential common method bias: 1.) Harman one-factor test (Harman, 1976), 2.) a partial correlation procedure using a marker variable[7], and 3.) an unmeasured latent method factor.

[7] Marker variable - A variable that is identified a-priori on theoretical grounds, that it should not be related to any other variable in the study (Lindell and Whitney, 2001)

In the Harman one-factor test, all of the variables in the study were loaded into an exploratory factor analysis and the un-rotated factor solution was examined to determine the number of factors necessary to account for the variance in the variables. As the number of variables increase, the likelihood of obtaining more than one factor also increases. If no single factor emerges, then common method bias is not an issue.

In addition, a partial correlation procedure using marker variables (Lindell and Whitney, 2001) was used to test for common method bias. A 'marker variable' describing a dimension of the realms of experience (Pine II and Gilmore, 1998) was selected from the tourism literature to control for common method bias. In particular, measurement items for the "memory of an experience" was used to partial out the average correlation between the marker variable and the other variables used in the study. The measurement items for the marker variable "memory of an experience" are:

- MV1 - I have wonderful memories about my last vacation
- MV2 - I will not forget my experience from my last vacation
- MV3 - I remember many things about my last vacation

In this procedure, two models were evaluated to assess the potential effects of common method bias. The first model contained items loaded onto their respective latent factors, and the second model contained the same items loaded onto their respective latent factor, and also onto the marker variable, memory of an experience. If the comparative fit index (CFI) between the two models is less than 0.01, there is no significant difference between the two models and hence common method bias is not an issue (Cheung and Rensvold, 2002).

To confirm the finding from the marker variable method, an unmeasured latent method factor was included to test for common method bias. This procedure is the most stringent, as it significantly improves the fit of the model by accounting for most of the covariance observed in variables. In this procedure, two models were compared to assess the potential effect of common method bias. The first model contained items loaded onto their respective latent factors, and the second model contained the same items loaded onto their respective latent factors, and also onto the first order common method factor. The main advantage of this technique was that it did not require the identification and measurement of the specific factor responsible for the method effects. In addition, this technique modeled the effect of the method factor on the measures rather than on the latent constructs they represented, and did not require the effects of the method factor on each measure to be equal (Podsakoff et.al., 2003).

4.3.2.3. **Agreement of multiple responses**

A test for inter-rater agreement (IRA) was conducted to assess whether multiple responses from the same plant agree with each other. Inter-rater agreement refers to the absolute consensus in scores assigned by multiple raters to the target subject (James et.al., 1993). The within-group index (R_{wg}) was used to evaluate inter-rater agreement. This agreement index represents the interchangeability of the respondents. In this study R_{wg} represented the interchangeability of the responses of the participating supervisors/team leaders and their managers. A mean R_{wg} of 0.7 or greater indicates inter-rater agreement (James et.al., 1993).

4.3.2.4. **Unidimensionality**

Since the analysis of reliability and construct validity is dependent on the assumption of unidimensionality (Al-Hawari et.al., 2005; Nunnally and Bernstein, 1994), a CFA was conducted to examine the unidimensionality of each factor in the model. This test also helps to reduce the possibility of misspecifications (Gerbing and Anderson, 1988). A CFI of above 0.9 suggests satisfactory unidimensionality for the factors (Al-Hawari et.al., 2005).

4.3.2.5. **Reliability**

As shown in Figure 4.1, data collected in the study is meaningless unless measurement properties of the constructs are found to be reliable and valid. The internal consistency (reliability) of the items was assessed through Cronbach's Alpha, composite reliability, and variance extracted to check if items 'hanged together'. Typically, reliability coefficients of Cronbach's Alpha and composite reliability of 0.7 or greater are considered adequate (Hair et.al., 1995; Nunnally & Bernstein, 1994; Nunnally, 1978), while the variance extracted should be greater than 0.5 to indicate reliable constructs (Hair et.al., 1995).

4.3.2.6. **Construct validity**

Construct validity lies at the heart of the scientific process, as it addresses the question of what the instrument is actually measuring. Its two components are convergent validity and discriminant validity. Together, they indicate whether the measures are similar within themselves and yet sufficiently different from other measures (Malhotra and Grover, 1998).

Convergent validity. Convergent validity evaluates the similarity, or convergence, between items measuring the same theoretical construct. In other words, if measures of constructs that theoretically should be related to each other are, in fact, observed to be related to each other, then they are said to have convergent validity.

In this study, the convergent validity for each construct was assessed by examining the relationship between each individual measurement item and its construct. If the relationship between each measurement item and its construct was significantly different from zero (Nunnally and Bernstein, 1994), convergent validity of the construct was recognized. Eigen values of the constructs and fit indices of the final measurement model were also determined. If the Eigen value of the construct was greater than 1.0, there was sufficient evidence of convergent validity (Hair et.al., 1995). Finally, if the fit indices (i.e. CFI and RMSEA) of the measurement model in which the constructs were freely correlated met the recommended guidelines (CFI > 0.9 and RMSEA < 0.05), convergent validity was established.

Discriminant validity. Discriminant validity refers to the degree to which each construct's measurement items are distinctly from each other. In other words, if measures of constructs that theoretically should not be related to each other are, in fact, observed to not be related to each other, then they are said to have discriminant validity. In this study, a CFA was used to assess discriminant validity.

Two models were constructed for all possible pairs of the latent factors in the study. In the first model, the covariance for each factor pair was freely estimated, while in the second model, the covariance for each factor pair was fixed to 1.0. A significant difference in the Chi-square values for the two models implies the distinctiveness of the two constructs (Bagozzi et.al., 1991). In addition, the average extracted variance of the two constructs was also calculated. If the average variance extracted (AVE) for the two constructs exceeds the square of their standardized correlation, there is evidence to suggest discriminant validity (Fornell & Larker, 1981).

4.3.3. **Structural validation**

Once the measurement properties of the constructs were found to be reliable and valid, a structural model was built to test the interrelationships between middle management support, social practices usage, technical practices usage, quality of work life, and employee performance. Structural equation modeling (SEM) was used to test the model and determine the significance of the structural paths among the constructs of the hypothesized model. More specifically, the direct effects and indirect effects of the hypothesized relationships were estimated.

The moderation hypothesis related to task interdependence and the relationship between social practices usage and employee performance was tested based on the guidelines prescribed by Kline and Dunn (2000) using SEM. In this approach, the items for the task interdependence and social practices usage constructs were first mean centered. Next, every item of each social practices usage factor was cross multiplied with every item of the task interdependence factor. As shown in Figure 4.3, the outcome of this process formed the moderator construct (i.e., social practice usage x task interdependence). This moderator construct, along with the constructs of social practices usage, task interdependence, and employee performance, was included in the structural model. The significance of the direct effect of the moderator construct determined if the interaction effect of task interdependence on social practice usage and employee performance existed.

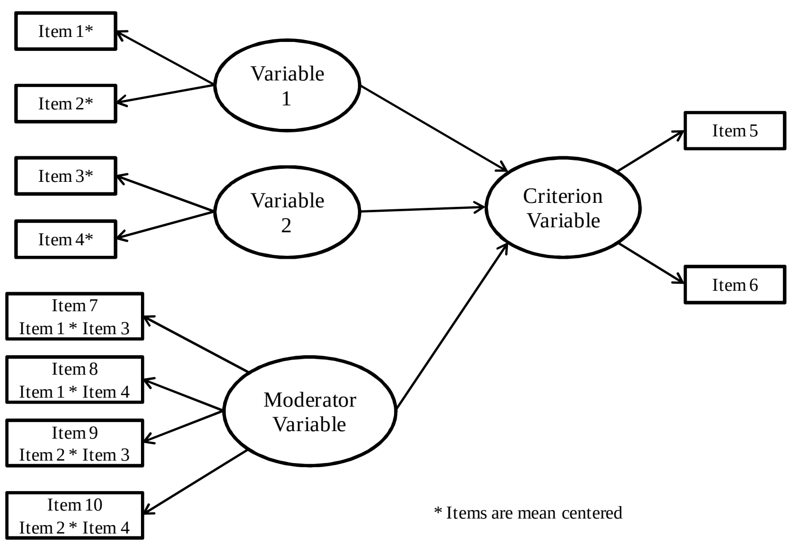

Figure 4.3 Procedure to test interaction effect

CHAPTER 5. RESULTS

This chapter contains the results of the data analyses. More specifically, it contains the results from the pre-testing, pilot testing and final survey phases of this study. The pre-test results provide insight to the q-sort process that determined which survey items to include in the pilot test. The pilot tests results help purify the survey items such that they have high factor loadings and a high Cronbach's alpha for the final survey. This last phase provides results from the assessment of the measurement properties of the constructs, and from the evaluation of the hypotheses proposed in this study.

5.1. Pre-testing

Measurement items were purified and pretested through several rounds of item sorting. Based on the q-sort exercises with students at Clemson University and the interviews with experts, many items in the initial questionnaire were revised for easier readability and better coverage of the construct content. The number of items that were initially entered into the pre-testing process is listed in Table 5.1

Table 5.1 Number of items entering q-sort process

Construct	Sub-construct	# of items
Middle Management Support		6
Employee involvement	Information sharing	5
	Rewards	4
	Training	5
	Power	4
Employee Empowerment	Perceived control	7
	Perceived competence	5

	Goal Internalization	5
Quality of Work life	Physical context Social context Job satisfaction Job security	5 5 4 4
Task Interdependence		5
Technical practice	Standardization practice Pull production Continuous flow production Production leveling Setup time reduction Total Productive maintenance Zero Defects Visual Control 5-S Kaizen/Continuous Improvement	2 2 2 2 2 2 2 2 2 2
	Cellular manufacturing	2
Employee Performance		7
Marker Variable		3
	Total	**96**

Each round of item q-sorting produced independent samples of judgment-based, nominal data which was used to assess the inter-rater reliability of the measurement items. For each construct, the item placement ratio's from the final item sorting analysis is presented in Table 5.2. **Appendix A** provides the hit rate for each measurement item in the preliminary survey.

Table 5.2 Item placement ratios

Construct	**Sub-construct**	**Ratio**
Middle Management Support		80 %
Employee involvement	Information sharing Rewards Training	76 % 88 % 96 %
Employee Empowerment	Perceived control Perceived competence Goal Internalization	96 % 100 % 100 %
Quality of Work life	Physical context	100 %

	Psycho-social context Job satisfaction Job security	92 % 100 % 95 %
Task Interdependence		87 %
Technical practice		88 %
Employee Performance		100 %

Since all item placement ratios are above the suggested cut-off of 70%, they indicate adequate convergent and discriminant validity for each construct. In addition, the raw inter-rater agreement percentages, along with the Cohen's k value, were greater than 0.65 (sample calculation shown in **Appendix B**), which suggest that there is sufficient inter-rater reliability (Moore and Benbasat, 1991). The next step was to pilot test the survey instrument.

5.2. Pilot testing

The pilot test was based on a total of sixty usable responses obtained from Zoomerang. The data obtained was then used to assess the preliminary psychometric properties of the survey items. Table 5.3 provides the reliability statistics for each construct used in this study. The sample size was not large enough to allow for testing the model as a whole. Hence, the reliability statistics for each construct (Cronbach α) was estimated using a two-factor CFA.

Table 5.3 Construct reliabilities based on pilot data

Construct	**Sub-construct**	**Cronbach's Alpha**
Middle Management Support		0.88
Employee involvement	Information sharing Rewards	0.59 0.77

	Training	0.81
Employee Empowerment	Perceived control Perceived competence Goal Internalization	0.85 0.86 0.83
Quality of Work life	Physical context Social context Job satisfaction Job security	0.78 0.71 0.89 0.79
Task Interdependence		0.52
Employee Performance		0.77
Marker variable		0.93

As seen in table 5.3, there was adequate confidence (i.e. Cronbach's α value > 0.7) in the reliability of all but two scales, information sharing and task interdependence. Since there was no theoretical basis to drop these scales, they were included in the final survey. Thus, the final set of measurement items was selected based on the evaluation of the factor loadings of items on their individual constructs. The four strongest items for each construct were retained for final testing, while new items were written if a construct had fewer than four items. After this purification process, 94 items (listed in Table 5.4) were retained for the final study. **Appendix A** lists all of the preliminary measurement items and identifies whether they were retained, dropped or added to the final survey.

Table 5.4 Number of items entering the final survey

Construct	**Sub-construct**	**# of items**
Middle Management Support		4
Employee involvement	Information sharing – (top down) Information sharing – (bottom – up) Rewards Training Power	4 4 5 5 4
Employee Empowerment	Perceived control Perceived competence Goal Internalization	4 4 5

Quality of Work life	Physical context Psycho-social context Job satisfaction Job security	5 5 4 5
Task Interdependence		4
Technical practice	Standardization practice Pull production Continuous flow production Production leveling Setup time reduction Total Productive maintenance Zero Defects Visual Control 5-S Kaizen/Continuous Improvement Cellular manufacturing	2 2 2 2 2 2 2 2 2 2 2
Employee Performance		7
Marker Variable		3
Total		**94**

5.3. Final survey results

The final survey instrument (**Appendix C**) was administered after it was developed and refined through item generation, q-sorts, structured interviews, and pilot study. This section provides the descriptive statistics of the data collected from the survey. Following this is the assessment of the measurement properties of the constructs used in the research model. After this assessment, the structural model was tested, and any hypotheses that were not supported by the results were further analyzed with an ad hoc analysis.

5.3.1. **Descriptive Statistics**

5.3.1.1. **Response rate**

An initial e-mail contact was made with 1300 potential respondents, of which 325 e-mails bounced back. Of the valid 975 emails, 20 respondents refused to participate in the study. Hence, of the remaining 955 valid email ids, 230 respondents participated (i.e. completed the online survey) in the study. Thus, the response rate obtained for this study is 24.08% (230/955). This response rate is considered adequate, as it is above the suggested cut-off value of 20% (Malhotra & Grover, 2004; Dillman, 2000). A review of the data set revealed that 26 of the 230 participating respondents had completed less than 50% of the survey; therefore, they were eliminated from the usable data set. This resulted in a usable data set of 204 responses.

5.3.1.2. **Initial data screening**

The data set was first checked for univariate and multivariate outliers. Since responses were within +/- 3σ of the mean value of responses, there were no significant univariate outliers. The data was also checked for multivariate statistical outliers using regression diagnostics (i.e. leverage statistics and Mahalanobis distance) in SPSS. Using the process suggested by Kline (2005), four cases were identified as statistical outliers and were eliminated from the data set. This resulted in a final, usable data set comprised of 200 responses.

There were 181 missing values in the final, usable data set. These missing values accounted for less than 0.01% of the total number of values obtained from the 200 responses. Little's MCAR test, conducted in SPSS (v13.0), found that these 181 values were missing completely at random ($p > 0.05$). Since the data was missing completely at random, the values were imputed without violating the assumptions of MCAR (Allison, 2003). The direct maximum likelihood (ML) imputation method with the expectation maximization (EM) algorithm was used to impute the missing values.

The multivariate analyses were then done on the final dataset. These analyses indicate that there were issues with skewness and kurtosis. The analyses revealed that there was negative skewness in the data as all item values are less than zero. This suggests, that many observations in the survey were to the right on the measurement scale (i.e., closer to strongly agree on the Likert scale). The analyses also revealed the values of Kurtosis -3, were both greater and lower than items used in this study. This indicated that the different items had a mix of high peaks and flat tails, and low peaks and thick tails. Thus, suggesting different levels of kurtosis (see **Appendix E** details). Since there was no theoretical reason to drop those items, they were retained for further analysis.

Finally, Mardia's (1970) normalized estimate was examined to determine the extent of normality of the data. The resulting value was greater than 5.0.This indicates that the dataset had a non-normal distribution (Bentler, 2005). Thus, the Satorra-Bentler scaled $\chi 2$ statistic (Satorra and Bentler, 1988), and the corresponding robust fit estimates provided by EQS 6.1 (Byrne 2006) is used for all further statistical analyses. Computation of the Satorra-Bentler $\chi 2$ statistic takes into account the model, the estimation method, and the sample kurtosis values. The Satorra-Bentler $\chi 2$ statistic has been shown to be the most reliable test statistic for evaluating mean and covariance structure models under various distributions and sample sizes (Curran et al. 1996; Hu et al. 1992).

5.3.1.3. **Characteristics of sample data**

The 200 usable data sets represent all types of manufacturing industries except leather and allied products, and non-metallic mineral products. Table 5.5 details the industry representation of the sample.

Table 5.5 Industry representation in sample data

Type of Manufacturing Industry	**Frequency**	**%**	**Cumulative %**
Food manufacturing	23	11.5%	12%
Apparel manufacturing	5	2.5%	14%
Wood product manufacturing	5	2.5%	17%
Printing and related support activities	8	4.0%	21%
Petroleum and coal products manufacturing	3	1.5%	22%
Plastics and rubber products manufacturing	11	5.5%	28%
Fabricated metal products manufacturing	20	10.0%	38%
Computer and electronic product manufacturing	11	5.5%	43%
Transportation equipment manufacturing	17	8.5%	52%
Electrical equipment/appliance and component manufacturing	14	7.0%	59%
Textile mills	6	3.0%	62%
Leather and allied products	0	0.0%	62%
Paper manufacturing	6	3.0%	65%
Chemical manufacturing	14	7.0%	72%
Primary metal manufacturing	5	2.5%	74%
Non-metallic mineral products	0	0.0%	74%
Machinery manufacturing	12	6.0%	80%
Furniture and related product manufacturing	4	2.0%	82%
Miscellaneous manufacturing	36	18.0%	100%
Total	200	100%	

As is evident from Table 5.6, the data sample represents a fairly even distribution of the plant size (based on the number of employees) and the type of production process (used to manufacture the most important product). It is also seen that the data sample comes mostly from respondents who work in organizations that have implemented lean practices. This limits the generalizability of the study, but it does improve the validity of the study since the data sample includes organizations at different stages (i.e. the number of years) of lean implementation.

Table 5.6 Organizational characteristics of sample data

	Frequency	%	Cumulative %
Plant Size (based on number of employees)			
Less than 100	31	15.5%	15.5%
Between 100 and 200	55	27.5%	43.0%
Between 200 and 500	61	30.5%	73.5%
Greater than 500	53	26.5%	100.0%
Total	200	100.0%	
Age of the plant			
Between 0 and 7 years	9	4.5%	4.5%
Between 8 and 20 years	38	19.0%	23.5%
More than 20 years	153	76.5%	100.0%
Total	200	100.0%	
Lean Implementation			
Yes	184	92.0%	92.0%
No	16	8.0%	100.0%
Total	200	100.0%	
Number of Years of Lean Implementation			
Between 0 and 3 years	94	47.0%	47.0%
Between 4 and 7 years	64	32.0%	79.0%
More than 7 years	42	21.0%	100.0%
Total	200	100.0%	
Type of Production Process			
Job Shop process	26	13.0%	13.0%
Assembly Line Process	59	29.5%	42.5%
Continuous Flow Process	62	31.0%	73.5%
Batch Shop Process	53	26.5%	100.0%
Total	200	100.0%	

As seen in Table 5.7, data was collected from a diverse pool of respondents. Half of the respondents worked in plants that had lay-offs in the past two years, while the other half did not. Of the 200 respondents, one-third had more than five years of experience in their current plant, and two-thirds had between zero and five years of experience. Also, one-third worked in plants with some union representation, while two-thirds worked in plants with no unionization.

Table 5.7 Respondent characteristics of data sample

	Frequency	%	Cumulative %
Respondent's job title			
Team Leader	54	27%	27.0%
Shop Floor Coordinator	4	2%	29.0%
Shop Floor Supervisor	46	23%	52.0%
Manufacturing Supervisor	30	15%	67.0%
Production Supervisor	27	14%	80.5%
Other	39	20%	100.0%
Total	200	100.0%	
Lay-offs in the past two years			
Yes	101	50.5%	50.5%
No	99	49.5%	100.0%
Total	200	100.0%	
Years of experience at this plant			
Between 0 and 5 years	136	68.0%	68.0%
More than 5 years	64	32.0%	100.0%
Total	200	100.0%	
Union representation in the plant			
None	135	67.5%	67.5%
Between 0 and 50%	17	8.5%	76.0%
Between 50 and 100 %	30	15.0%	91.0%
100%	18	9.0%	100.0%
Total	200	100.0%	

5.3.1.4. **Test of non-response bias**

The impact of potential non-respondent bias was assessed using wave analysis. The sample data was split into two waves – early and late respondents – according to the dates that the responses were received. The early respondent wave consists of 110 responses, while the late respondent wave consists of 90 responses. A one-way ANOVA was run on two factors that could have impacted the response rate. As seen in Table 5.8, the early and late respondent waves for middle management support and employee performance show no differences, and they are not significant at the 0.05 level. This suggests that there is no evidence of non-response bias.

Table 5.8 Assessment of non-response bias

	N	Mean	S.D.	F-value	d.f.	Sig.
Middle Management Support				1.56	198	0.213
Early Respondents	110	5.50	1.18			
Late Respondents	90	5.69	0.94			
Employee Performance				2.61	198	0.108
Early Respondents	110	5.58	1.05			
Late Respondents	90	5.80	0.81			

5.3.2. **Assessment of measurement properties**

In order to test the research model, it is important to assess the measurement properties of the constructs to make certain they are both reliable and valid. In this section, results of convergent validity and discriminant validity are presented. As suggested by Churchill (1979), the items of the hypothesized constructs are empirically assessed using Cronbach’s alpha value, factor loading, and model fit statistics. Having assessed the validity and reliability of the items in the constructs, the hypothesized constructs are evaluated for convergent and discriminant validity using structural equation modeling (SEM). In this study, CFA analyses were done in EQS 6.1, a widely used SEM software, to assess the measurement properties of the constructs and their measurement items.

Before presenting the results of the assessment of the measurement properties, it is important to discuss the requirements for using the SEM software. To obtain meaningful results from the SEM analyses, the following five conditions were required.

Data type. The data used in SEM analysis must be ratio/interval type. In this study, the measurement items for all constructs have an interval scale. The items are measured on a 7-point Likert scale, which ranges from "strongly disagree" to "strongly agree".

Number of indicators. Ideally, there should be four indicators for each observed construct. In certain cases, two indicators can also be used, if the researcher is confident in the indicators' validity and reliability (Bollen, 1989). There are a minimum of three indicators for each construct used in the study.

Model identification. The model has to be over identified. In other words, it is a model for which all the parameters are identified, and for which there are more known than free parameters. In this study, the measurement and structural models are over-identified, even with the addition of a method factor and a marker variable.

Data distribution. Multivariate normal data is preferred. Since the sample data has a non-normal distribution, the Satorra-Bentler scaled Chi-square statistics, corresponding robust fit estimates, and the robust standard errors were reported (Byrne, 2006; Bentler, 2005). This was done by using the 'Robust' option in EQS 6.1. The statistics obtained are valid despite the violation of the normality assumption underlying the estimation method suggested by Byrne (2006).

Sample size. The sample size should be sufficiently large (Shah & Goldstein, 2006). In this study, the sample size is adequate, as it meets the suggested cut-off of 200.

5.3.2.1. **Convergent and discriminant validity**

Convergent validity is assessed to determine the extent to which measurement items for a given construct refer to only that construct and no other. Table 5.9 provides the results of the two-factor CFA that was performed to determine the range of confirmatory factor loadings for each item, along with its reliability scales (i.e. Cronbach's alpha and co-efficient Rho).

Table 5.9 Factor Loadings and Reliabilities

Factors	No. of items	CFA Factor Loading Range	Reliability (Cronbach's alpha)	Reliability (Co-efficient Rho)
Middle Management Support	6	0.72 – 0.88	0.88	0.84
Information Sharing (Top-Down)	5	0.69 – 0.82	0.73	0.72
Information Sharing (Bottom – Up)	4	0.71 – 0.82	0.85	0.85
Reward Practice	5	0.83 – 0.94	0.88	0.87
Training Practice	4	0.69 – 0.90	0.84	0.80
Perceived Control	7	0.67 – 0.87	0.90	0.89
Perceived Competence	5	0.64 – 0.77	0.85	0.85
Goal Internalization	5	0.71 – 0.86	0.88	0.88
Task Interdependence	5	0.82 – 0.92	0.82	0.82
Physical Context	5	0.72 – 0.76	0.75	0.73
Social Context	4	0.70 – 0.81	0.69	0.70
Job Satisfaction	4	0.77 – 0.80	0.89	0.89
Job Security	5	0.64 – 0.85	0.82	0.83
Employee Performance	7	0.70 – 0.85	0.88	0.87
Marker Variable	3	0.78 – 0.89	0.88	0.88
Lean Practice Usage	2	0.78 – 0.85	0.82	0.80

The items retained after the two-factor CFA were then tested in the overall measurement model, where all the constructs were freely correlated. The fit indices suggest that the data fits the model well (Satorra-Bentler χ^2 = 1020.05; d.f. = 861; CFI = 0.94; RMSEA = 0.037; 90% C.I. = 0.03, 0.04). As evident in Table 5.10, the standardized factor loadings of all items meet the minimum recommended value of 0.70 (Fornell and Larcker, 1981), except one item for task interdependence and one item for job security. The values of the loading for these two items were between 0.6 and 0.7. The items were retained, as there was no theoretical rationale to drop them.

Table 5.10 Factor Loadings

Item #	Item	Factor Loading
Middle Management Support		
MMS2	My manager provides me with the necessary resources to accomplish my tasks effectively	0.84
MMS3	My manager facilitates in the implementation of quality improvements in this department	0.71
MMS4	My manager provides me with the necessary resources to improve product quality	0.85
Information Sharing (Top – Down)		
IS1	Information regarding company policies and procedures is shared with my team members	0.80
IS4	My team members are kept informed when something important occurs in the department	0.70
Information Sharing (Bottom – Up)		
IS5	My team members share information about their work processes with each other in this department	0.89
IS6	My team members share information regarding best practices with each other in this department	0.82
Reward Practices		
R3	My team members are rewarded when they make an extra effort to improve overall performance of this department	0.89
R5	My team members are rewarded when they learn additional skills related to their work	0.87

Training Practices		
T1	My team members are provided with training in specific job skills needed to do their job	0.74
T4	My team members are provided with training in problem solving skills related to their work	0.72
T5	My team members are provided with training in quality improvement skills related to their work area	0.81
Perceived Control		
PCTRL1	My team member influence process changes that affect their work	0.85
PCTRL2	My team members influence changes in their work methods	0.81
PCTRL3	My team members influence the way in which tasks are completed in their work area	0.74
PCTRL4	My team members influence decisions about issues that affect their work	0.85
Perceived Competence		
PC1	My team members are confident that they can do their job well	0.81
PC2	My team members demonstrate competence in meeting their job tasks	0.83
PC3	My team members have the capabilities to meet their job demands	0.79
Goal Internalization		
GI1	Working towards the goals (objectives) of this department is important to my team members	0.83
GI2	My team members are enthusiastic and ready to act towards achieving the goals (objectives) of this department	0.78
GI3	My team members are inspired by the goals (objectives) of this department	0.79
GI4	My team members are willing to help this department achieve its goals (objectives)	0.80
Task Interdependence		
TI1	My team members work in groups to get the job done in this department	0.87
TI2	My team members rely on each other to get the job done	0.63
TI4	My team members work in groups to get the job done in this department	0.81
Physical Context		
PHYC4	Eating areas within the plant are clean and hygienic	0.71
PHYC5	Restrooms within the plant are clean and hygienic	0.80
Social Context		
SC1	My team members can always count on each other for support at work	0.75
SC4	My team members are friendly with each other at work	0.72

Job Satisfaction		
JSAT1	My team members enjoy coming to work everyday	0.88
JSAT3	My team members enjoy performing their daily job activities	0.91
Job Security		
JS1	My team members do not worry about losing their job	0.69
JS2	My team members have job security within this organization	0.83
JS3	My team members have job stability within this organization	0.81
JS4	My team members jobs have not been affected by layoffs in this plant	0.62
Marker Variable		
MV1	I have wonderful memories about my last vacation	0.91
MV2	I remember many things about my last vacation	0.84
MV3	I will not forget my experiences from my last vacation	0.77
Employee Performance		
EP1	My team members’ abilities to deliver work output on time has improved over the past three years	0.85
EP4	My team members’ work quality has improved over the past three years	0.68
EP5	My team members’ overall performance has improved over the past three years	0.80
EP6	My team members’ dependability in meeting this department’s goals (objectives) has improved over the past three years	0.83
Technical practice		
LP1	My team members use lean practices on a regular basis	0.78
LP2	There is a strong commitment to using lean practices at all levels within this department	0.85

Discriminant validity is assessed to determine the extent to which the measurement items for each construct are distinctively different from each other. Since the survey sample data had a non-normal distribution, a scaled version of the Satorra-Bentler pairwise Chi-square difference test - as opposed to the regular pairwise chi-square test (Satorra & Bentler, 2001) - was used to evaluate discriminant validity for two constructs at a time.

Two measurement models were compared. In the first model tested, all of the constructs were freely correlated. In the second overall measurement model, correlation the between two constructs (said not to be different) was constrained to unity, thus suggesting that the items for the two constructs are measuring just one construct. The fit of the first model was compared with the fit of the second model. A significant scaled Satorra-Bentler pairwise Chi-square difference between the free and the fixed models indicated discriminant validity among constructs.

This procedure revealed that employee involvement, consisting of information sharing (top down), information sharing (bottom-up), rewards, and training practice, was not significantly different from employee empowerment, consisting of perceived control, perceived competence, and goal internalization practices. Thus, these two second order constructs were re-modeled as just one second order construct (Figure 5.1). This new construct, henceforth called “social practices usage”, now consists of the seven first order factors from the original two constructs.

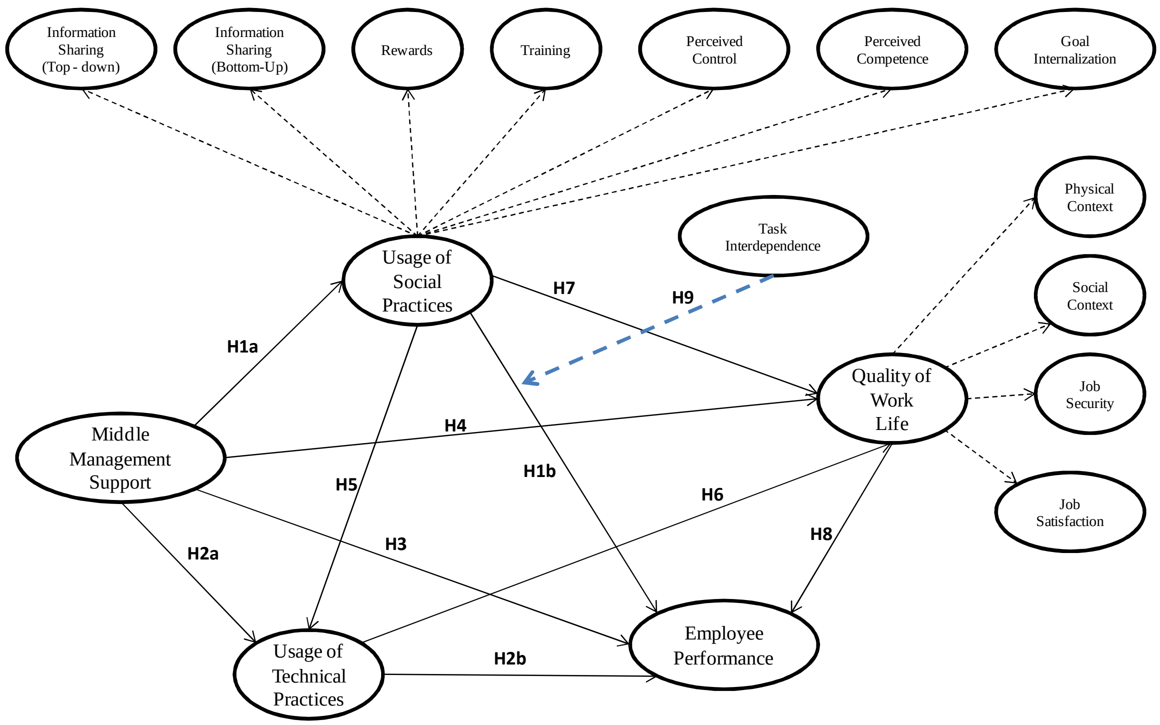

Figure 5.1. Revised research model

As shown in Table 5.11, the scaled version of the Satorra-Bentler pairwise Chi-square difference test was performed again with the revised research model. The results of all pairwise comparisons are significant ($p < 0.05$), indicating support for discriminant validity.

Table 5.11 Assessment of discriminant validity

Constructs	Constrained Satorra-Bentler Model χ^2 (d.f. 801)	Constrained Normal Model χ^2 (d.f. 801)	Unconstrained Satorra-Bentler Model χ^2 (d.f. 800)	$SB\Delta_\chi^2$	P-Value
Middle Management Support (MMS) with					
Social Practices (SP)	1028.1	1240.7	1020.0	15.03	0.000
Task Interdependence (TI)	1037.7	1249.9	1020.0	53.40	0.000
Technical practices (LP)	1025.2	1235.7	1020.0	7.17	0.007
Quality of work life (QWL)	1030.9	1243.6	1020.0	52.47	0.000
Employee Performance (EP)	1022.3	1232.6	1020.0	44.82	0.000
Social Practices (SP) with					
Task Interdependence	1027.3	1237.3	1020.0	50.27	0.000
Technical practices (LP)	1039.3	1251.8	1020.0	48.93	0.000
Quality of work life (QWL)	1028.3	1241.6	1020.0	8.91	0.002
Employee Performance (EP)	1038.7	1251.2	1020.0	47.18	0.000
Task Interdependence with					
Technical practices (LP)	1025.4	1235.5	1020.0	17.84	0.000
Quality of work life (QWL)	1031.2	1240.9	1020.0	24.28	0.000
Employee Performance (EP)	1039.6	1250.6	1020.0	21.42	0.000
Technical practices (LP) with					
Quality of work life (QWL)	1021.1	1232.4	1020.0	13.36	0.000
Employee Performance (EP)	1039.3	1251.8	1020.0	89.55	0.000
Quality of work life (QWL) with					
Employee Performance (EP)	1042.1	1270.5	1020.0	3.90	0.048

Unconstrained normal model χ^2 = 1231.7 with 800 df

Convergent and discriminant validity is further assessed using the Fornell and Larcker (1981) analysis. As shown in table 5.12, the average variance extracted (AVE) for each of the new constructs was above the suggested cut-off of 0.5 (i.e. variance explained by the construct is greater than the measurement error), thus suggesting evidence of convergent validity. Moreover, the square root of AVE for each construct was greater than all the inter-construct correlations, further suggesting evidence of discriminant validity.

Table 5.12 Correlation and Average Variance Extracted

	AVE	MMS	ISA	ISB	R	T	PCTRL	PC	GI	TI	PHYC	SC	JSAT	JS	EP	MV	LP
MMS	**0.64**	**0.80**															
ISA	**0.57**	0.55	**0.75**														
ISB	**0.73**	0.56	0.62	**0.86**													
R	**0.78**	0.44	0.49	0.50	**0.88**												
T	**0.57**	0.62	0.68	0.69	0.54	**0.76**											
PCTRL	**0.66**	0.61	0.67	0.68	0.54	0.75	**0.81**										
PC	**0.66**	0.44	0.49	0.50	0.39	0.54	0.54	**0.81**									
GI	**0.64**	0.57	0.63	0.64	0.50	0.70	0.69	0.50	**0.80**								
TI	**0.60**	0.46	0.64	0.65	0.51	0.71	0.70	0.51	0.65	**0.78**							
PHYC	**0.57**	0.39	0.38	0.38	0.30	0.42	0.41	0.30	0.39	0.40	**0.76**						
SC	**0.54**	0.57	0.55	0.56	0.44	0.61	0.60	0.44	0.56	0.59	0.44	**0.73**					
JSAT	**0.80**	0.58	0.56	0.57	0.45	0.62	0.61	0.45	0.57	0.60	0.45	0.65	**0.89**				
JS	**0.55**	0.55	0.29	0.28	0.29	0.23	0.31	0.31	0.23	0.29	0.30	0.22	0.33	**0.74**			
EP	**0.63**	0.63	0.52	0.52	0.53	0.42	0.58	0.57	0.41	0.53	0.56	0.38	0.56	0.29	**0.79**		
MV	**0.71**	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.84**	
LP	**0.67**	0.67	0.55	0.60	0.61	0.48	0.67	0.66	0.48	0.62	0.61	0.37	0.54	0.28	0.61	0.00	**0.82**

Note: Construct variance is shown on the diagonal.

5.3.2.2. **Analysis of common method bias**

The validity of the study was also analyzed by testing for common method bias. Three statistical procedures were used to diagnose and control for common method bias: Harman's single factor test, a partial correlation procedure using a marker variable, and use of a single unmeasured latent method factor (Podsakoff et.al., 2003).

The Harman's single factor test extracted nine factors from the data that correspond to the latent variables in this study. These factors account for 70.34 % of the variance, with one factor accounting for 36.1%. No single factor accounted for a majority of the covariance, suggesting that common method bias does not pose a severe threat to the validity of the study.

Next, common method bias was assessed using the partial correlation procedure with a marker variable of "memory of an experience". Two models were compared (Table 5.13) to assess the potential effects of the common method bias. Model 1 contained the items loaded onto their respective latent factors, and model 2 contained items loaded onto their respective latent factors and also onto the first order marker variable. When the two models are compared with each other, the Satorra-Bentler Chi-square difference is found to be significant ($p < 0.005$). This implies that the marker variable may have an impact on the validity of the study and it could lead to common method bias.

Table 5.13 Results of partial correlation procedure

Without marker variable (Model 1)			With marker variable (Model 2)			Satorra-Bentler Chi-square difference		
Satorra-Bentler Model 1 χ^2	Model 1 χ^2	df	Satorra-Bentler Model 2 χ^2	Model 2 χ^2	Df	SB$\Delta\chi^2$	Δdf	P-Value
1026.80	1285.16	800	1146.36	1426.41	884	120.34	84	0.005

In addition to comparing the two models, the structural parameters of the model with the marker variable were assessed. This revealed that the loadings on the factors are much higher than the loadings on the marker variable (Table 5.14). The low factor loading on the marker variable contradicted the Satorra-Bentler Chi-square difference results. This inconclusive finding prompted the use of a more stringent procedure to test for common method bias.

Table 5.14 Item loading based on marker variable

Item #	**Item**	**Factor Loading**	**Marker Variable Loading**
Middle Management Support			
	Average Variance Extracted	*0.65*	*0.01*
MMS2	My manager provides me with the necessary resources to accomplish my tasks effectively	0.84	0.10
MMS3	My manager facilitates in the implementation of quality improvements in this department	0.71	0.13
MMS4	My manager provides me with the necessary resources to improve product quality	0.85	0.11
Information Sharing (Top – Down)			
	Average Variance Extracted	*0.57*	*0.01*
IS1	Information regarding company policies and procedures is shared with my team members	0.80	0.12
IS4	My team members are kept informed when something important occurs in the department	0.70	0.06
Information Sharing (Bottom – Up)			

	Average Variance Extracted	*0.73*	*0.01*
IS5	My team members share information about their work processes with each other in this department	0.89	0.10
IS6	My team members share information regarding best practices with each other in this department	0.82	0.07
Reward Practices			
	Average Variance Extracted	*0.78*	*0.00*
R3	My team members are rewarded when they make an extra effort to improve overall performance of this department	0.89	0.06
R5	My team members are rewarded when they learn additional skills related to their work	0.87	0.07
Training Practices			
	Average Variance Extracted	*0.57*	*0.04*
T1	My team members are provided with training in specific job skills needed to do their job	0.74	0.07
T4	My team members are provided with training in problem solving skills related to their work	0.72	0.14
T5	My team members are provided with training in quality improvement skills related to their work area	0.81	0.30
Perceived Control			
	Average Variance Extracted	*0.66*	*0.04*
PCTRL1	My team member influence process changes that affect their work	0.85	0.27
PCTRL2	My team members influence changes in their work methods	0.81	0.13
PCTRL3	My team members influence the way in which tasks are completed in their work area	0.74	0.18
PCTRL4	My team members influence decisions about issues that affect their work	0.85	0.23
Perceived Competence			
	Average Variance Extracted	*0.66*	*0.01*
PC1	My team members are confident that they can do their job well	0.81	0.17
PC2	My team members demonstrate competence in meeting their job tasks	0.83	0.08
PC3	My team members have the capabilities to meet their job demands	0.79	0.07
Goal Internalization			
	Average Variance Extracted	*0.60*	*0.02*
GI1	Working towards the goals (objectives) of this department is important to my team members	0.83	0.20
GI2	My team members are enthusiastic and ready to act	0.78	0.18

	towards achieving the goals (objectives) of this department		
GI3	My team members are inspired by the goals (objectives) of this department	0.79	0.12
GI4	My team members are willing to help this department achieve its goals (objectives)	0.80	0.05
Task Interdependence			
	Average Variance Extracted	*0.60*	*0.03*
TI1	My team members work in groups to get the job done in this department	0.87	0.17
TI2	My team members rely on each other to get the job done	0.63	0.16
TI4	My team members work in groups to get the job done in this department	0.81	0.14
Physical Context			
	Average Variance Extracted	*0.57*	*0.02*
PHYC4	Eating areas within the plant are clean and hygienic	0.71	0.17
PHYC5	Restrooms within the plant are clean and hygienic	0.80	0.14
Social Context			
	Average Variance Extracted	*0.54*	*0.02*
SC1	My team members can always count on each other for support at work	0.75	0.14
SC4	My team members are friendly with each other at work	0.72	0.17
Job Satisfaction			
	Average Variance Extracted	*0.80*	*0.05*
JSAT1	My team members enjoy coming to work everyday	0.88	0.18
JSAT3	My team members enjoy performing their daily job activities	0.91	0.26
Job Security			
	Average Variance Extracted	*0.55*	*0.01*
JS1	My team members do not worry about losing their job	0.69	-0.05
JS2	My team members have job security within this organization	0.83	0.11
JS3	My team members have job stability within this organization	0.81	0.04
JS4	My team members jobs have not been affected by layoffs in this plant	0.62	0.10
Employee Performance			
	Average Variance Extracted	*0.63*	*0.01*
EP1	My team members' abilities to deliver work output on time has improved over the past three years	0.85	0.04
EP4	My team members' work quality has improved over the past three years	0.68	0.09

EP5	My team members' overall performance has improved over the past three years	0.80	0.13
EP6	My team members' dependability in meeting this department's goals (objectives) has improved over the past three years	0.83	0.12
Technical practice			
	Average Variance Extracted	*0.67*	*0.03*
LP1	My team members use lean practices on a regular basis	0.78	0.18
LP2	There is a strong commitment to using lean practices at all levels within this department	0.85	0.17

Finally, common method bias was assessed using a single unmeasured latent method factor. Here, once again, two models were compared. Model 1 contained items loaded onto their respective latent factors, and model 2 contained items loaded onto their respective latent factors and also onto a first order unmeasured latent method factor. When the two models were compared (Table 5.15) the Satorra-Bentler Chi-square difference revealed that the latent method factor may have an impact on the validity of the study and thus, common method bias may be an issue.

Table 5.15 Results of unmeasured latent method factor

Without unmeasured latent method factor (Model 1)			With unmeasured latent method factor (Model 2)			Satorra-Bentler Chi-square difference		
Satorra-Bentler Model 1 χ^2	Model 1 χ^2	df	Satorra-Bentler Model 2 χ^2	Model 2 χ^2	df	SB$\Delta\chi^2$	Δdf	P-Value
1026.80	1285.16	800	939.52	1137.66	759	73.54	41	0.000

In addition to comparing the two models, the structural parameters of the model with the unmeasured latent method factor were assessed. This revealed that the loadings on the method factor were unusually high. This indicates that there was a significant method effect.

Table 5.16 Item loading based on unmeasured latent method factor

Item #	Item	Factor Loading	Method Factor Loading
Middle Management Support			
	Average Variance Extracted	*0.56*	*0.10*
MMS2	My manager provides me with the necessary resources to accomplish my tasks effectively	0.77	0.33
MMS3	My manager facilitates in the implementation of quality improvements in this department	0.68	0.26
MMS4	My manager provides me with the necessary resources to improve product quality	0.78	0.34
Information Sharing (Top – Down)			
	Average Variance Extracted	*0.41*	*0.23*
IS1	Information regarding company policies and procedures is shared with my team members	0.72	0.34
IS4	My team members are kept informed when something important occurs in the department	0.55	0.59
Information Sharing (Bottom – Up)			
	Average Variance Extracted	*0.50*	*0.25*
IS5	My team members share information about their work processes with each other in this department	0..73	0.55
IS6	My team members share information regarding best practices with each other in this department	0.68	0.44
Reward Practices			
	Average Variance Extracted	*0.59*	*0.19*
R3	My team members are rewarded when they make an extra effort to improve overall performance of this department	0.78	0.43
R5	My team members are rewarded when they learn additional skills related to their work	0.76	0.43
Training Practices			
	Average Variance Extracted	*0.45*	*0.20*
T1	My team members are provided with training in specific job skills needed to do their job	0.55	0.50
T4	My team members are provided with training in problem	0.71	0.38

T5	solving skills related to their work My team members are provided with training in quality improvement skills related to their work area	0.74	0.45
Perceived Control			
	Average Variance Extracted	*0.34*	*0.37*
PCTRL1	My team member influence process changes that affect their work	0.49	0.72
PCTRL2	My team members influence changes in their work methods	0.57	0.60
PCTRL3	My team members influence the way in which tasks are completed in their work area	0.56	0.53
PCTRL4	My team members influence decisions about issues that affect their work	0.68	0.55
Perceived Competence			
	Average Variance Extracted	*0.47*	*0.20*
PC1	My team members are confident that they can do their job well	0.72	0.40
PC2	My team members demonstrate competence in meeting their job tasks	0.71	0.44
PC3	My team members have the capabilities to meet their job demands	0.62	0.50
Goal Internalization			
	Average Variance Extracted	*0.45*	*0.23*
GI1	Working towards the goals (objectives) of this department is important to my team members	0.65	0.53
GI2	My team members are enthusiastic and ready to act towards achieving the goals (objectives) of this department	0.79	0.31
GI3	My team members are inspired by the goals (objectives) of this department	0.61	0.49
GI4	My team members are willing to help this department achieve its goals (objectives)	0.61	0.54
Task Interdependence			
	Average Variance Extracted	*0.52*	*0.11*
TI1	My team members work in groups to get the job done in this department	0.79	0.36
TI2	My team members rely on each other to get the job done	0.54	0.39
TI4	My team members work in groups to get the job done in this department	0.80	0.27
Physical Context			
	Average Variance Extracted	*0.55*	*0.07*
PHYC4	Eating areas within the plant are clean and hygienic	0.71	0.19

PHYC5	Restrooms within the plant are clean and hygienic	0.77	0.32
Social Context			
	Average Variance Extracted	*0.45*	*0.08*
SC1	My team members can always count on each other for support at work	0.67	0.29
SC4	My team members are friendly with each other at work	0.67	0.26
Job Satisfaction			
	Average Variance Extracted	*0.53*	*0.28*
JSAT1	My team members enjoy coming to work everyday	0.70	0.55
JSAT3	My team members enjoy performing their daily job activities	0.75	0.50
Job Security			
	Average Variance Extracted	*0.51*	*0.06*
JS1	My team members do not worry about losing their job	0.70	0.11
JS2	My team members have job security within this organization	0.77	0.30
JS3	My team members have job stability within this organization	0.78	0.26
JS4	My team members jobs have not been affected by layoffs in this plant	0.59	0.22
Employee Performance			
	Average Variance Extracted	*0.49*	*0.18*
EP1	My team members' abilities to deliver work output on time has improved over the past three years	0.74	0.42
EP4	My team members' work quality has improved over the past three years	0.75	0.15
EP5	My team members' overall performance has improved over the past three years	0.72	0.39
EP6	My team members' dependability in meeting this department's goals (objectives) has improved over the past three years	0.59	0.59
Technical practice			
	Average Variance Extracted	*0.66*	*0.04*
LP1	My team members use lean practices on a regular basis	0.83	0.06
LP2	There is a strong commitment to using lean practices at all levels within this department	0.80	0.27

In addition to the Satorra-Bentler scales Chi-square difference test, and estimating the item loading on the unmeasured latent method factor, the model fit (i.e. CFI) value for the model with the unmeasured latent method factor (model A) and without it (model B) was also evaluated. Byrne (2006) suggests that since Chi-square differences are sensitive to sample size, researchers must evaluate ΔCFI for the two models. As the ΔCFI of 0.013 (model A CFI = 0.951; model B CFI = 0.938) in this study was greater than the recommended value of 0.01 (Cheung & Rensvold, 2002), we conclude that common method bias was an issue. Hence for all further analyses, the unmeasured latent method factor is included in the structural model to partial out any method factor.

5.3.3. **Hypothesis testing**

This section provides the structural properties of the hypothesized research model. This is followed by the results of the analyses of direct effects and moderation effects of the proposed hypotheses in the study. Lastly, post-hoc analyses provide possible explanations for the proposed hypotheses that were not supported by the data.

5.3.3.1. **Structural model**

The measurement model was tested with all factors being freely correlated with one another. The measurement items were loaded onto their respective factors and also onto the unmeasured latent method factor. This was then included in the structural model that was used to test the hypothesized research model. The moderator variable (i.e. task interdependence) was excluded, as it was tested separately. The fit indices, as shown in Table 5.17, suggest that the revised structural model fits the data well. The CFI fit index is above the suggested cut-off of 0.90, and the RMSEA value is below the cut-off of 0.05 (Kline, 2005).

*Table 5.17 Fit of the hypothesized structural model**

	Satorra-Bentler Chi-Square (df)	CFI	RMSEA
Measurement model	1020.05 (800)	0.95	0.037
Structural model	1295.17 (934)	0.91	0.044

* These models do not include the task interdependence construct

5.3.3.2. **Analysis of direct effects**

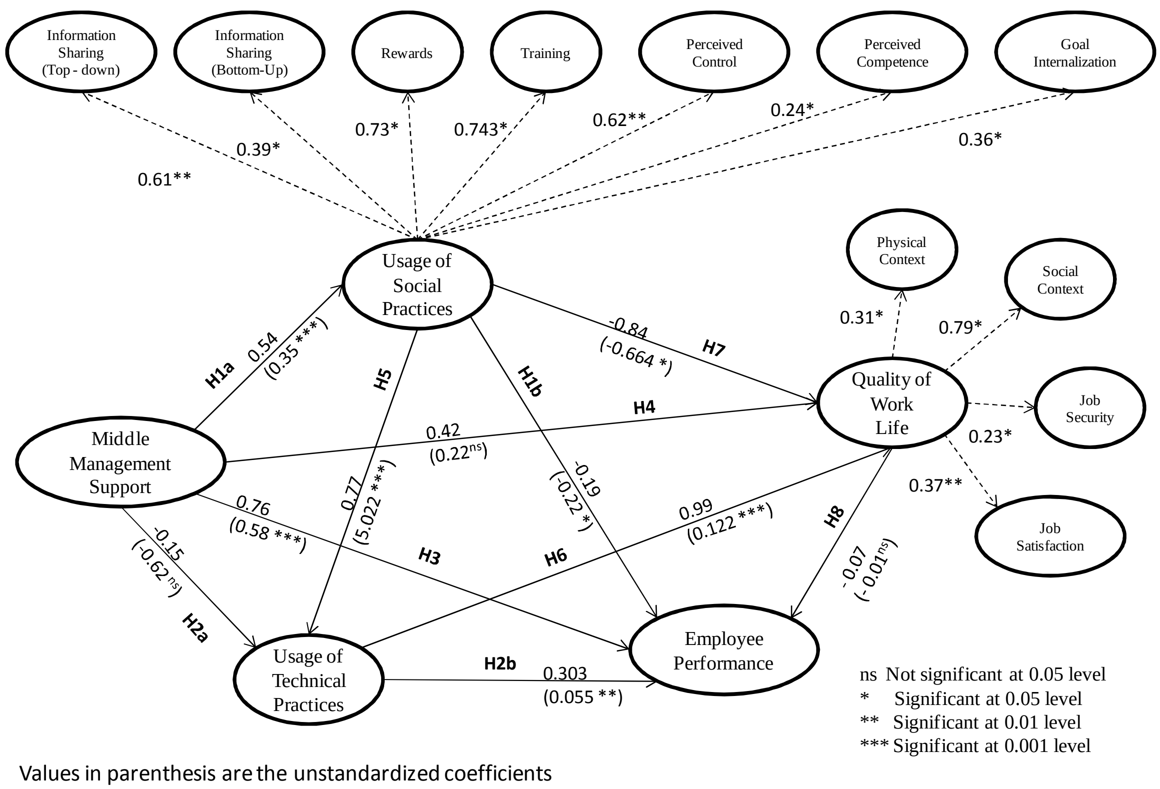

Figure 5.2 Hypothesized structural model with standardized path loadings

The result from this analysis is provided in four categories. First, the direct effect of middle management support on social practice usage, technical practice usage, employee performance, and quality of work life is presented. Second, the direct effect of social practice usage of technical practice usage, employee performance, and quality of work life is presented. Third, the direct effect of technical practice usage on employee performance and quality of work life is presented. Fourth, the direct effect of quality of work life on employee performance is presented. Table 5.8., provides a summary of the results from the analyses. The structural model shown in Figure 5.2 provides the nature (i.e. direction) and the standardized path loadings of the hypothesized direct relationships in the study.

Table 5.18 Summary of direct effectsin the proposed model

Hypothesis	Direct Effect	Unstd. Loading	Std. Error	C.R.	p-value	Supported ?
H1a	Middle Management Support → Social Practices Usage	0.35	0.10	3.51	0.00	Yes
H2a	Middle Management Support → Technical Practices Usage	-0.62	0.43	-1.45	0.15	No
H3	Middle Management Support → Improvement in Employee Performance	0.58	0.08	7.55	0.00	Yes
H4	Middle Management Support → Quality of Work Life	0.22	0.13	1.58	0.115	No
H5	Social Practices usage → Technical Practices Usage	5.220	0.97	5.16	0.00	Yes
H1b	Social Practices Usage → Improvement in Employee Performance	-0.221	0.11	-2.10	0.01	Yes
H7	Social Practices usage → Quality of Work Life	-0.664	0.21	-3.18	0.00	No
H2b	Technical Practices Usage → Improvement in Employee Performance	0.055	0.02	2.75	0.01	Yes
H6	Technical Practices Usage → Quality of Work Life	0.122	0.02	5.08	0.00	Yes
H8	Quality of Work Life → Improvement in Employee Performance	0.100	0.99	0.10	0.47	No

Direct effects of middle management support. In the study, middle management support is proposed to have a direct effect on social practice usage, technical practice usage, quality of work life and improvement in employee performance. More specifically, hypothesis 1a proposed that middle management support is positively related to the social practices usage. This hypothesis was supported ($\beta = 0.54$, $p < 0.001$). Hypothesis 2a proposed that middle management support is positively related to technical practices usage. This hypothesis was not supported ($\beta = -0.064$, $p < 0.15$). Hypothesis 3, proposed a positive relationship between middle management support and improvement in employee performance. This hypothesis was supported ($\beta = 0.76$, $p < 0.001$). Finally, hypothesis 4 proposed a positive relationship between middle management support and quality of work life. This hypothesis was not supported ($\beta = -0.18$, $p < 0.15$). This contradictory finding may be explained by conclusions from Sirgy et.al (2001) and Martel and Dupius (2006), who found that employees' perceptions of their quality of work life change constantly, based on their immediate individual needs. In other words, employees have changing dispositions to the dimensions (i.e. physical environment, social context, job satisfaction, job security) of quality of work life. Therefore, middle management support will not have a significant effect on individuals' perceptions of their quality of work life.

Direct effects of social practice usage. In this study, social practice usage is proposed to have a direct effect on improvement in employee performance, technical practice usage and employees' quality of work life. More specifically, hypothesis 1b proposed a positive relationship between social practice usage and improvement in employee performance. This hypothesis was not supported. However, contrary to the expectation, there was a significant negative relationship between the social practices usage and employee performance ($\beta = -0.18$, $p < 0.04$). To investigate this contradictory finding, correlation analyses for all items of social practices, middle management support, quality of work life, and employee performance were analyzed (**Appendix D**).

The bi-variate correlation between the constructs of social practice usage and employee performance was found to be positive. Further the first order correlations between middle management support and employee performance was much greater than the correlation between social practice usage and employee performance. This suggests a case of net suppression. The result of hypothesis 1b can now be interpreted as follows: given that the level of middle management support remains constant, increasing the level of social practices usage will have a negative impact on employee performance. Stated differently, this means that increasing the usage of social practices does not automatically translate into improved employee performance. Social practices usage will have a positive impact on employee performance, only when we control for the level of middle management support.

Hypothesis 5 proposed a positive relationship between social practices usage and technical practices usage. This hypothesis was supported ($\beta = 0.77$, $p < 0.0001$). Finally, hypothesis 7, proposed a positive relationship between social practices usage and employees' quality of work life. This hypothesis was not supported. However, contrary to the expectation, there was a significant negative relationship between the social practices usage and employee performance ($\beta = -0.664$, $p < 0.0001$).

Direct effects of technical practice usage. In this study, technical practice usage is proposed to have a direct effect on employees' performance and quality of work life. More specifically, hypothesis 2b proposed that technical practice usage is positively related to improvement in employee performance. This hypothesis was supported ($\beta = 0.30$, $p < 0.01$). Hypothesis 6 proposed a positive relationship between usage of technical practices and the employees' quality of work life. This hypothesis was also supported ($\beta = 0.99$, $p < 0.001$).

Direct effects of quality of work life. In this study, hypothesis 8 proposed that employees' quality of work life is positively related to their improvement in performance. Contrary to the expectation, this hypothesis was however not supported ($\beta = - 0.007$, $p < 0.95$).

5.3.3.3. **Analysis of interaction effect**

Hypothesis 9 proposed an interaction effect of task interdependence on the relationship between social practice usage and improvement in employee performance. The SEM analysis revealed that this interaction effect was insignificant ($\beta = -0.017$, $p < 0.68$). Thus hypothesis 9 was not supported. A detailed examination of the results reveals that although task interdependence is not a significant moderator between these two constructs, the data indicates that for low levels of task interdependence, employee performance reduces as the usage of social practices increases. For high levels of task interdependence, employee performance increases as social practices usage increases.

The insignificant interaction effect found in this study may be attributed to a phenomenon called as the ceiling effect (Cohen et.al., 2003). More specifically, a careful examination of the study sample revealed that 184 of the 200 respondents worked in organizations that had implemented lean practices and therefore we suppose that they heavily depended on teams. As a result of this sample characteristic, the variance in the independent variable (i.e. task interdependence) could not be measured or estimated above a certain level of dependency. Scores for task interdependence were bunched at the upper level of the Likert scale. Hence future studies should collect data from firms that have implemented a lean approach to work design, and also ones that have not.

5.3.3.4. **Post-hoc analyses**

Indirect effect. Indirect effects are the mediation effects in the hypothesized research model (Figure 5.2) that were determined post-hoc using the Sobel test (Sobel, 1982). In this approach, "a" and "b" represented the unstandardized path loadings for path X→Z and Z→Y respectively, for an overall path model represented as X→ Z → Y. In addition to the unstandardized path loadings, SE_a and SE_b represented the standard error for paths X→Z and Z→Y respectively. The unstandardized indirect effects were obtained by taking the product of the two unstandardized path loadings a and b, while the standard error for the indirect effect SE_{ab} was calculated as $\sqrt{b^2SE_a^2 + a^2SE_b^2}$. The Sobel test statistic ($a*b/SE_{ab}$) was interpreted as the z-test for the indirect effect. Table 5.20 provides the results for the post-hoc propositions.

Table 5.19 Sobel test for indirect effects

Proposition	Indirect Effect	Mediating effect	Std. Error	Z- Statistics	p-value
P1	Middle Management Support → Social Practices Usage → Technical Practices Usage	1.763	0.61	2.901	0.003
P2	Middle Management Support → Social Practices Usage → Quality of Work Life	-0.223	0.11	-2.195	0.02
P3	Middle Management Support →Technical Practices Usage → Quality of Work Life	-0.076	0.06	-1.382	0.17
P4	Middle Management Support → Quality of Work Life → Employee Performance	-0.002	0.24	-1.611	0.10
P5	Middle Management Support → Social Practices Usage → Employee Performance	-0.078	0.04	-1.805	0.07
P6	Middle Management Support →Technical Practices Usage → Employee Performance	-0.034	0.03	-1.273	0.20
P7	Social Practices Usage →Technical Practices Usage → Quality of Work Life	0.613	0.17	3.620	0.00
P8	Social Practices Usage → Quality of Work Life → Employee Performance	0.007	0.00	2.841	0.003
P9	Social Practices Usage → Technical Practices Usage → Employee Performance	0.276	0.11	2.426	0.01
P10	Technical Practices Usage → Quality of Work Life → Employee Performance	-0.001	0.00	-5.077	0.000

Technical practices. This test aimed to determine if process type (i.e. assembly line, batch shop, job shop, or continuous flow process) had an impact on the usage of technical practices, which was measured as the following bundles: total quality management (TQM), total preventative maintenance (TPM), and just-in-time (JIT). The one-way ANOVA for process type and the technical practices usage (Table 5.21) revealed no significant difference (α = 0.95). This result indicates that the production process used by a plant (to manufacture its main product) has no influence on the specific technical practices implemented in that plant.

Table 5.20 One-way ANOVA for process type and technical practices

	Sums of Squares	Df	Mean Squares	F_{stat}	Significance
TQM bundle					
Between Groups	4.545	3	1.515	1.752	0.158
Within Groups	169.470	196	0.865		
Total	174.014	199			
TPM bundle					
Between Groups	7.642	3	2.547	1.055	0.369
Within Groups	473.313	196	2.415		
Total	480.955	199			
JIT bundle					
Between Groups	1.831	3	0.610	0.670	0.571
Within Groups	178.512	196	0.911		
Total	180.344	199			

This study confirmed the earlier findings of Shah and Ward (2003), that size of the firm has an influence on the usage of technical practices (measured as the lean bundles). Additionally, one-way ANOVA tests (Table 5.22) revealed which technical practices are influenced by plant size.

Table 5.21 One-way ANOVA for Organizational Size and Technical Practice

	Sums of Squares	Df	Mean Squares	F_{stat}	Significance
TQM bundle					
Between Groups	14.901	9	1.656	1.977	0.044
Within Groups	159.113	190	0.837		
Total	174.014	199			
TPM bundle					
Between Groups	25.486	9	2.830	1.180	0.310
Within Groups	455.487	190	2.397		
Total	480.955	199			
JIT bundle					

Between Groups	10.908	9	1.212	1.359	0.209
Within Groups	169.436	190	0.892		
Total	180.344	199			

Test results for the TQM bundle were significant ($\alpha = 0.95$). This indicates that plant size influences the implementation of the technical practices of standardized work, kaizen, zero defects, visual control, and 5-S. The analyses of the JIT and TPM bundles, with respect to plant size, were not significant.

CHAPTER 6. SUMMARY AND CONCLUSION

This chapter discusses the contributions that this dissertation makes to the field of operations management. Key findings from the data analyses are presented first, followed by applications of this research to academia and the industry. Finally, this chapter addresses limitations of the study and presents directions for future research.

6.1. Key findings

The key findings of this dissertation are presented with respect to the four research questions posed in Chapter 1:

1. What work practices integrate socio-technical and lean approaches to organizational work design within manufacturing?
2. What are the effects these organizational work practices have on the employee quality of work life?
3. What are the effects these organizational work practices have on employee performance?
4. How does task interdependence affect employee performance in manufacturing?

6.1.1. Key finding 1: Integration of STS and lean principles

Based on a systemic method of comparing and then categorizing the STS and LP principles which are based on a common overarching goals the principles are trying to achieve, work practices were identified that could help in achieving those goals (see section 3.1). The work practices identified thus reflected an integrated STS and LP approach to work design. These work practices were middle management support, social practices usage, and technical practices usage. Usage of social practices consists of information sharing practice (both top-down information sharing and bottom–up information sharing), reward practice, training practice, and practice of power manifested as perceived control, perceived competence, and goal internalization. Usage of technical practices consists of the lean practice bundles identified by Shah and Ward (2003) – TQM bundle, TPM bundle, and the JIT bundle.

To provide a succinct explanation of the impact of the above identified work practices on employees' quality of work life and performance, a parsimonious model was tested (Figure 6.1). This model contained only the significant direct effects of the relationships proposed in the full model (Figure 5.2). The fit of this model (CFI - 0.91, RMSEA – 0.044) was not significantly different than the fit of the full model (CFI - 0.91, RMSEA – 0.044). Hence, we suggest that the parsimonious model succinctly describes the relationships.

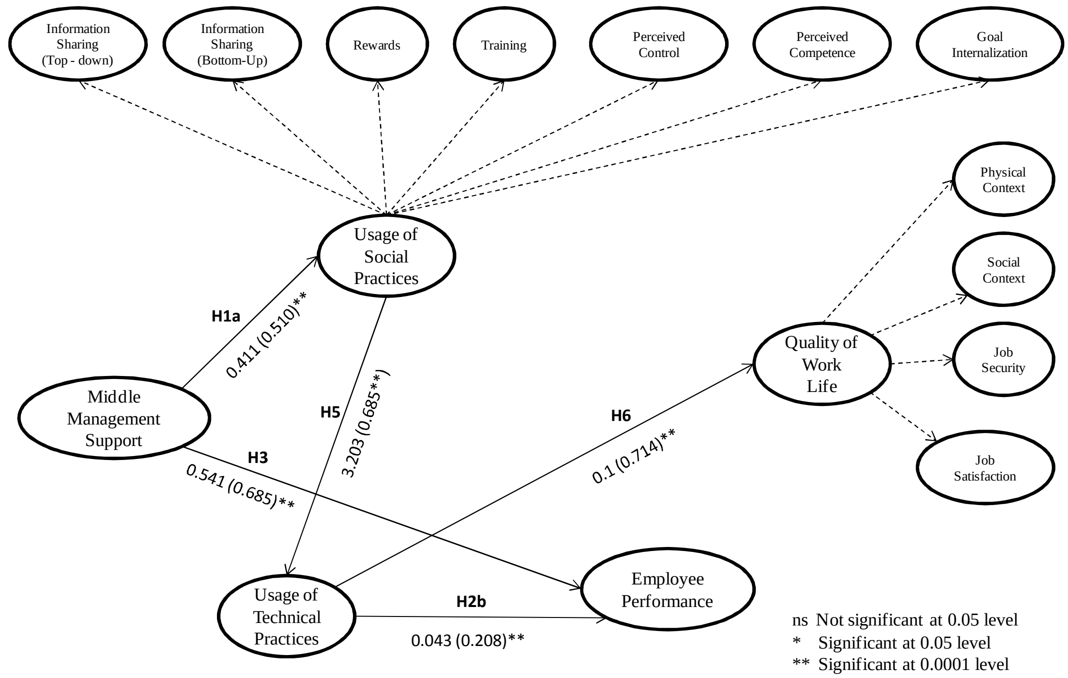

Figure 6.1 Significant paths in the research model

6.1.2. **Key finding 2: Impact on quality of work life**

The decomposition of the total effects of middle management, social practices usage and technical practices usage as shown in Table 6.1, reveals that only technical practices usage had a significant direct effect on employee's quality of work life. Social practices usage and middle management support had no direct significant effect on the employees' quality of work life. Social practices usage had a significant positive indirect effect of quality of work life when mediated through technical practices usage. This means that usage of technical practices, when complementing usage of social practices, improves employees' quality of work life. Furthermore, the indirect effect of the social practice usage on quality of work life is greater than the direct effect of technical practice usage on employees' quality of work life. This suggests that both social practices and technical practices are needed to have a greater impact on the employees' quality of work life.

Middle management support like social practices usage also has a significant positive indirect effect on the quality of work life when mediated through social practices usage and technical practices usage. This supports prior findings in the literature that when middle managers promote the usage of social practices (i.e. bi-directional information sharing, providing access to relevant and appropriate training, instating a reward structure, and empowering employees (Menon, 2001; Bowen & Lawler, 1992), employees are more likely to utilize technical practices effectively. This leads to improved working conditions and therefore, employees experience a better quality of work life (Rethinam & Ismail, 2008; Treville & Antonakis, (2006); Sumukadas, 2005; Shah & Ward, 2003; Pun et.al., 2001; Brown et.al., 2000).

Table 6.1 Total effect decomposition

Causal Variables	Endogenous Variables			
	Social practices usage	Technical practices usage	Quality of work life	Employee Performance
	Unstd.	Unstd.	Unstd.	Unstd.
Middle management support				
Direct effect	0.41	-	-	0.54
Indirect effect	-	1.31	0.13	0.06
Total	***0.41***	***1.31***	***0.13***	***0.60***
Social practices usage				
Direct effect		3.203	-	-
Indirect effect		-	0.32	0.14
Total		***3.203***	***0.32***	***0.14***
Technical practices usage				
Direct effect			0.1	0.04
Indirect effect			-	
Total			***0.1***	***0.04***

* Effect of quality of work life on employee performance was non-significant

6.1.3. **Key finding 3: Achieving employee performance**

The decomposition of the total effects of middle management, social practice usage and technical practice usage as shown in Table 6.1, reveal that middle management support has both a significant positive direct and indirect effect on improvement in employee performance. Technical practices usage also has a positive significant direct effect on improvement in employee performance. Social practices usage and quality of work life however, had no positive significant direct effect on employee performance. Social practices usage infact has a significant positive indirect effect on improvement in employee performance. Technical practices usage mediates the relationship between social practices usage and improvement in employee performance. Furthermore, the indirect effect of social practices usage on improvement in employee performance is greater than the direct effect of technical practices usage on improvement in employee performance. This suggests that, it is important to have both the social practices as well as the technical practices to have a greater impact on improvement in employee performance.

6.1.4. **Key finding 4: Effect of task interdependence**

In recent years, the focus of organizational work design has shifted from individuals to teams (Liker, 2004; Shah & Ward, 2003; Sohal & Egglestone, 1994). Tasks have become highly interdependent, and hence the need for employees to interact and coordinate with each other has increased (Wageman, 1995). This interdependency creates opportunities for conflicts, which can result in lower employee performance (Wilmont & Hocker, 2001; Guzzo & Shea, 1992). Thus, task interdependence was posited to have a moderation effect on improvement in employee performance (Treville and Antonakis, 2006; Seibert et.al, 2004; Kozlowski & Bell, 2003). However, the research results do not offer support for this claim.

6.2. Overall conclusions

6.2.1. Integration of the social and technical practices usage

Social practices usage has a significant indirect effect on both employees' quality of work life and improvement in employee performance. This effect is mediated through the usage of technical practices. This suggests that organizations that promote the usage of social practices by encouraging information sharing practices, training practices, reward practices, and empowerment practice which is measured as power through perceived control, perceived competence, and goal internalization has an effect on employees' quality of work life and improvement in employee performance only if employees use the technical practices (i.e., the TPM, TQM, JIT bundles). This conclusion supports the underlying methodology for the redesign of work practices based on the socio-technical systems philosophy – to enable more effective integration of human and technological resources (Cherns, 1979, 1987; Cleggs, 2000) – and the lean production system – an integrated socio-technical system whose main objective is to eliminate waste (Shah & Ward).

The above finding supports the definition of 'lean production' provided by Shah and Ward (2007), in which they consider LP to be an integrated socio-technical system that focuses on the usage of social practices to harness the benefits of the technical practices. This finding also resonates with anecdotal comments made by practitioners. For example AME president Ralph Keller, in his key note address at the AME annual conference in Covington, KY (2009), acknowledged that the industry has now turned its focus to the usage of social practices. According to him, the 80s and 90s was all about using the technical practices alone, now it is the time to promote the usage of social practices to gain benefit from the usage of technical practices and improving the workers quality of work life in the process.

6.2.2. **Implications of middle management support**

Middle management support had a significant direct effect on the employee performance. This implies that when middle managers provide employees with resources to accomplish their task(s) and interpret the top management directives, have a significant effect on the performance of their employees. However, middle management support had no significant direct effect on the technical practice usage and the employees' quality of work life. Middle management support infact had a significant indirect effect on the usage of technical practice and employees' quality of work life.

Social and technical practice usage mediated the relationship between middle management support and quality of work life, while technical practices mediated the relationship between middle management support and employee performance. This implies that the both social practice usage and technical practice usage is vital for middle management support to have an impact on both the employees quality of work life and the employee performance.

6.3. Contributions of research

This dissertation makes several contributions to both research and practice. Until now, researchers studying lean production have defined and described lean production primarily in terms of achieving the end goal – minimizing buffers, reducing variability, and eliminating all kinds of waste (Dennis, 2007; Narasimhan et.al., 2006; Treville & Antonakis, 2006; Bonavia & Marin, 2006; Li et.al., 2005; Hopp & Spearman, 2004; Liker, 2004; Womack & Jones, 1996). Of these researchers, only Shah and Ward (2003) defined and described lean production as a multi-dimensional approach that encompasses a wide variety of management practices that work synergistically to create a high quality management system. In 2007, they further refined their work by defining lean production as an integrated socio-technical system; however, they only focused on the technical practices. This study extends the research stream by operationalizing STS and LP principles to identify both social and technical practices that reflect an integrated socio-technical system. The developed model for lean design includes both social and technical practices (along with middle management support) and explains how these practices impact employees' quality of work life and performance.

Secondly, this study is an answer to the call to research which focuses on understanding the interaction between operations research and human behavioral research (Bendoly et.al., 2006; Boudreau et.al., 2003; Manz & Stewart, 1997; Forza, 1996). The empirical model developed for this study examined the integrated approach to work design by including the effects of human considerations (i.e. usage of social practices) on classical operations management results (i.e. employee performance), and operational considerations (i.e. usage of technical practices) on classical human resource management results (i.e. quality of work life).

Thirdly, while prior research in operations management has operationalized lean production and described it in terms of its practices (Shah & Ward, 2003; Narasimhan et.al., 2006), this study is the first to examine technical practices usage as a formative construct. Shah and Ward (2003) classified the various technical practices into four bundles (i.e. TPM, TQM, JIT, and HRM), it is clear that the items used to measure those practices within each bundle do not share a common theme. There is little reason to believe that all these practices are sampled from a common domain and are interchangeable. Thus this research uses a measurement approach which presumes that changes in the indicators cause variation in the construct, rather than the other way round. The eleven technical practices of standardized work, pull production, continuous flow, production leveling, cellular manufacturing, total productive maintenance, setup time reduction, zero defects, visual controls, continuous improvement, and 5-S determine the construct of technical practice usage. This method of measurement adds to the understanding of technical practices usage within an organization.

Fourthly, this study demonstrates that middle management support is critical in the implementation and sustenance of a lean system. Researchers need to measure the level of middle management support when evaluating the factors that determine the success of lean implementation.

In more recent years, practitioners' focus within lean production has been changing. During the 80's and 90's, they sought to implement the tools and practices of lean. Now, they have come to realize that although tools are necessary, they are not sufficient (Keller, R., 2009). The focus now is all about the "people" who use these tools and the work practices that help facilitate in the usage of those tools. From a practical stand point, this study describes specific and identifiable factors that can lead to improved employee performance and quality of work life. In particular, it provides practitioners with key ingredients necessary to successfully implement a true lean production system which incorporates elements of both the social as well as the technical system. The social system incorporates the middle management support, employee involvement practices, and the empowerment initiatives. The technical system incorporates the practices used in lean production (depending on the operational process within that plant).

6.4. Limitations of the study

A major limitation of this study is the use of a single respondent to measure both independent and dependent variables. Supervisors' were asked to assess their organizations' implementation of work practices based on the STS and LP approaches (i.e. independent variable), and the same individual was also asked to assess the impact of these work practices on their employees' performance and quality of work life (i.e. dependent variable). This self-reported data is a cause for common method bias. To counter the effects of using a single respondent in this study, multiple responses from 54 companies were collected, and the analysis of inter-rater agreement revealed that there was adequate reliability between the respondents (Ketokivi & Schroeder, 2004). However, the limited sample size did not allow the use of multi-trait multi-method

(MTMM) analysis with the data. Hence, it was not possible to evaluate the whole data set (of 200 responses) for common method bias.

The type of respondent chosen for this study also created a limitation. Since it was not possible to access shop floor employees to complete the survey, their supervisors were selected as the key respondents to answer survey questions on behalf of their employees. According to organizational behavior and psychology literature, supervisors generally believe that employees are treated more favorably than employees themselves are actually treated (Lester, Turnley, Bloodgood, & Bolino, 2002). To account for this limitation, a familiarity scale was developed to test how familiar the respondents (i.e. supervisors) were with their shop floor employees.

The measures of the different technical practices used in this study (i.e. JIT, TQM, and TPM bundles) limited our ability to fully understand: 1) how long have employees been using the individual technical practices, and 2) how often employees use these practices in their daily work task(s). Future research should assess the length of time and frequency of technical practices usage in order to better measure this construct.

This study is unable to establish causality for the proposed model. The cross-sectional survey used in this study does not allow for the examination of the possible causal direction between quality of work life and performance of employees. Future research should employ a longitudinal approach to more fully understand the causal direction and possible reciprocal relationship between these two independent variables.

The insignificant interaction effect found in this study may be attributed to a phenomenon called as the ceiling effect (Cohen et.al., 2003). Since the study sample consisted of 184 respondents that worked for organizations that had implemented lean practices and therefore were heavily depended on teams, the variance in the independent variable (i.e. task interdependence) could not be measured or estimated above a certain level of dependency.

6.5. Suggestions for future research

This study provides a stepping stone for several fertile areas for future research. Conduct another cross sectional study with a revised survey to be able to measure employees changing dispositions to the dimensions of quality of work life (i.e. physical environment, social context, job satisfaction, job security). This may provide support for the effect of quality of work life on employee performance. Also include plants that have not implemented lean so as to test the effect of task interdependence on the relationship between social practice usage and employee performance.

Next, conduct a multi-national study to test the validity of the model across different cultures (e.g. India, Taiwan, and the U.S.). Also organizational culture has been known to have an impact on many quality management initiatives (Zu, 2005). It is important that we enhance our understanding of the impact of organizational culture (e.g. Organizational Citizenship Behavior) on the implementation and the execution of the work practices identified in this study. Future research should focus on how organizational culture results in improved employee quality of work life and performance.

Also conduct a multi-level case study to determine how this integrated approach to work design impacts the quality of work life and performance of employees at different level within an organization (e.g. middle manager, team leader, shop floor employee).

Finally, investigate how service operations can leverage the usage of social and technical practices by customers in the co-production of products. As service sectors progresses towards the concept of mass customization, the usage of social practices and technical practices will play an important role in impacting the business performance. Hence researchers should undertake case studies to gain deeper insight into how the above practices can be used in a co-production environment.

APPENDICES

APPENDIX A

Items dropped, retained, and added after pilot test

Scales used	Hit Rate
Middle Management Support	
My manager spends time with me to explain my job priorities	1.00
My manager provides me with the necessary resources to accomplish my task(s) effectively	0.88
My manager facilitates in the implementation of quality improvements in my department	0.90
My manager provides me with the necessary resources to improve product quality	0.75
My manager supports my efforts to improve my work quality *	0.60
My manager spends time with me to explain the department's goals (objectives) *	0.40
Information Sharing (Top – Down)	
Information regarding company policies and procedures is shared with my team members	0.88
My team members receive feedback about their work quality	0.86
My team members productivity is shared with them on a regular basis **	**0.86**
My team members are alerted when something important occurs in the department **	**0.71**
Information Sharing (Bottom – Up)	
My team members report (record) their production quality data in a timely manner *	0.54
My team members share information about product quality issues with each other *	0.62
My team members report their productivity data in a timely manner *	0.65
My team members share information about their work processes with each other in this department **	**0.75**
My team members share best practices with each other in this department **	**0.76**
My team members share their productivity data with each other in this department **	**0.75**
My team members share their frequency of machine breakdown with each other in this department **	**0.75**
Reward Practice	
My team members' pay increases are based on their job performance *	0.65
My team members receive recognition/praise when they help achieve the goals (objectives) set for this department	0.75
My team members are rewarded when they make an extra effort to improve overall performance of this department	1.00
My team members are financially rewarded when they learn additional skills related to their work	0.90
My team members are rewarded with bonuses when the business performs well **	**1.00**
My team members receive letters or certificate of appreciation when they	**0.88**

perform well **	
Training Practice	
My team members are provided with training in specific job skills needed to do their work	
My team members are provided with cross-training to perform other jobs within the department *	0.58
My team members are provided with training to improve their ability to work as a team	0.85
My team members are provided with training in problem solving skills related to their work	0.90
My team members are provided with safety training related to their work *	0.60
My team members are provided with training in quality improvement skills **	**0.88**
Perceived Competence	
My team members demonstrate competence in meeting their job duties	1.00
My team members have the capabilities to meet their job demands	1.00
My team members have the ability to perform their jobs effectively	1.00
My team members are confident that they can do their job well	1.00
My team members are capable of doing their jobs well *	0.60
Perceived Control	
My team members influence process changes that affect their work	1.00
My team members influence changes in their work methods	1.00
My team members influence decisions about issues that affect their work	1.00
My team members influence their schedule for overtime hours *	0.45
My team members influence the way in which task(s) are completed in their work area **	**0.90**
My team members have influence over how their work schedule is created *	0.60
My team members influence managerial decisions that affect their work *	0.45
My team members influence the allocation of resources within this department *	0.62
Goal Internalization	
Working towards the goals (objectives) of this department is important to my team members	
My team members are inspired by the goals (objectives) of this department	1.00
My team members are willing to help this department achieve its goals (objectives)	1.00
My team members are enthusiastic about working towards the goals (objectives) of this department **	**1.00**
Achieving this department's goals (objectives) is meaningful to my team members	1.00
Achieving the goals (objectives) of this department is important to my team members *	1.00
Physical context	
The quality of air, lighting, and noise in my work area is satisfactory	1.00
Eating areas within the plant are clean and hygienic	1.00
Restrooms within the plant are clean and hygienic	1.00
Safety hazards are controlled/eliminated in my department *	0.65
Safety protocols are enforced strictly in this department **	**0.88**

Workplace safety and health issues are taken seriously in this department *	0.65
**Health issues are taken seriously in this department ** **	**0.88**
Social Context	
My team members are satisfied with the quality of social interaction with their colleagues at work	0.70
My team members can always count on their colleagues for support at work**	**0.75**
My team members have a good relationship with their colleagues at work	0.88
My team members take an interest in each other's well-being at work	1.00
My team members are always willing to help each other in this department**	**0.90**
My team members can talk frankly about their job with my each other at work	1.00
My team members treat each other with respect at work *	0.40
My team members are friendly with each other**	**1.00**
Job Satisfaction	
My team members enjoy coming to work everyday	1.00
My team members are satisfied with their job in this department	1.00
My team members enjoy performing the daily activities of their job	1.00
My team members have very few complaints about their job in this department	1.00
Job Security	
My team members do not worry about losing their job	1.00
My team members have job stability with this organization	1.00
My team members job will not be affected by a recession	1.00
This organization offers full-time employment *	1.00
**My team members have job security with this organization ** **	**0.88**
**Lay-offs have not affected the jobs of my team members within this organization ** **	**0.86**
Task Interdependence	
My team members rely on one another to get the job done within the department	1.00
Different task(s) are performed sequentially by different team members in this department *	0.50
**My team members work in groups to get the job done in this department ** **	**0.70**
My team members need to work together to complete a job effectively	0.75
**My team members share their resources (equipments) with each other to complete the job within the department ** **	**0.86**
My team members work together to complete a job within this department *	0.59
**My team members frequently have to coordinate their efforts with other in the department to complete the job ** **	**1.00**
My team members perform different task(s) in a pre-determined order to complete the job *	0.62
Employee Performance	
My team members' ability to deliver work output on time has improved over the past three years	1.00

My employee absenteeism has decreased over the past three years	1.00
My team members' work quality has improved over the past three years	1.00
My team members' overall performance has improved over the past three years	1.00
My team members' dependability in meeting this department's goals (objectives) has improved over the past three years	1.00
My employee turnover rate has decreased over the past three years	1.00
My team members' productivity has improved over the past three years *	1.00
Marker Variable	
I have wonderful memories about my last vacation	1.00
I will not forget my experiences from my last vacation	1.00
I remember many things about my last vacation	1.00

* Items that were dropped after the pilot test

** Items that were added after the pilot test and used in the final large scale survey

APPENDIX B

Sample calculation for Cohen's K value

	Survey Items	KEY	J1	J2	J3	J4	J5	HIT	Hit Rate
1	My employees are provided with cross-training to perform other jobs within the organization	4	4	4	4	4	12	4	80%
2	My employees need to coordinate their job activities with others to complete their jobs	12	12	12	12	12	12	5	100%
3	My employees are competent in their jobs	6	6	6	6	6	4	4	80%
4	My employees have to rely on one another to get the job done	12	12	12	6	12	12	4	80%
5	I have a good relationship with my colleagues at work	9	9	9	9	9	11	4	80%
6	My employees' promotions are based on their job performance	3	3	3	3	3	3	5	100%
7	My employees are provided with training to learn the safety protocols (procedures) related to their work	4	4	4	4	4	4	5	100%
8	Information regarding company policies and procedures are shared with my employees	2	2	2	2	2	2	5	100%
9	My employees receive recognition (praise) based on their job performance	3	3	3	3	3	3	5	100%
10	My employees have a great deal of control in how they do their work	5	5	5	5	6	5	4	80%
11	This organization uses many setup time reduction techniques	13	13	13	13	13	13	5	100%
12	My manager provides me with resources necessary to accomplish my task	1	1	1	1	1	1	5	100%
13	My employees are willing to help this organization achieve its goals	7	7	7	7	7	7	5	100%
14	I do not worry about losing my job	10	10	10	10	10	10	5	100%
15	I enjoy coming to work everyday	11	11	9	11	11	11	4	80%
16	My employees share their process quality data with others in the plant	2	2	2	2	2	2	5	100%
17	This organization uses many quality improvement techniques	13	13	13	13	13	13	5	100%
18	My employees share their product quality data with others in the plant	2	2	2	2	2	2	5	100%
19	My employees are provided with training in problem solving skills related to their work	4	4	4	4	4	4	5	100%
20	I have job stability with this organization	10	10	10	10	10	10	5	100%

Counting Occurrences of Numbers					
Factors	**J1**	**J2**	**J3**	**J4**	**J5**
1	1	1	1	1	1
2	3	3	3	3	3
3	2	2	2	2	2
4	3	3	3	3	3
5	1	1	1	0	1
6	1	1	2	2	0
7	1	1	1	1	1
8	0	0	0	0	0
9	1	2	1	1	0
10	2	2	2	2	2
11	1	0	1	1	2
12	2	2	1	2	3
13	2	2	2	2	2

Total Answered					
	J1	**J2**	**J3**	**J4**	**J5**
	20	20	20	20	20

Frequency of Number Chosen					
Factors	**J1**	**J2**	**J3**	**J4**	**J5**
1	0.1	0.1	0.1	0.1	0.1
2	0.2	0.2	0.2	0.2	0.2
3	0.1	0.1	0.1	0.1	0.1
4	0.2	0.2	0.2	0.2	0.2
5	0.1	0.1	0.1	0.0	0.1
6	0.1	0.1	0.1	0.1	0.0
7	0.1	0.1	0.1	0.1	0.1
8	0.0	0.0	0.0	0.0	0.0
9	0.1	0.1	0.1	0.1	0.0
10	0.1	0.1	0.1	0.1	0.1
11	0.1	0.0	0.1	0.1	0.1
12	0.1	0.1	0.1	0.1	0.2
13	0.1	0.1	0.1	0.1	0.1

Summed Product of Marginal Probabilities									
1&2	**1&3**	**1&4**	**1&5**	**2&3**	**2&4**	**2&5**	**3&4**	**3&5**	**4&5**
0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10

Agreement of Judge Pairs									
1&2	1&3	1&4	1&5	2&3	2&4	2&5	3&4	3&5	4&5
1	1	1	0	1	1	0	1	0	0
1	1	1	1	1	1	1	1	1	1
1	1	1	0	1	1	0	1	0	0
1	0	1	1	0	1	1	0	0	1
1	1	1	0	1	1	0	1	0	0
1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1
1	1	0	1	1	0	1	0	1	0
1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1
0	1	1	1	0	0	0	1	1	1
1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1

Calculations										
	1&2	1&3	1&4	1&5	2&3	2&4	2&5	3&4	3&5	4&5
Fo =	19	19	19	17	18	18	16	18	16	16
TOT =	20	20	20	20	20	20	20	20	20	20
A =	1.0	1.0	1.0	0.9	0.9	0.9	0.8	0.9	0.8	0.8
Fc =	2.0	2.0	2.0	2.1	2.0	2.0	2.0	2.0	1.9	2.0
K =	0.9	0.9	0.9	0.8	0.9	0.9	0.8	0.9	0.8	0.8

Mean Cohen's K = 0.9

APPENDIX C

Key respondent survey booklet

pg 1

PART – B
Survey of Lean Production Practices

Survey Structure

This questionnaire evaluates how lean work practices within manufacturing organizations improves employees' productivity and their quality of work life. It is designed in an easy to read format and should take *15-20 minutes* of your valuable time.

Target Respondent

This questionnaire should be completed by a shop floor supervisor or a team leader associated with manufacturing in an organization.

Optional $100 Visa gift card lucky draw

If you fully complete and mail in this survey and you provide your contact information, you will be entered into a $100 Visa gift card drawing. Three winners will be contacted at the end of this study (September 30th, 2010).

What do you get for completing this survey

* An executive summary of the results of this study will be provided to all participants free of cost, upon request.
* This executive summary can be used to benchmark your plant's use of lean work practices, and their impact on employees productivity and quality of work life, against other plant's participating in this survey.

Confidentiality

* Full confidentiality of your responses will be maintained at all times in the study and in any published report.
* This survey is completely voluntary.
* **Your survey responses are confidential and will not be shared with your manager. You will mail this survey directly to the researchers in the self-addressed return envelope provided.**

If you have any questions about your rights as a research participant, you may contact the Office of Research Compliance (Clemson University) at 864-656-6460.

If you need to get in touch with the researchers, you may contact Mohammed Raja at 864-508-0161 or mraja@clemson.edu, and Dr. Lawrence Fredendall at 864-656-2016 or flawren@clemson.edu.

pg 2

1. **Please select the industry that best represents your major product:**
   - ☐ Furniture and related product manufacturing
   - ☐ Apparel manufacturing
   - ☐ Wood product manufacturing
   - ☐ Printing and related support activities
   - ☐ Petroleum and coal products manufacturing
   - ☐ Plastics and rubber products manufacturing
   - ☐ Fabricated metal products manufacturing
   - ☐ Computer and electronic product manufacturing
   - ☐ Transportation equipment manufacturing
   - ☐ Electrical equipment/appliance & component manufacturing
   - ☐ Textile mills
   - ☐ Leather and allied products
   - ☐ Paper manufacturing
   - ☐ Chemical manufacturing
   - ☐ Primary metal manufacturing
   - ☐ Non-metallic mineral products
   - ☐ Machinery manufacturing
   - ☐ Food manufacturing
   - ☐ Miscellaneous manufacturing

2. **Please select the operation process of your major product at your plant:**
   - ☐ Job Shop– manufacturing standardized one of a kind of product in low volumes (e.g. Die Casting)
   - ☐ Batch Process– manufacturing multiple products in low volumes (e.g. Printing Press)
   - ☐ Assembly Line Process– manufacturing multiple products in high volumes (e.g. Automobile Mfg.)
   - ☐ Continuous Flow Process– manufacturing highly standardized products in high volume (e.g. Beer Mfg.)

3. **Please select how many employees work at your plant:**

   ☐ 0-49 ☐ 50–99 ☐ 100–149 ☐ 150–199 ☐ 200–249 ☐ 250–299
   ☐ 300-349 ☐ 350–399 ☐ 400–449 ☐ 450–499 ☐ 500+

4. **Please select the job title that best describes your position in the organization:**
   - ☐ Production manager
   - ☐ Operations manager
   - ☐ Shop floor supervisor
   - ☐ Team leader
   - ☐ Other (please provide your title): ____

5. **Who do you directly supervise?**

- ☐ Shop floor supervisor
- ☐ Team leader
- ☐ Shop floor employees / Machine operators / Associates
- ☐ Other: ____

6. **Has this plant implemented lean production techniques** (e.g. 5-S practice, visual control practice, standardized practice, setup time reduction practice, zero defects, cellular manufacturing, etc.)**?**

☐ Yes ☐ No

7. **How many years ago did the plant implement lean production techniques?**

☐ 0-3 ☐ 4–7 ☐ 8–11 ☐ 12–15 ☐ 16–19 ☐ 20+

8. **How many years ago did this plant open for production?**

☐ 0-3 ☐ 4–7 ☐ 8–11 ☐ 12–15 ☐ 16–19 ☐ 20+

9. **How many years have you worked in this organization?**

☐ 0-2 ☐ 3–5 ☐ 6–9 ☐ 10 +

10. **How many years of work experience do you have in manufacturing?**

☐ 0-2 ☐ 3–5 ☐ 6–9 ☐ 10 +

11. **Approximately what percentage of this plant's employees are represented by a union?**

☐ 0 ☐ 25% ☐ 50% ☐ 75% ☐ 100%

12. **How many shifts are operated per day at this plant?**

☐ 1 ☐ 2 ☐ 3

13. **Have there been layoffs in your department during the past 2 years?**

☐ Yes ☐ No

14. **To ensure that survey responses are matched correctly for data analysis, please provide your manager's full name:**

Last Name: Last Name:

Your survey responses are confidential and will not be shared with your manager. You will mail this survey directly to the researchers in the self-addressed return envelope provided.

On a scale of 1-7, please circle the number that best indicates your level of agreement with each statement as it relates to your department.

Rating Scale

1 Strongly Disagree	**2** Disagree	**3** Mildly Disagree	**4** Neither	**5** Mildly Agree	**6** Agree	**7** Strongly Agree

Workstations are arranged in a sequence to reduce transportation and delay of materials through the production process	1	2	3	4	5	6	7
The quality of air, lighting, and noise in my work area is satisfactory	1	2	3	4	5	6	7
My team members are satisfied with their job	1	2	3	4	5	6	7
My team members influence the way in which tasks are completed in their work area	1	2	3	4	5	6	7
I remember many things about my last vacation	1	2	3	4	5	6	7
My team members receive regular feedback about their work quality	1	2	3	4	5	6	7
My team members absenteeism has decreased over the past three years	1	2	3	4	5	6	7
My manager facilitates in the implementation of quality improvements in this department	1	2	3	4	5	6	7
My team members' overall performance has improved over the past three years	1	2	3	4	5	6	7
My team members are provided with training in problem solving skills related to their work	1	2	3	4	5	6	7
My team members can talk frankly about their job with each other at work	1	2	3	4	5	6	7
My team members initiate continuous improvement activities in their work area on a regular basis	1	2	3	4	5	6	7
My team members participate in determining how best to implement management decisions in their work area	1	2	3	4	5	6	7
My team members are rewarded when they learn additional skills related to their work	1	2	3	4	5	6	7
My team members are rewarded when they make an extra effort to improve overall performance of this department	1	2	3	4	5	6	7
My team members have a good relationship with each other at work	1	2	3	4	5	6	7
Working towards the goals (objectives) of this department is important to my team members	1	2	3	4	5	6	7
I have worked with most of my team members for several years now	1	2	3	4	5	6	7
Achieving this department's goals (objectives) is meaningful to my team members	1	2	3	4	5	6	7
My team members demonstrate competence in meeting their job tasks	1	2	3	4	5	6	7

On a scale of 1-7, please circle the number that best indicates your level of agreement with each statement as it relates to your department.

Rating Scale

1	**2**	**3**	**4**	**5**	**6**	**7**
Strongly Disagree	Disagree	Mildly Disagree	Neither	Mildly Agree	Agree	Strongly Agree

Workstations are arranged in a sequence to reduce transportation and delay of materials through the production process	1	2	3	4	5	6	7
The quality of air, lighting, and noise in my work area is satisfactory	1	2	3	4	5	6	7
My team members are satisfied with their job	1	2	3	4	5	6	7
My team members influence the way in which tasks are completed in their work area	1	2	3	4	5	6	7
I remember many things about my last vacation	1	2	3	4	5	6	7
My team members receive regular feedback about their work quality	1	2	3	4	5	6	7
My team members absenteeism has decreased over the past three years	1	2	3	4	5	6	7
My manager facilitates in the implementation of quality improvements in this department	1	2	3	4	5	6	7
My team members' overall performance has improved over the past three years	1	2	3	4	5	6	7
My team members are provided with training in problem solving skills related to their work	1	2	3	4	5	6	7
My team members can talk frankly about their job with each other at work	1	2	3	4	5	6	7
My team members initiate continuous improvement activities in their work area on a regular basis	1	2	3	4	5	6	7
My team members participate in determining how best to implement management decisions in their work area	1	2	3	4	5	6	7
My team members are rewarded when they learn additional skills related to their work	1	2	3	4	5	6	7
My team members are rewarded when they make an extra effort to improve overall performance of this department	1	2	3	4	5	6	7
My team members have a good relationship with each other at work	1	2	3	4	5	6	7
Working towards the goals (objectives) of this department is important to my team members	1	2	3	4	5	6	7
I have worked with most of my team members for several years now	1	2	3	4	5	6	7
Achieving this department's goals (objectives) is meaningful to my team members	1	2	3	4	5	6	7
My team members demonstrate competence in meeting their job tasks	1	2	3	4	5	6	7

On a scale of 1-7, please circle the number that best indicates your level of agreement with each statement as it relates to your department.

Rating Scale

1	**2**	**3**	**4**	**5**	**6**	**7**
Strongly Disagree	Disagree	Mildly Disagree	Neither	Mildly Agree	Agree	Strongly Agree

Safety protocols are enforced to prevent accidents in this department	1	2	3	4	5	6	7
My team members dedicate a portion of each day to equipment inspection / maintenance activities	1	2	3	4	5	6	7
My team members are willing to help this department achieve its goals (objectives)	1	2	3	4	5	6	7
My team members share information regarding best practices with each other in this department	1	2	3	4	5	6	7
My team members participate in the creation of their work schedules	1	2	3	4	5	6	7
My team members are provided with training to perform multiple tasks in this department	1	2	3	4	5	6	7
My team members turnover rate has decreased over the past three years	1	2	3	4	5	6	7
My team members receive recognition / praise when they help achieve the goals (objectives) set for this department	1	2	3	4	5	6	7
I have gotten to know my team members on a personal level over the years	1	2	3	4	5	6	7
My team members move material in small batches through the production process with almost no waiting at work stations	1	2	3	4	5	6	7
My team members share information about their work processes with each other in this department	1	2	3	4	5	6	7
My team member influence process changes that affect their work	1	2	3	4	5	6	7
Health issues are considered when designing / changing the way tasks are accomplished in this department	1	2	3	4	5	6	7
My team members frequently have to coordinate their efforts with each other to complete their jobs in this department	1	2	3	4	5	6	7
My team members have the capabilities to meet their job demands	1	2	3	4	5	6	7
My team members' productivity has improved over the past three years	1	2	3	4	5	6	7
My team members receive a letter or a certificate of appreciation when they perform well	1	2	3	4	5	6	7
My team members are kept informed when something important occurs in the department	1	2	3	4	5	6	7

On a scale of 1-7, please circle the number that best indicates your level of agreement with each statement as it relates to your department.

Rating Scale

1	**2**	**3**	**4**	**5**	**6**	**7**
Strongly Disagree	Disagree	Mildly Disagree	Neither	Mildly Agree	Agree	Strongly Agree

My manager provides me with the necessary resources to accomplish my tasks effectively	1	2	3	4	5	6	7
My team members jobs have not been affected by layoffs in this plant	1	2	3	4	5	6	7
My team members are provided with training in specific job skills needed to do their job	1	2	3	4	5	6	7
My team members develop special toolings (fixtures) to reduce setup times	1	2	3	4	5	6	7
My team members are provided with training in quality improvement skills related to their work area	1	2	3	4	5	6	7
My team members eliminate the root cause of problems when quality defects occur in their work areas	1	2	3	4	5	6	7
My team members work in groups to get the job done in this department	1	2	3	4	5	6	7
My team members enjoy coming to work everyday	1	2	3	4	5	6	7
My team members' abilities to deliver work output on time has improved over the past three years	1	2	3	4	5	6	7
My team members share their frequency of machine breakdown with each other in this department	1	2	3	4	5	6	7
There is a strong commitment to using lean practices at all levels within this department	1	2	3	4	5	6	7
I am familiar with my team members	1	2	3	4	5	6	7
My team members have job security within this organization	1	2	3	4	5	6	7
Any decisions implemented by my team members have to be approved by me first	1	2	3	4	5	6	7
My team members are inspired by the goals (objectives) of this department	1	2	3	4	5	6	7
My manager spends time with me to explain my job priorities	1	2	3	4	5	6	7
My team members are confident that they can do their job well	1	2	3	4	5	6	7
My team members' opinion are given importance when managers make work decisions in this department	1	2	3	4	5	6	7

On a scale of 1-7, please circle the number that best indicates your level of agreement with each statement as it relates to your department.

Rating Scale

1 Strongly Disagree	**2** Disagree	**3** Mildly Disagree	**4** Neither	**5** Mildly Agree	**6** Agree	**7** Strongly Agree

My team members work in groups to get the job done in this department	1	2	3	4	5	6	7
My team members use well documented standardized operating procedures to complete their tasks	1	2	3	4	5	6	7
My team members influence decisions about issues that affect their work	1	2	3	4	5	6	7
My team members' productivity details are shared with them on a regular basis	1	2	3	4	5	6	7
I will not forget my experiences from my last vacation	1	2	3	4	5	6	7
My team members' job will not be affected by a recession	1	2	3	4	5	6	7
My team members influence changes in their work methods	1	2	3	4	5	6	7
Information regarding company policies and procedures is shared with my team members	1	2	3	4	5	6	7
My team members enjoy performing their daily job activities	1	2	3	4	5	6	7
My team members' dependability in meeting this department's goals (objectives) has improved over the past three years	1	2	3	4	5	6	7
My team members share their tools/equipment with each other to complete their jobs in this department	1	2	3	4	5	6	7

Answer to this question is voluntary:
If you want to be eligible for a $100 Visa gift card drawing, please provide your name and e-mail:

Last Name: _____________________________________ First Name: _________________________

E-mail: ____

Three lucky winners will be contacted at the end of this study (September 30, 2010).

Please mail this survey immediately using the self-addressed return envelope provided.

Mailing address: Mohammed Raja
909 Georgetown Street
Clemson, SC 29631

Thank you for completing this survey!

APPENDIX D

Correlation analyses for all items

Correlations													
	MMS	ISA	ISB	T	R	PCTRL	PCOMP	GI	PHYC	SC	JSAT	JS	EPERF
MMS	1.00												
ISA	0.50	1.00											
ISB	0.41	0.42	1.00										
T	0.48	0.59	0.55	1.00									
R	0.43	0.49	0.51	0.38	1.00								
PCTRL	0.52	0.61	0.61	0.66	0.58	1.00							
PCOMP	0.32	0.44	0.55	0.47	0.42	0.53	1.00						
GI	0.52	0.52	0.54	0.56	0.54	0.62	0.41	1.00					
PHYC	0.32	0.30	0.23	0.35	0.36	0.32	0.27	0.36	1.00				
SC	0.43	0.33	0.53	0.39	0.42	0.40	0.35	0.52	0.28	1.00			
JSAT	0.37	0.35	0.59	0.48	0.58	0.53	0.39	0.58	0.35	0.51	1.00		
JS	0.24	0.17	0.18	0.32	0.28	0.30	0.15	0.23	0.14	0.18	0.35	1.00	
EPERF	0.77	0.43	0.43	0.50	0.47	0.54	0.39	0.55	0.40	0.45	0.40	0.24	1.00

	MMS	TP	SP	QWL	EP
MMS	1.00				
TP	0.27	1.00			
SP	0.54	0.69	1.00		
QWL	0.24	0.54	0.08	1.00	
EP	0.74	0.38	0.43	0.30	1.00

APPENDIX E

Univariate descriptive statistics

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
						Statistic	Std. Error	Statistic	Std. Error
MMS2	200	1	7.00	5.43	1.32	-1.34	0.17	1.69	0.34
MMS3	200	1	7.00	5.41	1.38	-1.09	0.17	0.87	0.34
MMS4	200	1	7.00	5.44	1.38	-1.27	0.17	1.17	0.34
IS1	200	1	7.42	6.09	0.98	-2.05	0.17	6.58	0.34
IS4	200	1	7.00	5.83	1.25	-1.83	0.17	3.93	0.34
IS5	200	3	7.00	5.52	0.97	-0.68	0.17	0.37	0.34
IS6	200	2	8.15	5.54	1.05	-0.80	0.17	0.83	0.34
R3	200	1	7.00	4.71	1.56	-0.63	0.17	-0.53	0.34
R5	200	1	7.00	4.31	1.57	-0.38	0.17	-0.85	0.34
T1	200	1	7.00	5.59	1.21	-1.45	0.17	2.70	0.34
T4	200	1	7.00	5.15	1.29	-0.89	0.17	0.55	0.34
T5	200	1	7.00	5.33	1.33	-1.18	0.17	1.21	0.34
PCTRL1	200	1	7.00	5.41	1.01	-1.13	0.17	2.34	0.34
PCTRL2	200	1	7.18	5.24	1.10	-1.08	0.17	2.01	0.34
PCTRL3	200	2	7.00	5.54	1.03	-1.04	0.17	1.33	0.34
PCTRL4	200	1	7.68	5.36	1.15	-1.29	0.17	2.34	0.34
PC1	200	3	7.00	5.96	0.77	-0.46	0.17	0.29	0.34
PC2	200	2	7.00	5.96	0.81	-0.72	0.17	1.76	0.34
PC3	200	2	7.52	6.09	0.89	-0.98	0.17	1.70	0.34
GI1	200	2	7.00	5.55	1.09	-0.69	0.17	0.48	0.34
GI2	200	3	7.22	5.48	0.97	-0.27	0.17	-0.30	0.34
GI3	200	1	7.00	5.18	1.16	-0.47	0.17	0.29	0.34
GI4	200	3	7.24	5.80	0.98	-0.45	0.17	-0.49	0.34
TI1	200	2	7.00	5.68	1.13	-1.21	0.17	1.63	0.34
TI2	200	2	7.00	5.83	1.10	-1.20	0.17	1.51	0.34
TI4	200	3	7.32	5.60	1.04	-0.83	0.17	0.53	0.34
PHYC4	200	1	7.00	5.47	1.35	-1.15	0.17	0.78	0.34
PHYC5	200	1	7.00	5.55	1.25	-1.10	0.17	0.92	0.34
SC1	200	3	7.00	5.61	0.92	-0.76	0.17	1.04	0.34
SC4	200	2	7.00	5.74	0.92	-0.88	0.17	1.50	0.34
SC5	200	2	7.00	5.91	0.92	-1.05	0.17	1.80	0.34
JSAT1	200	1	7.00	4.92	1.26	-0.63	0.17	0.20	0.34
JSAT3	200	1	7.00	5.07	1.13	-1.11	0.17	1.76	0.34
JS1	200	1	7.00	4.46	1.67	-0.55	0.17	-0.66	0.34
JS2	200	1	7.00	5.06	1.58	-1.04	0.17	0.53	0.34
JS3	200	1	7.00	5.49	1.34	-1.13	0.17	1.21	0.34
JS4	200	1	7.00	4.36	2.06	-0.22	0.17	-1.40	0.34
JS5	200	1	7.00	3.98	1.84	-0.07	0.17	-1.18	0.34
LP1	200	1	7.00	5.14	1.41	-1.19	0.17	1.29	0.34
LP2	200	1	7.00	5.18	1.43	-1.02	0.17	0.66	0.34
MV1	200	1	7.00	5.97	1.15	-1.50	0.17	3.04	0.34
MV2	200	1	7.00	5.91	1.30	-1.68	0.17	3.34	0.34
MV3	200	1	7.00	5.69	1.34	-1.24	0.17	1.52	0.34
EP1	200	2	7.00	5.59	1.10	-0.79	0.17	0.64	0.34
EP4	200	1	7.00	5.76	1.09	-1.18	0.17	1.97	0.34
EP5	200	2	7.00	5.58	1.00	-1.03	0.17	1.81	0.34
EP6	200	1	7.00	5.56	1.11	-0.93	0.17	1.23	0.34

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