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An Assessment of the Use of Research Methods in Lean Manufacturing Environments: An Introduction to the Relational Theory of Continuous Improvement and the Seven Wastes of Lean Research

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An Assessment of the Use of Research Methods in Lean Manufacturing Environments: An Introduction to the Relational Theory of Continuous Improvement and the Seven Wastes of Lean Research

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We certify that we have read this dissertation and approved it as adequate in scope and quality. We have found that it is complete and satisfactory in all respects, and that any and all revisions required by the final examining committee have been made.

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Acknowledgements

This work is dedicated to the 1000 and 42 assemblers who shined so brightly and whose influence and participation made this project possible. Knowing and working with each of you has been one of my greatest pleasures. This work is also dedicated to the legend of the dragon that sleeps in the river until called. May he slumber in peace, until he is again summoned forth.

One does not undertake a project of this magnitude and scope without the help, support, and caring of family, friends, and faculty. Writing a dissertation is truly, in so many ways, a group effort and project. To all who assisted and supported me, I sincerely thank you. The completion of this project is your accomplishment as well as mine. I share and celebrate in its completion with you. Your kindness, support, and encouragement will never be forgotten.

Abstract

This study focuses on the effective application and execution of research methods in lean manufacturing production environments. The study is an attempt to measure the progress toward the development of a culture of continuous improvement. Included in the study is a review of the use of questionnaire, interview, sociogram, and observation research methods in measuring and monitoring the development of a culture of continuous improvement. Although not the primary focus of the study, I constructed the relational theory of continuous improvement and the Seven Wastes of Lean Research to aid in the review of the execution of the chosen research methods. The relational theory of continuous improvement theorizes that if assemblers are not aware of the development and use of higher-level communication methods and the development of higher-level working relationships, then problem-solving activities and continuous process improvement programs will remain at or near the levels experienced prior to the implementation of lean manufacturing methods. The Seven Wastes of Lean Research criteria were developed and incorporated into the architecture of the study as a systematized approach to the analysis of the study's research processes and procedures for the identification of nonvalue-added activities. The intent of identifying nonvalue-added activities and waste was to develop solutions for design and efficiency improvements and to incorporate the identified improvements into the design of the next generation of this research.

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Statement of the Problem

Once again, at the beginning of a new century, manufacturing methods are evolving and experiencing significant change. On a global scale, Henry Ford's mass production methods which revolutionized the manufacturing of goods at the beginning of the last century are today being replaced by the more profitable lean manufacturing methods which were developed in Japan after World War II (Ohno, 1988).

Although the development of Japanese lean manufacturing methods was heavily influenced by Henry Ford's mass production methods, there are major differences. Mass production methods focus on the interchangeability and ease of assembly of parts, the reduction of actions required of each worker, and the moving assembly line. Lean manufacturing methods encompass these techniques. In addition, lean methods also emphasize providing the highest quality product at the lowest cost and in the shortest time by continually eliminating waste in the production process through continuous improvement efforts and the development of a culture of continuous improvement (Dennis, 2007). In order to accomplish these goals, lean manufacturing methods stress the elimination of waste through continuous improvement efforts focusing on productivity, quality, costs, delivery time, safety, environment, and morale (Dennis, 2007).

Lean Methods

The ultimate goal of a lean system is to focus on the creation and preservation of value for the customer by eliminating waste in the production system (Dennis, 2007). Value is often defined as any action or process that a customer who uses and consumes the product is willing to pay for. As a means of creating value, lean methods focus on eliminating all waste from the production system. By focusing on the elimination of waste, all actions except the actions the customer is willing to pay for have the potential to be reviewed and eliminated. As a result of the continuous elimination of waste in lean systems, production time and cost are reduced and overall profitability and quality is improved within the manufacturing system.

Lean methods are interrelated and mutually supportive. Conceptually a lean system is often represented as two pillars. Together, the two pillars encompass the flow of materials and machines and equipment in a lean manufacturing facility.

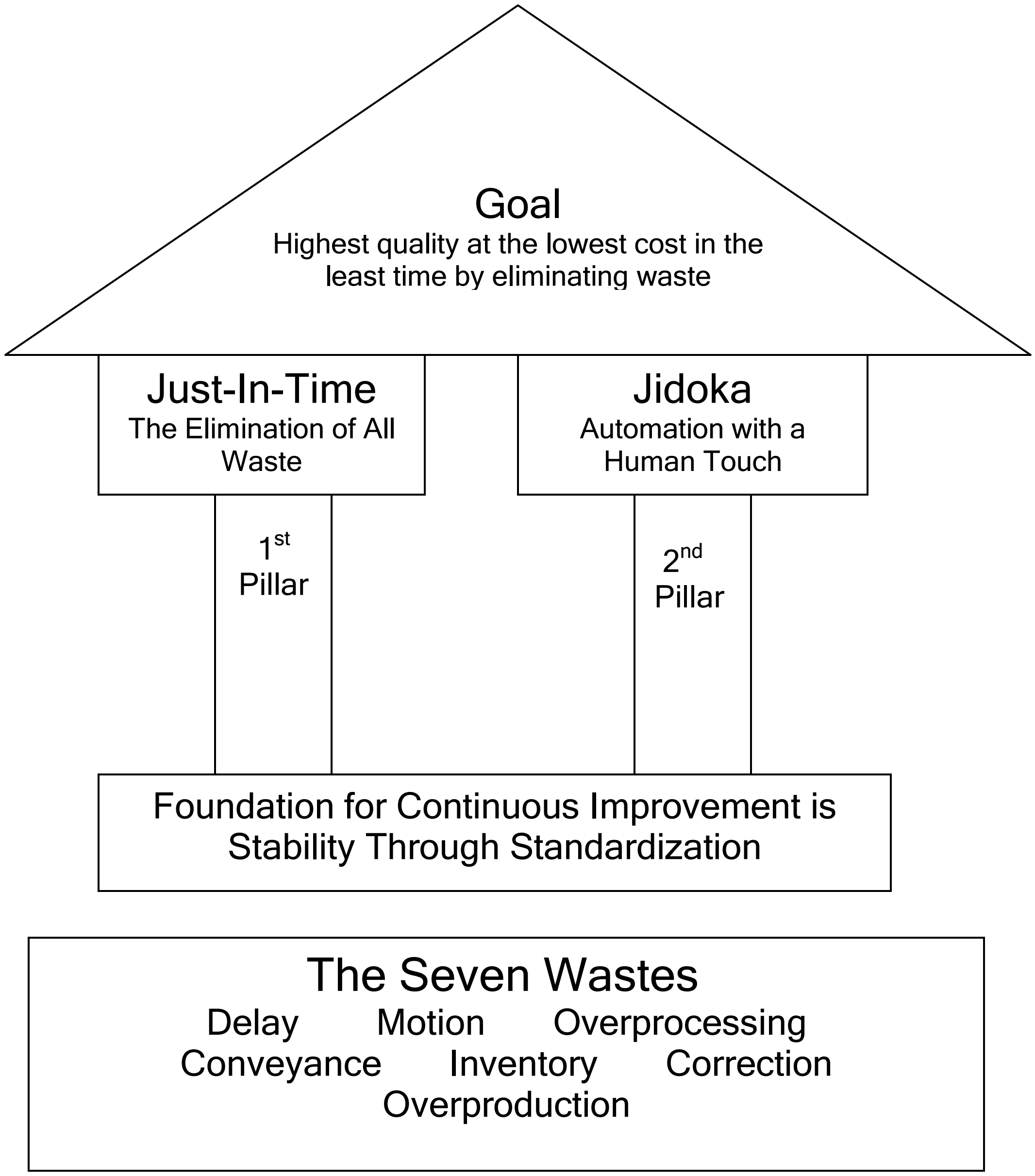

Figure 1. Chart of basic lean concepts and methods. Adapted from *Lean Production Simplified*, by Dennis Pascal, 2007. Copyright 2007 by the Productivity Press.

The first pillar of lean is referred to as JIT or *just-in-time* (Dennis, 2007). The fundamental concept of JIT is to have only the inventory required when it is time to produce the product. Excess inventory in a lean system is considered waste. When inventories are minimized, quality often improves due to an increase in focus on the remaining product. Less product also promotes faster flow through the manufacturing process.

The second pillar of the lean system is referred to as Jidoka (Dennis, 2007). Jidoka roughly translates into automation with a human mind. This fundamental concept of lean methods states that machines should be designed to stop when there is a problem, such as when the product is manufactured out of specification. The advantage of designing stops into machines is that overall quality is improved and the cost of producing inferior parts has been avoided.

Within lean systems, improvements are a matter of daily practice and are never ending, hence the term *continuous improvement* is used. Continuous improvements are often, but not always, small-step improvements rather than big-step improvements. Within lean systems, stability and standardization are viewed as requirements for ease in the facilitation, management, control, and implementation of the improvements being made.

In lean systems, the way in which continuous improvements and the elimination of waste and nonvalue-added activities is determined is based upon an analysis of manufacturing work process that applies a standard criteria called the Seven Wastes. Often, upon analysis, only 5% of the activities in manufacturing work processes are value-added activities. The other 95% of activity can generally be classified as waste or nonvalue-added activities. The Seven Wastes as outlined by Dennis (2007) are

1. Motion: This waste has a human and machine element. Poor ergonomic design affects productivity. Productivity diminishes with unnecessary walking, reaching, or twisting by the worker. Waste of machine motion also

exists when machines are placed too far apart on the production line or placed individually away from production areas.

2. Delay: This waste refers to delays caused by waiting. If a worker must wait for material or for a machine to finish processing, this causes a delay. Waiting is wasteful because it increases the time it takes for a product to move through the factory.
3. Conveyance: This waste is most often created by an inefficient workplace layout, overly large equipment, or manufacturing in large quantities. The inefficiency is created by unnecessary movement—of machines or workers. The concept is to eliminate costly unnecessary steps or transport time.
4. Correction: This waste is related to having to fix defective product. It includes all time, material, and labor required to fix the defective part.
5. Overprocessing: This waste refers to doing more than the customer requires. Doing more than is required is considered a costly and unnecessary activity.
6. Inventory: This waste refers to keeping unnecessary materials. In lean systems, having more than the quantity of materials required to produce the product when it is time to produce the product is deemed wasteful.
7. Overproduction: This waste addresses producing product that does not sell. Once an item is manufactured and is not sold, it must be stored, handled, and administratively tracked, all of which are considered unnecessary costs.

Many working in industry believe lean methods to be a special. Many regard lean systems as a philosophy for conducting business rather than a method or means of effectively managing a factory. Regardless, due to continuous improvement efforts and the elimination of waste, a substantial increase in profitability is commonly experienced by an organization when lean manufacturing methods are implemented (Womack and Jones 1996).

It is estimated that the average manufacturing organization, when transitioning from mass to lean manufacturing methods, immediately experiences a 100% increase in labor productivity, a 50% decrease in production time per unit, a 90% reduction in all major types of inventory, and a 50% reduction in production errors (Womack & Jones, 1996). With the allure of high financial gains and the promise of substantial productivity improvements, it is understandable why *going lean* has become a common practice in the industrial world (Schonberger, 2007).

However, in spite of the competitive advantage and substantial increase in profitability that lean methods offer, current long term research suggests that U.S. companies are having difficulty developing cultures of continuous improvement and sustaining lean production methods over time (Dixon, 2007). Evidence further suggests that, during the past several years, this developing negative trend is increasing. Except for the non-U.S. Americas and Japan, the available research indicates the difficulty in sustaining lean manufacturing methods and developing cultures of continuous improvement is a global trend (Schonberger, 2007).

In manufacturing literature, the root cause of the difficulty of sustainability is often portrayed as, and attributed to, a lack of true commitment and support by executive management. Although other reasons such as quitting too soon, distraction by other priorities, an unstable and uneducable workforce, or resistance to change may be cited, it is often quickly suggested that these circumstances might also be overcome with firm executive management action (Dixon, 2007).

Prevalent in this type of thinking is an underlying assumption that lean theory, methods, and tools are complete. In manufacturing literature, it is often assumed that the current body of knowledge about lean theory, methods, and tools offer executive management a comprehensive conceptual framework that successfully supports assessing and facilitating an organization's transition to the use of lean methods and the development of a lean culture.

It is not surprising then that a review of manufacturing literature reveals minimal research of alternative theoretical frameworks that can aid executive management in facilitating an organization's transition to a culture of continuous improvement through the use of lean methods. Most often, imitation of the manufacturing policies, processes, and methods of the more successful lean organizations, particularly the more successful Japanese companies, is the most common approach to implementing lean methods and developing cultures of continuous improvement.

Although there are examples of successes around the globe, many organizations are finding it difficult to imitate the prescribed formula with lasting success. Often the widely accepted explanation for the growing rash of lean failures is attributed to a lack of true commitment and support by executive management. Subsequently, with little incentive to look further, there is a lack of detailed research about other possible causes for lean failures and alternative approaches to guide and assist executive management in successfully implementing lean methods and developing cultures of continuous improvement.

To gain a deeper understanding of lean failures and the key elements required to successfully develop and support lean methods and cultures of continuous improvement, a robust body of research should include attempts to apply and refine theory from other disciplines. Historically, the absence of varied avenues of inquiry is understandable in light of manufacturing's strong emphasis and reliance on the physical and engineering sciences and deductive reasoning. However, the absence of rigorous research based on varied avenues of inquiry, including the social sciences, could prove limiting in the development of American industries' successful transition from mass to lean manufacturing methods and the development of cultures of continuous improvement. Continued research, the development of new theory, and the application of theory from other disciplines may contribute to a deeper understanding of the successful transition to and the sustainability of lean systems and cultures of continuous improvement. Alternative theoretical frameworks that may better support executive management in the facilitation of lean manufacturing methods and developing cultures of continuous improvement should be pursued and explored.

The manufacturing sector of any nation impacts the lives of many if not all of its citizens. Manufacturing is vital to continuing the economic strength and prosperity of a nation. Successfully developing and supporting cultures of continuous improvement is a critical step toward national and global prosperity.

Purpose of the Study

The purpose of this study is to determine the effectiveness of the application and execution of research methods in measuring and assessing the development of cultures of continuous improvement in lean manufacturing environments. This study is an attempt to gain new knowledge about the effectiveness of the use of questionnaire, interview, sociogram, and observation research methods to assess and monitor the development of a culture of continuous improvement. In order to test the effectiveness and application of research methods, I developed and tested the relational theory of continuous improvement for this study.

Further, although of secondary concern, I applied the Seven Wastes of Lean Research (Dennis, 2007) to the execution of the research processes and methods used in this study. The Seven Wastes of Lean Research was born out of the desire to develop criteria with which to analyze the research processes in such a manner that costs could be minimized and the research design and processes improved.

Research Design and Methodology

The focus of this research was the assessment of changes in the perception of assemblers regarding changes in workplace relationships and communications when transitioning from mass to lean production methods. This focus was chosen as the first to be explored due to the difficulties of conducting research in manufacturing environments. Difficulties include the costs incurred and the loss of production time when assemblers are involved in research activities. Methods of measure and assessment pertaining to the study of assemblers must be designed as efficiently and effectively as possible to minimize cost and loss of production time.

This research attempted to answer the question: During the transition from mass to lean manufacturing techniques can progress in developing cultures of continuous improvement be measured and assessed by using changes in an assembler's perception of communication and interdependent work relationships?

For this research, I reviewed the current literature on lean failures as well as the key elements believed to be required for the development of cultures of continuous improvement such as innovation, diffusion of ideas in organizations, cooperation, partnership, and egalitarian cultures. I used the first five steps of Robert Dubin's (1978) eight-step theory-building methodology to develop the relational theory of continuous improvement. The five steps used were:

1. Identification of the theoretical units of the theory.
2. Description of the relationship and interaction between the units of the theory.
3. Identification and definition of the boundaries within which the theory is expected to hold up and apply.
4. Description of the system states of the theory. System states are the expectation of how the theory is expected to operate in the real world.
5. Identification of propositions of the theory.

The perceptions of assemblers were then measured and assessed using the relational theory of continuous improvement. I used Robert K. Yin's (2003) positivistic case study methodology in the design of the study. The study was conducted in a small manufacturing facility in the electronics industry.

Methods of measurement and assessment of an assembler's perception of changes in communication and workplace relationships based on lean activities within the organization may eventually be refined for use by executive management in supporting and monitoring the progress of the development of cultures of continuous improvement and the use of lean methods. Additional tools to assist in the direction and facilitation of the development of cultures of continuous improvement would be useful and of benefit to manufacturing organizations on a global level.

Significance of the Study

The manufacturing sector of any nation impacts the lives of many of its citizens. Industry is vital to continuing the economic strength and viability of a nation (Watts, 2005). Lean appears to be the next step in the evolution of production techniques that will ensure our economic prosperity. Alternative theoretical frameworks that aid executive management in facilitating an organization's transition from mass to lean manufacturing methods and developing cultures' continuous improvement would be of global benefit and have significant economic impact.

Further, there is the potential of substantial environmental impact when an organization's capability to continuously improve is successfully implemented. On a global level, it is increasingly apparent that current methods of production and their design must be changed and improved to be more compatible with naturally occurring systems. Although mass methods of production have only been in existence for less than 100 years, the damage to the world's environment is becoming apparent and is deeply concerning.

Increasingly lean manufacturing methods, because of the emphasis on continuous improvement, are being teamed with the development of green environmental strategies. Currently lean and green strategies seem the most promising for aligning production systems with naturally occurring systems and thereby minimizing environmental concerns. To be successful, however, research must be done and global efforts must be made to improve and broaden the number of organizations achieving success in the use of lean methods and the development of cultures of continuous improvement.

Chapter II

Literature Review

The focus of this literature review is to highlight the historical and present day expectations surrounding the job responsibilities and working relationships of the manufacturing assembler. The assembler and management relationship is examined in the context of the changes in Henry's Ford and Fredrick Taylor's mass production model and Kiichiro Toyoda and Taiichi Ohno's lean manufacturing model. An assembler's job responsibilities and working relationships are viewed in terms of the relational theory of continuous improvement with the intent of developing a better understanding of the changes in communication and working relationships required in support of lean management systems and the development of cultures of continuous improvement.

Manufacturing History

Lacey's (1986) historical account of the industrial revolution depicted the United States as a country that experienced increased prosperity and widespread change as manufacturing methods improved and profitability increased. During this period in the nation's history, frequent changes in the workplace were common. However, few experienced the extreme social changes and expectations in job responsibilities as much as the manufacturing assembler.

According to an historical account by Womack, Jones, and Roos (1990), early in the 20th century craft production methods, which were characterized by highly skilled workers who were proficient in product design and all facets of machine operations, faded into obscurity as Henry Ford's mass production techniques and Fredrick Taylor's Principles of Scientific Management took center stage. The new mass production techniques were based on the assembly line, the interchangeability of parts, and the interchangeability of the assembly worker. Upon introduction of Taylor's Principles of Scientific Management, the lengthy apprenticeships so common in the training and development of craft assemblers became obsolete (Lacey, 1986). In sharp contrast to craft production assemblers, mass production assemblers, using Taylor's principles, were trained to perform only one small segment of the manufacturing process (Taylor, 2006; Womack et al., 1990). In comparison to earlier craft assemblers, mass production assemblers had become de-skilled and interchangeable. The Principles of Scientific Management and the speed of the assembly line served to minimize the job knowledge required by an assembler (Womack et al., 1990).

With the use of Ford's mass production techniques and Taylor's Principles of Scientific Management, the working relationships of the assembler changed dramatically. No longer was the development of deeper working relationships necessary or practical (Fujimoto, 1999). Working in groups, which was integral to the success of the working life of the craft assembler, was no longer required.

Although Ford's mass production techniques and Taylor's Principles of Scientific Management resulted in the minimization of the human spirit and creativity, both men perceived themselves to be innovators contributing to the common good (Ford, 1922; Taylor, 2006). Each believed, as he created and implemented his contribution for the improvement of industry, that he was contributing to the greater good of society and to the benefit of the common man as he was represented by the assembler.

For Taylor, the maximum prosperity of the assembler and society could only be obtained as a result of achieving and continuing to achieve maximum productivity

(Taylor, 2006). Taylor developed the Principles of Scientific Management based on his ideal of the highest states of manufacturing efficiency and productivity possible. Taylor believed that individual prosperity could be obtained only when the individual obtained their highest state of efficiency and was producing their largest daily output (2006, p.2).

To Taylor, the end result of the application of the Principles of Scientific Management was an increase in productivity that resulted in an increase in profits for the employer and an increase in wages for the assembler (Taylor, 2006). At the core of his ideal of achieving the highest states of manufacturing efficiency and productivity possible was the formation of a prosperous partnership between employer and assembler. In the pursuit of his vision of prosperity for all, Taylor created innovative concepts and founded programs such as labor management cooperation, servant leadership by management, and incentive wage systems (Kanigel, 1997).

Ford also believed that individual prosperity was obtained through efficient work. To Ford, the most basic of all economic fundamentals was labor and the most basic of all moral fundamentals was a man's right to the benefit from his labor (Ford, 1922). Ford believed that a man who is willing to work should be able to work and that a man should be given full monetary value for that work. A man should live on a scale commensurate with the service or work that he rendered. According to Ford, there was no place in civilization for the idler. Human labor, Ford believed, through all its forms, is one immense illustration of the perfect compensation of the universe (Lacey, 1986).

Ford acted, as did Taylor, on his vision of the assembler and employer relationship in innovative and unprecedented ways. In 1926, 10% of the workforce employed by Ford Motor Company was black (Lacey, 1986). The Ford Motor company employed more black assemblers than all the other car companies combined. True to his conviction and against the protest and outcries from other car companies, Ford was well known by all to never pay a man more or less based on the color of his skin.

Both Taylor and Ford, based on the importance they placed on increased productivity, supported work environments that encouraged continuous improvement. Continuous improvement and innovation was fundamental and substantive in achieving the highest states of manufacturing efficiency and productivity possible (Taylor, 2006). However, both men also realized that in order to achieve the necessary improvements, a relationship of cooperation and partnership with the assemblers was necessary (Kanigel, 1997; Lacey, 1986).

It was unforeseen by both Ford and Taylor that their work would be misused and incorrectly implemented (Ford, 1922; Kanigel, 1997; Lacey, 1986; Taylor, 2006). Often in factories across America, rather than developing relationships of cooperation and paying fair wages, a partnership between management and the assembler was nonexistent and wages were frequently less than fair (Lacey, 1986; Watson, 2005; Watts, 2005). Too often management and assembler relationships were based on blatant exploitation, mistrust, violence, and at times, riveting tragedy that would erupt into the national consciousness and stir debate about the social benefit, if any, of the assembly line and scientific management.

One such example of tragedy and debate was the Triangle Shirtwaist Factory located in New York. In March of 1911, at the end of the shift, a fire broke out on the eighth floor of the factory complex. The assemblers became trapped inside the factory with no escape as management had, as a matter of standard procedure, padlocked the emergency exits. As New Yorkers gathered on the street below, they watched in horror as assembler after assembler either leaped to their death or burned to death at the windows in full view of those on the street below. The fire only raged for 18 minutes but within that short period of time 146 assemblers died (Wignot & Zwonitor, 2011). Later in court the owners testified that they ordered the emergency exits padlocked to prevent theft by the employees. By locking all the exits except one, the owners forced employees to pass through security at the end of every shift. For many, the Triangle Shirtwaist Factory fire became a symbol of the inhumane working conditions and the extremes to which the new industrialism could be taken (Christian, 2003).

The next year, the national debate on the social benefit of the assembly line and scientific management was again ignited by the tragedy of the Bread and Roses strike in Massachusetts. Striking parents, who could no longer afford to take care of their children, were told by management and civic authorities that they could not send their children away to be cared for by family and friends (Watson, 2005). Efforts to prevent the exodus of the children erupted into violence. Americans were shocked and horrified by the story of mothers and children being beaten and arrested on the train station platform as mothers attempted to help their children board the train.

Over the course of the next two decades there were numerous instances of exploitation, mistrust, violence, and tragedy. By the time of the 1934 Minneapolis trucker’s strike, a strike in which strikers were fired upon with machine guns wounding 65 and killing 1, a turning point was reached nationally. In response, laws were enacted acknowledging and protecting workers' rights (De Graaf, 2009). In the process, the work of both Ford and Taylor was scrutinized in various court and Congressional proceedings and their ideas publicly questioned (Kanigel, 1997; Watts, 2005). In the minds of the general public, and in factories across America and eventually the world, Ford and Taylor's message of the need for cooperation between management and labor to aid in achieving prosperity for all had not been heard (Emiliani, 2008).

In the late 1920s and early 1930s, in the midst of national debate, turmoil, and violence, a creative but unknown father and son manufacturing team from Japan made several visits to the United States. The father and son, Sakichi and Kiichiro Toyoda, were owners of Toyoda Loom Works, a successful weaving manufacturing facility located in Japan. The pair, known for their innovation, had recently sold the patent rights to their new automated loom (Mass & Robertson, 1996). Based on their belief in the future of the automobile and influenced by their study of Ford's assembly line, the pair decided to manufacture cars in Japan (Toyoda, 1985).

Using their knowledge of Ford's assembly line and their previous experience in the weaving industry and the manufacturing of looms, Toyota Motors developed a unique style and new approach to manufacturing (Toyoda, 1985). Many thought the Toyota Motors approach to manufacturing an oddity when it was compared to Ford's assembly lines (Ohno, 1988). In spite of the differences, until the early 1980s, Toyota Motors quietly prospered and labored in obscurity while perfecting its new manufacturing method (Womack et al., 1990). Using the concept of the elimination of waste that drove the new manufacturing system, the system would eventually be referred to as lean manufacturing or lean for short.

When successfully implemented, a lean manufacturing system has at its very core the positive partnership between management and assemblers that was viewed as a requirement and so strongly advocated by both Ford and Taylor (Dennis, 2007; Ford, 1922; Taylor, 2006).

At the heart of the lean manufacturing system is the practice and philosophy of “respect for people” (Emiliani, 2008; Ohno, 1988). In a truly lean manufacturing system, people are never considered to be waste (Womack et al., 1990). Rather, if people are not accomplishing tasks and contributing it is considered a management issue. In a lean manufacturing system, a strong partnership between management and assemblers is deemed necessary to develop and support the culture of continuous improvement necessary to eliminate waste from the system and ensure the continued prosperity for both management and the assembler (Dennis, 2007; Ohno, 1988).

Lean Manufacturing Today

Today, lean manufacturing methods continue to be adopted around the globe. Since the early 1980s, the new lean manufacturing methods have gained worldwide acceptance and international acclaim (Womack, 2007). Further, lean methods are being modified and adopted for use in economic sectors other than manufacturing and are commonly being used in both the service and health care fields (Garban, 2008).

Lean methods are based on a disciplined and highly effective approach to manufacturing operations which pursues the elimination of waste and the continuous improvement of all manufacturing processes (Dennis, 2007). Ultimately, by continuously improving manufacturing processes through the elimination of waste, more value is created for the customer as quality is improved and costs ultimately decrease (Dennis, 2007; Emiliani, 2005).

Lean methods comprise a system of highly flexible tools and strategies that form a management system (Dennis, 2007). Within a lean management system, all lean tools and strategies are interrelated based on the Seven Wastes and become mutually supportive (Dennis, 2007). Whichever lean tools or methods are chosen by an organization for implementation, they will ultimately culminate in improved quality, increased product value, quickened response to customers, and the greater design of flexibility into the manufacturing process to increase speed and reduce costs (Schonberger, 2007). To accomplish these goals, lean tools and methods support continuous improvement and the elimination of waste and focus on operations in the areas of productivity, quality, costs, delivery time, safety and environment, and morale (Dennis, 2007).

When an organization advances in its implementation of lean methods they realize substantial financial gain in many areas of the organization (Dennis, 2007). Womack and Jones (1996) estimated that the average manufacturing organization, when transitioning from mass to lean manufacturing methods, experiences a 100% increase in labor productivity, a 50% decrease in production time per unit, a 90% reduction in all major types of inventory, and a 50% reduction in production errors.

Further, research from the Lean Enterprise Institute (2005) also showed that organizations experience substantial gains from implementation of lean systems and methods. The research showed that typically productivity will increase by 50% and the amount of capital required to support the same amount of manufacturing capacity will decrease by 50%. Production and product development processes will improve and the time required for production and product development will decline substantially. Further, by using the new system, it will be possible to manufacture a wider variety of products with improved quality.

Transition of the Lean Assembler

Fundamental to the support of continuous improvement and the elimination of waste are the communication, problem solving, and team skills of the lean assembler. The lean assembler's primary task is to continually accumulate, reorganize, and apply production knowledge and skills (Fujimoto, 1999). Unlike the craft production assembler who possessed in-depth knowledge and the mass production assembler who possessed very little, the role of the lean assembler requires the development of working relationships, high levels of group participation, being a contributor of knowledge, and being a creator of information (Fujimoto, 1999). To carry out this new role and job responsibilities, the lean assembler is frequently required to participate in a variety of group activities, continuously master new knowledge and skills, develop strong problem-solving skills, and effectively communicate results (Holbeche, 1998; Mann, 2005).

While highly flexible tools and strategies form the lean management system, at the very heart of the lean system is the practice and philosophy of "respect for people" (Emiliani, 2004; Ohno, 1988). In a truly lean management system, an assembler is not viewed as disposable or as an adversary. Rather, an assembler is considered a partner in the lean process (Holbeche, 1998; Mann, 2005). In a lean management system, an assembler is encouraged and trained to make contributions in the elimination of waste and to participate in problem solving and continuous improvement activities (Fujimoto, 1999).

In lean systems it is recognized that it is ultimately the employees that create increased value for the customer which in turn leads to increased prosperity for the assembler and the company (Emiliani, 2004; Ohno, 1988). In theory, lean manufacturing systems provide a positive outcome for all involved.

With such promises of prosperity and financial gain, it is understandable why going lean has become a very well-traveled path in the industrial world (Schonberger, 2007). However, in the last 30 years, in spite of the promise of substantial financial gain, few organizations have succeeded in their lean transformation (Emiliani, 2005; Womack, 2007). For most organizations, success in the use of lean methods and tools and developing a lean management system still remains elusive.

Lean Failures

The literature suggests that globally, except for the non-U.S. Americas and Japan, there is difficulty in sustaining lean manufacturing methods and continuous improvement programs (Schonberger, 2007). Credible statistics on lean failures and successes are difficult to obtain, though many are now estimating lean failures to be high (Emiliani, 2005; Hall, 2008; Lean Enterprise Institute, 2004).

When interviewed about his findings, Clifford Ransom, a financial analyst who studies lean companies for investing purposes, stated he “finds very few companies have advanced with lean manufacturing until you can see the results financially, perhaps one or two percent at best. Another two-three percent are ‘getting there” (Hall, 2008, p.1). In a survey conducted by the Lean Enterprise Institute (2005), similar results revealed that only 4% of respondents stated they considered their companies progress in implementing lean tools to be advanced.

In his article "Leaders Lost in Transformation," Emiliani (2005), a well-known lean researcher and author, stated that while companies worldwide have been engaged in lean transformation for 5 or 10 years or more, most have achieved only modest levels of improvement. A survey conducted in 2004 by the Lean Enterprise Institute (2005) confirms Emiliani's observation. In response to the survey, 67% of respondents stated they believed their organization to be in either the initial planning stages or early stage of their lean implementation. Clifford Ransom, the financial analyst, when asked during his interview about the status of lean implementations in organizations, made a similar observation. He stated that "the majority of companies, 80 percent or so, still don't have the buzz words [lean terminology] straight" (Hall, 2008, p.1).

In recent years, as realizations about the high rate of lean failures have increased and manufacturing organizations continue to struggle with mastering lean methods, debate on the cause(s) of lean failures has come to the forefront in the manufacturing world. In manufacturing literature, the root cause of lean failures is most often cited as a lack of understanding and true commitment in support of lean methods by executive management (Dixon, 2007; Emiliani, 2005). Although other reasons such as quitting too soon, distraction by other priorities, an unstable and uneducated workforce, or resistance to change, may be cited, it is often suggested that these circumstances might be overcome with firm executive management action (Emiliani, 2005; Rubrich, 2004).

In the lean literature, it appears to be a common practice to cite the causes of lean failures in a list. Although there are differences in the lists, similar factors are often identified. Below are the 11 factors listed by Emiliani (2005) in his article *Leaders Lost in Transformation.* The list is typical of the causes commonly cited.

1. Management System: Senior managers do not understand lean as a manufacturing system but rather as a set of isolated tools.
2. Leadership Behaviors: Senior managers do not make the transition to lean tools and methods. People notice the inconsistency and question management's commitment.
3. Leadership Participation: Senior management says they support lean efforts but then claim they are too busy to get involved with continuous improvement activities.
4. Management Turnover: Senior managers that come and go every few years cannot and do not do lean management effectively.
5. Business Metrics: Senior management does not change metrics to reflect the new lean system. Therefore, the old system is still being reinforced.
6. Layoffs: Based on productivity gains made by implementing lean processes, excess labor is let go rather than retained. Management does not plan to use excess labor to make productivity improvements. Rather, lean is used as a method for reducing the head count.
7. Strategy Integration: Senior management fails to link lean activities with overall corporate strategies. This leads to a haphazard application of lean methods.
8. Total Cost: Senior management allows use of purchasing tools and practices that are inconsistent with lean tools, methods, and practices.
9. Time Horizon: Senior management focuses on short term gains rather than long term gains.

10. Focus: Senior management makes decisions favoring the interests of shareholders and overlooks the interests of stakeholders such as employees.
11. Supply Chain: It is difficult for suppliers to practice lean methods if their customers do not. Applying lean principles and tools throughout a supply chain requires organization-to-organization cooperation.

In his book, *How to Prevent Lean Implementation Failures*, lean consultant Larry Rubrich (2004), developed a list of the common causes of lean failures. The causes Rubrich identified are similar to the causes identified by Emiliani (2005).

1. Lack of Support: Senior management fails to support necessary changes for lean implementation.
2. Lack of Communication: Senior management fails to communicate effectively with the organization.
3. Lack of Middle Management or Supervisor Support: Middle management and supervisors fail to support necessary changes for lean implementation.
4. Not Understanding it is About Your People: Management does not support the training and employee development necessary for the lean implementation.
5. Lack of Customer Focus: Management has not defined the customer focus necessary for a successful transition.
6. Lack of Improvement Measures: Senior management incorrectly structures metrics. Metrics are not tied to the lean system and the lean system is not directed toward company goals.
7. Lack of Lean Leadership: Management does not participate in lean activities. Management requires lean methods but they do not practice or participate.

8. People Measures are not Aligned with Lean Goals: Management does not critique or give feedback to employees based on performance toward obtaining lean goals and company goals.
9. Not Using a Variety of Lean Tools or Methods to Make Improvements: Management, rather than focusing on a series of small improvements at many levels and in many areas of the company, focuses on larger one-time lean events.
10. Bonus Payment Systems: Management bases the bonus payments on measures of profitability rather than on a series of measures that reflect company operations and goals.

When a comparison of Emiliani's (2005) and Rubrich's (2004) lists are made, one element is cited in almost every cause given on both lists: the failure of management to act in accordance with lean principles and philosophies when implementing a lean manufacturing system. By consistently citing management as the root cause of lean failures, questions about the completeness of lean tools, methods, and philosophies are not being asked or pursued (Womack, 2007).

It is being assumed, when citing management as the root cause of lean failures, that lean tools, methods, and philosophies offer a comprehensive framework that supports the sustainability of the lean manufacturing system. It is also being assumed that a framework that offers a clearly defined set of tools and methods for success is available (Dennis, 2007; Womack et al., 1990).

When senior management is cited as the cause of the failure, it is assumed that some type of intellectual, character, or leadership issues exist, and senior management is not up to the challenge (Emiliani, 2005: Rubrich, 2004). While there are exceptions, in reality most senior managers are known to be very intelligent, very hard working, and very committed to success. Such character traits are the traits that helped them obtain their positions (Schonberger, 2007). It is unlikely, given the demands of a senior management position, that such levels of incompetence would be so pervasive in the manufacturing industry and the global marketplace.

Realistically, it is likely that the performance of senior management is not related to incompetence or indifference, but rather their performance is based on their actual experiences. It is most likely they do not see a clear, concise, and logical path for implementing and maintaining a lean management system and that, based on the high failure rates of lean management systems around the world, lean tools and methods are either not complete or not easily understandable (Schonberger, 2007; Womack, 2009).

In the face of consistently high failure rates, we must rethink our ability to understand and explain the lean manufacturing system in its entirety (Womack, 2007, 2009). We must consider continuing our research efforts with the intent of improving and clearly defining lean manufacturing tools and methods so that the conceptual framework offered is comprehensive and fully supports continuous improvement programs and an organization's lean transformation (Womack, 2007). Further, to assist in improving the lean failure rate, we must become open to models and theories beyond the disciplines of management science and search other scientific disciplines for knowledge that may be used in research and could ultimately aid in our deeper understanding of lean systems and the development of cultures of continuous improvement.

Broadening the Field of Lean Research

Historically, the incorporation of theory and models from a variety of scientific disciplines in support of lean manufacturing systems has been infrequent (Gittell, 2003). The absence of broader avenues of inquiry is understandable considering manufacturing's historical reliance on and orientation toward the physical and engineering sciences and deductive reasoning (Farber, 2002; Lacey, 1986; Watts, 2005). This legacy encourages oversight of the possible benefits of using the perspective, theories, and models of other disciplines, particularly the social sciences, in the study of lean manufacturing systems.

Historically, organizations have copied the lean tools and methods of successful lean companies but ultimately fail in the development and continued support of a lean manufacturing system (Womack, 2007). According to the manufacturing literature, imitating only the lean tools and methods without a lean-focused management system and development of a culture of continuous improvement is often referred to as "fake lean" (Emiliani, 2008b; Emiliani & Stec, 2004). It is often assumed that fake lean is either due to incompetence of management or that it is a quick fix chosen by management (Emiliani & Stec, 2004). The possibility that existing lean manufacturing tools and methods do not offer a comprehensive and clearly defined framework for consistency in the implementation of the lean manufacturing systems is not readily considered.

An example of "fake lean" is Womack's (2007) suggestion in his article, "The State of Lean 2007," that the use of value stream managers may be beneficial in minimizing the failure of lean systems. A value stream is a lean concept and is defined as the series of steps required to bring a product or service to the customer (Dennis, 2007). In terms of organizational structure, a value stream is conceptualized as horizontal and as the steps and processes required to produce a product or service for the customer crosses departmental boundaries within the organization (Rother & Shook, 2003).

Womack (2007) made the observation that contributing to the lean failure rate is the habit of lean practitioners of imitating the more successful lean companies by implementing lean tools and methods without developing a clear blueprint of the overarching design of their own lean management system. He suggested that the focus should be changed from one of imitation to one of the design and development of unique and customized lean systems (Womack, 2009).

Womack (2007) suggested it would be beneficial to focus attention on the horizontal alignment and value streams within lean organizations. He encouraged designating a responsible person for monitoring the state of chosen value streams within an organization. Generally, the individual responsible for a specific value stream has another job in the organization and does not have any direct management responsibility for the value stream. By spanning departmental boundaries within the organization, the value stream manager’s task is to monitor and periodically audit the value stream with the intent of clarifying priorities and exposing problems that are contrary to organizational objectives. Womack (2007) cites the dramatic success of General Motors’ use of a horizontal focus and appointment of lean leaders to monitor chosen value streams within the company.

Given General Motors’ positive results, Womack’s (2007) suggestion that more attention be given to the horizontal alignment and value streams within an organization has strong merit. However, without offering a more detailed explanation and deeper understanding as to why value stream managers can successfully promote lean management systems, lean practitioners are once again being encouraged to merely imitate a more successful lean company. As history has shown, merely imitating a more successful lean company is a dubious practice for achieving success (Emiliani & Stec, 2004; Womack, 2009).

The same trend of imitation is found upon examination of the position of the lean assembler. Expectations concerning the elimination of waste and contributing to continuous improvements efforts are clearly defined for the supporting role of the lean assembler (Fujimoto, 1999). However, the support necessary to successfully assist assemblers in their transition from mass manufacturing methods and lower-skilled work to lean manufacturing methods and the requirements the high performance work remains thinly explored by scientific research (Gittell, 2003).

Theory of Relational Coordination

One theory that holds the promise of assisting in the development of a deeper understanding of the necessary changes and requirements for successfully supporting a lean manufacturing system is the *theory of relational coordination.* The theory of relational coordination addresses the changes and type of high-level interaction necessary in the areas of communication and working relationships to support and sustain high performance work systems that produce high performance outcomes (Gittel, 2003).

The central premise of the theory is that organizations can achieve high performance outcomes by adopting practices that recognize and leverage an employee's ability to create value (Gittell, Seidener, & Wimbush, 2010). The theory proposes the causal mechanism through which value is created and high performance is obtained is centered in the promotion and building of employee-to-employee relationships (Gittell, Weinberg, Pfefferle, & Bishop, 2008). Gittell (2003) referred to employee-to-employee interaction in high-power work systems as relational coordination.

The facilitation and development of relational coordination within an organization is expected to support high performance outcomes in potentially significant ways (Gittell et al., 2008). The theory proposes that it is possible to redesign, facilitate and support formal work practices and routines to create the occurrence of relational coordination (Gittell, Seidener, and Wimbush, 2010). Designing high performance work practices and routines is most desirable as they can serve to overcome the silos of bureaucracy and the mechanistic work processes by connecting employees (Gittell, et al., 2010).

Gittell (2003) acknowledges that the building of employee-to-employee relationships and development of high quality human connections is in stark contrast to mechanistic and lower level standard work processes so commonly used in the past. She observes that the traditional perspective on work routines, such as Taylor's and Ford's, is that work routines served as a substitute for connections among participants in the work process. In lower level work processes, standard work eliminates the need for further communication and works best in situations with low levels of uncertainty, where the employee can depend on the same scenario being repeated (Gittell et al., 2010).

Contrary to mechanistic work processes, the theory of relational coordination proposes that the practice of strategically facilitating employee-to-employee relationships supports the high performance of the organization by building a mutually reinforcing web of employee communication and working relationships carried out for the purpose of task integration (Gittell et al., 2010). The theory proposes that the effectiveness of the coordination and execution of tasks is determined by the level of relational performance obtained by employees (Gittell et al., 2008). Attaining relational performance is particularly important in achieving desired outcomes that are characterized by high levels of task interdependence (Gittell et al., 2010).

The development of relational coordination is characterized by the presence of seven dimensions which are organized into two major categories. The first major category is high quality communication. In support of highly quality communication, Gittell (2003) identified the relational dimensions of higher level communication to include: *frequent, timely, accurate, and problem solving*. These dimensions must be present for the development of high performance work systems and high levels of task interdependence to unfold.

The second major category of relational coordination is the category of higher-level working relationships. Gittell (2003) identified the dimensions of higher-level working relationship as: *shared goals, shared knowledge,* and *mutual respect*. These relational dimensions are critical in strengthening working relationships which in turn support high levels of task interdependence and performance outcomes.

In summary of the theory of relational coordination, Gittell (2003) suggested the seven dimensions of relational coordination must be present to be successful in the creation of high performance work systems in which employees create value. High quality relational connections and communications support a work system in which high levels of task interdependence and organization are possible (Gittell et al., 2010).

Theory of Relational Coordination and Lean Manufacturing Systems

Once the theory of relational coordination is applied to a lean manufacturing system consideration can then be given to the lean system as a high performance and high outcome work system. In a lean manufacturing system, the creation of value lies in an employee's ability to create value for the customer by producing product and by participating in the process of the elimination of waste through continuous improvement activities. For an employee to be successful in creation of value on both levels, formal work practices and routines must be designed that facilitate task interdependence as well as the interaction and coordination with others.

To be successful in facilitating interdependent activities, higher-level employee-to-employee relationships and communication must be present within the organization (Gittell et al., 2010). It is through higher-level employee relationships and communications that work in a lean system can effectively be coordinated and value created (Gittell et al., 2010). One has only to consider the extensive task integration responsibilities and activities of the lean assembler to understand the importance of facilitating higher-level communication and working relationships within a lean work system.

When the theory of relational coordination is applied within lean manufacturing environments, the gap between manufacturing's past practices and the expectations of a present day high performance lean manufacturing work system become readily apparent (Gittell, 2003). One has only to consider the changes in the job responsibilities of the lean assembler to understand the importance of the presence of higher-level communication and working relationships in achieving success. Task integration is an integral part and requirement of the daily working life of the lean assembler (Gittell et al., 2010). Unlike the mass production assembler, the lean assembler is required to participate in problem solving and team activities and to continually accumulate, reorganize, and apply production knowledge and skills (Fujimoto 1999).

Historically, manufacturing has had a heavy reliance on mechanistic and lower level standard work processes. These lower level methods were used as a substitute for coordinating and relating to others. They minimized the need for further communication (Gittell, 2003). In mass production systems, the focus of the creation of value was the improvement of productivity (Lacey, 1986; Watts, 2005). Creation of value through continuous improvement and the elimination of waste, although conceptualized by Ford and Taylor, was minimal (Womack, Jones, & Roos, 1990).

In summary, organizations have historically mimicked the lean tools and methods used by the more successful lean companies and have failed in their lean implementations in the development of a lean manufacturing management system (Womack, 2007; Emiliani & Stec, 2004). As suggested, the possibility that currently lean manufacturing tools and methods do not offer the necessary comprehensive and clearly defined framework for consistency in the implementation of the lean manufacturing systems is very seldom considered.

Gittels's (2003) theory of relational coordination, however, offers a possible alternative framework for clarifying the requirements of a successful lean system. To be able to coordinate tasks effectively, the seven relational dimensions of frequency, timeliness, accuracy, problem solving, shared goals, shared knowledge, and mutual respect must be present. Seeking ways to monitor the development and presence of the seven dimensions of relational coordination in lean systems may offer an alternative or complementary approach for monitoring the progress of the implementation and development of lean systems. The benefit of further exploring the theory of relational coordination as a possible alternative for monitoring and gaining a deeper understanding of lean systems could be substantial in the development of lean systems when considered in terms of global difficulty with lean implementations.

Literature Review Summary

A review of lean manufacturing literature reveals minimal influence from a broader range of disciplines or complimentary theoretical models; seldom are lean methods and continuous improvement programs questioned. Further, improved approaches for the sustainability of lean methods and lean management systems are seldom sought. Instead, the imitation of the lean manufacturing and continuous improvement programs of the more successful lean companies is often unknowingly encouraged. If efforts to imitate successful organizations results in failure the most common explanation for the failure is an incompetent management team. Other causes are seldom explored.

The absence of broader avenues of inquiry is understandable considering manufacturing’s history and organizations’ reliance on the physical and engineering sciences and deductive reasoning. This historical legacy promotes a lack of consideration of the possible benefits of applications of theories and models from other disciplines. However, ignoring the research based on other disciplines and theoretical models limits the continued development and improved support for lean manufacturing enterprises and accompanying continuous improvement programs.

Looking at the application of other theoretical models, the theory of relational coordination shows promise in helping organizations gain a deeper understanding of the lean manufacturing system and continuous improvement programs. With the model, lean manufacturing system and continuous improvement activities are viewed in the context of a high power work system. As a high power work system, the development of high level communications and working relationships encourages the higher levels of task interdependence necessary to accomplish and maintain continuous improvement activities that result in the elimination of waste from the lean manufacturing system. In light of the high failure rate of lean efforts, exploring the theory of relational coordination to gain a deeper understanding of the necessary communication and working relationships to support lean systems has merit.

Chapter III

Methodology

I designed this study using a positivistic case study research methodology. A positivistic case study is distinguished from an interpretive case study by the development of a theory prior to data collection. The prior development of theory guides the design, collection, and analysis of data. Fundamentally the design of a positivistic research study is a logical sequence that connects the data to the study's research question and conclusions (Yin, 2003).

By using a positivistic case study methodology, I attempted to gain knowledge of effective approaches for capturing data about communication and relationship phenomenon that occurred among assemblers working in a manufacturing environment that was transforming from mass to lean manufacturing methods. Use of a positivistic epistemology and case study strategy supported an explanation and evaluation of the effectiveness of the method chosen to collect data about communication and relationship phenomenon (Yin, 2003).

Research Design Overview

Yin's research method framework (2003) and Dubin's theory-building method (1978) served as the primary elements for the design of this research project. By using both, I was able to combine Yin's logical approach to positivistic case study design and Dubin's iterative approach for the refinement and application of theory (Dubin, 1978; Yin, 2003). Together, both elements allow for a well-structured inquiry that facilitates the creation of new knowledge and its application through the modification or building of theory (Dooley, 2002).

Design Phase

Following Yin's (2003) three-phase design process, I used a structured and logical approach for the design and completion of this research. My intent in using a more rigorous structured design was to avoid situations in which the evidence did not address the initial research question.

As illustrated in Figure 2, the design phase for this research included building the relational theory of continuous improvement using Dubin's (1978) theory-building method. Further, the design phase included development of the research question, construction of the eight units of analysis, selection of data collection methods, and design of data collection protocols. The design phase concluded with the review and validation of all questionnaires by manufacturing management students at the Dakota County Technical College in Apple Valley, Minnesota.

I crafted and published a data collection schedule for the execution phase of this research. I used the data collection schedule as a primary means of communication with the hosting organization to coordinate data collection opportunities.

The analysis phase of this research was unusual in that the relational theory of continuous improvement was a secondary concern. For this research, the primary concern was an assessment of the effectiveness of the use of the questionnaire, interview, sociogram, and observation research methods which chosen for this research. Although of a secondary nature, the data collected for the support or lack of support of the relational theory of continuous improvement was analyzed and reported.

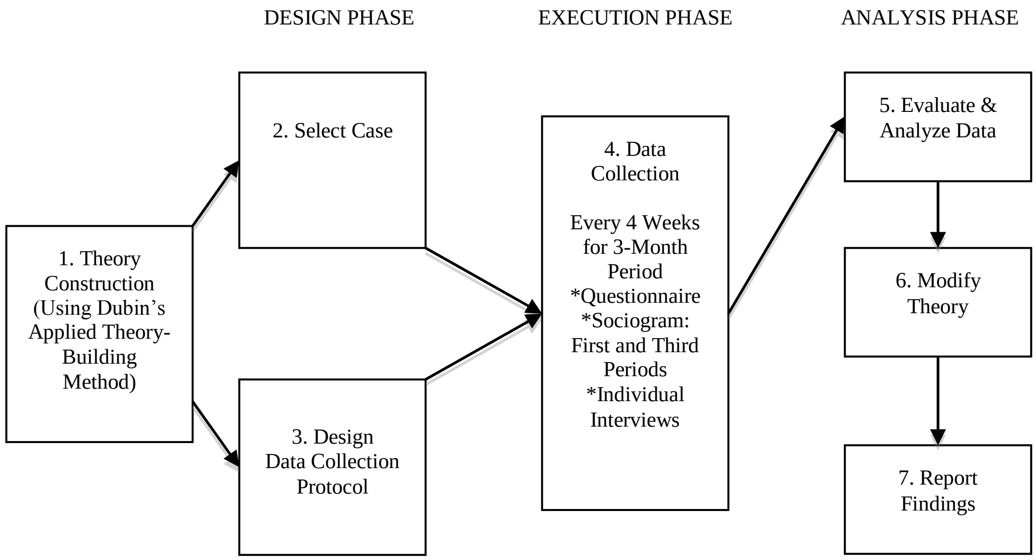

Figure 2. Yin's design method. Adapted from *Case Study Research: Design and Methods*, by R. Yin 2003, p. 50. Copyright 2003 by Sage Publications.

I used the elements of Dubin's (1978) applied theory-building method for the construction, application, and refinement of the theory for this study. Dubin's method consists of an eight-step process that is divided into two phases (Dubin, 1978; Lynham, 2000; Lynham, 2002). The completion of Phase 1, also referred to as the Theory Development phase, results in a conceptual framework of the theory. The completion of Phase 2, also referred to as the Theory Verification phase, results in an empirical verification of the theory.

For the purpose of this study I used Steps 1 through 5 of Dubin's (1978) applied theory-building method. Completion of the first five steps is fundamental in the completion of the theory-building process. As Lynham (2002) summarized, completion of the first five steps of the applied theory building model is the point at which the theory is often considered developed and made ready for further translating into practice and further testing.

The applied theory-building method (Dubin, 1978) focuses on the analysis of processes of interaction as they contribute to an understanding and the creation of new knowledge about the topic being researched. According to Dubin, new knowledge and understanding may be achieved by limiting the system being analyzed, by simplifying the variables and or the laws of interaction, and by focusing on the broad relationships among variables.

By focusing on the development of new understandings and knowledge, the applied theory-building method does not necessarily focus on predictions regarding the topic being researched (Dubin, 1978). Rather, the intent of the applied theory-building method is to refine theory through the reinvestigation of accepted conclusions and the reinvestigation of theoretical models through the application of new knowledge and understanding. Application of the applied theory-building method is an ongoing process of producing, confirming, applying, and adapting theory (Lynham, 2000).

Phase 1: Theory Development Cycle

Phase 1 or the Theory Development Cycle (Dubin, 1978) includes Steps 1 through 4 as outlined in Figure 3. Completion of the Theory Development Cycle includes an interactive and iterative process that on completion becomes the systemic conceptual framework of the theory. The four steps of the Theory Development Cycle include:

1. Theoretical Units: Identification and definition of the units that comprise the theory. Units represent things or variables.

2. Laws of Interaction: Description of the limits, interaction, and relatedness of the theoretical units of the theory.
3. Boundaries: Clarification of the limits or domain of the theory.
4. System States: Description of the conditions under which the theory operates in reality.

Phase 2: Theory Verification Cycle

The second phase or the Theory Verification Cycle contains Steps 5 through 8 as outlined in Figure 3. When completed, these four steps empirically verify the theory (Lynham 2002b, p. 244). The four steps of the Theory Verification Cycle include:

5. Propositions: Identification of the assumptions or limited truths about the theory.
6. Empirical Indicators: A procedure or operation employed by the researcher to secure measurements of a theoretical unit.
7. Hypotheses: Testing the predictions about the values of units of the theory.
8. Testing: Creating and executing a research plan to test and confirm the validity and reliability of the theory.

A diagram of Dubin's (1978) applied theory building and construction method is outlined in Figure 3.

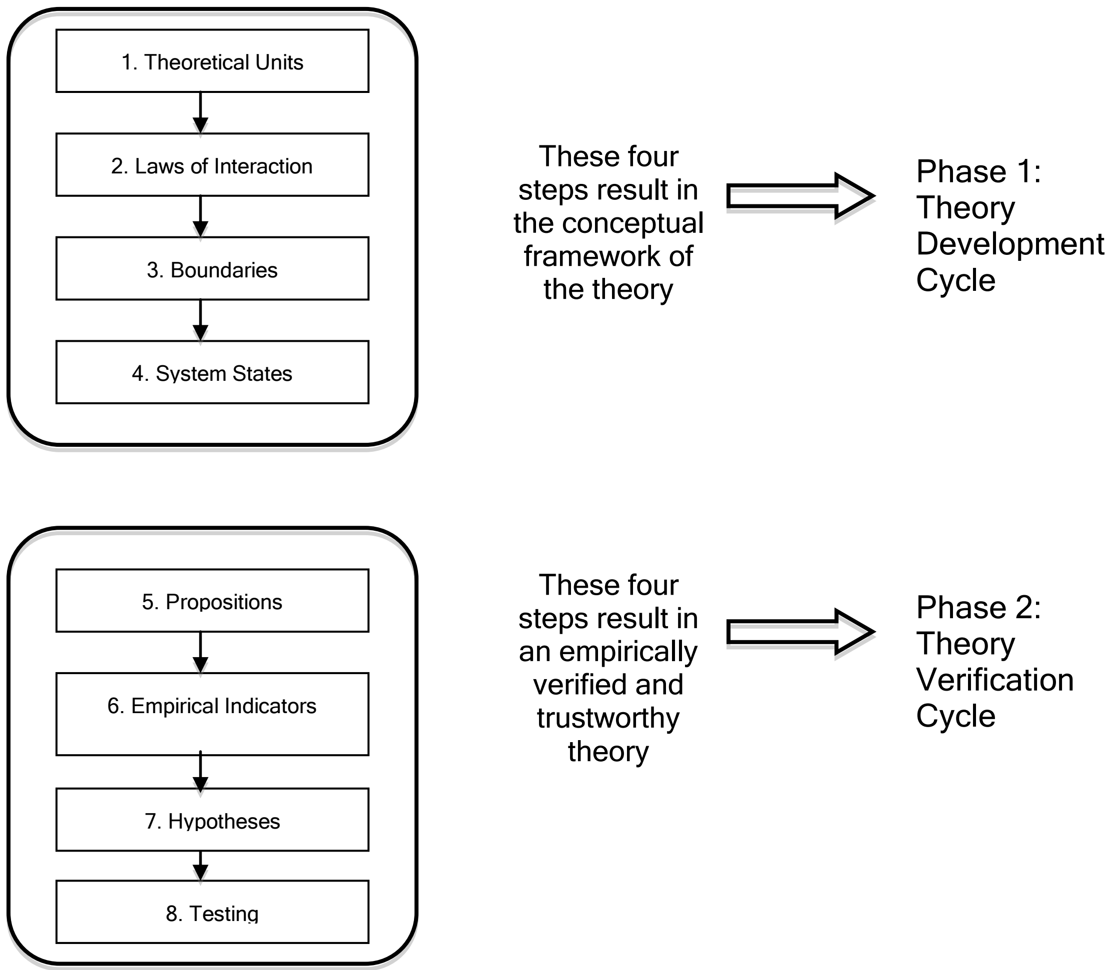

Figure 3. The elements of Dubin's applied theory building and construction. Adapted from "Quantitative Research and Theory Building: Dubin's Method," by S. Lynham, 2002, *Advances in Developing Human Resources,* p. 243. Copyright 2002 by Sage Publications.

Theory Building: The Relational Theory of Continuous Improvement

The initial step in the Design Phase of the research methodology framework (Figure 2) was to construct the relational theory of continuous improvement. The theory states that in lean production systems, the execution of work routines requires higher-level communications and the development of higher-level interdependent work relationships. The required increase in communication skills and the development of interdependent work relationships is in contrast to the requirements of mass production systems.

In mass production systems, work routines are often structured to be mechanistic and are generally intended to substitute for communications. During the transition from mass to lean manufacturing techniques, assemblers influenced by formal training and changes in daily operations and routines will subjectively experience a transition from mechanistic lower-level work routines to the use of higher-level work routines.

Consistent execution of continuous-process improvement activities is critical to the sustainability and success of lean manufacturing implementations.

Continuous-process improvement activities are a form of higher-level work that requires the use of higher-level communications and the development of interdependent work relationships. If an assembler does not become aware of and perceive a higher level of communication and the development of interdependent work relationships, continuous-process improvements will remain near the levels experienced during the use of mass production techniques. If a higher level of communication and higher level work relationships are experienced, but are perceived by the assembler to regress, it is likely that the level of continuous process improvements will fluctuate and eventually decrease (Figure 4).

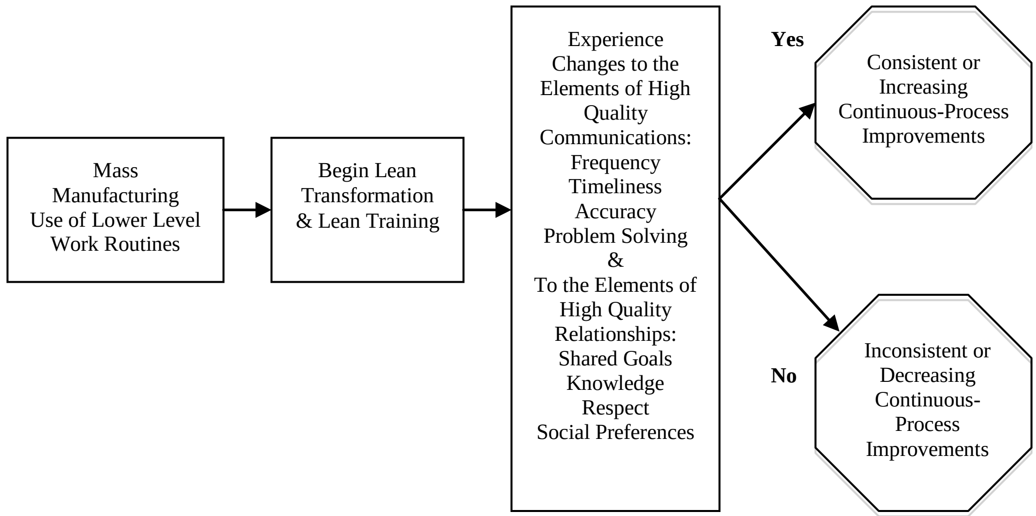

Figure 4. The relational theory of continuous improvement.

Data Collection Method for Use in Manufacturing Environments

I chose and used data collection methods based on their capability to collect data about the phenomenon being studied and their compatibility for use in a manufacturing environment. Some data collection methods may be more efficient than others for use in manufacturing environments. The capability and effectiveness of the data collection methods used for research in a manufacturing environment is critical.

Due to high costs, staffing, and engineering concerns, production lines cannot be stopped. The time available to collect data and an assembler's ability to leave the production area for data collection activities is often very limited. The effectiveness and efficiency of the data collection methods I selected and the time required to collect data were critical factors in the design of this research study.

Construction of the Relational Theory of Continuous Improvement

Step 1: Theoretical units. I chose the theoretical units for this study as the basis of observation (Dubin, 1978). The theoretical units identified for the study of the proposed relational theory of continuous improvement were adapted from Gittell's (2003) theory of relational coordination.

Gittell (2003), in her theory of relational coordination, suggested that to execute highly interdependent work requires higher levels of communication and higher-level work relationships. These types of human interactions and connections are characterized by Gittell as being in stark contrast to the more commonly used mechanistic work processes. Often, mechanistic work processes are designed to function as a substitute form of communication and as a way to coordinate the action of prespecified tasks to be performed.

Gittell (2003) suggested that in the area of communication, the elements of frequency, timeliness, accuracy, and problem solving are required and must be present for highly interdependent work to successfully occur. For interdependent work relationships to be continually strengthened, Gittell identified shared goals, shared knowledge, and mutual respect as elements that must be present in interdependent working relationships.

For this research project, I used the elements identified by Gittell (2003) as necessary for higher-level communication and work relationships to occur as the theoretical units of this study. Some modifications, however, were required. For the purpose of this study I created the theoretical unit of preferred relationships and included the category of interdependent working relationships (see Table 1).

The major category of High Quality Communication (see Table 1) was defined and organized into the theoretical units for this study as follows:

- Frequent Communication: Builds relationships through the familiarity that grows with repetition.
- Timely Communication: Builds relationships through appropriateness. Communication can be frequent and still be of poor quality. Delayed communication may result in errors or delays. Timing is critical in highly interdependent work.
- Accurate Communication*:* Supports effective group processes. Highly interdependent work depends on accurate communication.
- Problem Solving Communication: Promotes effective coordination. Task interdependencies often result in problems that require joint problem solving.

The category of High Quality Relationships (see Table 1) was defined and broken down into theoretical units as follows:

- Shared Goals: With shared goals for the work process, participants have a powerful bond and can more easily come to compatible conclusions about how to respond as new information becomes available.
- Shared Knowledge: When participants share knowledge regarding each other's task and how they fit together, they have a powerful bond that provides a context for knowing who will be impacted by any given change, and therefore for knowing who needs to know what and with what urgency.
- Mutual Respect: Relational coordination depends on the respect that participants have for the roles played by other participants in the same work process. Respect for each other's competencies creates a powerful bond and is integral to the effective coordination of highly interdependent work.

- Preferred Relationships**:** Changes within the social network can be revealed by administering a sociometric questionnaire as a method for discovering the preferred relationships which exist among a group of individuals.

Table 1

The Eight Theoretical Units for the Relational Theory of Continuous Improvement

	Unit	Indicator	Data Collection	Data Assessment
High Quality Communication	**Frequency of Communication**	**Participant's subjective perception of the frequency of communication.**	**Relational Coordination Questionnaire (RCQ):** **Questions answered by participants addressing changes in the frequency of communication, answered on 4-point Likert scale ranging from *strongly agree* to *strongly disagree.*** **Interviews (IT): Participants provide narrative description of changes in the frequency of communication.** **Observation of Researcher (R): Provides narrative on observed changes in the frequency of communication.**	**Outcomes demonstrated when:** **RCQ: Majority of responses on survey are either 3 or 4.** **IT: Participants affirm that they perceive positive changes in the frequency of communication.** **R: Affirms in narrative that they perceive positive changes in the frequency of communication.**
	Timely Communication	**Participant's subjective perception of the timeliness of communication.**	**Relational Coordination Questionnaire (RCQ):** **Questions answered by participants addressing changes in the timeliness of communication, answered on a 4-point Likert scale ranging from *strongly agree* to *strongly disagree.*** **Interviews (IT): Participants provide narrative description of changes in the timeliness of communication.** **Observation of Researcher (R): Provides narrative on observed changes in the accuracy of communication.**	**RCQ: Majority of responses on survey are either 3 or 4.** **IT: Participants affirm that they perceive positive changes in the timeliness of communication.** **R: Affirms in narrative that they perceive positive change in the accuracy of communication.**

Table 1 continued.

	Unit	Indicator	Data Collection	Data Assessment
High Quality Communication	Accuracy of Communication	Participant's subjective perception of the accuracy of communication.	Relational Coordination Questionnaire (RCQ): Questions answered by participants addressing changes in the accuracy of communication, answered on 4-point Likert scale ranging from *strongly agree* to *strongly disagree*. Interviews (IT): Participants provide narrative description of changes in the accuracy of communication. Observation of Researcher (R): Provides narrative on observed changes in the accuracy of communication.	Outcomes demonstrated when: RCQ: Majority of responses on survey are either 3 or 4. IT: Participants affirm that they perceive positive changes in the accuracy of communication. R: Affirms in narrative that they perceive positive changes in the accuracy of communication.
	Problem Solving	Participant's subjective perception of the effectiveness of problem-solving activities and programs.	Relational Coordination Questionnaire (RCQ): Questions answered by participants addressing the effectiveness of problem-solving activities on a 4-point Likert scale ranging from *strongly agree* to *strongly disagree*. Interviews (IT): Participants provide narrative description of changes in problem-solving activities and programs. Observation of Researcher (R): Provides narrative on positive changes in the problem-solving skills of assembler teams and in other members of the organization.	RCQ: Majority of responses on survey are either 3 or 4. IT: Participants affirm that they perceive increased capability in the problem-solving skills of their team and other members of the organization. R: Affirms in narrative that they perceive positive changes in the problem-solving skills of assembler teams and in other members of the organization.

Table 1 continued.

	Unit	Indicator	Data Collection	Data Assessment
High Quality Relationships	**Shared Goals**	**Participant's subjective perception of shared goals.**	**Relational Coordination Questionnaire (RCQ):** **Questions answered by participants addressing changes in shared goals, answered on a 4-point Likert scale ranging from *strongly agree* to *strongly disagree*.** **Interviews (IT): Participants provide narrative description of changes in shared goals.** **Observation of Researcher (R): Provides narrative on observed changes in shared goals.**	**Outcomes demonstrated when:** **RCQ: Majority of responses on survey are either 3 or 4.** **IT: Participants affirm that they perceive an increase in shared goals among themselves and team members.** **R: Affirms in narrative that they perceive positive change in shared goals.**
	Shared Knowledge	**Participant's subjective perception of shared knowledge.**	**Relational Coordination Questionnaire (RCQ):** **Questions addressing changes in shared knowledge, answered on a 4-point Likert scale ranging from *strongly agree* to *strongly disagree*.** **Interviews (IT): Participants provide narrative description of changes in the sharing of knowledge.** **Observation of Researcher (R): Provides narrative on observed changes in shared knowledge.**	**RCQ: Majority of responses on survey are either 3 or 4.** **IT: Participants affirm in narrative that they perceive positive changes in the sharing of knowledge among team members.** **R: Affirms in narrative they perceive positive change in shared knowledge.**

Table 1 continued.

	Unit	Indicator	Data Collection	Data Assessment
High Quality Relationships	**Mutual Respect**	**Participant's subjective perception of mutual respect.**	**Relational Coordination Questionnaire (RCQ):** **Questions answered by participants addressing changes in mutual respect, answered on a 4-point Likert scale ranging from *strongly agree* to *strongly disagree*.**	**Outcomes demonstrated when:** **RCQ: Majority of responses on survey are either 3 or 4.**
			Interviews (IT): Participants provide narrative description of changes in mutual respect.	**IT: Participants affirm in narrative that they perceive an increase in mutual respect among themselves and team members.**
			Observation of Researcher (R): Provides narrative on observed changes in mutual respect.	**R: Affirms in narrative that they perceive positive change in mutual respect.**
	Preferred Relationships	**Participant's preferences for association with other assemblers.**	**Sociogram Questionnaire (SG):**	**Outcomes demonstrated when:**
		Assessment of data collected during data collection periods 1 and 3 of the study.	**SG: Sociometric status is the number of social connections per assembler for each of the data collection periods calculated using Keyhubs™ software. Data is then organized into naturally occurring groups.**	**SG: There is an increase in the number of social connections per assembler within each of the occurring groups.**
			Observation of Researcher (R): Provides narrative on observed changes in preferred relationships.	**R: Affirms in narrative that they perceive positive change in preferred relationships.**

Step 2: Laws of interaction. Step 2 in Dubin's (1978) theory-building method addresses identifying the interaction and relationship among the theoretical units. Laws of interaction illustrate how the units of a theory are linked and how they are related to each other (Lynham, 2002b). There are three types of laws of interaction used to describe relationships among theoretical units:

1. Categorical laws of interaction describe the values of a unit of the theory as it relates to one or more other units of the theory.
2. Sequential laws of interaction use a time dimension to order the relationships between two or more units.
3. Determinant law of interaction relates the determined value of a unit with the determined values of another unit of the theory.

The laws of interaction for the relational theory of continuous improvement can be described as categorical laws since each law describes the value(s) of a unit as it relates to one or more other units of the theory. The relational theory of continuous improvement has two categorical laws of interaction.

First law of interaction-communication. This law describes how the four theoretical units that comprise higher quality communication are interrelated and necessary for facilitating the development of the higher levels of communication required for consistent levels of continuous improvement to occur. The four units that comprise higher quality communication include frequency, timeliness, accuracy, and problem solving.

When assessing communication, the description of the value(s) of the theoretical units and their relationship is defined by an assembler's subjective perception of the unit's quality and value. If the assembler does not believe they have experienced or participated in higher-level communications, they will be less likely to participate in continuous improvement activities.

Second law of interaction-working relationships. This law describes how the four theoretical units that comprise higher quality working relationships are interrelated and necessary for the development of interdependent working relationships. This development is necessary for consistent continuous improvement efforts to occur. The four units that comprise higher quality working relationships include shared goals, shared knowledge, mutual respect, and preferred relationships.

When assessing the quality of working relationships, the description of the value of the units and their relevance is dependent on an assembler's opinion and satisfaction with the quality and inherent value of the units. If the assembler does not believe they have formed or participated in higher-level working relationships, they will be less likely to contribute to continuous improvement activities.

Step 3: Boundaries. Step 3 in Dubin's (1978) theory-building method is identifying the boundaries of the theory. Boundaries are an important specification of the theory which limits, specifies, and clarifies the real-world domain of the theory. Boundaries define the real world in which the theory is expected to apply. Boundaries are not determined by data but rather by the logic of the researcher and the aspects of the real world being modeled by the theory.

According to Dubin (1978), the boundaries of the relational theory of continuous improvement can be defined by using the following criteria:

1. Type of organization.

2. Type of manufacturing system used.
3. Type of job skills and job assignment required.

The first boundary of the relational theory of continuous improvement is that the participating organization must be a manufacturing organization which produces product. The specific products or manufacturing processes were not a consideration. The second boundary is the type of manufacturing system used. For the relational theory of continuous improvement, the manufacturing system in use or being implemented must be a lean production system. It is acceptable for an organization to be in transition from traditional manufacturing techniques to lean production techniques and methods. Movement away from traditional manufacturing methods, however, must be evident. The third boundary is the required job skills and the job responsibilities of an assembler participating in this study. To participate in this study, an assembler had to be working in a manufacturing organization and be actively engaged in the production of product.

Step 4: System states. Step 4 in Dubin's (1978) theory-building method is the system states of the theory. The basic concept of a system state is that the system as a whole has distinctive features when it is in a state of the system. The criteria for identifying system states as summarized by Lynham (2002b) are as follows:

1. Inclusive: All theoretical units must be included in the system state.
2. Persistent: The system state must exist through some meaningful period of time.
3. Distinctive: All theoretical models must develop unique values or characteristics for that system state.

The system state (Dubin, 1978) for the relational theory of continuous improvement is inclusive of all eight units. It is necessary, when working in the lean production system, that the elements of frequency, timeliness, accuracy, and problem solving which comprise the elements of higher-level communication are believed to be present and are perceived as being experienced by the assemblers. Further, the theoretical units of shared goals, shared knowledge, mutual respect, and preferred relationships must also be believed to be present and be perceived as being experienced by the assemblers.

For the formation of higher-level work relationships and communications to occur, it is necessary that the eight theoretical units of this study are believed to be present. The presence of both interrelated working relationships and higher-level communication are theorized as necessary for consistent levels of continuous improvement to be enacted and experienced in lean production systems.

Step 5: Propositions. Step 5 in Dubin's (1978) theory-building method is the development of theoretical propositions. According to Dubin, a proposition is a special and limiting truth statement about the theory. It is a logically constructed truth statement about the model by the theorist when the model is fully specified in its theoretical units, laws of interaction, boundary, and system states. The sole test of accuracy of a proposition is whether it applies or follows logically from the model. Propositions allow the researcher to attempt to make real-world predictions about the value of the theoretical units. There are three types of propositional statements:

1. Propositions that are concerned with the value of a single unit or with the unit's value in relationship to all other units in the model.

2. Propositions that predict the continuity of the system based on the value of all units in the model.
3. Propositions that, based on the value of all units of the system, predict the oscillation from one state to another.

I developed three propositional statements that describe the value of the theoretical units and allow predictions to be made about the relational theory of continuous improvement.

Proposition one. Assemblers influenced by formal training and changes in daily manufacturing operations during the transition from mass to lean production methods will become aware of and participate in higher-level communication and higher level interdependent work relationships. The development of higher-level communication and higher level interdependent work relationships are necessary to achieve and sustain consistent levels of continuous improvement.

Proposition two. If the assembler does not become aware of and participate in higher-level communications and a higher level of interdependent work relationships, levels of continuous-process improvement will remain near the levels experienced during the use of mass production techniques.

Proposition three. If a higher level of communication and a higher level of interdependent work relationships are experienced but are then perceived by the assembler to regress, it is likely that the level of continuous-process improvement will fluctuate and eventually decrease from previous levels.

Case Selection

The second step in the design phase of the research method framework was the selection of a case. The case itself is a descriptive account of a series of events that reflect the activity or problem. A case is generally taken from real life and includes the following components: setting, the individuals involved, the events, the problems, and the conflicts (Dooley, 2002).

For the purpose of this research, the case required a manufacturing organization that was transitioning from mass to lean manufacturing methods. The type of manufacturing processes or the product being manufactured by the participating organization was not a consideration. After a search, a microelectronics manufacturer that had embarked on the transition from mass to lean manufacturing methods 14 months earlier was located in Victoria, Minnesota.

An additional requirement in choosing a case for this research project was that the participating manufacturing organization must employ a population of manufacturing assemblers who have experienced the transition from mass to lean manufacturing methods. The ages, ethnicity, and number of years of work experience of the assemblers were not a consideration for this study.

Data Collection Methods

The third step in the research method framework was the design of the data collection methods and protocols. The data collection methods and protocols for this study were reviewed by the Department of Organizational Development in the School of Education at the University of St. Thomas and were further reviewed and approved by the University of St. Thomas Internal Review Board.

The data collection design of this study included three methods administered over approximately a 12-week period in three data collection periods. The data collection periods were approximately 4 weeks apart and were scheduled based on production volumes and assembler availability. The data collection methods, their design and processes and procedures were chosen based on their capability to ensure validity and overall reliability.

For the purpose of this study, data collection was focused on the assembler group. Managers and support personnel were not included in the data collection activities. The choice to focus on one group was intentional as the focus of this study was to do an assessment of chosen research methods.

I chose these research methods based on their compatibility for use in manufacturing environments. The design and methods of a study conducted in a manufacturing environment must not only address reliability and validity but also suitability and efficiency (Dubin, 1978). Assemblers are required to keep the production lines running. The time assemblers can leave the production area and be available for data collection is minimal.

During the course of the 12-week study, the total time required of each participant for data collection activities was approximately 2 hours. The initial information meeting included a data collection period which was 60 minutes in length, and each additional data collection period required 30 minutes of each participant.

Questionnaire. The Relational Coordination Questionnaire (Appendix B) enabled the lean assemblers to independently answer a series of questions. The Relational Coordination Questionnaire was administered during each of the three data collection periods. The questions on the questionnaire were structured using the study's theoretical units (see Table 1). The lean assemblers answered the questions by recording the strength of their agreement to the 15 questions using a 4-point Likert scale: 1. *Strongly Disagree*, 2. *Disagree*, 3. *Agree*, and 4. *Strongly Agree.*

Interview. The Relational Coordination Interview Guide (Appendix C) was constructed and used during the face-to-face individual interviews with lean assemblers. Interviews were conducted during the last data collection period. The interview guide used the theoretical units as the structure for conducting the interviews (see Table1). Due to time constraints, interviews were approximately 5 minutes in length and limited to two questions. Approximately 95% of the lean assemblers participating in the study were interviewed. Although I did not record the interviews, I did take personal notes during the interviews.

Sociogram. The Sociometric Questionnaire (Appendix A) was administered to all assemblers participating in the study in collection periods 1 and 3 of the study. A sociometric questionnaire is a means of discovering the preferred relationships which exist among a group of individuals; it is also a means of disclosing the structure of the group (Northway, 1967). The Sociometric Questionnaire allowed each participant to state which members of the group they preferred to associate with for communication and higher skilled working relationships. The answers received from each participant were electronically recorded in Keyhubs™ software. Keyhubs™ software is especially designed to graph and display sociograms.

Observation. During the project, I made personal observations about changes in communication or working relationships. Changes were observed in group interaction, structure of meetings; positive and negative changes were both noted. As a former employee, I was familiar with manufacturing operations and manufacturing processes and procedures. I inferred and interpreted changes based on observed changes in group interaction and meeting structures.

Data Assessment Methods

Data was gathered using several methods which included questionnaires, interviews, sociograms, and observation. A different means of analysis was used for each of the chosen methods.

Questionnaire. Data from the Relational Coordination Questionnaire was analyzed using a 4-point Likert scale. For data to be considered positive and in support of the relational theory of continuous improvement, the weighted average of a response to a question on relational coordination questionnaire had to fall within the range of 3.00 to 4.00 on the 4-point Likert scale.

Interviews. The notes from the individual interviews were analyzed based on similarities in content and consistency of opinions concerning the positive and negative beliefs about changes in communication and working relationships since the lean implementation. Common themes were then identified representing the assembler group opinions about changes in communication and working relationships. To be deemed a positive show of support for perceived changes in communication or working relationship, at least 75% of participants had to affirm in narrative that they perceived positive changes in communication and working relationships.

Sociogram. The data from the Sociogram Questionnaire was analyzed based on the changes in the number of preferred social connections or social links per assembler.

The data from the Sociogram Questionnaire was electronically recorded in Keyhubs™ software and organized into naturally occurring groups based on the number of social links per assembler. For the data to be considered positive and in support of the relational theory of continuous improvement, an increase in the number of preferred social connections had to be noted in all groups.

Observation. During the observational process I was required to interpret behavior and make inferences about its meaning. Making an interpretation about the observed changes in communication or working relationships was based on my judgment as the researcher.

Because interpretations are based on my judgment and my knowledge of manufacturing operations and manufacturing processes and procedures, it is necessary that I be as competent and unbiased as possible about the task being observed. To be considered positive support for perceived changes in communication or working relationships, I affirmed in narrative that positive changes had occurred.

Validity and Reliability

Four tests have commonly been used to establish the quality and validity of any empirical social research (Yin 2003). The four tests were used for this research and include construct validity, internal validity, external validity, and reliability.

1. Construct Validity: To ensure construct validity, multiple sources of evidence were sought and collected. Collecting multiple sources of data better demonstrated changes in an assembler's perception about changes occurring in communications and working relationships during the transition from mass to lean manufacturing methods.

2. Internal Validity: To ensure internal validity, data collection protocols were repeated monthly over a 3-month period. Collecting data over a 3-month period better demonstrated changes in assembler perceptions concerning the changes in communication and working relationships during the transition from mass to lean manufacturing methods.
3. External Validity: To ensure external validity of this study, the data will only reflect the subjective experiences of assemblers during the lean manufacturing implementation at the participating facility in Victoria, Minnesota. Although this research may generate new knowledge about the possible changes in communication and relationships during such an implementation, these changes cannot be extrapolated to all manufacturing facilities undergoing a lean transformation.
4. Reliability: To ensure reliability, the data collection methods and protocols for this study were clearly identified and systematically implemented. This was in attempt to minimize errors and biases and to properly document case study research procedures.

In preparation for the collection of data and the informational meeting explaining the research project to the assemblers, I conducted a review of the meeting presentation and Relational Coordination Questionnaire with a group of students studying supervision at a local technical college. The feedback obtained was used to improve and finalize the questionnaire document and presentation materials. The changes made from the review assisted in strengthening the external validity of the questionnaire and improving the presentation materials.

Procedures for Protection of Human Subjects

All assemblers were invited to an informational meeting during which the details of the study were explained and the assemblers were invited to participate. It was made clear that participation was voluntary and, should assemblers decide to participate, they could withdraw from the study at any time without repercussions.

During the meeting, each assembler who agreed to participate was given a copy and detailed explanation of the consent form. During the meeting, the issues of confidentiality, protection of identities, and security procedures for the storage of data were reviewed with the assemblers who agreed to participate. I emphasized that the intention was to keep the identities of participants confidential and that I was the only one who would have access to the data from the study.

The assemblers were informed that the Relational Coordination Questionnaire, the Sociometric Questionnaire, and individual interviews would be created in both hard and electronic copy. The electronic copy would be confidentially coded and maintained separately while all hard copies and handwritten notes from the project would be stored in a locked filing cabinet to which only I had access.

Research Study Limitations

Each research study has limitations. Limitations set parameters on the generalizations relating to the findings of the study. This research project has four notable limitations.

First, this study was limited to administering the questionnaire, interview, sociogram, and observation research methods to the assembler population. Managers and support staff were not included in the study. This was deemed appropriate as the primary focus of the study was an assessment of the effectiveness of the application and execution of research methods in measuring and assessing the development of cultures of continuous improvement in lean manufacturing environments. The relational theory of continuous improvement which focuses on a wider array of relationships including manager and support staff was of secondary concern.

Second, this study is limited as the data collected for this study reflects only the subjective experiences of assemblers from one manufacturing organization during a lean manufacturing implementation. Although this research may generate new knowledge about possible changes in working relationships and communication during a lean manufacturing implementation, these changes cannot be extrapolated to all manufacturing facilities involved in a lean transformation.

Third, this study is limited in that the data is not representative of a wide array of industries. The data collected is only representative of one manufacturing facility in the electronics industry.

Forth, this study is limited in its time frames. Data was collected approximately once every 4 weeks for a 3-month period of time. For this study, a 3-month data collection period was deemed reasonable and sufficient. However, for further investigation of the relational theory of continuous improvement, a 3-month period may be deemed insufficient.

Case Study Reporting

Yin (2003) expressed that the author of a case study report should be aware of the members of the audience. Case study reports have the potential to be used as a significant communication device and should be targeted to the audience.

The case study should be structured and organized in such a manner to suit the purpose of the study and the audience (Yin, 2003). Unlike experimental research, it is common for case study research to have a primary, secondary, and tertiary audience.

For the purposes of this research, Dubin’s (1978) theory-building model and Yin’s (2003) case study design were used as models to structure the design of this research. Further, as the author and researcher, I structured and crafted the written report with the intent of engaging both academics and manufacturing professionals.

Chapter IV

Findings

The findings for this research will be presented in two major sections. The first section of this chapter will address the support or lack of support for the relational theory of continuous improvement. Support or lack of support for the theory will be presented based on the eight theoretical units that were put forth in the Methodology Chapter.
In the first section of this chapter the presentation of data for each of the eight theoretical units will be discussed in a repetitive format. Each theoretical unit will be described and the findings for the unit summarized. Then, for each theoretical unit, the supporting detail for the use of the questionnaire, interview, and observation method will be presented in narrative and summarized using a chart format.

The second part of this chapter will address the findings for the research question posed by this study. Included will be an application of the Seven Wastes of Lean Research to the research process. The Seven Wastes of Lean Research is an analytical framework developed specifically for this research. Its purpose is to identify the inefficiencies and nonvalue-added activities in the processes, procedures, and protocols of this research. The Seven Wastes of Lean Research will be used for recommending improvements for future research studies about the relational theory of continuous improvement.

Support for the Relational Theory of Continuous Improvement

Based on the results of this research, the relational theory of continuous improvement was not refuted. However, it is important to state that the theory is not the primary focus of this research. Rather, the development of the theory was necessary in support of the research question which focuses on effective methods for assessing an assembler's change in perception regarding communication and working relationships during lean implementations in manufacturing environments. In order to pursue this inquiry, the development of the relational theory of continuous improvement was necessary.

Sample Information

This study was conducted at a small microelectronics manufacturer located in the Twin Cities area in the state of Minnesota. In September of 2008, the facility completed rearranging its production facility from a mass to lean production floor layout and implemented a lean production flow. Although the manufacturing area was considered lean, the cultural and workforce transition continued. All assemblers participating in this study also participated in the organization's transition from mass to lean manufacturing methods.

From August 2009 to November 2009, data was collected from a population of 13 full-time assemblers who had agreed to and signed written consent forms (Appendix D) to participate in this study. Three males and 10 females volunteered to participate in the study. At the time of the study, 25 full-time assemblers were employed at the facility. Within the assembler population, the number of females outnumbered the males by a ratio of 2 to 1. The assemblers who participated in the study ranged from 25 to 65 years of age. The number of years of work experience as an assembler ranged from 4 to 40 years of experience.

Analysis of the Relational Coordination Questionnaire

The Relational Coordination Questionnaire was administered to participants at approximately 4-week intervals over a 90-day time period. The administering of the questionnaire was scheduled based on manufacturing activity and the availability of assemblers. During the 90-day data collection period, the questionnaire was administered on August 18th, October 7th, and November 10th of 2009. During each of the three data collection periods, the questionnaire was completed by each of the 13 participating assemblers.

The August administering of the questionnaire took place immediately after the informational meeting informing the assemblers about the study and the signing of the consent form signifying their agreement to participate in the study. During the October visit to the facility, the only instrument I administered was the Relational Coordination Questionnaire. During the November visit, the Relational Coordination Questionnaire was administered during a private 20-minute meeting with each participant. In addition, the Sociogram Questionnaire was administered, and a short interview was conducted during the meeting.

The Relational Coordination Questionnaire was organized into three major sections. Each major section included five questions for a total of 15 questions on the questionnaire. Questions 1 through 5 comprised the communication section, questions 6 through 10 comprised the working relationship section, and questions 11 through 15 comprised the problem-solving section. Each question was measured using a 4-point Likert scale as follows: *Strongly Agree, Agree, Disagree, Strongly Disagree.*

A weighted numeric value was assigned to each answered question on the questionnaire. The value assigned corresponded to points on the 4-point Likert scale as follows: *Strongly Agree*=4, *Agree*=3, *Disagree*=2, *Strongly Disagree*=1.

Based on the answers chosen and the assigned value, a weighted average was calculated for each of the 15 questions answered by assemblers during each of the three data collection periods. Using the three weighted scores, a final average for each question was then calculated. Based on the final averaged value, support was determined to be positive or negative for each question.

Analysis of Individual Interviews

During the November visit to the facility, a private 20-minute meeting was held with each participant. During the meeting, a short two-question interview was conducted. No tape recorder was used. Rather, I took notes during each interview. The questions asked were as follows:

1. What kind of changes have you experienced in workplace communications and relationships since implementing lean techniques?
2. What can the organization do to make their continuous improvement programs more effective?

The interview had two purposes: The first was a review and triangulation of data in support for or in lack of support of the relational theory of continuous improvement. Support was determined by examining an assembler's awareness about the changes in working relationships and communications during the transition from mass to lean manufacturing methods. Secondly, the questions were designed to gain insight into an assembler's opinions and perceptions about the success of problem solving activities and continuous improvement programs within the organization.

Analysis of Theoretical Units—Higher Quality Communication

The theoretical units for this study were organized into three major categories. The major categories were: communication, working relationships, and problem-solving activities that include continuous improvement programs. Table 2 comprises the data collected for the category of communications that includes the theoretical units of timeliness of communication, accuracy of communication, and frequency of communication.

Table 2

Relational Coordination Questionnaire-Higher Quality Communication

	Unit	Question	Survey	Wt. Avg.	Strongly Agree	Agree	Disagree	Strongly Disagree
Higher Quality Communication	Timeliness	1. I receive the information I need to do my job in a timely manner.	1	3.23	3	10	0	0
			2	3.30	4	9	0	0
			3	2.84	2	7	4	0
				3.12				
	Accuracy	2. I receive accurate information and instructions about the jobs and tasks I am assigned.	1	3.07	1	12	0	0
			2	2.76	1	10	2	0
			3	2.61	1	9	1	1
				2.81				
	Frequency	3. I believe it is important to talk to all of my team members on a daily basis.	1	3.54	7	6	0	0
			2	3.38	5	8	0	0
			3	3.46	7	5	1	0
				3.46				
	Frequency	4. I can easily contact and talk to my team members if I need to.	1	3.08	3	8	2	0
			2	3.15	3	9	1	0
			3	3.38	5	8	0	0
				3.20				
	Frequency	5. I believe the communication between my team members is good.	1	3.31	6	5	2	0
			2	3.31	4	9	0	0
			3	3.15	4	7	2	0
				3.26				

Note. Wt. Avg. = weighted average.

Theoretical Unit 1: Frequency of Communication

Theoretical unit description. In lean manufacturing environments, work processes and group interaction become highly interdependent. An increase in communication is required to successfully support new levels of developing interdependency.

Findings. For this study, indicators for increased communication are assessed using the subjective perception of the participants. The methods and criteria used to assess changes in support based on an assembler's perception of the changes in the frequency of communication are summarized in Table 3. A more detailed explanation of the findings follows.

Table 3

Theoretical Unit 1: Findings for Frequency of Communication

Method	Criteria for Support	Findings for Support or Lack of Support
1. Relational Coordination Questionnaire	The weighted averages of the responses to questions on survey are within the range of 3.00 to 4.00 on the Likert scale.	Support was positive. Weighted averages for the responses to Questions 3, 4, and 5 on the questionnaire were within the range of 3.00 to 4.00 on the Likert scale. Question 3 showed positive support with a weighted average of 3.46. Question 4 showed positive support with a weighted average of 3.20. Question 5 showed positive support with a weighted average of 3.15.
2. Interview	At least 75% of participants affirm in narrative that they perceive positive changes in the frequency of communication.	Support was negative. Only 54% of assemblers interviewed expressed the belief that communication had improved since the lean implementation. This was less than the required 75% for positive support.
3. Observations	Researcher affirms in narrative that positive changes in the frequency of communication are perceived to have occurred.	Support was positive. After the lean implementation, communication meetings were observed being held at the beginning of each shift.

Relational Coordination Questionnaire. The results from Questions 3, 4, and 5 of the Relational Coordination Questionnaire address different aspects of the topic of frequency of communication. Question 3 was designed to gain an understanding of group beliefs about the importance of frequency of communication. Questions 4 and 5 were designed to gain an understanding of any barriers perceived by the assemblers that may hinder the frequency of communication.

Based on the results of the questionnaire for Questions 3, 4, and 5, assemblers showed support in their perceptions of positive changes in the frequency of communication after the lean implementation. The weighted average score for Questions 3, 4, and 5 was above the required minimum weighted average score of 3.00, indicating positive support by the assemblers for the frequency of communication. Table 2 reports the actual responses to the Relational Coordination Questionnaire.

Interview. During the interview, seven of the 13 assemblers interviewed, or 54% of participants, expressed the similar belief that communication had positively improved since the lean implementation. In the interviews, this group expressed the belief that noticeable and positive changes occurred in the frequency of communication.

In contrast, six of the 13 assemblers interviewed, or 46% of participants, stated they perceived communication negatively. This group expressed the belief that since the lean implementation, communication had remained the same, and they did not perceive any positive changes to have occurred in the frequency of communication.

The theme of “still the same” was often expressed in the context of feeling isolated and physically confined to the manufacturing area with little contact with other members of the organization and management. Actual and tangible changes in the frequency of communication appeared to have little influence on changing the negative perceptions of the group. As one assembler stated, “Contact with management is still the same. Even though they just built new offices and moved upstairs, I still only see them in the hallway. It is just like before." Another assembler, when expressing her perception, stated that "things are still the same" after the lean implementation, and that "management is still missing and the rumors still fly."

Another assembler revealed her perception of things remaining the same, as well as her personal sense of isolation, "We may have gone lean, but I still work with Assembler Jane. I've worked with Jane for over 20 years. She has always been a little touchy, and I've always had to watch what I say. It makes no difference if we are lean or not. As long as I work with Jane, I have to communicate in the same way. Jane isn't going to change, so for me, everything is still the same. Nothing has really changed at all."

For this individual, the perception of things as still the same is based on a set of personal experiences and perceptions regarding her lengthy personal working relationship and interaction with Assembler Jane. The assembler's comments highlight that, regardless of the best planned lean implementation, prior work relationships and histories among employees can be very influential in the perceived success of newly implemented lean systems.

Observations. I observed that, as a direct result of the lean implementation, the frequency of formal communication to the manufacturing area increased. After the lean implementation, meetings were held at the beginning of each production shift. During the meetings, work instructions were given and discussed. I observed that an increase in the frequency of communication was required because of the more succinct operational requirements of supporting lean methods and manufacturing practices.

As a result of a lean implementation, more frequent work instruction is necessary to support manufacturing activities. Manufacturing capacity increases because of the elimination of nonvalue-added activities from the production system. Product moves faster through the manufacturing process. If production is not supported and more closely coordinated there is a noticeable increase in lost production time. More frequent communication is necessary to manage the additional capacity found in lean organizations

I also observed that the meeting at the beginning of the shift served as a platform for assembler teams to discuss work and work instructions. Lean methods encourage the use of assembler teams and foster increased levels of interaction.

Conclusion. The theoretical unit of frequency of communication was not positively supported by the data in Table 3. During the individual interviews, less than the required 75% of assemblers expressed positive perceptions about the frequency of communications. Rather, only 54%, or seven of the 13 assemblers interviewed, supported positive changes in the frequency of communication and higher-level communication.

Theoretical Unit 2: Timely Communication

Theoretical unit description. In lean manufacturing environments, work processes become highly interdependent. In order to manage more highly interdependent work processes and support increased group interaction, more timely communication is necessary. Timely communication assists in minimizing delays and errors in task performance.

Findings. For this study, indicators for the timeliness of communication were assessed based on the subjective perception of the assemblers. The research methods and criteria used to assess support based on an assemblers' perception of the changes in the timeliness of communication are outlined in Table 4. A more detailed explanation of the findings follows.

Table 4

Theoretical Unit 2: Findings for Timeliness of Communication

Method	Criteria of Support	Findings of Support or Lack of Support
1. Relational Coordination Questionnaire	The weighted averages of the responses to questions on the survey are within the range of 3.00 to 4.00 on the Likert scale.	Support was positive. The weighted average of the response to Question 1 on the questionnaire was 3.12 and was within the range of 3.00 to 4.00 on the Likert scale.
2. Interview	At least 75% of participants affirm or remain neutral in narrative that they perceive positive changes in the timeliness of communication.	Support was negative. Only 54% of assemblers interviewed expressed the belief that timeliness of communication had improved since the lean implementation. This is less than the required 75%. .
3. Observations	Researcher affirms in narrative that positive changes in the timeliness of communications are perceived to have occurred.	Positive changes in communication were observed. After the lean implementation, communication meetings that included the opportunity for discussion were held at the beginning of each shift.

Relational Coordination Questionnaire. The results for Question 1 of the Relational Coordination Questionnaire address the topic of timeliness of communication. Based on the results of the questionnaire, support was shown for the assemblers experiencing positive changes in their perceptions about the timeliness of communication. For all three data collection periods, Question 1 scored above the weighted minimum average score of 3.00 which, for this research, indicates positive support. Question 1 scored a total weighted average of 3.12. Table 2 reports the actual responses to the Relational Coordination Questionnaire.

Interview. During the interview process, 75% of participants failed to affirm positive support for the timeliness of communication. Two themes were expressed during the interview process.

The first theme, expressed by 54% of assemblers interviewed, was that communication was perceived as more timely. As one operator stated, “Communication is better. The internal communication of the manufacturing teams has improved. Also, I am being told the stuff I need to know in a timely manner.” Further, two assemblers verbalized their belief that more timely communications led to better quality. They believed this was true because more timely communication improved support for manufacturing processes, and ultimately the manufacturing of the product. As one of the two assemblers stated, “I think communications and quality are better. We are more informed, and support for production is more responsive. Now, if you have a problem, it doesn’t take two days to get help.”

A second theme expressed during the interviews was that communication was nonexistent. During the interview process, six of the 13 assemblers, or 46% of participants, expressed the belief that, regardless of the implementation of a lean manufacturing system, things were still the same. This group defined “still the same” to mean communication was nonexistent and not happening at all. This group of assemblers did not focus on any specific quality that was lacking in communication. Rather, it was an all-encompassing belief expressed by the group that meaningful communication was nonexistent.

Observations. I observed that as a result of the lean implementation, the timeliness of communications improved. After the lean implementation, I observed a change was made and work instructions were communicated in daily group meetings held at the beginning of each shift. The meeting format gave assemblers an opportunity to discuss issues, ask questions, and received answers in a timelier manner. Prior to the lean implementation, group meetings were not held at the beginning of the shift.

Often, as a direct result of implementing a lean manufacturing system, an improvement in timeliness of communication is experienced. This is attributed to the more frequent and succinct communication required for support of lean manufacturing operations.

Conclusion. The theoretical unit of the perceived timeliness of communication was not supported by the data (Table 4). Timeliness of communication was positively supported based on the results from the questionnaire and my observations. However, the timeliness of communication was not perceived to have positively occurred by participants when interviewed. Rather, during the interviews, only 54%, or seven of the 13 assemblers, perceived positive changes in the timeliness of communication and higher-level communications. This is less than the 75% of participants required to indicate positive support.

During the interview process, the timeliness of communication was not positively supported by 46% of participants. The group perceived communication as the same as before the lean implementation. I was able to observe the communication meetings that were being held at the beginning of each shift. Assemblers participated in these meetings. Varied members of management and the support teams did not participate. It is possible that perceptions of communication as still the same may have been in reference to the absence of members of management and support teams members from the meetings. It is beyond the scope of this research, however, to make a determination and more research is required.

Theoretical Unit 3: Accurate Communication

Theoretical unit description. In lean manufacturing environments, work processes become highly interdependent. Accurate communication is required to coordinate activities and to avoid errors and delays in manufacturing processes.

Findings. For this study, indicators of the accuracy of communication are assessed based on the subjective perception of the participants. The methods and criteria used to assess changes in support based on an assembler’s perception of the changes in the accuracy of communication are outlined in Table 5. A more detailed explanation of the findings follows Table 5.

Table 5

Theoretical Unit 3: Findings for the Accuracy of Communication

Method	Criteria of Support	Findings of Support or Lack of Support
1. Relational Coordination Questionnaire	The weighted averages of the responses to questions on the survey are within the range of 3.00 to 4.00 on the Likert scale.	Support was negative. The weighted average of the response to Question 1 on the questionnaire was 2.81. This was not within the positive range of 3.00 to 4.00 on the Likert scale.
2. Interview	At least 75% of participants affirm or remain neutral in narrative that they perceive positive changes in the accuracy of communication.	Support was negative. Only 54% of assemblers interviewed expressed the belief that accuracy of communication had improved since the lean implementation. This is less than the required 75% for positive support.
3. Observations	Researcher affirms in narrative that positive changes in the accuracy of communications are perceived to have occurred.	Positive changes in the accuracy of communication were observed. After the lean implementation, communication meetings that included the opportunity for discussion were held at the beginning of each shift.

Relational Coordination Questionnaire. The results for Question 2 of the Relational Coordination Questionnaire address the topic of accuracy of communication. Based on the results of the questionnaire, support was not shown for the assemblers experiencing positive changes in their perceptions about the accuracy of communication after the lean implementation. Question 2 obtained a score of 2.81 which was below the minimum weighted average score of 3.00 required to show support. Table 2 reports the actual responses to the Relational Coordination Questionnaire.

Interview. There were two major themes expressed during the interview. The first theme expressed was that communications had improved. The assemblers in the group who believed that communication had improved perceived communication as improving in accuracy. As one operator stated, “Communication is better. It is much clearer and to the point.” Another assembler stated, “Communications are improving. Communication happens more often and is more effective.”

The second theme expressed was that, rather than being accurate, communication was nonexistent and not happening at all. Six assemblers, or 46% of the 13 participants, expressed that communication after the lean implementation communication was “still the same” and was nonexistent. During the interview, the focus of the group was on the absence of communication rather than on discussing or acknowledging any perceived qualities of communication.

Observations. I observed that, as a direct result of the lean implementation, the accuracy of formal communications to the production floor improved. Improvement in the accuracy of communication is common due to the needed increased involvement and interaction of members in organizations implementing lean methods. Further, more succinct and precise communication is required to support the more precise operational requirements of a lean manufacturing system. If accuracy of communications were not improved it would be evident, as the difficulty in avoiding errors and delays in the manufacturing process would be highly visible.

Conclusion. The theoretical unit of the accuracy of communication was not supported by the data (Table 5). I made positive observations concerning the accuracy of communication. However, based on the results of the questionnaire and individual interviews, the accuracy of communication was not positively perceived by assemblers. When interviewed, only 54%, or seven of the 13 assemblers, perceived positive changes in the accuracy of communication and higher-level communication. This is less than the 75% of participants required to affirm in narrative that they perceive positive changes in the accuracy of communication. Further, for the results of the questionnaire, Question 2 which pertained to the accuracy of communication obtained a weighted average score of 2.81. This was below the minimum weighted average score of 3.00 required to show support. Table 5 reports the actual responses to the Relational Coordination Questionnaire.

Summary of Findings of Higher Quality Communications

Relational coordination questionnaire. The Relational Coordination Questionnaire suggested negative support by the assemblers for the presence of higher quality communication. The theoretical unit of accuracy of communication scored a weighted average of 2.81. This score was below the minimum weighted average score of 3.00 which would indicate positive support by the assemblers. To indicate positive support, the theoretical units of frequency, accuracy, and timeliness of communication, which together comprise the elements of higher-level communication, must each receive a weighted average score of at least 3.00.

Based on lack of support by assemblers for the accuracy of communication, the absence of higher-level communication is suggested. Although it is premature to claim causality, the absence of higher-level communication does suggest, based on the relational theory of continuous improvement, that assembler participation in problem-solving activities and continuous-process improvement programs will remain at or near the levels experienced during the use of mass production techniques.

The theoretical units of frequency and the timeliness of communication scored above the weighted minimum average score of 3.00 suggesting positive support for these units by assemblers. However, for assembler participation in problem-solving and continuous-process improvement programs to be effective, a positive awareness at or above the minimum requirement of 3.00 must be present for all three of the theoretical units which comprise higher communication.

Interview. The results of the individual interviews do not support the presence of higher quality communication. During the interview process 54%, or 7 of the 13 participating assemblers, perceived that the lean implementation communication improved. This is less than the 75% of participants required to affirm in narrative that they perceive positive changes in communication. The results of the interviews indicate lack of support by assemblers for the presence of higher-level communication.

Further, six of thirteen assemblers interviewed, or 46%, expressed they perceived no improvement in communication and expressed the belief that communication was still the same as before the lean implementation. For this group, the theme of “still the same” was synonymous with higher-level communication being nonexistent. The group of assemblers who perceived and expressed communication as “still the same” minimally recognized any changes in the frequency, accuracy, or timeliness of communication during their individual interviews. These perceptions were absent. Rather, the group chose to focus on and verbalize their perception of lack of communication and contact with management and other members of the organization. They also expressed their feelings of being isolated in the production area. The lack of positive support for the elements of frequency, accuracy, and timeliness of communication indicate the absence of the elements of higher-level communication. The absence of higher-level communication suggests assemblers' lack of positive support for problem-solving activities and continuous-process improvement programs.

Observations. I observed that, because of recognized requirements to support the lean manufacturing system, communication became more accurate, frequent, and timely. Daily communications meetings were established and held at the beginning and end of each work day. During these daily meetings, work instructions were communicated and questions were asked and answered.

I observed that the operational requirements of a lean manufacturing system necessitated that the elements of accuracy, frequency, and the timeliness of communication be improved to some degree. Without positive changes in communication, the improved production capabilities that are commonly experienced when transitioning from mass to lean production methods could not be supported.

Theoretical Unit 4: Problem Solving

The theoretical units for this study were organized into the three major categories—communication, working relationships, and problem-solving activities which includes continuous improvement programs. Table 6 comprises data collected for the category of problem-solving activities.

Table 6

Relational Coordination Questionnaire-Problem Solving

	Unit	Question	Survey	Wt. Avg.	Strongly Agee	Agree	Disagree	Strongly Disagree
Problem Solving Unit 4	Problem Solving	11. My team frequently discusses ideas to improve production processes.	1	3.00	2	9	2	0
			2	2.92	1	10	2	0
			3	2.92	1	10	2	0
				2.94				
	Problem Solving	12. I am comfortable discussing my ideas for job improvements with my team members.	1	2.38	4	9	0	0
			2	2.54	5	8	0	0
			3	2.54	3	8	1	1
				2.48				
	Problem Solving	13. My team frequently organizes and holds problem-solving events.	1	2.38	0	5	8	0
			2	2.61	0	8	4	1
			3	2.54	0	7	6	0
				2.51				
	Problem Solving	14. My team has many new ideas for improvements that have not yet been implemented.	1	2.77	1	8	4	0
			2	2.92	1	10	2	0
			3	2.69	0	9		
				2.79				
	Problem Solving	15. My team is successful in implementing new ideas.	1	2.69	1	7	5	0
			2	2.69	0	9	4	0
			3	2.69	1	7	5	0
				2.69				

Note: Wt. Avg. = weighted average.

Theoretical unit description. Problem solving is the ability to interact and communicate with others in the recognition, analysis, and execution of perceived solutions to problems and to making improvements. Effective problem solving requires the ability to act based on the level of difficulty required to generate and implement solutions to the problem.

Findings. For this study, indicators for problem solving are assessed using the subjective perception of the participants. Table 7 outlines the methods and criteria used to assess changes in support based on an assembler's perception of the changes in problem solving activities and continuous improvement programs. A more detailed explanation of the findings follows.

Table 7

Theoretical Unit 4: Findings for Problem Solving

Method	Criteria of Support	Findings of Support or Lack of Support
1. Relational Coordination Questionnaire	The weighted averages of the responses to questions on the survey are within the range of 3.00 to 4.00 on the Likert scale.	Support was negative. The weighted average of the responses to Questions 11, 12, 13, 14, and 15 were not within the range of 3.00 to 4.00 on the Likert scale.
2. Interview	At least 75% of assemblers affirm in narrative that they perceive positive changes in problem-solving activities and continuous improvement programs.	Support was negative. Less than 75% of assemblers failed to express positive support for problem-solving activities and programs. Rather, 92% of assemblers believed problem-solving activities required improvement.
3. Observations	Researcher affirms in narrative that positive changes in problem-solving activities were observed.	Support was negative. Levels of problem-solving activities were observed to be unchanged and at levels prior to the lean implementation.

Relational Coordination Questionnaire. Questions 11 through 15 of the questionnaire were designed to collect data about an assembler's perception of their problem-solving activities with other team members and different facets of the organization. Questions 11, 12, and 14 of the questionnaire were designed to specifically collect data about group communication and working relationships centered on problem-solving activities. Question 13 of the questionnaire was designed to collect data about an assembler's perception of problem-solving activities as a collective exercise with other facets and members of the organization. Question 15 was designed to gain an understanding of the participant's perception of the organization's success in implementing new ideas.

Results of the questionnaire showed a lack of positive support for Questions 11, 12, 13, 14, and 15. Questions 11-15 comprised the entire problem solving section of the questionnaire. Each question of the problem solving section of the questionnaire failed to achieve the minimum weighted average score of 3.00 which indicated positive support. Table 6 reports the actual responses to the Questions 11 through 15 of the problem solving section of the Relational Coordination Questionnaire.

Interview. The interview process revealed an apparent lack of positive support by assemblers for problem solving and continuous improvement programs. Less than 75% of the required participants affirmed in narrative that they perceived positive changes in problem solving and continuous improvement programs. Rather, interview results showed that 92% or 12 of the 13 assemblers interviewed believed problem solving and continuous improvement programs were poor. Two common themes emerged during the interviews as possible solutions to improve problem solving and continuous improvement programs.

The first theme to emerge was the belief that more planned problem-solving opportunities and activities with management, engineering, and support teams would be beneficial. As one assembler stated, "We need more management involvement in the manufacturing areas. There is little interaction to solve problems. To work, it's got to be mutual. I get the impression that management thinks we are lying about problems or that we don't want to do the work." Or, as another assembler stated when commenting on the lack of opportunities to work with management, engineering, and support teams to solve problems, "We are told to develop solutions for problems but not all problems are solvable by assemblers. How do you solve those types of problems? They are not my problems to solve. What can you do?" The lack of formalized, joint problem-solving activities and implementation of newly created ideas was summarized by one assembler as follows, "There isn't an outlet for ideas. Good ideas just die. We get good ideas from our meetings. We can't implement. We don't have enough help or support."

The second theme that emerged and was expressed by assemblers was the belief that the attitude toward assemblers by the different facets of the organization would have to change before problem solving and continuous improvement programs could improve. The assemblers perceived there was a lack of trust and recognition by management engineers and the support team members that assemblers were capable of engaging in problem-solving activities and the creation of new ideas. Some assemblers expressed their belief that the negative opinions held by management, engineers, and support teams about the capability of assemblers was the basis for the lack of formally planned, joint problem-solving and continuous improvement activities.

One assembler stated, “You can talk to support teams but a lot of times they don’t listen. They often have an attitude toward assemblers that gets in the way of accepting new ideas. You’d have to change their attitude toward assemblers and that is hard to do. We don’t take time to get used to one another. Their attitudes hurt new ideas. We need to trust one another and get used to one another.” Or as another assembler stated when suggesting possible solutions to improve continuous improvement programs, “We need more opportunities to discuss ideas.”

The perceived lack of trust and partnership was further illustrated by a common and shared experience told by several assemblers during their interviews. Their same story, with some modification, was repeated to me by several assemblers as an illustration of how good ideas are lost.

In their story, the assemblers described how they shared what they believed to be a good idea with an engineer or support team member. The engineer or support team member would seem enthused and respond by telling the assembler they liked the idea and intended to implement it. As time passed, however, the engineer or support team member took no action to implement or communicate the idea to the rest of the organization. It eventually became apparent that the engineer or support team member did not intend to implement the idea. As a result, the assembler’s idea was just ignored.

In another slightly different version of the story, the engineer or support team member liked the idea and decided to implement it. In this version of the story, action was taken by the engineer or support team member to implement the idea. However upon implementing the idea, the engineer or support team member presented the idea to the rest of the organization as their idea rather than as the assembler's idea. As the story was told, although the idea was not ignored, no credit was ever given to the assembler.

As the assemblers told their story, they stated they perceived they were doing everything they could to invoke change under the current system. After they communicated their new idea, they believed themselves to be no longer responsible. Further, after a new idea was communicated, they perceived themselves to actually become powerless with no recourse other than to let their ideas be stolen or die.

The assemblers perceived the current problem-solving processes and procedures only allowed for the communication of a good idea. After the communication of an idea, the assemblers perceived themselves to be powerless, with little influence in the implementation, and hence the outcome of their ideas once they were communicated to others in the organization.

Observations. According to comments made to me and comments made by the assemblers to each other, the assemblers believed themselves to be very capable of creating new ideas within their assigned groups. However, the assemblers also perceived they had a passive role in problem-solving and continuous improvement processes within the organization. The assemblers often commented to me and discussed with each other their powerlessness and lack of responsibility for implementing the ideas they themselves created.

The assemblers seemed acutely aware of the limitations and barriers surrounding the creation of new ideas within the organization. A common theme expressed during the interview process was the desire to participate in formal planned problem-solving events with management and support teams. The desire for formal problem-solving activities seemed to be in an effort to overcome the barriers and limitations of the current problem-solving process. Formal problem-solving activities seemed to be viewed by the assemblers as a means to gain the trust of other facets and members of the organization by illustrating their ability to participate in problem-solving activities.

Summary of Findings for Problem Solving

Relational Coordination Questionnaire. According to results of the questionnaire, lack of positive support was shown for Questions 11, 12, 13, 14, and 15. Questions 11-15 comprised the entire problem solving section of the questionnaire. The results for Questions 11-15 were below the required minimum weighted average score of 3.00 (Table 6).

The findings in the problem solving section of the questionnaire support that problem-solving activities were not positively perceived by assemblers as improving. A score below 3.00 suggested that the levels of problem-solving activities and continuous improvement programs within the organization will not increase and will remain at or near levels experienced during the use of mass production techniques.

Interview. Ninety-two percent or 12 of the 13 assemblers interviewed believed that increased interaction between the different facets of the organization would be required for problem solving and continuous improvement programs to improve. The assemblers believed that they alone could not be effective in problem-solving activities. Although it is premature to interpret the results as causal, the themes that emerged during the interview process were similar to the findings of the Problem Solving section of the Relational Coordination Questionnaire. Both were supportive and predictive of the level of continuous improvement activity not increasing after the lean manufacturing implementation.

One of the major obstacles the assemblers perceived to achieving more effective joint problem-solving opportunities was the lack of trust by other members of the organization toward assemblers. The assemblers perceived that other members of the organization were biased and did not believe that assemblers were capable of positively contributing to collective problem-solving activities and the creation of new ideas.

Observations. My observations were based on interaction with the assemblers during the course of this study. I observed that there appeared to be a general dissatisfaction with problem-solving activity and continuous improvement programs. I also observed, but could not quantify for this research, that there was a minimal level of problem-solving activity and continuous improvement programs within the organization.

Conclusion. The questionnaire, interviews, and my own observations showed a lack of positive support for increased problem-solving activities and continuous improvement programs. The findings for the perceived presence by assemblers of an increase in problem-solving activities did not refute the relational theory of continuous improvement. However, it is premature to interpret the results as predictive of, or causal for, levels of problem-solving activity to be found in organizations that have completed a lean implementation.

I observed that there was an absence of a fostered sense of partnership and cooperation between the assemblers and other members of the organization for the creation and implementation of new ideas. Rather, a sense of isolation seemed to prevail. In contrast, a sense of partnership and an exchange of new ideas is a common occurrence in lean organizations; it is often observed in organizations with successful continuous improvement programs and problem-solving activities.

The lack of partnership seemed to promote the assemblers' perception that they were only responsible for creating new ideas but that they were not responsible for implementing new ideas. The assemblers perceived themselves as powerless and not in equal partnership with engineers and support team members in the implementation of new ideas.

Analysis of Theoretical Units-Higher Quality Relationships

The theoretical units for this study were organized into the three major categories—communication, working relationships, and problem-solving activities which included continuous improvement activities. Table 8 comprises data collected for the category of working relationships which includes the theoretical units of shared knowledge, mutual respect, and shared goals.

Table 8

Relational Coordination Questionnaire—Working Relationships

		Question	Survey	Wt Avg.	Strongly Agee	Agree	Disagree	Strongly Disagree
Higher Quality Relationships	Shared Knowledge	6. My team members and I frequently share information about the new things we learn on the job.	1	2.92	1	10	2	0
			2	2.92	2	8	3	0
			3	3.07	3	8	2	0
				2.97				
	Mutual Respect	7. My team members respect each other.	1	3.07	2	10	1	0
			2	2.92	1	11	0	1
			3	2.76	2	9	1	1
				2.91				
	Shared Goals	8. My team members cooperate with each other.	1	3.00	1	11	1	0
			2	3.00	1	11	1	0
			3	3.00	1	11	1	0
				3.00				
	Shared Goals	9. My team members care about the success of our team.	1	3.07	2	10	1	0
			2	3.15	2	11	0	0
			3	3.31	4	9	0	0
				3.17				
	Mutual Respect	10. I am treated fairly and equally by my team members.	1	3.08	2	10	1	0
			2	2.85	0	12	0	1
			3	3.00	2	10	0	1
				2.97				

Note. Wt. Avg. = weighted average.

Theoretical Unit 5: Shared Goals

Theoretical unit description. Through the continued development of relationships, participants create bonds which allow for the creation of shared goals for the execution of work processes. With shared goals, participants can more easily come to conclusions about how to respond and execute work processes as new information becomes available.

Findings. For this study, indicators for shared goals are assessed according to subjective perception of the participants. The methods and criteria used to assess changes in support, based on an assembler's perception of the changes in shared goals, are outlined in Table 9. A more detailed explanation of the findings follows.

Table 9

Theoretical Unit 5: Findings for Shared Goals

Method	Criteria of Support	Findings of Support or Lack of Support
1. Relational Coordination Questionnaire	The weighted averages of the responses to questions on survey are within the range of 3.00 to 4.00 on the Likert scale.	Support was positive. The weighted averages of the responses to Question 8 and 9 were within the range of 3.00 to 4.00 on the Likert scale. The weighted score for question 8 was 3.00, and the weighted score for question 9 was 3.17.
2. Interview	At least 75% of participants affirm in narrative that they perceive positive changes in the sharing of goals by team members.	Support was negative. The required 75% of participants did not affirm they perceived positive support for shared goals. However, 10 of the 13 participants interviewed expressed a strong camaraderie with other assemblers. This may infer support for shared goals.
3. Observations	Researcher affirms in narrative that positive changes in goal sharing by team members have occurred.	Support was positive. A strong reliance on other members of the assembler group was witnessed to be present.

Relational Coordination Questionnaire. The results from Questions 8 and 9 of the Relational Coordination Questionnaire address different aspects of the topic of shared goals. Question 8 was designed to gain an understanding of group support for working together toward shared goals. Question 9 was designed to gain an understanding of group support for the achievement of shared goals.

Results of the questionnaire showed positive support for Question 8. Question 8 obtained the minimum weighted average score of 3.00 indicating assemblers' positive support for working together toward shared goals.

Question 9 on the questionnaire had a weighted average score of 3.17. A weighted average score of 3.17 indicates positive support by assemblers of their team members' attitudes and caring about the success and achievement of the team. Table 8 reports the actual responses to the Relational Coordination Questionnaire.

Interview. During the interview process, the assemblers did not directly address in narrative the topic of shared goals. Rather, 10 of the 13 assemblers or 76% of participants expressed camaraderie and a bond with their fellow assemblers based on shared experiences. As one assembler commented, "I still rely on the same operator group." Or as another assembler commented, "I mostly communicate with my team." It is possible that shared experiences and an expressed strong sense of camaraderie by assemblers may infer the presence of shared goals. However, the results for this research are inconclusive and more research would be required.

Observations. Assemblers appeared to identify and acknowledge the presence of strong working relationships among members of the assembler group. Shared goals seemed to be present and expected based on the level of camaraderie and shared experiences among the assemblers.

Although shared goals among the assembler group seemed to be present, shared goals with other members within the organization such as support team and management appeared weak. Other than the profitability of the business, an awareness of organizational goals by assemblers was not expressed or acknowledged during the interview process.

Conclusion. As shown in Table 9 the theoretical unit of shared goals was not supported by this research. Individual interviews showed a lack of positive support for shared goals by assemblers. However, I observed positive shared goals among individuals and working teams. During the interview process, 10 of the 13 assemblers or 76% of participants focused on and expressed camaraderie with their fellow assemblers implying the presence of shared goals and experiences.

Theoretical Unit 6: Shared Knowledge

Theoretical unit description. A bond is created when participants share knowledge regarding each other's task and how each task fits together. Such interaction provides a context for knowing who will be impacted by a change in work processes and who needs to know about any changes and with what priority and urgency.

Findings. For this study, indicators for shared knowledge are assessed according to subjective perception of the participants. The methods and criteria used to assess changes in support based on an assembler's perception of the changes in shared knowledge are outlined in Table 10. A more detailed explanation of the findings follows.

Table 10

Theoretical Unit 6: Findings for Shared Knowledge

Method	Criteria of Support	Finding of Support or Lack of Support
1. Relational Coordination Questionnaire	The weighted averages of the responses to questions on survey are within the range of 3.00 to 4.00 on the Likert scale.	Support was negative. The weighted average of the response to Question 6 on the questionnaire was 2.97 and not within the required range of 3.00 to 4.00 on the Likert scale.
2. Interview	At least 75% of participants affirm in narrative that they perceive the positive sharing of knowledge by team members.	Support was negative. Seventy-five percent or more of assemblers did not specifically express any recognition of or support for shared knowledge.
3. Observations	Researcher affirms in narrative that positive changes in the sharing of knowledge by team members are perceived to have occurred.	Support was negative. It was observed that at times assemblers viewed knowledge as a means to secure their job and position.

Relational Coordination Questionnaire. Question 6 of the questionnaire addresses the topic of shared knowledge. Question 6 was designed to gain an understanding about group interaction and the support for shared knowledge.

Results of the questionnaire indicated a lack of positive support for the sharing of knowledge. A weighted average score of 2.97 was obtained for Question 6. A weighted average score of 2.97 is below the required minimum weighted average score of 3.00 for indicating positive support. Table 8 reports the actual responses to the Relational Coordination Questionnaire.

Interview. Comments specifically directed toward shared knowledge were not expressed by assemblers during the interview process. Rather, 10 of the 13 assemblers participating, or 76 %, voiced a sense of shared experience or relatedness with their fellow assemblers or team members. Comments such as, "I rely on the same operator group" were frequently made.

Observations. I observed that the open sharing of knowledge among members of the assembler group appeared at times to be difficult. Knowledge appeared to be viewed as a means to secure one's personal position or employment rather than using one's knowledge to contribute to the well-being and goals of the group. Subsequently, at times, knowledge was not readily shared.

Conclusion. The assemblers lacked positive support for the presence of shared knowledge (Table 10). Question 6 of the questionnaire obtained a weighted average score of 2.97. This was below the minimum weighted average score of 3.00 that is required to indicate positive support. Comments that were directed toward the presence of shared knowledge were not expressed by assemblers during the interview process. Rather, 10 of the 13 assemblers participating, or 76 %, voiced a sense of shared experience or relatedness to their fellow assemblers or team members. However, I observed that knowledge was not shared. At times, knowledge was viewed as a means to secure one's job.

Theoretical Unit 7: Mutual Respect

Theoretical unit description. Higher quality relationships depend upon the respect that participants have for the roles played by the other participants in the same work process. Respect for each others' competencies creates a bond that is part of the basis for the development of higher-level work relationships.

Findings. For this study, indicators for mutual respect are assessed based on the subjective perception of the participants. Table 11 outlines the methods and criteria used to assess changes in support based on an assembler's perception of changes for mutual respect. A more detailed explanation of the findings follows.

Table 11

Theoretical Unit 7: Findings for Mutual Respect

Method	Criteria of Support	Finding of Support or Lack of Support
1. Relational Coordination Questionnaire	The weighted averages of the responses to questions on survey are within the range of 3.00 to 4.00 on the Likert scale.	Support was negative. The responses to Questions 7 and 10 were not within the range of 3.00 to 4.00 on the Likert scale. The weighted average for Question 7 was 2.91, and the weighted response for Question 10 was 2.97.
2. Interview	At least 75% of participants affirm in narrative that they positively perceive support for mutual respect.	Support was negative. Seventy five percent of participants did not affirm positive support for mutual respect. Only 1 of the 13 assemblers or 7% commented positively on the topic of mutual respect.
3. Observations	Researcher affirms in narrative that mutual respect is perceived to be present in group relationships.	Support was positive. Mutual respect among members of the assembler group appeared to be present but mutual respect between the assemblers and other groups within the organization appeared to be weak.

Relational Coordination Questionnaire. The results from Questions 7 and 10 of the Relational Coordination Questionnaire address different aspects of the topic of mutual respect. Question 7 was designed to gain an understanding of an individual assembler's perception of the mutual respect present in their working relationships. Question 10 was designed as an attempt to gain an understanding of an individual's perception of the social climate for fostering mutual respect among the assembler population.

Results of the questionnaire showed that Question 7 obtained a weighted average score of 2.91 which is below the minimum weighted average score of 3.00. A weighted average score of 2.91 indicates negative support for the presence of mutual respect in working relationships.

Based on the results of the questionnaire, a weighted average score of 2.97 was obtained for Question 10. A minimum weighted average score of 2.97 indicates negative perceptions about social climate for fostering mutual respect among assemblers. Table 8 reports the actual responses to the Relational Coordination Questionnaire.

Interview. Less than the required 75% of participants affirmed in narrative that they positively perceived the presence of mutual respect among the assembler group. One of the 13 assemblers specifically expressed lack of support for the presence of mutual respect among assemblers by stating, “How do you improve when people are crabby to you 365 days a year? How can you trust them?”

During the interviewing process, the majority of assemblers did not specifically comment on trust and mutual respect issues in their working relationships with other assemblers. Rather, 54%, or 7 out of 13 assemblers, cited perceived mutual respect issues in their working relationships with management and support groups. As one assembler stated, “To work, it must be a joint effort. It's got to be mutual.”

Observations. Mutual respect among members of the assembler group appeared to be present. As a consequence, mutual respect seemed to be expected and a normal part of group life. However, while mutual respect among members of the assembler group seemed commonplace, mutual respect between the assemblers and members of other groups within the organization such as support teams and management appeared weak.

Conclusion. Mutual respect was not positively supported by assemblers according to results of the questionnaire (Table 11). The weighted average response of 2.91 for Question 7 and 2.97 for Question 10 on the questionnaire were not within the range of 3.00 to 4.00 indicating positive support on the Likert scale. The required 75% of participants did not positively affirm in narrative that they perceive support for mutual respect. During the interviewing process, the majority of assemblers did not specifically cite trust and mutual respect issues. Rather, they expressed experiencing a strong sense of camaraderie in their working relationships with other assemblers.

Based on my observations, mutual respect was perceived positively among the assembler group. However, mutual respect between the assemblers and members of other groups within the organization, such as support teams and management, appeared weak.

Summary of Findings of Higher Quality Relationships

Relational Coordination Questionnaire. The results for the presence of higher-level relationships were not supported by the results of the questionnaire. Questions 6, 7, and 10 fell below the minimum positive weighted average score of 3.00 indicating a lack of support.

The weighted average score for Question 6 was 2.97 which indicated lack of support for shared knowledge. Question 7 had a weighted average score of 2.91 which was below the minimum positive score of 3.00. Question 10 was also slightly below the minimum positive score of 3.00 with a weighted average of 2.97 which indicated a lack of support for mutual respect.

Proposition 2 of the relational theory of continuous improvement states that a score below the minimum score of 3.00 indicates that the levels of continuous-process improvement will not increase after the implementation of lean methods and will remain at or near the same levels experienced during the use of mass production techniques. Table 8 reports the summarized weighted averages for the responses to the questions of the Working Relationship section of the Relational Coordination Questionnaire.

Interview. The results for the presence of higher-level relationships were not supported by the results of the interviewing process. The required 75% of participants did not affirm in narrative that they perceive positive support for shared knowledge, shared goals, or mutual respect.

Observations. To support lean manufacturing operations, changes in working relationships are required. Commonly, a lean implementation creates an opportunity for increased production volumes and an increase in the number of products being produced. To support such increases, changes in working relationships in the form of cooperation and participation are to be expected. Many of the assemblers that participated in this research worked together for years, and the lean implementation appeared to have changed their required level of interface and depth of their social interaction.

While changes in working relationships occurred, however, they did not appear substantial enough to facilitate positive changes in problem-solving and continuous improvement programs. The group perception of a lack of partnership and cooperation with other facets of the organization may indicate phenomenon not addressed by this research. The perception of positive relationships in assembler teams, coupled with perceptions of lack of cooperation and lack of partnership with other members of the organization warrant further study. Such research may assist in developing a deeper understanding of the working relationships for successful lean operations and continuous improvement efforts.

Theoretical Unit 8: Preferred Relationships

Theoretical unit description. A preferred relationship is defined for this research as an assembler's preference for association and social interaction with other assemblers within the assembler group. The existence of a preferred relationship is subjective and is identified and communicated by the assembler. Once an assembler identifies a relationship with another assembler a link is assumed to exist between the two.

Findings. For this study, positive support for the development of higher-level working relationships and higher-level working relationships based on an increase in preferred relationships was not supported. There were increases as well as decreases in comparisons between the August and November data. The methods and criteria used to assess changes in support based on an assembler's changes in preferred associations are outlined in Table 12. A more detailed explanation of the findings follows Table 12.

Table 12

Theoretical Unit 8: Findings for Preferred Relationships

Method	Criteria of Support	Finding of Support or Lack of Support
1. Sociogram Questionnaire	An increase in the number of times an assembler is selected as a preferred association and is linked to another assembler as a social preference.	Support was negative for an increase in social relationships. For the November time period there was an increase from 8 to 12 assemblers in the 0-3 links per assembler group. However, in the same time period, there was a decrease from 10 to 8 assemblers in the 4-8 links per assembler group. In the 9+ links per assembler group, the number of assemblers remained the same.
2. Observations	Researcher’s perception of the social preferences and the change in the preferred associations of assemblers.	I observed that there was increased interaction and association among the assemblers after the lean implementation. Lean production methods appeared to create a necessity for more frequent interactions. This in turn led to an apparent deepening of work relationships and social ties among assemblers which appears to have manifested in a strong sense of camaraderie. However at the same time, the assemblers appeared to have minimal ties with support groups and management.

Use of sociograms. For this research, the sociogram method was used to gain knowledge about the changes in assembler relationships based on the development of higher-level relationships and higher-level communication. On the Sociogram Questionnaire, each participant was asked to state with whom, among group members, did he/she prefer or not prefer to associate for specific work-related activities. Keyhubs™ software was used to calculate the number of social connections or links per individual from the responses on the Sociogram Questionnaire. Keyhubs™ is a software program designed specifically for social network analysis and calculates the number of connections per assembler.

Commonly, when using the sociogram method, a map which pictorially discloses the structure and social preferences of the group is produced. However for this research, a pictorial map was not used. Rather, the number of links and changes in the number of links per assembler was chosen for analysis and presentation.

For this research, the Sociogram Questionnaire was administered twice during the 90-day data collection period. During the 90-day period, the questionnaire was administered to participants at the beginning of the study in August of 2009 and at the end of the study in November of 2009. During each period, the questionnaire was administered to each of the 13 assemblers participating in the study.

The August administration of the questionnaire took place immediately after the informational meeting informing the assemblers about the study and the signing of the consent form signifying their agreement to participate in the study. During the November visit, the Sociogram Questionnaire was included and administered during a private 20-minute meeting with each participant.

The Sociogram Questionnaire included six questions about preferences for association of the assemblers in work-related and social activities [Appendix A]. The questions requested information about an assembler's positive and negative preferences for association.

Depending on the question, an assembler was asked to choose and write in the names of three individuals with whom they preferred or did not prefer to interact. Although three names were requested, it was not mandatory that three names be submitted by an assembler.

In some instances, the participant chose to answer the question by submitting only one or two names. In other instances, the participant chose not to answer any questions seeking information about negative associations. Due to the variation in the number of choices made by each assembler, the number of associations and links tabulated for each administering of the sociogram was not consistent.

Upon completion of the Sociogram Questionnaires, the results were compiled using Keyhubs™ software. Keyhubs™ software was used to total the number of times an assembler was chosen by another assembler as a preferred association or social link. In some instances, assemblers participating in the study chose, as a preferred association, assemblers who were not participating in the study. To protect the confidentiality of all participants, as well as those individuals selected by participants, all names were assigned a randomly generated number selected by the Keyhubs™ program.

Sociogram Questionnaire. Using responses to the Sociogram Questionnaire, the number of times an assembler was chosen as a preferred social link was calculated by the Keyhubs™ software. The data was then organized into three naturally occurring groupings. The groupings were based on the naturally occurring clustering of the number of social links obtained per assembler. The first group formed was those assemblers who obtained 0-3 social links. The second group formed was those assemblers who obtained 4-8 social links. The third group was those who obtained 9 or more than 9 social links. A comparison was then made of the number of assemblers in each specific group in the August and November time periods (Figure 5).

Sociogram: Number of Social Links Per Assembler.

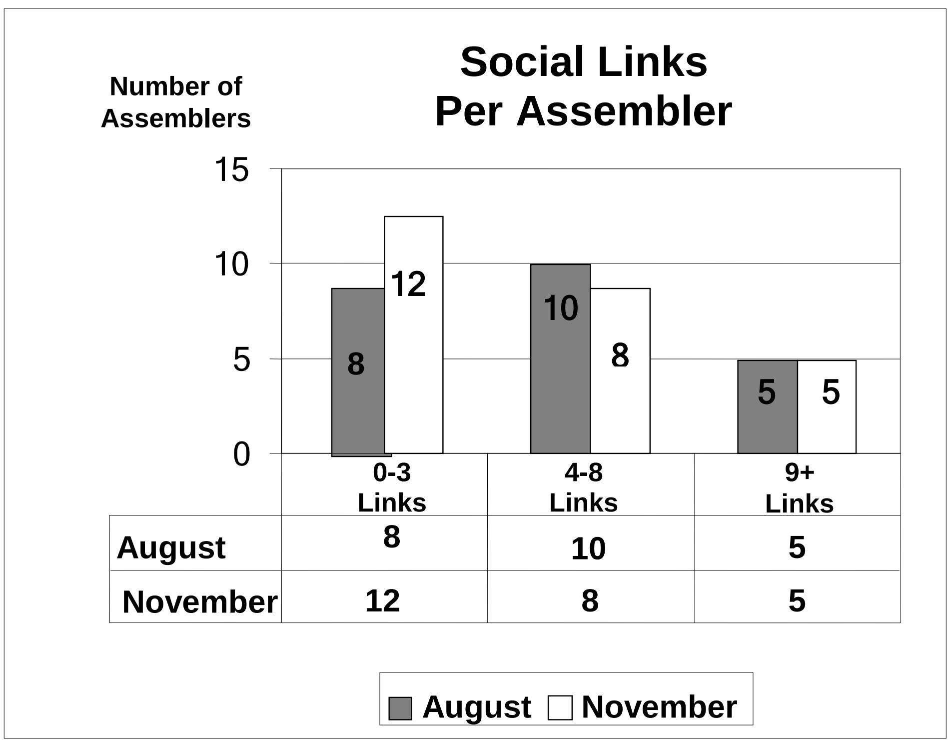

Figure 5. Sociogram: number of social links per assembler.

When comparing the results of the August and November data, the number of assemblers who obtained 0-3 links increased from eight assemblers in August to 12 assemblers in November. Further, when comparing the August and November time periods, the number of assemblers who obtained 4-8 links decreased from 10 assemblers in August to eight assemblers in the November period. In both time periods, the number of assemblers who obtained a higher number of links or 9+ links remained the same at five assemblers.

A comparison of the August and November time periods showed there is no decisive or definitive trend for an increase or decrease in the number of preferred social links acquired by each per assembler. The results are inconclusive.

Observations. I observed a change in communication and social interaction among the assembler population as a result of the requirements of lean manufacturing methods and need for working in a team structure. In comparison to mass production methods, I observed that lean methods created a need for more frequent interactions and as a result there appeared to be a deepening of work relationships and social ties among assemblers.

Changes in the communications and working relationships among the assemblers were observed to manifest in a strong sense of camaraderie and group identity. In contrast, it was observed that support team members and management were not perceived by assemblers to be included in the changes and deepening of working relationships that took place in the assembler group after the lean implementation.

Conclusions. I observed a deepening of working relationships among the assemblers. However, the observed changes were not captured and reflected in the Sociogram Questionnaire analysis. The results of the Sociogram Questionnaire were negative as there was not a positive increase in the number of all relationship groupings.

Findings for the Relational Theory of Continuous Improvement

This research is unique in that the relational theory of continuous improvement was not the primary focus of this research. Rather, the focus of this study was to determine the effectiveness of the application and execution of research methods in measuring and assessing the development of cultures of continuous improvement in lean manufacturing environments. This study was an attempt to gain new knowledge about the effectiveness of the use of questionnaire, interview, sociogram, and observation research methods to assess and monitor the development of a culture of continuous improvement. In order to test the effectiveness and application of research methods, I developed and tested the relational theory of continuous improvement for this study. Subsequently, the data to support the theory was not collected in abundance and was of secondary concern. However, it should be noted that a lack of support for increased problem solving and continuous process improvement activity was suggested based on the findings of this study.

The relational theory of continuous improvement states continuous improvement activities are forms of highly interdependent work that, in order to take place, requires the presence of higher-level communication and higher-level work relationships. If an assembler is not able to perceive and participate in higher-level communication and develop higher-level work relationships, problem solving and continuous process improvement activity will remain at or near the levels experienced prior to the lean implementation and while using mass production techniques.

The findings of this research demonstrate that the relational theory of continuous improvement was not refuted. The available data from this research suggests a lack of positive support by assemblers for problem solving and continuous improvement activities and a lack of support for higher-level communication and higher-level work relationships.

Findings for the Effectiveness of Research Methods

The primary focus of this research was to assess effective research methods for use in a lean manufacturing environment. Choosing research methods that can be executed in a timely manner to collect data in a manufacturing environment is fundamental to the success of conducting research in a manufacturing environment.

Timeliness and effectiveness were critical elements in the choice of research methods for this project. This is due to the continuous nature of manufacturing processes and the limited availability of assemblers to participate in research activities. In support of the completion of this research in a more timely and efficient manner, it was beneficial to include guidelines for identifying and eliminating waste and nonvalue-added activities from the processes and procedures of this project. Subsequently, included in the Effectiveness of Research Methods section of this report is an analysis of and recommendations for improvements based on the Seven Wastes of Lean Research as applied to the processes and procedures of this research project.

The seven wastes of lean research. The Seven Wastes of Lean Research is an analytical framework I specifically developed for this research. Its purpose was to aid in the analysis of the research question by improving the timeliness and efficiency of the study by assisting in the identification of waste and nonvalue-added activities in the processes and procedures of this research. Further, The Seven Wastes of Lean Research was used in this research to recommend improvements for future studies about the relational theory of continuous improvement.

The Seven Wastes of Lean Research assisted in the identification of activities that, by definition, add cost and time but not value to research processes and procedures. Identifying waste and nonvalue-added activities in the processes and procedures of this research created the potential for increased efficiency (Tapping, & Dunn, & Fertuck, & Baban, 2010). Increased efficiency often results in a decrease in cost and time and, at the same time, an improvement in the overall quality of the end products of a project (Tapping & Shuker, 2003). Table 13 is a summary of the types of possible waste identified in the Seven Wastes of Lean Research model and applied for this research.

Table 13

The Seven Wastes of Lean Research

The Seven Wastes	Definition	Examples
Overprocessing	Researching and collecting data or information that does not add value or data that cannot be effectively processed	Excessive data collection and research Collecting unnecessary data or information
Unnecessary Transportation	Travel of people, equipment, or materials that do not result in added value to the project	Unnecessary or excessive visits to the data collection site The nonvalue- added movement of people, material, and equipment from one data collection site to another
Unnecessary or Excess Motion	Movement or actions of people, paper, or electronic exchanges that does not result in added value to the project	Unnecessary time spent at the research site Unnecessary maintaining, sorting, or organizing of materials or information
Waiting	Idle time is created when information, people, equipment, or materials are not ready	Waiting for information Waiting for people Waiting for equipment set up Waiting for materials
Inappropriate Processing	Use of complex and more costly methods or processes when simpler methods would be sufficient	The choice of more complex methods encourages their overusage and often results in over processing and additional costs
Unnecessary Inventory	More information, people, equipment, or materials obtained than required or needed for right now	The presence of unnecessary information, people, equipment, and materials in the data collection period and the pre- and post-data collection period
Rework	Work that contains errors, defects, mistakes, or lacks something necessary (includes all work required in creating and correcting the mistake)	Process or procedure failures or inconsistencies

Effectiveness of Questionnaire Method

Assessment of method: questionnaire. A questionnaire is a written document often used to gather information about subjective perceptions, attitudes, beliefs, values, and perspectives (McMillian, 2004). My observations about the use of the questionnaire method were used to assess the effectiveness of the questionnaire method for this research. In addition, the Seven Wastes of Lean Research (Table 13) was applied to the use of the questionnaire to determine the presence of nonvalue-added activities. Based on the nonvalue-added activities identified, I was able to make suggestions for improvements in the future use of the questionnaire method for this research. Table 14 includes a summary of the assessment of the questionnaire method as it was used for this research.

Table 14

Assessment of the Questionnaire Method

Method	Empirical Indicators	Assessment
1. Questionnaire: Relational Coordination Questionnaire	Researcher's experience of the use of the questionnaire method to changes in an assembler's perception about changes in communications, work relationships, and problem-solving activities.	The use of the questionnaire proved to be an effective tool. However, due to its lower reliability, a questionnaire should not be used as a stand-alone method for this research.
2. Application of the Seven Wastes of Lean Research	Analysis of nonvalue-added activities and waste in the use of questionnaires by applying the Seven Wastes of Lean Research criteria.	Upon analysis, instances of overprocessing, unnecessary transportation, and unnecessary motion were identified in the processes and procedures of the use of questionnaires.

The questionnaire proved to be an effective tool for collecting data to assess the changes in an assembler's perception about changes in communication, working relationships, and problem-solving activities. The questionnaire developed for this research consisted of short, close-ended statements, and measured noncognitive changes in an assembler's perception. The use of the questionnaire had several advantages that proved beneficial during this research project.

First, the use of a questionnaire was relatively inexpensive and did not require as much administrative effort as some of the other methods used in the study. Compared to other methods, rapid turnaround time and standardized answers made the questionnaire an efficient means to compile data.

Secondly, the use of questionnaires proved a highly suitable tool for gathering data in a manufacturing environment. The paper and pencil administration of the questionnaire made the administration process flexible and made it possible to administer the questionnaire to assemblers in any area of the manufacturing facility at any time. This was beneficial given the limited availability of assemblers to participate in research projects.

However, there are also potential reliability issues in the use of the questionnaire method. The standardized answers so commonly used in questionnaires may limit responses. It was difficult for me to determine if this was the case. Further, respondents must be able to read the questions, comprehend the questions, and respond to the questions. A researcher cannot easily detect such situations.

In general, noncognitive questionnaires are perceived to have a lower reliability and less evidence for validity. This is due to the fact that there is no way to confirm the opinion expressed is actually the opinion of the assembler. Because of its lower reliability, a questionnaire should not be used as a stand-alone tool for this research.

Assessment of the seven wastes of lean research: questionnaires. The following is an application of the Seven Wastes of Lean Research criteria to identify nonvalue-added activities and waste in the questionnaire processes and procedures for this research project. The criteria of Seven Wastes of Lean Research is outlined in Table 13.

Overprocessing and unnecessary transportation. I identified overprocessing and unnecessary transportation activities while I was administering the questionnaire. The Relational Coordination Questionnaire was administered three times during this research project. The sole purpose of my October visit to the research site was to administer the second Relational Coordination Questionnaire. The second administration of the questionnaire appears to have added little value, if any, to the overall results of this research. The second administration of the questionnaire should be eliminated from future research designs. Upon review of the processes and procedures for administering the questionnaire, administering the questionnaire during the informational meeting and at the beginning of the study to those who decide to participate and at the end of the study during the meeting for conducting the individual interview would suffice.

Overprocessing and unnecessary motion. Nonvalue-added activities were identified based on the type of questions included in the major sections of the Relational Coordination Questionnaire for this research. In some instances, several questions were used to inquire about the same aspect of a theoretical unit. The use of more than one question to inquire about the same aspect of a theoretical unit appears to be a nonvalue-added activity which could be classified as overprocessing and unnecessary motion.

Summary of the use of the questionnaire method. The questionnaire is an efficient and effective research method for use in a manufacturing environment. The paper and pencil administration of the questionnaire makes the use of the questionnaire flexible and easy to administer to assemblers at any time, in any area of the manufacturing facility. Further, the flexibility of the questionnaire method is enhanced because of rapid turnaround time and standardized answers which makes compiling the data efficient.

The negative feature inherent in the sole use of a questionnaire is the lack of confirmation that the opinion an assembler chose to express in selecting his answer is indeed actually his or her opinion. Difficulty in verifying the opinions of the participants is the reliability and validity issue inherent in the questionnaire method. The questionnaire method, because of the inherent reliability and validity issues, should not be used as a singular or stand-alone method for this research.

Effectiveness of Interview Method

Assessment of method: interview. The purpose of an interview is to engage another in dialogue to find out what is in their heart and mind. An open-ended interview is based on the assumption that the perspective of others is meaningful and knowable and is able to be communicated (Patton, 1990).

For this research, I used observations and the Seven Wastes of Lean Research (Table 13) to assess the effectiveness of the interview method. Suggestions for improvements the use of the interview method for this research will be made using the identified nonvalue-added activities. Table X is a summary of the assessment of the questionnaire method as it was used for this research.

Table 15

Assessment of the Interview Method

Method	Empirical Indicators	Assessment
1. Interview	Researcher's experience in the use of interview methods to assess an assembler's change in perception about changes in communications, work relationships, and problem solving activities during an organization's transition from mass to lean manufacturing methods	The use of a short, semi structured, 2-question interview proved to be an effective tool for gaining a deeper understanding of changes in the perceptions of the assemblers.
2. The Seven Wastes of Lean Research	Analysis of value-added activities of the use of interview methods by applying the Seven Wastes of Lean Research criteria	Upon analysis, an instance of unnecessary transportation was identified in the processes and procedures of the use of the interview method.

The use of the interview method for this research proved to be an effective tool for gaining a deeper understanding of an assembler's perception of the changes in communication, working relationships, and problem-solving activities. Using the interview method allowed me to obtain information about the questions being asked. At the same time, the use of the interview method also created the possibility of obtaining unexpected significant information.

Given the continuous nature of the work environment and the limited availability of the assemblers to participate in the interview process, I needed to design the interview process to be as effective and efficient as possible. Because of the limited availability of the assemblers, I deemed it most effective to keep the assembler interviews short and no more than 15-minutes in length. Further, to obtain the most information in the shortest period of time, the interview format consisted of two questions designed to be delivered in a semi-structured format.

Keeping the interviews short made it practical to take handwritten notes during the interview and contributed to minimizing overall transcription time. Although care was taken to capture data accurately, the accuracy of the interview data was a concern as the choice was made to not use a recording device.

The practice of not using a recording device seemed of greater benefit. Not using a recording device seemed to make the assemblers feel more comfortable and less guarded in their conversation. Further, not using a recording device contributed to the overall efficiency and success of the interview process.

Assessment of the seven wastes of lean research: interview. The following is an application of the Seven Wastes of Lean Research criteria to identify nonvalue-added activities and waste in the interview processes and procedures for this research project. The criteria for the Seven Wastes of Lean Research is outlined in Table 13.

Unnecessary transportation. The interviews were conducted in a private conference room located on the other side of the facility. To participate in the interview process, assemblers were required to leave the manufacturing area and travel to the conference room. Traveling from the production area to the conference room required time; in future research projects, unnecessary transportation could be minimized by arranging to conduct interviews in a private setting as close to the manufacturing area as possible.

Summary of the use of the interview method. The use of the interview method was an effective method for this research. Conducting the interviews in a short and semi structured format proved to be a highly effective approach.

The use of a short two-question interview presented in a semi structured format allowed the maximum amount of information to be obtained in a very short time period. Further, the shorter interview period made handwritten notes possible which simplified the transcription process.

The information obtained from the interview process was of value in two primary ways. First, the information obtained during an interview often had the potential of creating new insights into the subject being studied. Such insights can influence the design and development of theory for current and future projects concerning this research.

Second, the interview data contributed to the process of the triangulation of the data. The triangulation of data occurs when cross-verification of data from two or more sources is possible. Such an occurrence is desirable because confidence in the research is increased if different methods lead to the same result.

In the case of this research, the data from the Relational Coordination Questionnaire validated the data from the interview process and vice versa. The data collected from each method suggested that the assemblers did not positively perceive or positively support the presence of higher-level communication, working relationships, or problem-solving activities, and continuous improvement programs.

Effectiveness of Observation Method

Assessment of method: observation. Unlike questionnaires and interviews, observations do not rely on a participant's self-reports. Rather, observations are made by the researcher and yield firsthand data in the research process. The observation method allows the researcher to take into account contextual factors that may influence the interpretation and use of results *(*McMillan, 2004*)*.

During the observational process for this research, I was required to witness behavior and make inferences about its meaning. A correct interpretation of what is observed depends on the judgment of the researcher. Because the interpretations are based on the judgment of the researcher, it is critical that the researcher be competent in the task being observed. Further, it is also important that the researcher be as unbiased as possible.

For this research, I used subjective experiences and observations that were made during the research process and the Seven Wastes of Lean Research (Table 13) to assess the effectiveness of the observation method. I made suggestions for improvements in the future use of the observation method for this research using my observations and the nonvalue-added activities I identified.

Table 16

Assessment of the Observation Method

Method	Empirical Indicators	Assessment
1. Observation	The researcher, using her competency, knowledge, and experience, gives meaning about the changes in an assembler's perception about communications and work relationships during an organization's transition from mass to lean manufacturing methods.	The use of the observational method was effective in creating and adding to the knowledge about the changes in activities and behaviors in the transition to a lean manufacturing system.
2. The Seven Wastes of Lean Research	Analysis of value-added activities of the use of observation methods by applying the Seven Wastes of Lean Research criteria	The application of the Seven Wastes of Lean Research was not specifically designed for internal cognitions. However, the model could be used to develop formal external guidelines for making observations.

For this research, use of the observational method was effective in creating and adding to the knowledge about the changes in activities and behavior in the transition to a lean manufacturing system. Observations about the lean manufacturing system required that the researcher give meaning to what was being observed. This required that the researcher be competent and have knowledge about the subject matter.

In the case of this research, I had a degree of competency. I am formally trained in manufacturing management techniques and have 30 years of manufacturing experience. I am certified in lean manufacturing methods at the Bronze Level by the Society of Manufacturing Engineering and have completed APICS the Association for Operations, CPIM certification. Further, I was familiar with the hosting organization's manufacturing processes and procedures. However, without the use of caution, familiarity may serve to increase the occurrence of bias in making observations. Bias is the most common error in observational research and occurs because of the researcher's background and expectations.

In the case of this research, I was at one time employed by the hosting organization for a period of three years and had previous working relationships with the assemblers. It would be inappropriate to say that I was totally without bias. Attempts were made to minimize bias through increased awareness and the triangulation of data from the Relational Coordination Questionnaire, interview process, and sociograms.

Assessment of the seven wastes of lean research: observation. The Seven Wastes of Lean Research was developed to assist in the identification of nonvalue-added activities incorporated into the processes and procedures of the scientific methods chosen for this study. Processes and procedures are objective in nature and most often take place external to the researcher. However, in the case of the observation method, the result of the observational method takes place within the cognition and experience of the researcher. The observational method differs from most other scientific methods in that the method is subjective in nature and based on the internal cognitions of the researcher. The application of the Seven Wastes of Lean Research could be used in future research to develop external formal procedures and guidelines for making observations.

Summary of the use of the observational method. For this research, the use of the observation method was effective and is believed to have added value to the research. The observational method served to increase the understanding of changes occurring during the transition from mass to lean manufacturing methods.

Because of the subjective nature of the observational method, the possibility of bias is inherent in the use of the method and is of continual concern. However, in attempting to minimize bias, this method was used in conjunction with other methods. For this research I attempted to minimize bias through increased awareness and the triangulation of data with the other methods used in this research.

Effectiveness of Sociogram Method

Assessment of method: sociogram. A sociogram is a method used for disclosing the structure of the group itself (Northway, 1967). The construction of a sociogram assists in determining the degree to which individuals are accepted in a group and for discovering the relationships that exist among the individuals that comprise the group. The criteria used to assess the effectiveness and value of the use of sociograms for this research are outlined in Table 17.

Table 17

Assessment of the Use of Sociogram Method

Method	Empirical Indicators	Assessment
1. Sociogram	Researcher's experience in the use of sociogram methods to assess an assembler's change in perception about communications and work relationships during an organization's transition from mass to lean manufacturing methods	To be effective for this research the Sociogram Questionnaire needed to be changed to include associations with support team members and management. The data collected during the study suggested these relationships were perceived by assemblers to be an influence on the ability of assemblers to engage in problem solving and continuous improvement programs.
2. The Seven Wastes of Lean Research	Analysis of value-added activities for the use of sociograms by applying the Seven Wastes of Lean Research criteria	Upon analysis, an instance of overprocessing was identified in the processes and procedures of the use of the sociogram method.

For the sociogram method to be effective for this research required a change in the current design of the questionnaire. The current Sociogram Questionnaire was designed to obtain only information about the social preferences and associations of the assemblers within the assembler group. An assembler's social preferences and associations with support team members and management were not investigated during this study and were excluded from the sociogram questionnaire and data collection process.

However, during the study, the importance of an assembler's relationship with support team members and management became known. The importance of an assembler's relationship with support team members and management became highlighted based on the perceptions of sameness and the feelings of isolation from the rest of the organization that were expressed by many of the assemblers during the interview process. Further, data collected during the study suggested that association with support team members and management was perceived by assemblers to be an influence on the ability of assemblers to effectively engage in problem-solving activities and continuous improvement programs.

Assessment of the seven wastes of lean research: sociogram. The following is an application of the Seven Wastes of Lean Research criteria to identify nonvalue-added activities and waste in the use of the sociogram in the processes and procedures for this research project. The criteria for the Seven Wastes of Lean Research are outlined in Table 13.

Overprocessing. When constructing sociograms, it is standard practice to include questions soliciting information about a participant's positive and negative social preferences for association. For this research, participants often felt uncomfortable and declined to state their negative social preferences on the sociogram questionnaire. For some assemblers, soliciting negative responses appeared to create feelings of mistrust and made participating in the study stressful. Upon further analysis, questions soliciting information about a participant's negative social preferences for association are not necessary in the study of the theory of relational coordination. Soliciting negative social preferences contributes little value to the study. Questions about negative social preferences can be viewed as an instance of overprocessing.

Summary of the use of the sociogram method. The use of the sociogram method can be an effective method for this research if changes are made to the design of the sociogram questionnaire. To be effective, the design of the sociogram questionnaire must be changed to include the collection of data about an assembler's social preferences and associations with support team members and management. The current Sociogram Questionnaire was designed only to obtain information about the social preferences and associations of assemblers. An assembler's social preferences and associations with support team members and management were not investigated in this research study. As a result of the perception of sameness and the feelings of isolation that were expressed during the interview process, assembler relationships with other members of the organization as they relate to the theory of relational coordination should be included in future design of this research.

Further design changes are required as questions about negative social preferences appeared to make the assemblers participating in the study uncomfortable. Questions about negative social preferences were observed to make participation more stressful than necessary and to create mistrust between the researcher and the participants. Questions about negative social preferences could most likely be eliminated from the sociogram questionnaire with little impact on the results of this research.

Chapter V
Discussion

Restatement of Purpose

The purpose of this research was to study the effectiveness of the application and execution of the questionnaire, interview, sociogram, and observation research methods in assessing and monitoring the development of a culture of continuous improvement in lean manufacturing organizations. For this research, assessing the effectiveness of various research methods was the initial step in the creation of new knowledge about possible methods for facilitating and monitoring the development of a culture of continuous improvement in lean manufacturing organizations. The relational theory of continuous improvement and the 7 Wastes of Lean Research were also developed for this study as a means of assessing the effectiveness and application of the chosen research methods.

The relational theory of continuous improvement states that in a lean production system, the execution of work routines and continuous improvement activities are a form of higher-level work that, to be supported, requires that higher-level communication and a higher-level of interdependent work relationships have been developed and are active within the organization. The theory states that, in lean organizations for work routines and continuous-process improvement activities to be consistently executed and maintained, higher-level communication and higher-level interdependent work relationships must be present.

Further, and also of secondary concern, the Seven Wastes of Lean Research criteria were developed to aid in the identification and elimination of nonvalue-added activities from the research processes and procedures of this study. Conducting research in a lean manufacturing organization presents a unique challenge to the researcher. It is advantageous to design the process and procedures of a study conducted in a lean manufacturing environment to be as effective and efficient as possible. It is advantageous in that the elimination of non value added activities minimizes the time required of participants to participate in the study and minimizes interruptions to manufacturing operations. In support of minimizing the time required, it is necessary to identify and eliminate non value added activities from the research processes and procedures. As a tool to support the identification and elimination of non value added activities in the processes and procedures of this study, the Seven Wastes of Lean Research was developed.

Restatement of Significance of Research

This research project was designed as an initial inquiry into the much larger issue of the development, facilitation, and sustainability of cultures of continuous improvement in lean manufacturing environments. This study focuses the assessment and effectiveness of chosen research methods with the intent of creating new knowledge about the development of possible methods that could be used to assist management in the development, facilitation, and support of cultures of continuous improvement.

Historically, both mass and lean production methods have emphasized cultures of continuous improvement. When developing mass manufacturing methods, both Ford and Taylor supported positive employee and management relationships. Both men believed positive employee and management relationships to be primary considerations in facilitating cultures of continuous improvement. Later, lean manufacturing methods also supported a positive relationship between management and labor and facilitated the philosophy and practice of "respect for people" (Emiliani, 2008; Ohno, 1988). Both manufacturing models supported the belief that successful continuous improvement programs were a by product of cooperation and positive relations between management and labor (Emiliani, 2008). Both manufacturing models emphasized the importance of social relationships in the successful development and support of cultures of continuous improvement.

Although historically the concept of positive management and employee relationships has been linked to successful cultures of continuous improvement, little progress has been made in developing specific frameworks and methods for use by management to facilitate, monitor, and maintain cultures of continuous improvement in lean organizations. To date, imitating and mimicking the processes and procedures of the more successful lean companies is the most common approach used to facilitate and support cultures of continuous improvement. Models that attempt to monitor the progress of the social relationships and elements necessary to develop and support cultures of continuous improvement are lacking.

Globally, evidence suggests that, except for the non-U.S. Americas and Japan, the common approach of imitation is often not sufficient to sustain lean manufacturing systems and continuous improvement programs (Schonberger, 2007). The root cause of the difficulty is often attributed to the lack of true commitment and support of lean methods by executive management (Emiliani, 2005). Since lean methods are viewed by many as complete, an alternative approach for sustaining and supporting lean methods and continuous improvement programs is seldom sought. This research, by seeking to apply methods and measures which attempt to assess relationships and communication within the context of continued support of cultures of continuous improvement, is significant as an initial attempt toward offering an alternative approach.

Limitations of Research

This study was designed to gain knowledge about the effectiveness of the application of the research methods chosen for the study and to minimize the time required to conduct and participate in the study. As with all studies, this study has limitations.

First, this study was limited to administering the questionnaire, interview, sociogram, and observation research methods to the assembler population. Managers and support staff were not included in the study. This was deemed appropriate as the primary focus of the study was an assessment of the effectiveness of the application and execution of research methods in measuring and assessing the development of cultures of continuous improvement in lean manufacturing environments. The relational theory of continuous improvement which focuses on a wider array of relationships, including managers and support staff, were of secondary concern for this study.

Second, this study is limited as the data collected for this study reflects only the subjective experiences of assemblers from one manufacturing organization during a lean manufacturing implementation. Although this research may generate new knowledge about possible changes in working relationships and communication during a lean manufacturing implementation, these changes cannot be extrapolated to all manufacturing facilities involved in a lean transformation.

Third, this study is limited in that the data is not representative of a wide array of industries. The data collected is only representative of one manufacturing facility in the electronics industry.

Fourth, this study is limited in its time frames. Data was collected approximately once every four weeks for a 3-month period of time. For this study, a 3-month data collection period was deemed reasonable and sufficient to assess the effectiveness of the application and execution of the chosen research methods. However, for future research and further investigation of the relational theory of continuous improvement, a 3-month period may not be deemed sufficient.

Support for the Relational Theory of Continuous Improvement

The relational theory of continuous improvement was not the primary focus of this project. Rather the development of the theory was necessary in order to support the research question of this study which focused on the assessment of the chosen research methods and their execution in a lean manufacturing environment.

For future research, it is of merit to note that the relational theory of continuous improvement was not refuted by this research and remains a viable theory. The application of the theory, for this study, was limited to a study of the assembler group and their individual awareness of the presence of higher-level communications and working relationships which, according to the theory, are necessary to support the execution of the higher-level work routines necessary in support of lean manufacturing systems and the development of cultures of continuous improvement. Using the relational theory of continuous improvement, if the assemblers are not aware of the use of a higher level of communication and the development of higher-level working relationships, it is theorized that problem-solving activities and continuous process improvements will remain at or near the levels experienced prior to the lean manufacturing implementation. A culture of continuous improvement will not develop.

In this study the assemblers verbalized negative perceptions and a lack of support for the presence of higher-level communications and the development of higher-level working relationships. Further, the assemblers expressed negative perceptions of, and a lack of support for, problem-solving activities and continuous improvement programs. When applying the relational theory of continuous improvement, the lack of support by assemblers for problem-solving activities and continuous improvement programs was a supported.

However, what was unexpected and was not a supported finding of the theory was that in addition to expressing a lack of support for higher-level communication, working relationships, and continuous improvement programs, 46 % the assemblers also expressed a prevailing sense of isolation. Their sense of isolation appeared to influence their perception about the effectiveness of the lean manufacturing implementation, the use of lean manufacturing methods, and the development of problem-solving activities and continuous process improvements activities.

This group of assemblers expressed that they perceived a lack of partnership and cooperation with other facets of the organization. The assemblers stated their perception of the lack of partnership and cooperation extended from a time before the lean manufacturing implementation. This perceived lack of partnership and cooperation, along with other negatively perceived facets of the organization, prompted the assemblers to express that, “nothing had changed,” in spite of the lean manufacturing implementation. This perception prevailed among assemblers in spite of an increase in communication and improved communication procedures that were implemented by management due to the additional coordination required to support lean manufacturing methods.

This study, based upon its initial design and limitations, did not make specific inquiry about the nature or frequency of contact between assemblers and other groups within the organization. Data about the frequency and type of contact between the assemblers, management and support staff were not collected. Based on the findings of this research, contact and frequency of contact with other groups may be an influential factor in an assembler's perception about communications, working relationships, the effectiveness of lean manufacturing methods, and continuous improvement programs.

In future designs of this research, it is recommended that the limitations of the study be changed. Inquiry about the nature and frequency of contact with management and staff members should be included in future research. Further, investigation is required to gain new knowledge about the influence of the presence of strong feelings of isolation, as reported by the assemblers in this study, and the failure of a culture of continuous improvement to develop and thrive.

Although the relational theory of continuous improvement was not refuted by this research, inquiry about the nature and frequency of contact with members of other groups within the organization may change the support or lack of support for the relational theory of continuous improvement. Inquiry about the nature and frequency of contact with management and staff members may lead to new insights into the relational theory of continuous improvement and influence its further development.

Development and Application of the Seven Wastes of Lean Research

I developed the Seven Wastes of Lean Research criteria specifically for use in this study. Prompting the development of the Seven Wastes of Lean Research criteria was the need to incorporate into the architecture of this study a systematized approach for the analysis of research processes and procedures to identify nonvalue-added activities. My intent, after identifying nonvalue-added activity, was to eliminate or improve upon the activity and incorporate the solution into the design of the next generation of research for the study of the relational theory of continuous improvement. Most recommended activities are solutions that, when implemented, will either reduce waste, reduce the time required, or will simplify the process or procedure.

In addition to the identification of non value added activities, there are other broader underlying implications regarding the application of the Seven Wastes of Lean Research criteria. Specifically, the application and use of the Seven Wastes of Lean Research criteria can be viewed as complimentary to and supporting of the models of research design and theory development used in this research process. I believe that the incorporation of the Seven Wastes of Lean Research criteria enhances and strengthens the architecture of this research and may have application in other types of research.

The design of a study is often characterized as a logical sequence that connects the empirical data collected to the study's research question and ultimately its conclusions (Yin, 2003). In the research process, the application of only a model of design is insufficient to support the research process. Rather, required and incorporated into the model of research the design is a model for the development of the theory of the study. A theory is characterized as a segment of the observable world that provides the researcher with one or more predictions that may be tested by the collection of data (Dubin, 1978). Theory development is a never ending process of gathering new data and of reprocessing old data in areas of study where models had not previously existed or of reconstructing old theories that no longer encompass the predictions they purport to model (Dubin, 1978).

In research endeavors, models of both research design and theory development are used simultaneously. Together they form the architecture of a research project in which each model supports the use of the other in an iterative process that support the creation of new knowledge. The models of research design and theory creation ultimately complement one another and are strategically joined by the researcher.

However, absent from this architecture is the benefit of the application of a criterion which can formally assist the researcher in the identification and elimination of waste and nonvalue-added activities from the next iteration of research design and theory testing. Application of criteria that supports the elimination of waste and nonvalue-added activities from the research process would ultimately assist in the reduction of the time required to complete a research project, a decrease in project costs, and an improvement in the presentation of the end product. In addition, there are other less obvious benefits to the researcher when the Seven Wastes of Lean Research criteria are applied.

The potential of decreased costs and the time required to complete a research project is advantageous in the academic world where publishing results, creating new knowledge, and completing one project and beginning another is often of major concern.

The application of the Seven Wastes of Lean Research criteria offers the novice researcher, working in almost any discipline, the opportunity to apply a continuous improvement process to the processes and procedures of their research and achieve results with little management experience. Application of the Seven Wastes of Lean Research criteria minimizes the need to have prior knowledge or experience of the more advanced management practices and skills often required to reduce time and costs.

I designed the application of the Seven Wastes of Lean Research criteria to be complimentary to the models of research design and theory development used in this research. Together, the triad of models forms an architecture that encourages the continuous improvement of the research design, lends support to the iterative process of theory development, and encourages a continual decrease in research costs, resources, and the time required to complete a study.

In conclusion, Yin (2003) once stated that the design of a research project is a logical plan for getting from here to there. When the Seven Wastes of Lean Research criteria are applied, a research project has the potential to be not only a plan that is logical, but also a plan that is being continuously improved upon as the journey for the creation of new knowledge continues.

Assessment of the Effective Use of the Questionnaire Method

For this research, the potential hazard inherent in the design and use of the questionnaire method is that the standardized answers so commonly used in questionnaires may act to limit the responses of the assemblers. Based on the inherent design of the questionnaire, where a participant selects a standardized answer, there is no evidence that the opinion expressed is actually the opinion of the participant. The means to verify that the opinion expressed by an assembler when selecting his or her answer is actually his or her opinion is not available. Further, the verification issue becomes more difficult when it is recognized that participants must be able to read and fully comprehend the questionnaire to respond.

For this research, a group of students at Dakota County Technical College studying manufacturing management were used as a pilot group for the administering of the questionnaire. Simplification and improvements to the questions and the design of the questionnaire were made based on feedback from the group. However, these students, due to their college background, most likely possessed reading and comprehension skills exceeding those of many of the assemblers participating in this study. For future designs of the Relational Coordination Questionnaire, I recommend the questionnaire be piloted to groups with reading and comprehension skills similar to those of the participants of the study.

Because of reliability concerns, I recommend questionnaires not be used as a stand-alone tool for this research. Rather, in the future design of this research, the questionnaire method should be used in conjunction and balanced with other research methods. Research methods should be chosen that give the participant ample opportunity to respond according to their capability and skill sets.

Additionally, I recommend that in future designs of this research the time frames between data collection periods for the questionnaire be lengthened. For this study, data was collected approximately once every four weeks for a 3-month period of time. Initially, this data collection protocol was deemed reasonable and sufficient to assess the effectiveness of the relational coordination questionnaire.

However, after examining the data, I discovered that the collection of data once every four weeks for a 3-month period was too short a time period to capture meaningful changes. Because of the short time span between data collections, it was difficult to determine if the fluctuations in the data were relevant. Subsequently, in order to attempt to make the data more meaningful, an average was calculated for each question on the Relational Coordination Questionnaire using each of the three data collected periods.

In future designs of this research, I recommend that the time frame in between data collection periods be lengthened. I recommend that, in the next design of this research, a minimum period of at least four months between data collection periods be explored.

There are also advantages to using the questionnaire method. One advantage is the potential for rapid turnaround times and standardized answers which makes compiling data efficient. The potential of a rapid turnaround time and standardized answers when conducting research or evaluations in a rapid moving manufacturing environment is highly advantageous.

Further, when conducting research or evaluations in a manufacturing environment, the flexibility of the questionnaire proved to be advantageous. A questionnaire can be administered electronically or easily by paper and pencil. This level of flexibility was found to be attractive in a manufacturing environment where not all assemblers had access to electronic media.

Use of the seven wastes of lean research: questionnaires. When applying the Seven Wastes of Lean Research criteria to the processes and procedures of the administration of the Relational Coordination Questionnaire, several nonvalue-added activities became evident. In the next study for this research, the following design changes are recommended for incorporation into the processes and procedures for the administering of the Relational Coordination Questionnaire.

First, the number of questions used to capture data for each theoretical unit in the Relational Coordination Questionnaire should be reconsidered and redesigned. For this research, more than one question was used in the Relational Coordination Questionnaire to capture data for the theoretical units of frequency and mutual respect. At the time of the initial design, more than one question was viewed as a prudent measure to capture the necessary data. During the analysis of data, such measures proved to be of little value and, based on the Seven Waste of Lean Research criteria, stood as an example of over processing. In future designs of this research, one question relating to the each theoretical unit is recommended.

Second, included in the architecture and design of this project was three data collection periods, each taking place at 4-week intervals. During the second data collection period, only the Relational Coordination Questionnaire was administered. No other data collection activities took place. Analysis of the data indicated that the data collected during the second data collection period was of little additional value when compared to the data collected during the first and third data collection periods. Based on the Seven Wastes of Lean Research criteria, the data collected during the second data collection period was an example of overprocessing and unnecessary motion. In future designs of this research project, the second data collection period should be eliminated and the Relational Coordination Questionnaire only administered during the first and last data collection period of the study. When viewed as a nonvalue activity, the second data collection period could easily be eliminated.

Although it is difficult to estimate accurately, the decrease in the time required to participate in the study due to the elimination of the second data collection period is substantial. It is estimated that the participation time for assemblers would most likely decrease by approximately 25% of the total time required to participate in this study. In planning future studies, the elimination of the second data collection period as a nonvalue-added activity offers the largest increase in efficiency to the researcher without compromising the collection of data. It is difficult to accurately estimate the reduction in administrative time as a result of the elimination of the second data collection period. The elimination of one data collection period eliminates so many other activities in the research process that it is difficult to assess total gains in efficiency, time, and cost.

In conclusion, the application of the Seven Wastes of Lean Research proved valuable as consistent criteria for the identification of nonvalue-added activities to be considered for elimination in future designs of this research. The criteria provided a consistent application for the discussion and planning of improvements in the future design of the processes and procedures for the Relational Coordination Questionnaire.

Assessment of the Effective Use of the Interview Method

The use of the interview method for this research proved to be an effective tool for gaining a deeper understanding of an assembler's perception of the changes in communication, working relationships, and problem-solving activities. Using the interview method allowed me to obtain information about the questions being asked and also created the possibility of obtaining unexpected significant information. The use of the short interview method was effective and highly complementary when combined with the use of the Relational Coordination Questionnaire.

Further, the use of the short interview format proved to be an efficient and highly effective approach for use in a manufacturing environment. The short interview format proved advantageous due to the limited availability of the assemblers to participate in the interview process. I hadn’t planned to use the short interview format but adopted it out of necessity. During the third data collection period, the time allotted for me to conduct interviews was unexpectedly shortened by management because of production requirements. The assemblers were needed in the manufacturing area.

Although unplanned, the benefits of the short interview approach were quickly recognized. The use of the short interview format required that I adopt strong listening skills. The limited number of questions prompted participants to focus and express significant and detailed information on the topic.

Further, use of the short interview method offered participants the opportunity to communicate with me using a method other than written communication. Based on the level of detail in their disclosures and the comfort displayed by the assemblers while being interviewed, it is recommended that the short interview method be included in future designs of this research.

From my perspective, another benefit of using the short interview format was that it was not necessary to use a recording device. Due to the length of the interviews, taking written notes was quite manageable. Further, the use of written notes eliminated the lengthy transcription process that often accompanies the use of a recording device. I observed the assemblers seemed to be more comfortable without a recording device being present.

One disadvantage of not using a recording device during the interview is that care must be taken to accurately capture data. Without the use of a recording device the accuracy of the interview data was a concern.

However, the experience and skill of the researcher in the interview process is also a factor that influences accuracy of capturing interview data. Interviewing and accurate note taking is a skill that the researcher develops through time. Ultimately it is the researcher's personal choice to use or not to use a recording device.

Use of the seven wastes of lean research: interview. For this research, when applying the Seven Wastes of Lean Research criteria to the processes and procedures of used for conducting a short interview, the nonvalue-added activity of unnecessary transportation became apparent. Due to privacy concerns, personal interviews were conducted in a private conference room away from the manufacturing area. In the case of this research, to participate in the interview process assemblers were required to leave the manufacturing area and travel to the other side of the facility to the conference room area. In future research, travel time could be minimized by arranging to conduct interviews in a private setting closer to the manufacturing area. If privacy concerns could be addressed, the ideal situation would be to conduct the interviews in the manufacturing area and eliminate any the travel time.

In conclusion, although discovered by circumstance, there are strong benefits to adopting the short interview format. The format offered the assemblers an alternative means of communicating with me and participating in the study using a means other than written communication. Further, use of the short interview format proved to be effective and highly compatible with data collection in a manufacturing environment as it minimizes the amount of time required to participate in the study. I recommend that the short interview format be formalized and included in future designs of this research.

Assessment of the Effective Use of the Sociogram Method

For this research, there were two design and application issues I recommend be improved on for the use of the sociogram method and Sociogram Questionnaire. First, the results of the Sociogram Questionnaire were based on a comparison of the change in the number of preferred social connections obtained and experienced by each assembler. Based on this method of analysis, there were increases and decreases when comparing the August and November data. The results obtained showed a lack of support for higher-level relationships even though I observed a deepening of working relationships and an increase in communication among the assemblers.

Second, the Sociogram Questionnaire was designed for this research to obtain information only about the social preferences and associations of the assemblers within the assembler group. A limitation of this study was that relationships outside of the assembler group were not examined. Therefore, an assembler's social preferences for association with support and management team members were not included in the study.

Reflecting on data collected during the short interviews, data about the social preferences and associations with support team members and management could be of value in gaining knowledge about the changes that influence an assembler's perception of higher quality communication and working relationships and the resulting change or lack of change in continuous improvement programs. The possible significance of an assembler's relationship with support team members and management became known based on the perception of feelings of isolation expressed by many assemblers during the interview process. The data collected during this study suggested that lack of association with support team members and management were perceived by assemblers as a major influence on their capability to effectively engage in problem solving and continuous improvement programs.

To address the design and applications issues for the use of the Sociogram Questionnaire, I recommend that two design changes be made to future designs of this research. First, I believe that an alternative approach to the analysis of the Sociogram Questionnaire data may be more revealing about the formation of relationships in lean manufacturing environments. I recommend that the analysis of the Sociogram Questionnaire data be expanded to include an analysis of any noted changes in the organization or structure of the assembler's social network reflected in the sociogram map and any noted changes in the number of preferred associations per assembler.

Such an analysis would require the interpretation of changes in the network based on selected social network models and characteristics. The study and analysis of changes in social networks is a growing field. Development work, such as the work of Barabasi (2002), in the study of social networks and social models is available to assist in understanding and interpreting the changes that can occur in social networks.

Second, I recommend that the Sociogram Questionnaire be redesigned to include an assembler's relationship with support and management team members. The collection of data regarding the frequency of contact and association with support team members and management would provide a more detailed description and understanding of an assembler's social contacts and associations. A wider spectrum of data collection about assembler relationships could provide more knowledge about the types of changes necessary in communication and working relationships to support and sustain problem solving activities and continuous improvement programs in organizations.

Use of the seven wastes of lean research: sociogram. For this research, when reviewing and applying the Seven Wastes of Lean Research to the processes and procedures of the Sociogram Questionnaire, one nonvalue-added activity within the category of over processing became apparent. The elimination of the over processing activity resulted in a recommended change in the design and administration of the Sociogram Questionnaire.

When constructing sociograms, it is standard practice to include questions soliciting information about a participant's positive and negative social preferences for association. During the administration of the Sociogram Questionnaire, several assemblers expressed their discomfort about being solicited for information about their negative social preferences. When compiling the data I discovered that many assemblers left the questions soliciting information about their negative social preferences unanswered. Soliciting negative responses appeared to create mistrust and stress among participants.

In the future, the Sociogram Questionnaire would be more effective if the solicitation of responses about negative social preferences and associations was eliminated. I believe it is possible to eliminate the solicitation of negative responses on the sociogram questionnaire without impacting the collection of data necessary for this research.

Negative social preferences and associations appear to have little value and are a nonvalue-added activity when considering the relational theory of continuous improvement. An underlying theme of the relational theory of continuous improvement is integration and cohesion rather than conflict. The focus of this research is assessing the changes in an assembler's perception concerning communication and working relationships as it relates to the group's level of integration and problem-solving abilities and continuous improvement activities. Eliminating the solicitation of negative responses most likely can be accomplished without impacting the results of this research.

Assessment of the Effective Use of the Observation Method

During the observational process for this research, I needed to see, interpret and make inferences about the meaning of the behavior witnessed. An interpretation of what is observed is dependent on the perception and judgment of the researcher. For this research, observations and their interpretations were a subjective exercise. Since the interpretations made were based on the judgment of the researcher, it is beneficial that the researcher be competent and knowledgeable about the task being observed. Further, it is also important that the researcher be aware of and not be unduly influenced by his or her biases.

In the case of this research, I was formally trained in manufacturing management techniques and have 30 years of manufacturing experience. I was certified by the Society of Manufacturing Engineering (SME) in lean manufacturing methods at the Bronze Level (LBC) and maintained a CPIM certification from the Operations Management Association (APICS).

Further, I was familiar with the hosting organization's manufacturing processes and procedures. Familiarity may increase the occurrence of bias in making interpretations about observations. Bias is the most common error in observational research and occurs because of the researcher's background and expectations. In the case of this research, I was at one time employed by the hosting organization for a period of 3 years and had previous working relationships with the assemblers. It would be not be appropriate to say that I was totally without bias. Attempts were made to minimize bias through increased awareness and through the triangulation of data from the data collection methods used.

Use of the seven wastes of lean research: observation. The Seven Wastes of Lean Research criteria is intended to assist in the elimination of nonvalue-added activities, the reduction in time required and the simplification the processes and procedures of the research methods for this study. In the case of the use of the observation method, all tangible concrete processes and procedures for this research can be observed and analyzed according to the Seven Wastes of Lean Research criteria.

The Implications of This Research

This study is an attempt to gain new knowledge about the effectiveness of the use of questionnaire, interview, sociogram, and observation research methods to assess and monitor the development of a culture of continuous improvement. In order to test the effectiveness and application of the chosen research methods, the relational theory of continuous improvement was developed and tested for this study.

This research project has been an attempt to apply theory from a discipline other than the management and engineering sciences to the research of cultures of continuous improvement. My intent was to support the creation of new knowledge about possible methods for monitoring and developing cultures of continuous improvement in lean manufacturing environments.

In this study, by applying different research methods and incorporating theory and knowledge from the social sciences, I developed a richer more holistic approach to monitoring the development of a culture of continuous improvement. Although not fully developed, attempts to use an approach that includes methods for assessment and feed back to the organization about the progression of the development of the culture of continuous improvement is preferable to attempting to merely imitate the more successful lean companies. Without knowledge about the on going development of a specific culture of continuous improvement, continued support and facilitation of that culture is difficult at best and the uniqueness of the developing culture could be lost.

In today's globally competitive business climate, successful cultures of continuous improvement can yield tremendous potential to an organization and ultimately to society at large. Many people working in manufacturing assume that the implementation of lean methods also implies that a culture of continuous improvement will simultaneously develop. Although some organizations succeed in developing cultures of continuous improvement, for many organizations the attempts to develop a culture of continuous improvement remains an elusive and daunting task.

The failure to create a culture of continuous improvement can have serious implications for the long-term viability of an organization. With failure comes the difficulty of an organization remaining competitive and making positive social and economic contribution to the communities in which it resides. On a global level there is also a social and economic cost incurred for the failure of manufacturers to create a deeper understanding of the development of cultures of continuous improvement.

At an ever increasing pace, lean methods are being teamed with environmental practices. When joined together, the two bodies of knowledge are referred to as *lean and green initiatives*. The motive for combining the two is the growing belief that current practices and systems of manufacturing are not sustainable. It is believed that the methods and means to balance systems of production with naturally occurring systems must be aggressively sought and developed using continuous improvement methods.

An approach commonly used in lean and green initiatives is for a group of organizations to organize and come together to jointly apply lean methods to a chosen facet of a supply chain with the intent of eliminating waste and nonvalue-added activities. All organizations involved would mutually benefit from the elimination of any waste. The elimination of waste and nonvalue-added activities could be in any area of the supply chain; for example, the use of raw materials, the production of the product, or the disassembly and disposal of the product when it is no longer useful.

Intertwined with the use of lean and green initiatives is the application of knowledge about continuous improvement methods and programs. Because of the number of organizations involved, the application of continuous improvement methods becomes more complex when used in support of lean and green initiatives than when used within a single organization.

The difficulty lies in that, based on the common interest of improving a shared facet of a supply chain groups of organizations must co-own and self-organize around a common goal within a shared supply chain. They must jointly manage their initiative to make improvements. This level of interaction requires more detailed and intricate continuous improvement activities than those undertaken within a single organization. To be successful, participating organizations must possess advanced skills and knowledge about lean methods and the utilization and application of continuous improvement methods.

In conclusion, in order to support and promote successful lean and green initiatives, it is vital that researchers in the various scientific disciplines add to the body of knowledge about the support required for successful continuous improvement programs. Any discipline that can contribute to facilitating increased knowledge and improve the creation of continuous improvement programs is critical to the support of engineering and manufacturing professionals in their lean and green activities. Creation of knowledge about supporting successful continuous improvement programs is ultimately to the benefit of all and fundamental to the creation of sustainable manufacturing systems.

Recommendations for Future Research

The relational theory of continuous improvement. I recommend that future projects for this research center on creating knowledge based on the relational theory of continuous improvement rather than on an assessment of methods to study the theory. I further recommend that future projects continue the use of questionnaires, short interviews, and sociogram methods along with the project design changes recommended in this report.

A combination of methods gives a richer understanding of the changes that are occurring in the organizational culture as the lean environment is being created.

Applying a combination of research methods extends beyond the mimicry and imitation so commonly used today. For this research the short interview was the most revealing and more research must be done.

The seven wastes of lean research. I recommend that the Seven Wastes of Lean Research continue to be developed by applying the Seven Wastes of Lean Research criteria to future projects for this research. In future projects, efforts should be made to establish metrics and measure any changes or savings gained in time or cost from applying the Seven Wastes of Lean Research criteria. I recommend that the results of the application of the Seven Wastes of Lean Research be included as an addendum in the written documentation of future research reports. As the Seven Wastes of Lean Research criteria is being developed, any recommendations for changes, additions, or deletions to the Seven Wastes of Lean Research criteria should also be included in the addendum.

Concluding Remarks

This particular study was challenging in its design as it focused primarily on an assessment of research methodology and its ease of use in a manufacturing environment rather than on the relational theory of continuous improvement. As stated in this report, conducting research in a manufacturing environment is challenging as production activities must always be fully supported and the minimal availability of assemblers to participate in research studies is a logistical issue.

To conduct research effectively in a manufacturing environment the researcher must acknowledge and respect that production activity must always be fully supported and the availability of assemblers is limited. This project was an attempt to respect those boundaries and search for better ways to conduct research in manufacturing environments. Based on my experience, a lack of understanding and common ground was, on numerous occasions, a major factor in manufacturing management refusing to consider hosting this research project. This made obtaining permission and gaining access to a hosting manufacturing facility difficult. Long-term this lack of understanding is detrimental to learning more about the development of effective continuous improvement programs. I hope that the Seven Wastes of Lean Research criteria will assist in encouraging an understanding between the researcher and manufacturing professionals by creating a common ground and by encouraging the use of a common ideology so progress can more readily be made and access granted.

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Appendix A

Participant Number:____________

Socio-metric Questionnaire

To answer the questions below, please select and write in the first and last names of individuals based on your personal preferences. To protect individual identities, no names will appear on the final chart. Each name written will be assigned a random number and only the assigned numbers will appear on the final sociogram chart.

1. Which 3 co-workers would you most like on your team?

   ____

2. Which 3 co-workers would you least like on your team?

   ____

3. Which 3 co-workers do you consult with the most on work related issues?

   ______________________________ ______________

4. Which 3 co-workers do you consult with the least on work related issues?

   ____

5. You have been given the assignment to pick a new team and learn a new manufacturing process. Which 3 co-workers would you choose to be on the new team?

   ____

6. Which 3 of your co-workers would you most enjoy having lunch with?

   ____

Please seal the completed survey in the envelope provided and then place the sealed envelope in the collection box in the gowning area.

Appendix B

Participant Number: ____________

Relational Coordination Questionnaire

To answer the questions below, please circle the answer that best describes your opinion.

Communications

1. I receive the information I need to do my job in a timely manner.

   a. Strongly Agree b. Agree c. Disagree d. Strongly Disagree

2. I receive accurate information and instructions about the jobs and tasks I am assigned.

   a. Strongly Agree b. Agree c. Disagree d. Strongly Disagree

3. I believe it is important to talk to all of my team members on a daily basis.

   a. Strongly Agree b. Agree c. Disagree d. Strongly Disagree

4. I can easily contact and talk to my team members if I need to.

   a. Strongly Agree b. Agree c. Disagree d. Strongly Disagree

5. I believe the communication between my team members is good.

   a. Strongly Agree b. Agree c. Disagree d. Strongly Disagree

Working Relationships

6. My team members and I frequently share information about the new things we learn on the job.

   a. Strongly Agree b. Agree c. Disagree d. Strongly Disagree

7. My team members respect each other.

   a. Strongly Agree b. Agree c. Disagree d. Strongly Disagree

8. My team members cooperate with each other.

   a. Strongly Agree b. Agree c. Disagree d. Strongly Disagree

9. My team members care about the success of our team.

a. Strongly Agree b. Agree c. Disagree d. Strongly Disagree

10. I am treated fairly and equally by my team members.

    a. Strongly Agree b. Agree c. Disagree d. Strongly Disagree

Continuous Improvement

11. My team frequently discusses ideas to improve production processes.

    a. Strongly Agree b. Agree c. Disagree d. Strongly Disagree

12. I am comfortable discussing my ideas for job improvements with my team members.

    a. Strongly Agree b. Agree c. Disagree d. Strongly Disagree

13. My team frequently organizes and holds problem solving activities and events.

    a. Strongly Agree b. Agree c. Disagree d. Strongly Disagree

14. My team has many new ideas for improvements that have not been implemented yet.

    a. Strongly Agree b. Agree c. Disagree d. Strongly Disagree

15. My team is successful in implementing new ideas.

    a. Strongly Agree b. Agree c. Disagree d. Strongly Disagree

Please seal the completed survey in the envelope provided and then place the sealed envelope in the collection box in the gowning area.

Appendix C

The Relational Coordination Interview Guide

To be used during the face-to-face individual interviews with assemblers. Questions should be presented in a short semi-structured format.

1. What kinds of changes have you experienced in workplace communications and relationships since implementing lean methods?

2. What can be done to improve and make your continuous improvement programs more effective?

Appendix D

CONSENT FORM
UNIVERSITY OF ST. THOMAS

An Assessment of the Transition of Manufacturing Assemblers from Mass to Lean Production Methods

[IRB-B09-011-2]

I am conducting a study about changes in co-worker communication and relationships in lean manufacturing environments. I invite you to participate in this research. You were selected as a possible participant because you are currently employed as a manufacturing assembler in an organization that is implementing or has implemented lean manufacturing. Please read this form and ask any questions you may have before agreeing to be in the study. This study is being conducted by: Alanna Kennedy under the guidance of Dr. John Conbere, Chairman of the Department of Organizational Development in the School of Education at the University of St. Thomas.

Background Information:

The purpose of this study is to explore effective methods for assessing an assembler's change in perception about the changes in workplace communications and relationships during an organization's transition from mass to lean manufacturing methods.

Procedures:

If you agree to be in this study, I will ask you to do the following things over the next 3 months:

- Answer a questionnaire four times over the next 3 months about your perceptions about changes in communications and working relationships in lean manufacturing environments.
- Participate in a short 20 minute interview with me once, at the end of the 3 month study.
- Fill in a questionnaire about your preferences about who you work with, two times, once at the beginning and once at the end of the study.

It is estimated that you will spend no more than 20 minutes every 3 weeks on the questionnaires and no more than 20 minutes on the interview.

Confidentiality:

All information will be kept confidential. No one will know what you, as an individual, said or wrote. In any report published, the information making it possible to identify a participant will not be included. The following is a list of records that will be created and destroyed at the end of the research project.

Two questionnaires, The General Questionnaire and the Socio-metric Questionnaire. These will be stored at my home in a secured locked filing cabinet. Only I will have access. Hard Copies of all questionnaires will be destroyed by January, 2012.

Interviews- I will take hand written notes, but will not include your name. The notes will be stored at my home in a secured locked filing cabinet. Only I will have access. The notes will be destroyed by January, 2012.

Risks and Benefits of Being in the Study:

The most apparent risk of this study, although unlikely, is that confidentiality will be compromised. In response to this risk, all data associated with the study will be kept locked in a secured file cabinet in the researcher's residence and remain off site at all times. The identities of the participants will be coded and the master list kept off site at the researcher's residence locked in a secured file cabinet. When questionnaires are distributed, an envelope that can be sealed will be made available in order to secure the privacy of the document during its return to the researcher.

Voluntary Nature of the Study:

Your participation in this study is entirely voluntary. Your decision whether or not to participate will not affect your current or future relations with your employer or the University of St. Thomas. If you decide to participate, you are free to skip any question in the questionnaires, and you are free to withdraw from the study at any time. Should you decide to withdraw any data you have contributed to the study thus far will not be included in the study.

Contacts and Questions

My name is Alanna Kennedy. You may ask any questions you have now. If you have questions later, you may contact me at 651.222.7713 or you may contact Dr. John Conbere at 651.962.4456. You may also contact the University of St. Thomas Institutional Review Board at 651-962-5341 with any questions or concerns.

You will be given a copy of this form to keep for your records.

Statement of Consent:

I have read the above information. My questions have been answered to my satisfaction. I consent to participate in the study. I am at least 18 years of age.

______________________________________ ________________

Signature of Study Participant **Date**

____

Print Name of Study Participant

____

Signature of Researcher **Date**