**BARRIERS AND SUCCESS STRATEGIES FOR SUSTAINABLE LEAN MANUFACTURING IMPLEMENTATION**

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**Appendix B**

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**Appendix C**

**DECLARATION**

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I hereby declare that this dissertation is the result of my own work, except for quotations and summaries which have been duly acknowledged.

Signature: Date:

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# **Chapter 1: Introduction**

According to Kallage (2006), more than 50% of lean manufacturing implementation efforts fail. The purpose of this qualitative, collective case study was to help leaders develop a deeper understanding of both the barriers and strategies for success in implementing lean manufacturing in small-to-medium sized companies. It was hoped that this proposed study would provide leaders of manufacturing organizations additional insights into achieving and sustaining gains from lean implementation efforts. Such insights are needed because so many lean manufacturing implementation efforts have failed to achieve their expected results (Emeliani & Stec, 2005; Hoyte & Greenwood, 2007; James, 2006; Mann, 2009; Roth, 2006).

## **Research Problem Statement**

Lean manufacturing is a strategy to create a “world class production system” (Black, 2009). By creating world-class systems for production during lean manufacturing, organizations are better able to compete globally (Ndahi, 2006). This is important to those with social and economic interests, as “manufacturing is key to economic success” (Pidgeon, 2002).

In 1990, the book titled The Machine that Changed the World introduced the Toyota Production System to manufacturers in Western society (Womack, Jones, & Roos, 1990). This book provided a summary of Japanese automobile manufacturing techniques, calling them lean production (Womack et al., 1990). Womack and Jones (1996) identified lean manufacturing or lean production to describe their observations during their research of the Toyota Production System. Since then, researchers and practitioners have called the Toyota Production System by various names, including “Toyota Management System, lean manufacturing, lean production, or lean management system” (Emeliani & Stec, 2005). For the purpose of this proposed study, the name lean manufacturing was used.

Womack and Jones (1996) identified lean manufacturing methods as a way to create lasting value for any business, thus implying that lean manufacturing methods are a way for manufacturers to sustain their organizations. This was supported by the identification of lean manufacturing as a “world class production system” (Black, 2009). As a world-class production system, lean manufacturing benefits to organizations have included decreased costs, reduced lead times, improved quality, and increased competitiveness (Dennis, 2006; Imai, 1997; Mann, 2009; Mathaisel, Cathcart, & Agripino, 2005; Womack & Jones, 1996). Ndahi (2006) identified that making changes to manufacturing systems using lean manufacturing approaches can help an organization gain a competitive advantage in the 21st-century global economy. This competitive advantage is important if leaders are to create sustainable manufacturing organizations.

Many strategies have evolved for lean manufacturing implementation. Spears and Bowen (1999) offered what they considered a framework of the Toyota Production System based on four rules. The main idea of the first rule is that “all work shall be highly specified as to content, sequence, timing, and outcome” (Spears & Bowen, 1999). The second rule indicated that a direct connection must exist between customers and suppliers. The third rule can be stated as follows: “the pathway for every product and service must be simple and direct” (Spears & Bowen, 1999). The fourth rule required using the scientific method for improvement with the caveat that improvement occurs under the “guidance of a teacher, at the lowest possible level in the organization” (Spears & Bowen, 1999).

Womack and Jones (1996) communicated an approach to implementing lean manufacturing in organizations. This approach has five main elements. The first element is the definition of value: those things that meet a customer’s needs. The second element involves identifying value streams for each product. Value streams are all activities required to produce and deliver a product to a customer (Womack & Jones). The third element involves making products and information flow through the value stream. Womack and Jones define flow as a product moving through a value stream without delay. The fourth element is pull. Pull, according to Womack and Jones, means to allow customers to pull products and value from an organization at the rate at which the customer needs the product. The fifth element involves a cycle of continuous improvement in which the organization is pursuing perfection in all of its activities.

Mathaisel, Cathcart, and Agripino (2005) created an architecture that could help organizations to implement lean manufacturing approaches. This architecture presented a three-phase approach using both lean principles and systems engineering that included conceptual, preliminary, and detailed design along with subsequent implementation and operation (Mathaisel et al., 2005). Maskell and Baggaley (2004) reported that accounting systems and performance measures needed to be changed and aligned for successful lean manufacturing implementation. Wood and Munshi (1991) discussed strategy deployment through Hoshin Kanri as “a critical ingredient in modern Japanese management,” also noting that this method of strategy deployment provides “target and means control” for organizations implementing lean manufacturing.

Despite this diverse range of strategies, the inability to achieve expected and sustainable gains from lean manufacturing efforts is still evident (Emeliani & Stec, 2005; Hoyte & Greenwood, 2007; Mann, 2009; Mathaisel, Cathcart, & Agripino, 2005; Roth, 2006). Emeliani and Stec indicated that organizations achieve only modest gains from their lean manufacturing efforts, regardless of the years of effort. Implementing a lean manufacturing strategy is often “difficult and prone to failure” (Hoyte & Greenwood, 2007). According to Mann, lean initiatives may start well but tend to fall short of expectations. In fact, “few firms…sustain those initial results, and may struggle to bring the results down to a bottom-line impact” (Roth). Results that organizations initially achieved, but were unable to sustain, included decreased costs, reduced lead times, improved quality, and increased competitiveness (Roth). Mathaisel et al. support the assertion that many organizations fail to achieve expected gains or to sustain gains from their lean manufacturing efforts.

A literature review was used to review the principles of lean manufacturing. An implementation plan was developed to implement lean manufacturing principles within the assembly through close-up area. A floor layout plan was designed to show the future state of the assembly line. Operators were used to assist in making the improvements to the assembly line and implement 12 these principles. Before and after illustrations were used to show the impact of implementing the lean principles. Data was collected and presented in this research to show the improvements in throughput and the financial impact to reduction in work-in-process. This chapter provides an introduction to Beyonics and the market in which they serve along with the manufacturing issues that were addressed to help better position them to be more competitive in the medial market. This chapter also lays the foundation for which the rest of this study provided by helping Beyonics achieve their goal of using lean manufacturing principles in their production process.

* 1. **Definition of Key Terms**

This section defines words, phrases in a unique way. In addition, terms that may be defined in an unusual way are included. The terms that follow are used in lean manufacturing and the Toyota Production System.

*4Ms*. Method, material, machine, and man. The term is used as a framework for problem analysis, considering potential causes in four categories: method, material, machine, and man (Dennis, 2007).

*5S*. A philosophy of workplace organization using each S as a specific activity.The five S’s represent Sort, Shine, Set-in-order, Standardize, and Sustain (Dennis, 2007).

*5 Why Analysis*: A method for getting to the root cause of a problem by continually asking why until the root cause is identified (Dennis, 2007).

*Cell:* A sequential arrangement of people, material, machines, and methods, permitting parts to be processed one by one through the production process (Dennis, 2007).

*Continuous Flow:* “The progressive achievement of tasks along a value stream so that product proceeds from design to launch, order to deliver, and raw materials into the hands of the customer with no stoppages, scrap, or back flows” (Womack & Jones, 1996).

*Cycle Time:* The time it takes to complete a single cycle of an operation (Womack & Jones, 1996). Cycle time is used in conjunction with takt time (see definition) to balance the work distribution in a production operation, calculate resources, and determine whether continuous flow can be achieved (Dennis, 2007).

*PDCA:* Plan, do, check, and act. PDCA was developed by quality expert Walter Shewart and later revised by W. Edwards Deming (Dennis, 2007). PDCA was developed to provide a framework for continuous improvement.

*Seven wastes:* The wastes seen in a typical process resulting from overproduction, transport, over-processing, inventory, movement, defects, and waiting (Womack & Jones, 1996).

*Single-piece flow:* This term is defined as “a situation in which products proceed one complete product at a time, through various operations in design, order-taking, and production, without interruptions, backflows, or scrap” (Womack & Jones, 1996).

*Standard work:* Work instructions that identify each work activity, cycle time, takt time, and sequence of work to be done (Womack & Jones, 1996).

*Takt time:* This term is used to identify the rate of customer demand or demand frequency, as defined by the customer. According to Dennis (2007), takt time is calculated by dividing the daily required quantity into the available work time per day.

*Value stream:* All activities that are required to take a product or service from request to delivery to the customer (Womack & Jones, 1996).

*Value stream map:* A visual representation process of identifying all activities, value added and non value-added, that it takes to bring a good or service from initial request to delivery (Womack & Jones, 1996).

* 1. **Research Objectives**

The purpose of this qualitative, collective case study was to help leaders develop a deeper understanding of both the barriers faced and strategies for success in small-to-medium–sized manufacturing companies implementing lean manufacturing. A qualitative method is appropriate when the purpose of the study is to explore “meanings, concepts, and descriptions of things” (Berg, 2008). A collective case study consists of multiple case studies in research (Creswell, 2008). A collective case study design was appropriate, as it provides for “systematically gathering enough information about a particular person, social setting, event, or group to permit the researcher to effectively understand how the subject operates or functions” (Berg, 2008). The use of a collective case study allowed comparison and contrast of experiences from multiple cases to provide insight into a specific issue (Creswell, 2008).

Participants for this study were executives from small-to-medium–sized manufacturing organizations in Colorado; these executives included plant manager, director of operations, vice president of operations, operations manager, president, general manager, chief operating officer, and chief executive officer. The chosen organizations were in the process of implementing lean manufacturing. The exploration of both the success strategies and barriers to lean manufacturing implementation provided insight for leaders of small-to-medium–sized manufacturing companies to support and sustain lean manufacturing implementation.

Based on the Research questions, the study will be trying to achieve the following:

## i) To make sure that all personal involved in the implementation of Lean must be aware of the fundamental value of Lean.

## ii) Benefits of Lean Manufacturing in achieving the perfect value stream.

## iii) To make Lean Manufacturing a company culture, where all stages of production from planning to shipment are aware of the concept.

* 1. **Research Question**

Lean manufacturing has been identified as a means to help to cut organizational costs, improve quality, and decrease both cycle and throughput times (Dennis, 2006; Imai, 1997; Mann, 2009; Mathaisel, Cathcart, & Agripino, 2005; Womack & Jones, 1996), as well as support the objective of world-class performance in a global marketplace (Black, 2009; Ndahi, 2006). Despite the benefits of lean manufacturing implementation, companies have failed to achieve or sustain expected gains from lean implementation efforts (Emeliani & Stec, 2005; Harkin 2008; Hoyte & Greenwood, 2007; Mann, 2009; Mathaisel et al., 2005; Sim, Rogers, & McQuilkin, 2008; Worley & Doolen, 2006). As a result, the overarching research question was:

1. *What are the most common mistakes in implementing lean?*

To start with, lean must never be seen as a tool for headcount reduction or mindless cost-cutting. This fundamentally misses the purpose of lean, which is to create value through eliminating waste. As companies improve their processes they should be able to reallocate their productive resources to new value-creating work.

1. *How does lean compare to other improvement processes such as Six Sigma or Theory of Constraints?*

While there are many specific differences among the different schools of thought, Jim Womack cautions against getting lost in the competing schools. For veterans of each practice often get lost in finely detailed arguments over technical or even philosophical differences. In an e-letter outlining the key differences, he nonetheless grounds the discussion by saying, “At the end of the day we are all trying to achieve the same thing: The perfect value stream.” His letter gives a nice overview of how to view each approach.

iii)  *How do I convince my leaders and associates to practice lean?*

## **Research Limitations**

The scope of this research study was the success strategies and barriers to sustainable lean manufacturing implementation that senior leaders experienced in small-to-medium–sized manufacturing organizations in Colorado. Leaders were chosen from manufacturing organizations that began their lean manufacturing implementation efforts at least two years ago, as success can take years to be realized (Womack & Jones, 1996). Participants for this study had have titles of president, chief executive officer, general manager, director of operations, vice president.

This research study had limitations; the first is limited generalizability. According to Creswell (2008), quantitative studies with large sample sizes are more transferable than qualitative studies with purposive sampling. In addition, although a collective case study can provide better insight and ability to theorize results, a case study approach limits generalizability (Berg, 2008). The second limitation was the direct interaction between the researcher and participants. Direct interaction between researcher and respondents can inadvertently result in the researcher leading the discussion in an intended direction (Creswell, 2008). This was avoided by keeping the interviewer’s opinions and feelings separate from the interview and by keeping a field journal to support this process (Creswell, 2008).

**1.6 Summary**

Chapter 1 provided an overview of this research study. This included an introduction to and background of the problem as they relate to lean manufacturing implementation. Included are the origins of lean manufacturing as described in The Machine that Changed the World (Womack et al., 1990), along with the assertion that lean manufacturing provides a means to create lasting value (Womack & Jones, 1996). However, most lean manufacturing implementation efforts fail to achieve expected or sustainable gains (Emeliani & Stec, 2005; Harkin, 2008; Hoyte & Greenwood, 2007; Mann, 2009; Roth, 2006; Sim, Rogers, & McQuilkin, 2008; Worley & Doolen, 2006).

Chapter 1 included the problem and purpose statement. The specific problem was the inability of companies to sustain gains in adopting and deploying lean manufacturing in their organizations. The purpose of the study was to help leaders develop a deeper understanding of the barriers faced and strategies for success in implementing lean manufacturing in small-to-medium–sized manufacturing companies. The population for this qualitative, collective case study was identified as senior leaders of small-to-medium–sized manufacturing organizations located in Colorado. The significance of the study was the importance of manufacturing in long-term economic stability (Schneider, 2010; Selko, 2009). This chapter also reviewed TQM and Deming’s 14 points as a theoretical framework for this study.

Chapter 2 will present a review of the literature. This will include information on title searches and an historical perspective of lean manufacturing. Also included will be current findings on barriers and success strategies related to lean manufacturing implementation.

# **Chapter 2: Literature Review**

**2.1 Introduction**

This chapter will include a review of literature related to total quality management (TQM), the Toyota Production System (TPS), and lean manufacturing. TQM originated with the works of quality experts Deming, Juran, Crosby, Ishikawa, and Feigenbaum (Fisher & Nair, 2009; Martinez-Lorente et al., 1998; Macdonald, 1998; Soltani et al., 2008). The works of Deming, Juran, and Ishikawa contributed to the development of the TPS (Schonberger, 1982). Lean manufacturing is synonymous with TPS. The Toyota Production System and lean manufacturing will be reviewed together, as Emeliani and Stec (2005) identified that the Toyota Production System and lean manufacturing are names describing the same production system. This chapter includes a summary of title searches, articles, research documents, books, and journals used to identify resources for this literature review. Afterward, it presents a historical perspective of the development of TQM, the Toyota Production System, and lean manufacturing. This is succeeded by the following sections: historical overview of TQM, historical overview of lean manufacturing, barriers to lean manufacturing implementation, success strategies for lean manufacturing implementation, conclusion, and summary. These sections include historical, current, and germinal research. Title Searches, Articles, Research Documents, Books, and Journals This section identifies resources used in conducting the literature review. Various databases were used to support this literature review, including: EBSCOHOST, Gale Powersearch, Proquest, Dissertations and Theses and University of Phoenix, Proquest Dissertations and Theses-Full Text, Google Scholar, Amazon.com, and Oxford Scholarship Online. The search keywords include lean transformation, sustainable lean, sustaining lean, lean manufacturing, lean barriers, lean strategies, Toyota Production System, just-in-time, lean management, W. Edwards Deming, Phillip Crosby, Joseph Juran, Feigenbaum, Kauro Ishikawa, total quality management (TQM), TQM, quality management, quality control, total quality control (TQC), and company-wide quality control (CWQC). These searches resulted in the representative research. Because lean manufacturing and TQM’s origins are traced back decades, this literature review required additional germinal resources.

**2.1 Method**

A case study provides a detailed description and analysis of at least one case (Christensen, Johnson, & Turner, 2011; Creswell, 2009). A qualitative case study is bounded by the system for which the researcher seeks to gain an understanding of a specific problem (Merriam, 2009). Yin (2009) said that case studies are used when a researcher seeks to understand real-life, descriptive experiences with a particular subject or problem. They are appropriate when a researcher is not in control of events and seeks to understand actual experiences of the participant (Yin). In addition, case studies are used when asking open-ended questions (Creswell, 2009).

A collective case study, according to Yin (2009), involves more than one case. Christensen, Johnson, and Turner (2011) noted that a collective case study includes both an analysis of individual cases and a cross-case analysis. Yin and Merriam (2009) commented that collective case studies provide more robust research than individual case studies. Creswell (2008) also noted that multiple cases in a single study are more generalizable. Based on the collection of data through open-ended questions, the objective of understanding real-life experiences of participants, and the lack of control over events experienced while implementing lean manufacturing, a qualitative case study is appropriate for this study.

This research has used a variety of research designs and study methods. A review of the literature indicates that quantitative, qualitative, and mixed method studies have been conducted but that the majority of the research studies use quantitative methods (Conti, Angelis, Cooper, Faragher, & Gill, 2006; Herkness, 2005; Liao, 2005; Raja, 2011; Shimizu, 2008; Sim et al., 2008; Woehl, 2011). Other researchers used either qualitative or mixed method studies (Emeliani & Stec, 2005; Keyes, 2006; McLeod, 2010; Pinheiro, 2010; Worley & Doolen, 2006). This qualitative, multiple-case study will contribute to the body of knowledge related to barriers and success strategies for lean implementation in small-to-medium–sized manufacturing companies. Herkness (2005) noted that additional research is required to gain an in-depth understanding of change agents to better comprehend success factors. Pinheiro (2010) indicated that additional research is required via qualitative methods to gain a deeper understanding from the perspective of companies implementing lean manufacturing. Keyes (2006) indicated that additional research needs to be conducted with small and medium-sized companies on their lean implementation efforts. Keyes also identified the need for case study research of lean manufacturing implementation. Conti et al. (2006), Herkness (2005), and Worley and Doolen (2006) posited that additional research is required across multiple cases using across-case analysis (Herkness).

**2.3 Historical Overview of Total Quality Management**

De Feo (2010) defined TQM as “a set of systematic activities carried out by the entire organization to effectively and efficiently achieve organization objectives so as to provide products and services with a level of quality that satisfies customers, at the appropriate time and price” . This definition is aligned with Deming’s 14 points as the theoretical framework for this study, as Deming’s 14 points address the systematization of improvement throughout an organization based on meeting the needs of customers (Deming, 1982). Macdonald (1998) commented that the term TQM was first introduced in 1983 by the Trade and Industry Department in the United Kingdom. The first published article on TQM was released in 1984 (Mann, 2008). Despite the official origin of TQM tracing back to the 1980s, many aspects of managing quality in organizations evolved earlier in the 20th century (Fisher & Nair, 2009).

According to Fisher and Nair, origins of TQM can be traced back to the 1920s in the work of quality expert Walter Shewart. Mann (2008) also noted that some of the concepts of TQM can be traced back to the work of Henry Ford in his book My Life and Work, published in 1926. Moreover, Martinez Lorente, Dewhurst, and Dale (1998) and Soltani, Lai, Javadeen, and Gholipour (2008) clarified that many of the roots of TQM are the result of work conducted in Japan in the late 1940s. Despite this broad view of origins of TQM as a management theory, there is a consensus in the literature regarding the key contributors to TQM and why it became of interest in the United States. Deming, Crosby and Juran were key contributors to TQM as a theory and management philosophy (Fisher & Nair, 2009; Martinez-Lorente et al., 1998; Macdonald, 1998; Soltani et al., 2008).

However, researchers differ in opinion regarding additional contributors to TQM. For example, Martinez-Lorente et al. stated that Feigenbaum and Ishikawa also contributed to total quality as a management theory and philosophy. Fisher and Nair (2009) noted Shewart’s work as contributing to TQM in the areas of statistical techniques; Deming also made references to Shewart’s work (Deming, 1982). This literature review of TQM will include the work of Juran, Deming, Crosby, Ishikawa, and Feigenbaum. Shewart’s work will not be reviewed, as there is much more to TQM than statistical techniques (Fisher & Nair, 2009). In addition, statistics are not relevant to this study, which seeks to understand the real-life experiences of senior leaders in implementing lean manufacturing. Joseph Juran. Juran’s philosophy of quality and quality management was influential in the development of TQM (Fisher & Nair, 2009; Macdonald, 1998; Soltani et al., 2008). Juran’s contribution to the development of TQM began in the 1940s (Evans & Linday, 2009).

In addition, Juran played an important role in the development of top- and middle-management responsibilities in the promotion of total quality in organizations (Fisher & Nair, 2009). Juran’s perspective on quality management included “identifying customers and their needs, establishing optimal quality goals, creating measurements of quality [and] planning processes of meeting goals, producing continuing results in improved market share, premium prices and reduction of errors” (Mann, 2008). Juran said quality management should focus on meeting the needs of customers rather than on conformance to product or service design standards; “customer satisfaction becomes the focus” (1995). Identifying customer needs requires answering specific questions. According to Juran and De Feo (2010), those questions include the following:

*Why is the customer buying this product?*

*What service does she or he expect from it?*

*How will the customer benefit from it?*

*How does the customer use it?*

*What has created customer complaints in the past?*

*Why have customers selected competitors’ products over ours?*

According to Juran (1993), setting quality goals involves not only establishing the goal but also developing and implementing a plan toward goal achievement, identifying measures to evaluate progress toward goals, and reviewing progress toward goals on a regular basis. Goals should be defined in key areas. Juran (1995) also noted that qualitybased goals should be included in an organizational business plan and that the goals should be “to improve customer satisfaction, to meet competitive standards, to reduce costs of poor quality, and to improve key processes” . W. Edwards Deming. Deming was a key contributor to the development of TQM (Fisher & Nair, 2009; Mann, 2008; Martinez-Lorente et al., 1998; Phelps, Parayitam, & Olson, 2007). However, Deming did not use the term TQM in his works (Phelps et al., 2007), and he was not in agreement with some of the early TQM philosophies of zero defects and quality costing (Deming, 1982; Martinez-Lorente et al.). Deming (1982) believed that zero defects were a fallacy. Instead, he used the term “deadly diseases” to describe issues that inhibit an organization from optimal performance. These diseases are identified in Table 1. Deming stated that “cure of some of the diseases requires a complete shake up of Western style of management” . Deming emphasized that management must create a common purpose toward improvement to sustain the company rather than focusing on short-term performance and profits. In addition, Deming presented a philosophy of management based on 14 points.

Table 1: *Deming’s Seven Deadly Diseases (Deming, 1982)*

|  |  |
| --- | --- |
| *1.* | *Lack of constancy of purpose to improve an organization’s product and service*  *meeting the needs of the market and to provide jobs* |
| *2.* | *Emphasis on short-term profits leading to management decisions regardless of*  *quality* |
| *3.* | *Performance evaluations that do not emphasize leadership’s role in helping*  *people and establishing teamwork to solve problems* |
| *4.* | *Short tenure of an organization’s managers creates uncertainty among employees*  *and results in fear that inhibits long-term performance* |
| *5.* | *Management failing to recognize the impact of customer dissatisfaction on repeat*  *sales, improvement of an upstream process on downstream processes,*  *improvement that results from training and teamwork.* |
| *6.* | *Excessive costs inhibiting price competitiveness* |
| *7.* | *Excessive costs of liability* |

**Point 1: Constancy of purpose for improving.**

According to Deming (1982), creating constancy of purpose for improving products and service is intended to address current and future problems. Deming stated that companies need to be dedicated “to the improvement of competitive position to keep the company alive and to provide jobs for their employees”. Organization leaders must strive to improve competitive positions and provide jobs for employees. Keim (2011) noted that constancy of purpose requires long-term management commitment.

**Point 2: Adopt the new philosophy.**

Deming (1985) believed that companies must adopt a new management philosophy to stop the decline in the manufacturing industry. According to Deming (1982), management can no longer tolerate commonly accepted levels of mistakes, defects, material not suited for the job, people on the job that do not know what the job is and are afraid to ask, handling damage, antiquated methods of training on the job, inadequate and ineffective supervision, management not rooted in the company, [and] job hopping in management. Evans and Lindsay (2009) indicated that everyone, from the board room to the shop floor, must adopt this new philosophy identified by Deming’s in this point.

**Point 3: Cease dependence on mass inspection.**

According to Deming (1982), mass inspection refers to a general acceptance by management that the processes in place cannot produce a product to specification. Inspecting the quality of goods does not improve the quality of product produced and is both ineffective and too costly. Deming identified the importance of “inspection at the right point for minimum total cost” (. Deming (1985) also noted that building quality into the process and product can eliminate dependence on mass inspection. Feigenbaum (1991) commented that responsible parties could include operators, inspectors, or automated quality control equipment.

**Point 4: Awarding business on the basis of price alone.**

According to Deming (1982), the materials and supplies purchased in manufacturing should be selected based on lowest total cost instead of lowest per-unit cost. This is supported by Cattani, Dahan, and Schmidt (2010), who noted that a lower per-item cost may actually result in a higher total-product cost. Deming (1982) noted that companies should consider how incoming materials, regardless of per-unit price, will affect production operations. One such consideration is that items (even when purchased at the lowest possible price per unit) that adversely affect production operations may carry a higher total cost than items purchased at higher per-unit costs. Deming (1982) also identified the importance of single-source suppliers, noting that focusing on longer-term supplier relationships can help a “supplier be innovative and develop economy in his production processes”. In turn, the buyer would benefit from the supplier’s development of economy and innovation. Alternatively, Ghosh and Federowicz (2008) noted that using single-source suppliers can result in trust issues between a manufacturer and supplier, as it is easy for a single-source supplier to use “power tactics” to leverage supplier benefits.

**Point 5: Constantly improve the system of production and service.**

Deming (1982) said that while improvement includes the production environment, it spans beyond that realm. Constant improvement includes all departments in a manufacturing organization, all processes used to produce a product and deliver a service, and every person’s ability to perform his or her job. Deming believed that improvement starts with an understanding of the customer and how the customer uses or may “misuse a product”. Crosby (1979), Feigenbaum (1991), and Juran and De Feo (2010) identified that organizations need to understand customers’ needs as an informational source to support quality improvement.

Production processes must include continuously removing waste and improving overall quality (Deming, 1982). Deming noted that this focus on waste and quality extends to all departments and activities, including “procurement, transportation, engineering, methods, maintenance, locations of activities, sales, methods of distribution, supervision, retraining, accounting, payroll, service to customers”. Deming (1982) further expanded the definition of constant improvement to the individual, noting that improvement at the individual level includes selection, placement, and training of people to advance their skill and best use their abilities.

**Point 6: Institute training.**

According to Deming (1985), training and education should occur on the job, and management should be included. Management needs to fully understand the company, from receipt of materials to customer reception of the materials (Deming, 1982). Deming (1982) identified that management’s job is to take action on problems that interfere with the production worker’s ability to meet production requirements. Management must be well versed in all activities of the company to fully understand and address the problems that production workers face. Deming (1982) stated that “the greatest waste in America is failure to use the abilities of people”. The best method of learning may differ from person to person based on individual learning styles, which include written instruction, spoken instruction, pictures, or some combination thereof (Deming, 1982). Dobson (2010) mentioned four styles of learning: visual, listening, reading and writing, and physical involvement through “touching and manipulating materials”. Alternatively, Pashler, McDaniel, Rohrer, and Bjork (2008) concluded in their research that there is insufficient evidence to support learning style assessments as part of education. Training and education for employees and managers should focus on customer needs and take into consideration the learning style appropriate for the trainee (Deming, 1982).

**Point 7: Adopt and institute leadership.**

Deming (1982) summarized that a leader’s job is to help workers achieve improvement in performance, quality, and output. He emphasized that leaders have to be knowledgeable of the jobs they supervise; otherwise, they will be incapable of helping employees to improve in those jobs. Deming stated that supervisors “must be empowered and directed to inform upper management concerning conditions that need correction”. The consequence of not having job knowledge results in meeting production requirements or quotas at the expense of quality and customers’ needs and satisfaction.

**Point 8: Drive out fear.**

Deming (1982) noted that fear will inhibit job performance if employees do not feel secure in their jobs. Fear results from uncertainty regarding company stability, a culture that does not permit employees to submit ideas or make suggestions, concerns regarding comparative ratings among employees, punitive styles of management, mistrust of management, management by numbers, and pressures to get to the next job (Deming, 1982). Juran and De Feo (2010) stated that “fear that management will view any negative comment as adverse is a powerful disincentive for workers to provide suggestions, challenge the status quo, or offer accurate and honest feedback”. Alternatively, Petitpas (2008) stated that “in the short run, fear can be a strong motivator, but over time prolonged fear can lose its power to coerce behavior”.

**Point 9: Break down barriers between staff areas.**

According to Evans and Linday (2009), Frederick Taylor’s Scientific Management resulted in the segmentation of job tasks leading to quality being a separate department. Deming (1982) noted that segmentation of departments such as engineering, marketing, sales, procurement, and inventory control from production departments can lead to production-related losses. He also stated that failure to break down barriers between the aforementioned departments can lead to “losses in production from necessity for rework caused by attempts to use materials unsuited to the purpose”. One method of breaking down these barriers is through the use of teamwork with members coming from these functional departments (Evans & Lindsay, 2009). In addition, Crosby (1979) noted that members from each functional area should participate in quality improvement teams.

**Point 10: Eliminate slogans, exhortations, and targets for the workforce.**

Deming (1982) stated that all “targets, slogans, exhortations, posters for the work force that urge them to increase productivity” should be eliminated, as “these never helped anyone to do a better job”. According to Deming (1982), these posters focused on the production worker although the majority of mistakes and errors are the result of the production system, which is the responsibility of management. Therefore, employees could not successfully achieve the desired objectives from slogans, exhortations, and targets. According to Evans and Lindsay (2009), these slogans and posters focus on increasing motivation for employees to change behavior and improve quality. However, Evans and Lindsay indicated that improvement can only occur if there is an understanding of actual causes; otherwise, workers’ attempt to correct a problem may only increase variation of the process. Alternatively, Crosby (1979) stated that organizations can create quality awareness by “providing visible evidence of the concern for quality improvement through communication materials such as booklets, films, and posters”.

**Point 11: Eliminate numerical goals for workforce and management.**

Deming (1982) stated that “a quota is a fortress against improvement of quality and productivity” and “is totally incompatible with never-ending improvement”. Deming supported this argument by adding that quotas are based on average performance; thus, high performers will reduce their output, and low performers will become dissatisfied with the additional pressures and stress related to quotas. This premise regarding low performers is supported by Deming’s view that the majority of problems that exist in an organization are system related, and system-related problems are a management, not production worker, responsibility. According to Evans and Lindsay (2009), these numerical quotas are often used as a punitive tool; as such, they fail to influence improvement. Deming further asserted that if organizations had a stable system, there would be no need for goals, as the output would match organizational capability. Implied in this view and in statements that management is responsible for the system is that management should be focused on stabilizing the system that produces the work.

**Point 12: Remove barriers that rob people of pride of workmanship.**

Deming (1982) noted that barriers robbing people of pride and workmanship must be removed for hourly workers and for managers. Evans and Lindsay (2009) noted that some of the barriers to pride in workmanship for hourly workers include dull and repetitive task assignments, substandard equipment, organizational pressures to meet sales quotas regardless of quality, and a supervisor’s lack of knowledge regarding an employee’s job. Management’s responsibility is to fix organizational systems to remove these barriers that rob hourly employees of their pride of workmanship. However, Deming (1982) noted that managers, too, have a barrier that robs them of their pride of workmanship: “annual rating of performance, or merit rating”. He said that annual performance ratings fail to address system-based improvements. In addition, Deming stated that performance rating systems result in a culture in which “everyone propels himself forward, or tries to, for his own good on his own life preserver. The organization is the loser”. Evans and Lindsay noted other factors that rob managers of pride in their work, including long hours and weekend work as a result of previous decisions, such as layoffs, to cut costs (Deming 1982).

**Point 13: Encourage education and self-improvement for everyone.**

According to Evans and Lindsay (2009), Deming is focused on continuing education for the long-term development of people. Deming (1982) stated that “advances in competitive position will have their roots in knowledge”. Deming noted that high levels of knowledge are required to support transformations of organizations. Individual improvement through education should provide the knowledge necessary to help the organization in transforming management approaches, improving processes, and improving quality. This view of education is supported by Ishikawa, Feigenbaum, and Crosby. Ishikawa (1991) noted that without good education, organizations are incapable of improvement. Feigenbaum’s opinion was that quality education is essential for an organization to achieve commitment to quality (1991). Crosby (1979) clarified that it is important to provide training on quality education even if employees are not interested in education and self-improvement. He posited that quality education should be focused on the product being produced, the service being provided, and the customer gaining buy-in, as “some people are just not interested in learning anything that will make them have to change”. Alternatively, Maleyeff (2011) concluded that individual education has little positive effect on recommendations for innovative ideas.

**Point 14: Take action to accomplish the transformation.**

Deming’s original work on taking action to accomplish the transformation does not seem to indicate the steps involved in taking such action. According to Evans and Linday (2009), this was intentional, as Deming realized that each organization is different and that action should be based on each organization’s culture. However, Deming did discuss key aspects important for this point to be successful. For example, Deming (1982) noted that management must “have the courage to break with tradition”, agree with the importance of the meaning and direction of the new philosophy, and “explain to a critical mass of people in the company why change is necessary”. Deming also noted the importance of understanding the flow of processes and of internal departments viewing the next step in the process as a customer.

The intent was to use a team-based approach to improve both the input and output of the processes. Deming (1982) presented in point 14 is a model to manage improvement activities, the Shewart Cycle. The Shewart Cycle included identifying the most important change, implementing the change, understanding through observations the “effects of the change”, and studying the results to identify what was learned and what predictions can be made. Deming also emphasized the continual cycle of improvement; this includes returning to identify the next most important change after completing the Shewart Cycle.

Deming used a model called plan-do-check-act as his version of the Shewart Cycle (Imai, 1997). Phillip Crosby. Crosby’s ‘philosophy’ of quality management contributed to the development of TQM (Fisher & Nair, 2009; Martinez-Lorente et al., 1998; Macdonald, 1998; Soltani et al., 2008). Macdonald (1998) noted that Crosby’s work in quality management was preceded by the works of Deming and Juran. However, it was Crosby’s book, Quality is Free, in 1972 that became the catalyst for TQM (Macdonald). Crosby presented 14 steps in the development of a quality management system; see Table 2.

Crosby emphasized an objective of zero defects (Crosby, 1972; Martinez-Lorente t al., 1998). The zero defects objective was to be obtained through prevention (Martinez Lorente et al.), and many of Crosby’s 14 steps reinforce this objective. For example, Crosby stated that management commitment involves a discussion, with management emphasizing “the need for defect prevention”. The creation of a committee to support zero defects emphasizes that “everyone should do things right the first time”. In step 9, too, Crosby identified that management should establish a108487 performance standard of zero defects. In step 11, Crosby emphasized removing the causes of errors, adding to the objective of zero defects and prevention of future defects.

This step includes getting employees to describe problems that prevent them from achieving “error-free work”. Alternatively, Deming (1982) noted that emphasizing zero defects and doing work right the first time adversely affects motivation to achieve high quality, as workers have little influence over issues that cause defects. Deming attributed defects in processes to system-related problems that are out of individual workers’ control.

Table 2

Crosby’s Quality Management (Crosby, 1979,)

|  |  |
| --- | --- |
| The Fourteen Steps | |
| 1. Management commitment | 8. Supervisor training |
| 2. Quality improvement team | 9. Zero defects day |
| 3. Quality measurement | 10. Goal setting |
| 4. Cost of quality evaluation | 11. Error cause removal |
| 5. Quality awareness | 12. Recognition |
| 6. Corrective action | 13. Quality Councils |
| 7. Establish an ad hoc committee for the zero defect program | 14. Do it over again |

Along with Crosby’s emphasis on zero defects, he emphasized awareness and commitment throughout the organization, as evidenced in several of his 14 steps. For example, the quality improvement team was to have representation across departments to provide each department with a voice and “to commit that [department] operation to action”. Crosby was explicit about creating awareness by including it directly in step 5. The intent of step 5 was to provide “visible evidence of the concern for quality improvement”. Creating this level of awareness could not be accomplished without understanding the cost of quality to an organization, as identified in step 4. In step 6, Crosby emphasized encouraging people to discuss problems that prevent them from doing the work right.

As part of step 10, goal setting, Crosby noted the importance of supervisors working with employees to establish short-term goals. These short-term goals were intended to assist in getting people involved and focused on achieving a team-based approach and motivating employees committed to improving quality (Crosby, 1979). Crosby (1979) also identified the importance of measurement in achieving improved quality in step 3. The objective of this step was to gain an understanding of where the work of each department was in terms of quality, to identify where opportunities for improvement exist, and to have a baseline for comparison to “document actual improvement”. In this step, Crosby also emphasized the importance of extending quality beyond the manufacturing floor to other departments, including purchasing, accounting, marketing, finance, and engineering (Crosby, 1979).

Crosby (1979) identified the importance of supervisory training in step 8. However, this extended beyond simply training supervisors to validating supervisors’ knowledge of the quality management system. For example, Crosby stated that “all managers must understand each step well enough to explain it to their people”. This is further emphasized in step 9, in which employees’ respective supervisors are expected to explain zero defects as a standard. Kaoru Ishikawa. Ishikawa’s work in the development of total quality control in Japan contributed to the evolution of TQM today (Cusumano, 1985; Fisher & Nair, 2009; Martinez-Lorente et al., 1998). According to Cusumano, Ishikawa shifted focus from statistical methods alone to involving everyone in the quality control program. In addition, his perspective included expanding quality control (QC) programs to include “methods for managing and coordinating cost control, production management, inventory control, market analysis, and design”.

Ishikawa also emphasized that reported data alone is not sufficient for understanding a problem; managers must go to where the work is done (Imai, 1997). Ishikawa (1991) noted that the location of the quality defect, whether the factory floor or office, is where careful investigation should occur. Another contribution of Ishikawa was the development of quality control circles (Deming, 1985). Schonberger (1982) stated that a quality control circle process “formally mobilizes small voluntary teams of workers in order to improve quality and productivity”. Interestingly, both Deming and Juran emphasized that the majority of problems that exist in an organization can be solved only by management. Juran indicated that quality circles could, at best, solve only a “trivial many” of a firm’s quality problems (Schonberger). Ishikawa formalized the use of seven tools for quality control and advocated that approximately 90% of problems faced by companies could be solved using these tools (Moore, 2007).

These tools included cause-and-effect diagrams, Pareto charts, flow charts, a check sheet, scatter plots, control charts, and histograms. Cause-and-effect diagrams are also called Ishikawa diagrams, named after him for his role in their creation, or fishbone diagrams, named based on their appearance (Imai, 1997; Juran & De Feo, 2010). Ishikawa’s diagrams help to visualize cause-and-effect relationships to identify various potential root causes of problems and to assist “the team to work more productively toward discovering the true root cause or causes” (Juran & De Feo). An example of a fishbone or Ishikawa diagram is presented in Figure 1. The remaining tools were not created by Ishikawa but were used by Ishikawa in his total quality control philosophy. A brief explanation of these tools is presented in Table 3.

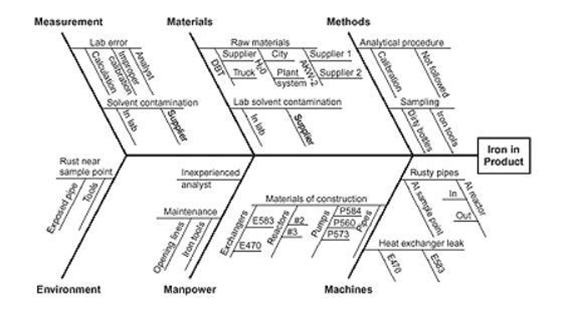


Figure 1. Ishikawa diagram (American Society for Quality, 2011)

Ishikawa also introduced a systematic method for dealing with quality and process improvement. This method was an extension of W. Edward Deming’s plan-docheck-act approach (American Society for Quality, 2011). Ishikawa’s approach emphasized identifying objectives or targets for improvement to decide on the method that should be used to achieve objectives, educate and develop staff to be able to make improvements, implement improvements, evaluate the effectiveness of changes implemented, and take action, as appropriate, if improvements did not achieve the desired outcomes (Ishikawa, 1991).

Table 3 :Seven Tools of Quality Control (American Society for Quality, 2011; Juran & De Feo, 2010)

|  |  |
| --- | --- |
| Seven Basic Tools for Quality | |
| 1. | Cause-and-effect diagram (Ishikawa diagram): tool for identifying numerous potential causes of a problem, sorting them into meaningful categories |
| 2. | Check sheet: form used to collect and investigate information |
| 3. | Control charts: formal method used to evaluate how a process changes over an extended period |
| 4. | Histogram: tool used for evaluating frequency of occurrences of a particular type |
| 5. | Pareto chart: chart used to identify the events that are more significant |
| 6. | Scatter diagram: graph that attempts to identify relationships of numerical data |
| 7. | Stratification: method for evaluating and separating data to identify patterns |

Armand Feigenbaum. Feigenbaum contributed to the development of TQM (Mann, 2008; Fisher & Nair, 2009). He authored the book Total Quality Control in 1951; however, Feigenbaum’s work can be traced back to the 1940s (Mazumder, Bhattacharya, & Yadav, 2011). Feigenbaum (1991) defined total quality control as follows:

Total quality control’s organization-wide impact involves the managerial and technical implementation of customer-oriented quality activities as a prime responsibility of general management and of the main-line operations of marketing, engineering, production, industrial relations, finance, and serves as well as of the quality control function itself.

Feigenbaum (1991) noted that total quality control “provided the foundation” for total quality management’s evolution. Mann (2008) reported that the key components of Feigenbaum’s total quality control include “quality leadership, companywide introduction, continuous motivation, education, and measurement”. In terms of quality leadership, the general manager has two primary responsibilities. The first is to establish an organization-wide quality level for the business. The second is to establish and communicate the plan for the quality system. This plan includes an organizational quality manual (Feigenbaum, 1991). Managers achieve continuous motivation by enlisting people who do the work to improve quality. Feigenbaum stated that “support, involvement, and motivation of these persons and groups are more likely to be secured if they have participated in formulation of the [quality] program”. Feigenbaum’s perspective of involving frontline staff is supported by other quality experts (Deming, 1982; Crosby, 1972). Education for employees must occur in the areas of job knowledge and skill and in understanding how to control quality and solve quality problems (Deming, 1982; Feigenbaum, 1991).

Measurement of quality takes into consideration manufacturing processes, the design of a product, and the product’s function (Feigenbaum, 1991). In developing appropriate quality measures, Feigenbaum commented that several decisions must be considered, one of which is identifying “the methods used for taking the measurement”. In supporting quality measurements, it is also important to decide on the frequency with which measures should be taken and the point in the production process at which they should occur. Feigenbaum noted that frequency could include every item produced or a sampling of products produced from a manufacturing process. The final decision in developing and implementing quality measures is identifying who is responsible for taking the measures. Feigenbaum noted that the people or machines responsible could be operators, inspectors, or automated quality control equipment. Mazumder et al. (2011) noted that Feigenbaum’s key contributions included a focus on prevention of errors rather than correction of errors, understanding customer needs, improving quality across all departments in an organization, and understanding “cost of quality”.

Feigenbaum (1991) clarified that cost of quality falls into two categories. The first is the cost to control quality and the second is the cost associated with a “failure of control”. Cost of control includes the cost to prevent defects and the cost to appraise or measure quality. Costs associated with failure to control quality are categorized as those internal and external to the organization. Feigenbaum said that internal costs include “scrap, spoilage, and reworked materials”, and external costs include costs associated with customer dissatisfaction. Feigenbaum’s view changed the focus with regard to the cost of quality. Feigenbaum identified although higher quality may initially seem to cost more, failing to improve quality ultimately costs more (Mazumder et al.). Feigenbaum reported that “satisfactory quality means satisfactory resource utilization and consequently lower costs”.

In summary, this section reviewed the historical overview of total quality management. Key contributors to the development of TQM included Juran, Deming, Crosby, Ishikawa, and Feigenbaum (Fisher & Nair, 2009; Martinez-Lorente et al., 1998; Macdonald, 1998; Soltani et al., 2008). Juran’s philosophy on managing quality included understanding the needs of customers, establishing appropriate goals to improve quality, developing and implementing a plan to meet goals, and having a means to measure progress toward those goals (Mann, 2008). Deming focused on creating a common purpose to improve quality and create and keep jobs for employees through his first point: create a constancy of purpose (Deming, 1982). Deming also noted that the majority of barriers to quality improvement are because of system-related problems. Deming presented his theory of quality management in 14 points. Crosby’s belief was that failing to focus on quality management ultimately costs organizations more because it results in rework and in customer dissatisfaction (Crosby, 1979). Ishikawa expanded quality control to all employees. Another important contribution of Ishikawa was the expanded definition of quality to include cost control, production processes, inventory, and design of products.

TQM contributed to the development of lean manufacturing (Turesky & Connell, 2010). According to Dennis (2007), works by Deming, Juran, Ishikawa, and Feigenbaum contributed to the development of lean manufacturing. Schonberger (1982) noted that the works of Deming and Juran was highly influential in the development of management and quality systems of Toyota and lean manufacturing. Fujimoto (1999) stated that Ishikawa’s work had a significant influence on the evolution of manufacturing systems in Japan and Toyota. The manufacturing systems in Japan were studied by Massachusetts Institute for Technology (MIT) and labeled as lean manufacturing (Keller, 2006; Levinson, 2009; Liker, 2004; Schonberger, 1982; Wilson, 1995). What follows is a review of literature on lean manufacturing.

**2.4 Historical Overview of Lean Manufacturing**

This section includes a review of literature for both the Toyota Production System (TPS) and lean manufacturing. The historical perspective begins with the foundation of Toyota Motor Company in 1918 (Holweg, 2007) and includes the historical development of the Toyota Production System. Lean manufacturing is another name for the Toyota Production System (Emeliani & Stec, 2005). Because the term “lean manufacturing” was not identified until 1990 by Womack, Jones, and Roos (1990), the term Toyota Production System will be used to discuss events and research prior to 1990. Events and research that occurred after 1990 will use the term lean manufacturing.

Sakichi Toyoda had a spinning and weaving business, Toyoda Loom Works. This is important in the historical development of the Toyota Production System for several reasons. First, Toyoda’s spinning and weaving business used patented technology (Schonberger, 1982); the sale of this patented technology resulted in the creation of Toyota (Holweg, 2007; Krafcik, 1988; Liker, 2004; Ohno, 1988). Kiichiro Toyoda provided a philosophy of just-in-time production, and this philosophy is a key contribution to the Toyota Production System (Liker, 2004) and Japanese manufacturing techniques (Schonberger, 1982).

Second, Toyoda Loom Works hired Taiichi Ohno in 1932 as a mechanical engineer (Holweg, 2007). This was an important development in the creation and evolution of the Toyota Production System (TPS), as Taiichi Ohno is given credit for founding TPS (Dennis, 2006; Holweg, 2007; Imai, 1997; Liker, 1998, 2004; Schonberger, 1982; Spears & Bowen, 1999; Womack & Jones, 1996; Womack et al., 1990). After the dissolution of Toyoda Loom Works in 1943, Taiichi Ohno joined Kiichiro’s automotive business, despite having no experience in manufacturing automobiles (Fujimoto, 1999; Holweg, 2007; Standard & Davis, 1999). The development of the Toyota Production System and lean manufacturing is, in part, the result of assembly-line observations made by Toyota executives at Ford’s Dearborn plant (Keller, 2006; Levinson, 2009; Liker, 2004; Schonberger, 1982; Wilson, 1995). This is supported by Keller (2006), Krafcik (1988), Schonberger (1982), and Wilson (1995), who indicated that the principles of the Toyota Production System were based on Henry Ford’s principles.

Some of the key observations identified included the concept to not push materials to the next production process but rather to pull them based on customer consumption (Cusumano, 1985). This concept of pulling is fundamental to the Toyota Production System (Dennis, 2007; Imai, 1997; Liker, 1998, 2004; Womack & Jones, 1996; Womack et al., 1990), and it led to better coordination of material flow to in-process and final assembly. According to Fujimoto (1999), better coordination of material flow “became a foundation for subsequent Toyota Production System changes” .

Toyota also began to focus on quality as a key contributor to its success. This started when W. Edwards Deming and Joseph Juran lectured in Japan in 1950 (Schonberger, 1982). Deming taught that “meeting and exceeding the customers’ requirements is the task of everyone within an organization” (Liker, 2004). Liker (2004) posited that Deming introduced and encouraged Japanese management to follow the plan-do-check-act approach to quality improvement. The result of Deming’s and Juran’s lectures included a deep immersion in quality training for managers and engineers at Toyota (Schonberger, 2007). The result was the development of a total quality control program and quality circles, another key element of the Toyota Production System (Schonberger).

According to Fujimoto (1999), Imai (1997), Liker (2004), and Standard and Davis (1999), a program developed in the United States during World War II provided significantly influenced aspects of the Toyota Production System. This program was Training Within Industry (TWI), which had three fundamental elements: job instruction, job methods, and job relations. Imai stated that this program “may well have been more influential” than the work of both Deming and Juran”. Imai reasoned that this program taught Japanese managers the “importance of human relations and employee involvement…the methodology and value of continuously improving processes and products…[and] the usefulness of a scientific and rational approach to managing people and operations”. This is supported by Fujimoto, who indicated that TWI was a catalyst for training supervisors on continuous improvement and kaizen, a structured approach used by Toyota to support the continuous improvement philosophy of TQM (Fujimoto, 1999). Liker (2004) stated that TWI “taught Japanese businesses standardization processes aligned with Toyota’s standardization philosophy.”

Other contributions of TWI included a process for the elimination of unnecessary work tasks, more efficient sequence of operations, and storage of needed items where they are used (Standard & Davis, 2004).

Ohno visited the United States in 1956. During his visit, he gleaned insight from visiting both automobile factories and grocery stores. One such insight was the replenishment of items in a retail supermarket, which led to the kanban supermarkets for replenishing parts in the Toyota Production System (Holweg, 2007). Fujimoto (1999) noted that kanban supermarkets are a means to manage both inventory and production based on downstream consumption and production of products. In addition, Ohno said that a critical challenge for Toyota would be to “create continuous flow in small-lot production” (Womack & Jones, 1996). This was an important deviation from manufacturing in the United States because large lot production created an intense demand on working capital and storage space for inventories and made it difficult for manufacturers to meet the diverse needs of customers (Holweg, 2007).

Ohno realized that the time spent changing over a machine from one type of part to the next type of part had to be shortened to produce a greater variety of smaller lots of discrete parts (Holweg, 2007). To accommodate smaller lot production, changeover times could no longer be viewed as a static variable to production; shorter changeover times would permit increased production flexibility through reduced lot sizes and more diverse part production (Dennis, 2007; Fujimoto, 1999; Shingo, 1985; Womack & Jones, 1996). This began with a shift in thinking: rather than being fixed in terms of time and cost, changeovers could be improved (Schonberger, 1982). Schonberger (2007) identified Taguchi as responsible for two key management innovations of the Toyota Production System. The first was the Taguchi method, an approach that considered the manufacturability of a design criterion (Fujimoto, 1999). Dura and Isac (2009) identified three aspects of the Taguchi Method that relate to quality.

The first was the need to provide training and instruction on quality to employees. The second involved including quality in the design phase, such that product function is achieved at a minimal cost (Dura & Isac). The third was the quality loss function (Dura & Isac; Schonberger, 2007), which, according to Dura and Isac, included a financial quantification of quality. The second key management innovation was quality function deployment (QFD) (Dura & Isac, 2009, Imai, 1997; Schonberger, 2007). According to Imai, QFD “is a powerful tool that enables management to identify the customer’s needs, convert those needs into engineering and designing requirements, and eventually deploy this information to develop components and processes, establish standards, and train workers”. These two innovations greatly enhanced the quality philosophy, extending it from the customer through production and then to design and engineering.

It is important to note that Toyota’s quality philosophy continued to evolve. Prior to this evolution, Toyota focused on training managers and engineers on quality concepts, as discussed earlier. Then Toyota started pushing quality training down the organizational hierarchy to the foremen level (Schonberger, 2007), thus continuing the strategy of pushing responsibility down to the lowest possible level (Conti et al., 2006) and obtaining involvement from frontline employees (Liker, 1998). Both Cusumano (1985) and Fujimoto (1999) identified other factors important to the development and integration of the Toyota Production System. For example, Fujimoto indicated that Toyota adopted total quality control in the early 1960s and was recognized for quality when Toyota was awarded in the Deming Prize. In addition, quality programs and supplier management programs were introduced to suppliers during this same period (Cusumano, 1985; Fujimoto, 1999). Cusumano goes further to indicate that just-in-time inventory and kanbans were extended to suppliers as well.

It was not until the late 1970s that the Toyota Production System was known to the West (Schonberger, 2007). Holweg (2007) also notes this, identifying 1973, during the first oil crisis, as the time when interest was raised about understanding Toyota and the Toyota Production System. According to Holweg (2007), Ohno and other key participants in the development of the Toyota Production System first authored literature about this in the 1970s. As a result of Toyota’s accomplishments in manufacturing quality and efficiency, the International Motor Vehicle Program, headed by researchers from the Massachusetts Institute of Technology (MIT), began a study titled The Future of the Automobile (Holweg, 2007). This study, published as a book in 1984, sought to determine the range of productivity performance of automobile manufacturers around the world (Krafcik, 1988). Consequently, there was an accelerated interest in and publicity for what Toyota was doing. According to Schonberger, interest spanned three primary areas: employee involvement, total quality control, and just-in-time manufacturing. Contributing to this accelerated interest was an NBC documentary in 1980, featuring Deming, titled If Japan can…Why can’t we (Macdonald, 1998). It is also important to note that in the early 1980s, the International Motor Vehicle Program began a second-phase research study, of which Womack became the research director in 1983 (Holweg, 2007). Fujimoto (1999) identified this study as the second phase of research looking at automobile assembly operations. This was important, as the research led to the publication of two books: The Machine that Changed the World (Womack, Jones, & Roos, 1990) and Lean Thinking (Womack & Jones, 1996) thereby creating a catalyst for the introduction of lean manufacturing (Emiliani, 2006; Holweg, 2007; Liker, 2004; Schonberger, 2007).

A summary of lean manufacturing and its development from early Toyota until now has been reviewed. This summary addressed many of the key concepts of lean manufacturing, including just-in-time production, kaizen, and kanban systems. In addition, this summary identified key influential leaders, such as Deming; contributions, such as research conducted by MIT; Training Within Industry; and observations made by early Toyota executives at Ford’s Dearborn manufacturing operation. This next section will review barriers to lean manufacturing implementation and success strategies.

**2.5 Barriers to Lean Manufacturing Implementation**

It is not easy to implement lean manufacturing (Pirraglia, Saloni, & Van Dyk, 2009). Barriers were identified in sources including journal articles and books written regarding lean manufacturing implementation. Such barriers include issues relating to senior leadership, middle management, knowledge, communication, and resources (Arthur, 2008; Pirraglia et al., 2009; Sayer & Williams, 2006; Worley & Doolen, 2006).

**Each of these barriers is presented below.**

**Senior leadership.**

A lack of commitment and focus is a barrier to successful implementation of lean manufacturing (Atkinson, 2010). According to Sayers and Williams (2006), lack of focus involves leaders getting sidetracked by new fads for improvement. Pirraglia, Saloni, and Van Dyk (2009) noted that one obstacle to sustainable implementation is senior leaders viewing it as a short-term improvement initiative. Turesky and Connell (2010) commented that a “false commitment by management” is a barrier. This occurs when senior leaders espouse commitment, but their actions and behaviors do not support this commitment (Turesky & Connell). Sayers and Williams noted that senior leaders who do not fully embrace lean manufacturing are a barrier to successful implementation.

Sayers and Williams (2006) identified complacency among senior leaders as a barrier to successful lean implementation. According to Webster’s Dictionary, complacency is a degree of satisfaction without awareness of deficient factors. Complacency occurs among senior leaders when initial lean manufacturing improvements are made; leaders become satisfied with the improvements achieved and lose focus on continuing lean manufacturing implementation (Sayers & Williams, 2006). Spears and Bowens (1999) noted that lean manufacturing implementation requires a continuous pursuit of perfection as an improvement culture. Womack and Jones (1996) also commented that lean manufacturing requires that an organization continuously improve.

**Middle management.**

Middle management could be a barrier to lean manufacturing implementation (Arthur, 2008; Pirraglia et al., 2009; Sayer & Williams, 2006). Arthur (2008) noted that an inability to gain collaboration across the organization, including middle management, can inhibit a firm’s lean manufacturing implementation. Pirraglia et al. (2009) indicated that some managers fear that making improvements will seem to imply that they were failing in their jobs. According to Hoyte and Greenwood (2007), middle managers are less likely to see the advantages of a lean transformation; the role of these managers shifts from directing and controlling to “listening, encouraging, teaching, and coaching”. Sayer and Williams noted that an obstacle to implementation is failure to develop frontline supervisors and middle managers to understand their changing roles in a lean organization (2006).

According to Pirraglia et al. (2009), a lack of knowledge related to “implementation know-how” is a barrier to lean manufacturing implementation. For example, Sayers and Williams (2006) and Pirraglia et al. noted that lean is sometimes used as a quick fix instead of as long-term, continuous improvement philosophy. Womack and Jones (1996) commented that lean manufacturing implementation is a longterm strategy. In addition, Sayers and Williams noted that a lack of knowledge regarding lean tools is a barrier. Lean tools include 5S, Quick Changeover, Total Productive Maintenance, Standardized Work, Heijunka, Visual Management, 5 Whys, and Kaizen. The definition of each of these tools and their use is included in the definition section in chapter 1. Sayers and Williams (2006) indicated that a barrier to successful lean implementation is that leaders use the wrong lean tool to solve specific organizational problems.

**Communication.**

Communication has been identified as a barrier to lean manufacturing implementation (Pirraglia et al., 2009; Worley & Doolen, 2006). For example, Pirraglia et al. stated that not having but communicating a “crisis to create a sense of urgency” is a barrier to lean manufacturing implementation. Worley and Doolen noted that disconnect between employees and management regarding the reasons for lean implementation is a barrier to success as well. Turesky and Connell (2010) stated that gaps in communication, both vertically and horizontally, within organizations is a key issue that inhibits successful lean manufacturing implementation.

**Resources.**

Pirraglia et al., (2009), Turesky and Connell, (2010), and Worley and Doolen, (2006) described the lack of resources as a barrier to lean manufacturing implementation. Each noted the lack of human resources as a barrier. According to Turesky and Connell, the lack of human resources exists in two areas: training and lean project completion. Hoyte and Greenwood (2007) noted the need for extensive training of employees and managers. Pirraglia et al. indicated that not having time for lean implementation is problematic. Hoyte and Greenwood also showed that the lack of training resources could inhibit an organization’s ability to implement lean manufacturing.

**Success Strategies for Lean Manufacturing**

According to Imai (1997), success strategies include focusing on process rather than on results, following plan-do-check-act and standardizing these cycles for improvement, using data and facts in decision making, providing value-adding processes time for improvement activity, creating a practice of management providing targets for improvement, and using people who do the work to make improvements and achieve targets. According to Dennis (2007), the scientific method includes identifying a plan, doing the work, checking the results, and taking action based on observation of the results achieved through the PDCA cycle.

Spears and Bowen (1999) support this, indicating that all improvement should be done using the scientific method. However, Kamhi (2011) noted that the “scientific method is fallible” positing that the scientific method may not lead to consistent interpretation of data. Liker (1998) discussed several success strategies, including that leadership should be actively involved and engaged and that lower levels of the organization should be intimately involved in improvement activities. In addition, management should build “trust through actions, not words” and include a “broad system vision” (Liker, 1998). Organizational vision, according to Liker (1998), should include focusing on flowing products to customers, creating an environment for change that lessens fear of job loss due to improvements, and implementing changes quickly. Spears and Bowen (1999) identified specific rules that organizations need to follow for successful lean manufacturing implementation.

These rules are listed in Table 4. The first rule is standardization of work and work tasks. Standardizing work tasks provides the foundation for improvement (Imai, 1997; Liker, 2004). Joosten, Bongers, and Janssen (2009) noted that one of the major concerns regarding lean manufacturing is the impact of work standardization on employee motivation. They posited that work standardization could make work tasks too routine and adversely affect motivation. The second rule is to connect with customers and suppliers to directly and effectively convey information. The third rule entails alignment of production processes.

This alignment is intended to simplify the flow of products by eliminating excess travel distances and improve communication and coordination of production activities. The final rule requires the use of the scientific method for improvement activities, with those improvements conducted at the lower levels of an organization. This is supported by Imai (1997), who noted that people who do the work should be responsible and accountable for making improvements. Liker (2004) identified 14 principles for successful implementation of a lean manufacturing and management system. These principles are identified in Table 5. Focusing on the long term involves creating a strategy for where the organization wants to be in the future. Hallgren and Olhager (2009) indicated that strategy is a key indicator in successful lean manufacturing implementation. The second principle, creation of continuous flow with the intent of making problems visible, is supported by Womack and Jones (1996), who stated that “everyone involved must be able to see and must understand every aspect of the operation and its status at all times”. Sayer and Williams (2006) indicated that visibility of problems makes it easier for everyone to see what is happening and respond quickly to issues and challenges. According to Southworth (2011), visibility “plays a critical role in providing information to team members at every level so that good decisions can be made”.

Table 4 :Lean manufacturing rules in use (Spears & Bowen, 1999)

|  |  |
| --- | --- |
| Rules | |
| 1. | “All work shall be highly specified as to content, sequence, timing and outcome” |
| 2. | “Every customer-supplier connection must be direct, and there must be an unambiguous yes-or-no way to send requests and receive responses” |
| 3. | Every product and service provided must have a simple and direct pathway |
| 4. | The scientific method must be used for any improvement, and these improvements should be conducted “under the guidance of a teacher, at the lowest possible level in the organization” |

The third principle is that pull systems should be used to prevent overproduction (Liker, 2004). The concept of pull systems, producing only when a downstream process or customer consumes a product, was previously identified by Womack and Jones (1996) as fundamental in a lean manufacturing system. This is also supported by Dennis (2007) who noted that making a product only after it has been consumed by a downstream customer will “lower operating expense, defects, and lead time”. Levelling the workload is also a key strategy for success in lean manufacturing implementation (Liker, 2004). Levelling work involves spreading work out evenly over a variety of processes based on customer demand (Fujimoto, 1999). According to Wilson (2009), levelling can “provide service, speed, and a decreasing cost structure”.

Table 5 :14 Principles of the Toyota Way (Liker, 2004)

|  |  |
| --- | --- |
| Principles | |
| 1. | Management decisions must be based on a long-term philosophy |
| 2. | Continuous flow must be created to make problems visible |
| 3. | Avoid overproducing by using pull systems |
| 4. | Level out the work |
| 5. | Build a culture that supports stopping production to fix problems |
| 6. | Standardize work content as a foundation for continuous improvement |
| 7. | Use visual control so no problems are hidden |
| 8. | Technology must support people and processes |
| 9. | Grow leaders who thoroughly understand the work, live the philosophy, and teach it to others |
| 10. | Develop employees and teams to support a lean philosophy |
| 11. | Challenge and help suppliers, and extended networks to improve |
| 12. | Adopt a management philosophy to go and see what is going on to have a better understanding of the situation |
| 13. | Consider all options in making decisions using a consensus-based decision-making |
| 14. | Use reflection and continuous improvement to become a learning organization |

Table 6 :Ten best practices (Sayer & Williams, 2006)

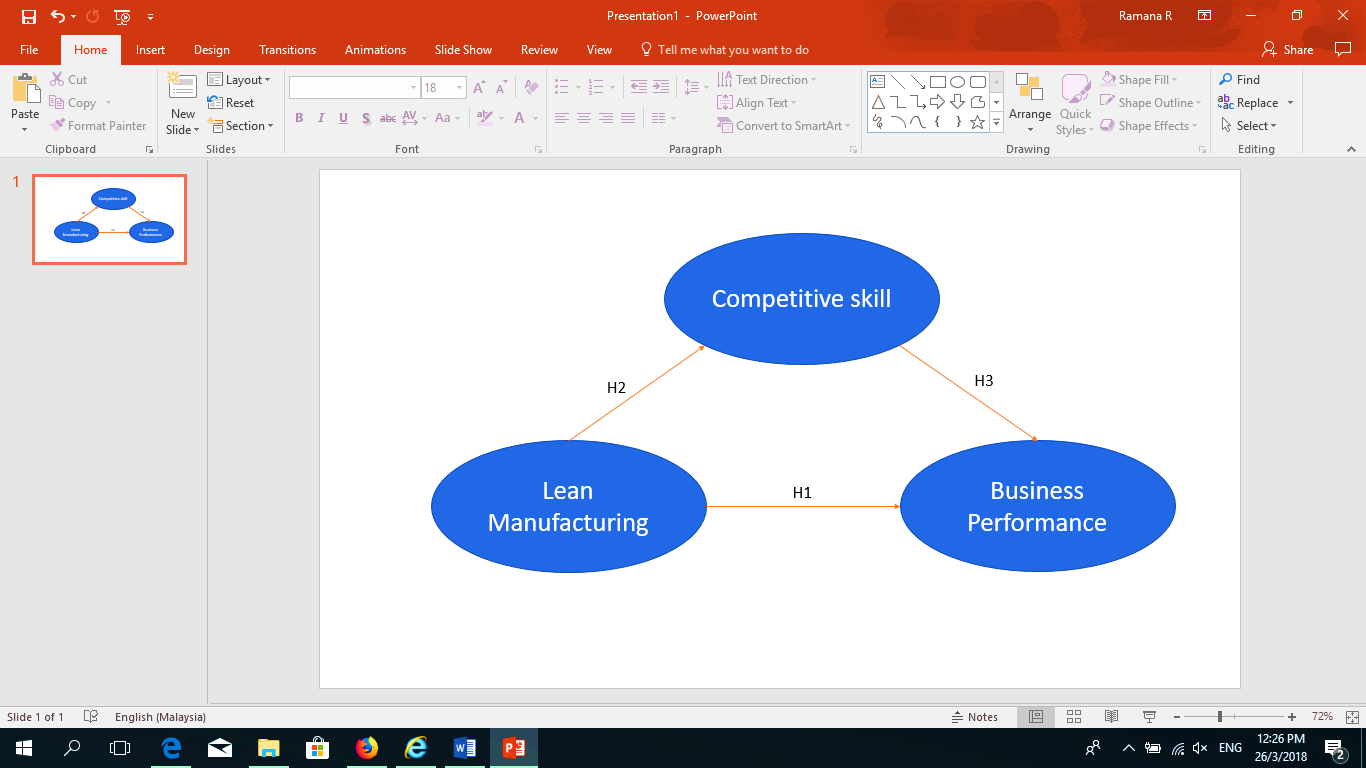
|  |  |
| --- | --- |
| Best Practices | |
| 1. | Keep the customer’s idea of value and their wants and needs as a focus |
| 2. | Relentless pursuit of perfection by “trying, doing, learning, and trying again” |
| 3. | Align efforts around the value stream |
| 4. | Use lean principles and tools simultaneously |
| 5. | Extend lean beyond manufacturing processes to all parts of the organization |
| 6. | Motivate and reward people for success |
| 7. | Go to where work is done to better understand processes |
| 8. | Use visual management systems to convey information at a glance |
| 9. | Keep improvement efforts simple; complex and convoluted solutions should be avoided |
| 10. | Standardize everything |

Sayer and Williams (2006) also identified ten best practices for success. These strategies are identified in Table 6, below. Womack and Jones (1996) demonstrate support for Sayers and Williams by commenting that the end customer must define what value is. In addition, Spears and Bowen (1999) identified the pursuit of perfection in all processes as a fundamental factor of a lean manufacturing system. Imai (1997) and Dennis (2007) identified the importance of work standardization as key to lean manufacturing success. In addition, Rothstein (2007) indicated that work standardization is a key factor of lean manufacturing implementation. Standardization of work processes, however, is not fully supported. For example, Seddon and O’Donovan (2010) said that work standardization may inhibit an organization’s ability to manage variety.

**2.6 Research Framework**

Lean manufacturing is based on the rationale of removing activities that do not add value to the productive system, especially those associated with elapsed times, methods, processes, places, people and movements (Womack et al., 1992). The elimination of activities that do not add value allows a densification of work and a better match of activities that generate wealth. Accordingly, the increase in profit comes from the reduction of costs, which improves business performance of the company (Shingo, 1996). However, to achieve the goal of improving performance, it is necessary to develop competitive skills (Dyer & Singh, 1998; Skinner, 1969; Teece, Pisano & Shuen, 1997; Wernerfelt, 1984) or operational capabilities associated with quality, flexibility and costs (Ferdows & Meyer, 1990; Flynn & Flynn, 2004).Considering works such as Womack et al. (1992) and Ferdows and Meyer (1990), one can construct a conceptual model based on assumptions relating to management of lean manufacturing, competitive skills and business performance as shown in Figure 1. The main theoretical foundations that give support to the constructs and to the set of hypotheses of the study are presented below.

Figure 1: Model of the relationship among constructs: Lean Manufacturing Management and Business Performance



Lean Manufacturing Management and Business Performance Customers demand quality products, implying the need for various actions undertaken by the company involving production as, for example, deliveries in small lots within short deadlines (Christopher, 1999). To meet these demands, manufacturers have adopted initiatives aimed at reducing the setup time of equipment, making manufacturing cell manufacturing more flexible and improving quality. The production of small lots, for instance, requires frequent adjustments in the equipment and thereby reducing the setup time allows improvement of competitiveness by diminishing costs. Moreover, companies with mass production generally have over-aged equipment in terms of market competitiveness (Fullerton & Wempe, 2009). Consequently, many companies seek the flexibility and efficiency resulting from cell manufacturing. In this context, lean manufacturing mechanisms provide reduced costs of quality failures.

It should be noted, however, that lean methods involve not only benefits but also costs. The effect of these methods on business performance is an open question, given the differences of empirical studies. Results of previous studies vary. Some works have identified that the adoption of just-in-time tools or the use of models based on total quality management do not improve profitability (Hudson & Nanda, 1995; Ittner & Larcker, 1995). In contrast, other studies suggest a positive association between modern manufacturing practices and financial performance (Kinney & Wempe, 2002; Fullerton et al., 2003). Considering the divergence of empirical findings, this paper seeks to examine the direct effects of lean production practices on performance, establishing the following hypothesis:

H1: Efficient lean manufacturing management is positively associated with business performance.

Lean Manufacturing Management and Competitive Skills The design of a lean manufacturing system depends on attributes that may influence the behaviour of the buyer. According to Chase, Jacobs and Aquilano (2006), different clients are attracted by different attributes. For example, some customers are more sensitive to the price of a product or service and therefore, in this case, companies should emphasize cost reduction. Skills applied to competitive business strategies can be presented in different perspectives or dimensions as, for instance, those based on resources (Wernerfelt, 1984), on dynamic capabilities (Teece et al., 1997), on business relationships (Dyer & Singh, 1998), on essential characteristics (Hamel & Prahalad, 1995) or on competitive priorities (Skinner, 1969; Ferdows & Meyer, 1990).

Competitive skills that can be considered closer to lean manufacturing management are the ones identified by Ferdows and Meyer (1990): quality, reliability, flexibility and cost. The study of Ferdows and Meyer (1990) does not deny the existence of trade-offs between generic industrial capabilities. Instead, the study suggests that the nature of these relationships depends on the compensation approach. Thus, if the approach focuses on cost, then cost and quality dimensions can be antagonistic, implying the existence of a trade-off, however if the approach is focused on quality, these dimensions can be simultaneously improved.

Accordingly, Swink, Narasimhan and Wang (2007) analysed the integration of strategic objectives and the process of knowledge that manufacturing companies explore from interactions through external interfaces. Swink et al. (2007) note that, although performance variables such as marketing and customer satisfaction were correlated with financial measures, including market share, ROI (Return on Investment) and ROA (Return On Assets), results were not conclusive enough. It must become clear that the implementation of a Lean manufacturing system that allows obtaining a desired performance is difficult (Brown et al., 2006). Investment in training is necessary, since lean manufacturing implies greater capacity and flexibility, demanding individuals to perform functions on other productive units in case of need. Thus, Brown et al. (2006) suggest that qualified personnel, able to identify and resolve problems, may have greater autonomy and responsibility to make operational decisions, to get involved and to take active participation in issues facing quality, maintenance, and production schedule. The quest for maximizing the flexibility associated with autonomy in decision making may involve defining new work arrangements, especially those grounded in teamwork. To examine the direct effects of the practices of lean manufacturing on competitive skills, we establish the following hypothesis:

H2: The efficient management of lean manufacturing is positively associated with competitive skills.

Competitive Skills and Business Performance Lean manufacturing management mechanism linked to the principle of the Toyota Production System, in which increasing profits come from reducing costs, contrasts with the focus on margin, in which costs are unquestionable and added up to a desired profit level. The Toyota System favours larger gains emphasizing activities and processes that reduce costs, given a price set by consumers. From this perspective, the profit is the difference between price and cost (Shingo, 1996). This approach was innovative, since it confronted be common sense associated with price as the sum of costs and margin, which implied the transfer, to the consumer, of the additional costs of inefficiencies in the production processes. Whereas the sustained profit should be a relevant goal of any company, there is a growing concern that, if profit is an end, the means by which it is obtained should be further explored. This perspective is similar to the Toyota production System approach that emphasizes the role not only of profits but also of costs. From a practical standpoint, in many organizations, board meetings begin with a review and analysis of the financial position, showing that the financial result is a relevant element. The functional relationships, the use of plant capacity and the production efficiency may be variables which generate results and therefore represent metrics by which business is evaluated and consequently controlled. The rationale behind this view is that performance is related to profitability and, therefore, management’s attention to issues such as customer satisfaction, empowerment and commitment of employees (Christopher, 1999), i.e., competitive skills, may influence performance. To examine the direct effects of competitive skills on performance, we define the following hypothesis:

H3: Competitive skills is positively associated with business performance.

It is important to highlight that even though there are extensive studies of lean manufacturing not only in the international context (i.e., Shah & Ward, 2003, 2007; Furlan, Vinelli, & Pont, 2011; Eroglu & Hofer, 2011) but also in the Brazilian environment (i.e., Arkader, 1999; Miyake, Torres Jr, & Favaro, 2010; Corrêa & Corrêa, 2011), none analyzes relationships mediated by competitive skills.

## **2.7 Summary**

In summary, chapter 2 included a historical perspective of total quality management and lean manufacturing, a discussion of literature findings on success strategies, and a review of literature on barriers to lean manufacturing implementation. The next chapter will present the method for this proposed study. This chapter will include a discussion of methodology, population and samples, methods for sampling, a description of survey questions, a process for data analysis, and an explanation of reliability and validity for the proposed study.

# 

**Chapter 3: Methodology**

**3.1 Introduction**

The purpose of this qualitative, collective case study was to help leaders develop a deeper understanding of both the barriers and strategies for success in implementing lean manufacturing in small-to-medium–sized companies. A qualitative method was appropriate for this study because it is expected that this study will result in further insight into experiences, application of lean manufacturing concepts, and interpretation of the concepts as they relate to small-to-medium–sized manufacturing companies. Berg (2008) noted that in a qualitative study, the researcher seeks to explore and understand descriptions, meanings, and concepts. A case study is used gain an understanding of a particular event, setting, group, or person as it relates to the experience and interaction between the subject within the context of the problem or issue (Berg, 2008). A collective case study design was appropriate, as it provides for a means to understand personal experiences related to lean manufacturing implementation in small-to-medium–sized manufacturing companies. The use of a collective case study permitted comparison and contrast of experiences from multiple cases to provide insight into specific issues (Creswell, 2009).

The research variables for this collective case study included barriers faced and strategies for success in implementing lean manufacturing, as previously noted. The study included at least three small-to-medium–sized manufacturing companies located in the state of Colorado. Open-ended interview questions were used to gain insight into the barriers faced and success strategies used in implementing lean manufacturing to obtain responses from these executives. Responses to the interview questions were used to identify the practices participants believe are valuable in implementing lean manufacturing.

Chapter 3 presents the research study methodology, discussing the research method, and appropriateness of design. In addition, it discusses the population, sampling, data collection procedure and rationale, internal and external validity, and method of data analysis, concluding with a summary.

**3.2 Primary Data**

Looking at the research question, data was collected using questionnaire. 30 responded was chosen from the Racam Line and given a questionnaire and was required to be answered within 1 hour. The board room was used to collect the required data. This location was picked to show the respondents the importance of the survey questionnaires. This study will assume applied research method and deductive approach due to the objective of the research to determine the effectiveness of Lean Manufacturing.

**3.3 Research Design**

The subsequent research design flow was used;

1) Identify the problem

a) To develop via general introduction and define problem statement.

2) Define problem

a) To develop the research questions and research objective that need to be achieved and answered.

b) To perform the literature review on related journals to establish conceptual problem and empirical framework and hypotheses.

**3.4 Research method**

Creswell (2009) identified three methods for conducting research: quantitative, qualitative, and mixed methods, noting that a mixed methods approach involves a combination of quantitative and qualitative methods. Cooper and Schindler (2008) indicated that quantitative research methods are used to test a theory and gain a measurement of variables to determine a cause-and-effect relationship. In quantitative research, closed-ended interview questions are used (Creswell, 2009), and statistical analysis of numerical values are applied to test a theory (Creswell, 2009; Hesse-Biber & Leavy, 2011). Quantitative research seeks to confirm or disconfirm a possible cause-and-effect relationship between variables in a study (Bloomberg & Volpe, 2008).

In qualitative research, meanings attributed to a specific problem are explored for understanding (Creswell, 2009). Cooper and Schindler (2008) noted that qualitative methods involve a researcher’s engagement in the study with the intent to gain a deeper understanding of the situations and interactions affecting an event. Qualitative methods use open-ended questions and words to describe experiences of participants (Creswell, 2009). These detailed descriptions and experiences are analyzed, interpreted, and synthesized to draw conclusions for the study (Bloomberg & Volpe, 2008).

A quantitative method is not most appropriate for this study because the purpose is to develop a deeper understanding of the real-life experiences of senior leaders implementing lean manufacturing in small-to-medium–sized manufacturing companies. In addition, as Bloomberg and Volpe (2008) indicated, quantitative research seeks to test a cause-and-effect relationship; in this study, a cause-and-effect relationship between variables is neither sought nor explained.

A qualitative research method was most appropriate for this study, as the researcher sought to explore lived experiences in sustaining lean manufacturing implementation. This required an explanation, exploration, and interpretation of experiences by senior leaders, as previously noted. Berg (2008) expressed that a qualitative method is ideal for the exploration of experiences. The experiences described will help readers understand the contextual barriers to and success strategies for sustaining lean manufacturing implementation. Creswell (2009) emphasized that qualitative research is framed through words, as opposed to the framing of quantitative research in numbers. The analysis and interpretation of these experiences permitted the researcher to identify key themes and draw conclusions to develop a theory regarding sustainable lean manufacturing implementation in small-to-medium–sized manufacturing companies.

Research method is the processes or mythology to gather data and information for making business decisions that include publication journals research, survey and questionnaire. Interview as well as other research techniques, which including present and historical data or both (Hair, Celsi, money, Samouel and Page, 2012). The three types of research method are qualitative and the mix of both quantitative study using mathematical model, theories, hypotheses and statistical analysis while qualitative using investigation of 4W’s and 1H (Zikmund 2013).

This project utilizes quantitative method because it requires the participants of the study to fill up the questionnaire that relates their participation of Lean Manufacturing. The study explores the implementation and effectiveness of Lean.

**3.5 Population Sampling**

According to Nenty (2009), the population as the entirety of all the subjects, objects or member that conform to selection criteria that are grouped to be studied is taken for examination. The universe is defined as the total of all population (Zikmund 2013).

The population of the study will cover the operators working in the Radar line located in Beyonics IPark. A total of 30 operators will be asked to fill up a survey form.

**3.6 Data Collection**

The case here is the consideration of a questionnaire. This includes a standardized formal interview, the postal, self-administered questionnaire and the group administered questionnaire. Each method has its strengths and weaknesses, and this should help in coming up with an appropriate one to suit a specific survey need.

Questionnaires are presented to respondents, but the researcher is available to make little clarifications. He does not, however, interpret the questions for the respondents as this may increase interviewer bias. There is some degree of personal contact as the two parties would be interacting. The advantage with this is that response rate is high and clarification are made where need arises.

The respondent was given 2 hours to fill up the questionnaire. As most of the respondents were foreign workers, we have to explain to them the questionnaire using their own language.

During the research period 30 respondent was selected and all 30 of them got involved in answering the questionnaire.

**3.7 Instrument and Measurement**

For this research a continuous measure Scala was use. Continuous variable, as the name suggest is a random variable that assumes all the possible values in a continuum. Simply put, it can take any value within the given range. So, if a variable can take an infinite and uncountable set of values, then the variable is referred as a continuous variable.

A continuous variable is one that is defined over an interval of values, meaning that it can suppose any values in between the minimum and maximum value. It can be understood as the function for the interval and for each function, the range for the variable may vary.

The continues measure scale with the Likert-type scale form 1 (Very poor) to 5 (excellent). Question 1 to 10 in the questionnaire requires the operator to rate the various aspects of the Lean manufacturing processes.

From the results obtained, the responses will be tabulated to see the effectiveness of the Lean improvement.

**CHAPTER 4: Result and discussion**

The data collected for this study was used to evaluate the opportunity to implement lean manufacturing principles in the assembly process. Through the use of Kaizen events, the team was able to make the small, incremental changes required to improve the assembly line and close-up area. Members of the Kaizen team were assigned an assembly station to record the times of each operator. Each time study was documented, and this data was then evaluated by comparing the times of each assembly process using batch manufacturing and one-piece flow. By comparing the data, Beyonics could take the reduction in time for each process using one-piece flow as opposed to batch manufacturing and convert that time into a cost savings per medical device. With the time standards captured for one-piece flow, each workstation was adjusted to equal time to improve line efficiency and eliminate work-in-process build-up within the assembly line.

By performing the time studies, in-process Kanban’s (IPK's) were calculated and larger work-in-process racks removed and replaced with smaller in-process Kanban racks. This provides a visual aid to the operator that if the in-process Kanban rack is full, the operator must stop building and move to another station that is not full the operator will not move back to their original work location until there is another space available for the product to be placed. Through the use of in-process Kanban racks, the production floor has been able to reduce the amount of work-in-process by forty five percent.

**4.1 Result of questionnaire**

Graph 1 : A Key Performance Indicator is a measurable value that demonstrates how effectively a company is achieving key business objectives. Organizations use KPIs at multiple levels to evaluate their success at reaching targets. The operators have a good understanding on their KPI’s and delivery schedule



Graph 2: As the implementation of customer feedback corner and “lesson learned” the operators have good knowledge on the quality issues. good work practice or an innovative approach that is captured and shared to promote repeat application or avoid recurrence. Well-documented lessons learned enable us to further mature our project management capability and our ability to deliver projects that leverage repeatable processes. Both advantageous and adverse consequences within a project can result in lessons learned and those that are particularly positive may be communicated outside of the team and promoted as a best practice.



Graph 3: The root cause of the problem is identified, as well as all contributing factors, is eliminated from the system, process or infrastructure in order to permanently solve the problems. Detection and investigation of problem is still average as Beyonics has a shortage of engineers currently.



Graph 4: The implementation of Layer Audit and shop floor meeting has made the problem solving and action taken to be very fast. The line supervisor has the responsibility for auditing to ensure that structures and processes such as standard work, 5S, safety, and quality checks are adhered to. The supervisor is usually the only one who is knowledgeable enough about the process to make these observations. This results in a narrow organizational view of the process. By providing cross functional involvement of the support staff, the collective perspective and experience of the broader organization is integrated into the process directly at the point of value added.



Graph 5: On-the-job training, also known as OJT, is teaching the skills, knowledge, and competencies that are needed for employees to perform a specific job within the workplace and work environment. Employees learn in an environment in which they will need to practice the knowledge and skills taught in the on-the-job training.

On-the-job training uses the regular or existing workplace tools, machines, documents, equipment, knowledge, and skills necessary for an employee to learn to effectively perform his or her job. On Job Training (OJT) given to operators in different languages (according to their own language makes it easier for them to understand instructions.



Graph 6: In manufacturing engineering, a product layout refers to a production system where the work stations and equipment are located along the line of production, as with assembly lines. Usually, work units are moved along a line (not necessarily a geometric line, but a set of interconnected work stations) by a conveyor. Work is done in small amounts at each of the work stations on the line. To use the product layout, the total work to be performed must be dividable into small tasks that can be assigned to each of the workstations.Because the work stations each do small amounts of work, the stations utilize specific techniques and equipment tailored to the individual job they are assigned. This can lead to a higher rate of production.



Graph 7 : Lot batches from 2000pcs was brought down to 20pcs per work station. The Single piece flow is the pull process in which the products are produced based on the customer requirements. Here the word single has a literal meaning, i.e. having specified quantity of WIP between the stations or completely eliminating it. The single piece flow with specified number of WIP can be implemented using Kanban technique. This Single piece flow eliminates the high WIP and facilitates the immediate identification of quality defects.



Graph 8: Changeover is the time it takes to go from the last good part of one product run to the first good part of the next product run. Quick changeover is critical to Lean. It provides the flexibility to match the product mix to actual demand. As each product and process is different, it is difficult to implement the same changes across the board.



Graph 9. A Continuous Improvement Plan is a set of activities designed to bring gradual, ongoing improvement to products, services or processes through constant review, measurement and action. The Shewart Cycle (also known as PDCA which stands for the Deming Cycle of Plan, Do, Check, Act) or an approach called Kaizen are the two most well-known frameworks used to support continuous improvement. Yield improved from 3.5% to 2.9%.



Graph 10: Andon is a principle and is also a typical tool to apply the Jidoka principle in Lean Manufacturing – Jidoka is also referred to as ‘autonomation’, which means the highlighting of a problem, as it occurs, in order to immediately introduce countermeasures to prevent re-occurrence. Andon lights was installed on all critical machines which is used for production.

Based on the A3 VSM done there is also improvement the manufacturing lead time from 42days to 14 days. First pass yield improbed from 85% to 90%. As a result Beyonics was able to save USD 26000 a year with a working capital cash flow improvement of USD 92000 a year.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  |  |
| **Cost Element** | | | | **Cost Saving  (USD)** |
| 1. Material holding cost saving from Inventory Reduction | | | | 5,562 |
| 2. Labour Cost Saving Estimation | | | | 21,209 |
| **Total Saving / Annum:** | | | | **26,771** |
|  |  |  |  |  |
| Working Capital Cash Flow Improvement | | | | **92,701** |

Figure 5: Cost saving table

As per Figure 5 the total saving of USD 26771. This saving consist of material holding cost saving from inventory reduction and labour cost saving



Figure 6: Material Cost Saving

Figure 6 shows the break down on the material cost saving. The current inventory cost was at USD 185901 and after improvement activities it drop to USD 93200, which has a delta of USD 92701. This USD 92701 will be used as working capital cash flow.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Labour Cost Saving Estimation** | | |  |  |
| **Labour Cost** | **Current** | **Future** | **Shift** | **Cost Saving per Annum  (USD)** |
| 1. Integrate CNC,Water Jet Clean and Auto functional Check | 3 | 2 | 2 | 10,605 |
| 2. Balance Dimension Check | 3 | 1 | 1 | 10,605 |
|  |  |  |  | 21,209 |

Figure 7: Labour cost saving.

As per figure 7, the labour saving shows a manpower saving 3 person which will have a total cost saving od USD 21209 per year.

**4.2 Analysis on hypothesis**

From all the results collected and discussed, significant respondents believe that Lean manufacturing can and should be implemented. The result confirms the hypothesis to be true.

H1: Efficient lean manufacturing management is positively associated with business performance.

H2: The efficient management of lean manufacturing is positively associated with competitive skills.

H3: Competitive skills is positively associated with business performance.

**4.3 Summary**

In this chapter, participant demographics were given. Next, a detailed review of data collection was conducted. Data collection included scheduling interviews, after participants received and signed informed consent forms in ink. Interviews were scheduled and conducted on the company premises of each participant. As part of the interview process, each participant provided the researcher with an opportunity to tour their facilities to observe lean implementation. Interviews were recorded and transcribed by the researcher. Each participant was offered an opportunity to review the transcribed notes and provide additional feedback for revisions based on the interview. Aside from minor grammatical changes, the deletion of names of individuals, and the deletion of other company names, participants approved the transcribed notes.

The data analyses included a review of the purpose and primary research question for alignment. Emergent themes were then identified on the basis of participant responses. The emerging themes included a) lean manufacturing implementation should be implemented in a way specific to the context of the individual organization; (b) time, resources, and changes in customer demand present challenges in sustaining lean manufacturing implementation; (c) resistance to change is a barrier to lean manufacturing implementation; (d) small-to-medium sized companies use of outside consultants and trainers for training staff on lean manufacturing implementation; (e) frontline workers need to be trained to apply lean tools and concepts for successful lean manufacturing implementation; (f) frontline workers have to own and believe in lean manufacturing implementation for it to be successful; (g) leaders have varying definitions of what their roles are in leading lean manufacturing implementation; (h) leaders have differing perspectives regarding the degree of leadership knowledge required for successful lean manufacturing implementation; and (i) leaders struggle to expand lean manufacturing implementation into support departments such as engineering, purchasing, administrative functions, and sales. A brief description of each emergent theme and examples of participant responses supporting them were given.In chapter 5, the implications of findings, based on the theoretical framework and literature review, are provided. Assumptions for the study are reviewed. Conclusions, recommendations for leaders, and recommendations for further research are included. Finally, a summary is provided.

**CHAPTER 5: Conclusion and recommendation**

**5.1 Discussion**

The results of the study were a success with the implementation of using lean principles. Production personnel were instrumental to the success of each Kaizen event. By applying their knowledge to the processes allowed the teams to provide the best solutions to the issues within the process. With this product being a medical device, everyone involved in the Kaizen events had to keep in mind that each one of the proposed changes had to be justified not only from a financial standpoint but more importantly from a Regulatory and Quality Systems standpoint. All of the changes required an engineering change notice with a minimum of three signatures from appropriate departments in order for the changes to be implemented. With the product being a medical device, any changes to assembly procedures had to ensure that the design of the device was not impacted. Verification that the design of the device was not impacted was captured in the engineering change notice prior to approval. With the elimination of over 9 minutes of process time per device along with a savings of over USD 26000 annually shows that correct implementation of lean principles can have a positive impact within any organization. Through proper training and staying with smaller projects, Kaizen leaders and teams can get a good understanding on how to effectively run and participate in Kaizen events and use the proper tools to find and eliminate the waste that is in any manufacturing process.

**5.2 Discussion on finding**

The present study highlights that process department of Beyonics is the most efficient in the elimination of the waste which is clearly indicated by 90% respondents. Eliminating any waste, no matter how much, will add up and make things more productive. Lean methodology appears to be very significant and result oriented in eliminating such kinds of waste. Lean involves 1) first understanding one’s work in great step-by-step detail, 2) seeing problems where the prescribed steps don’t pan out exactly as expected and 3) realizing the waste involved in doing the job or created to others by the way we do the job so that 4) the person thinks of ways to solve the problems or find another way of doing the work which minimizes the waste. It is also disclosed that production department is also quite watchful about the elimination of waste related to production. Higher production is always touted as a good thing, but higher production means nothing if there is any demand for the product. Otherwise, it simply represents the amount of money tied up in producing the product. It has a vital role restraining over production. 80% respondents confirm this view. It is very imperative to maintain the man and machine. The onus lies on maintenance department to maintain the symphony in the different operations. 80% respondents consider the role of maintenance department very crucial in removing the waste. Planning department is regarded as the back bone for any organization. Instrumental in get rid of waste. Research and development is nowadays of great importance in business as the level of competition, production processes and methods are rapidly increasing. 90% respondents believe that function of this department is inevitable in eliminating the waste. 6% respondents find that sales department also renders its great help in removing the waste. It is very necessary for any organization to use human resources at the optimum level. 5% respondents feel that a well-structured human resource department can be a big helping hand in mitigating waste.

**5.3 Implication, Limitation and Recommendation.**

**5.3.1 Limitations**

The limitations of the study are:

1. The results of this study are limited to final assembly through close-up for Beyonics. The current state value stream maps created only included the final assembly and close-up areas. Any additional improvements would have been outside the scope of this study. The Future state value stream map, though all-inclusive to the entire production process, was only updated with the information from the final assembly and close-up area.

2. The study does not include all lean manufacturing principles. The Kaizen teams utilized existing knowledge of lean principles and relied on the expertise of production personnel, involved in the Kaizen events, to perform their job functions as they would on a day to-day basis, so the collection of data was as accurate as possible by giving a true representation of the current state value stream.

3. The study is intended to show the results of implementing lean manufacturing principles within a manufacturing environment. Creating the spaghetti diagrams and value stream map was critical to understanding the manufacturing process from final assembly to close-up. It also gave the team the necessary tools required to present the findings to upper management and show that the improvements would be turned into a cost savings for the company.

**5.3.2 Conclusions**

Lean production is a dynamic system that requires fewer resources (material, labour, overhead) and brings better outputs (quality, variety, cost & safety) to add value. Most of the works that has been done in lean manufacturing was based on these approaches. Lean structure. (Shah & Ward, 2003) framework consists of four “bundles” of interrelated and internally consistent practices; these are Just-in-Time, Total Quality Management, Total Preventive Maintenance, and Human Resource Management.

**5.3.3 Recommendations**

Additional research could prove insightful in assisting leaders in small- to medium-sized companies in successfully implementing lean manufacturing. One possibility for additional research may be to broaden the research across more small- to medium-sized companies. This study focused on three companies located in Colorado and included only leaders as participants. Broadening the research across a larger population may provide additional insights. In addition, expanding participants beyond leaders to include middle managers, frontline supervisors, and frontline staff could provide additional perspective of success strategies and barriers to lean manufacturing implementation.

A common theme in small- to medium-sized manufacturing companies is that leaders have diverse responsibilities beyond their individual job titles and responsibilities. Diverse responsibilities appear to affect a leader’s ability to encourage and lead lean manufacturing implementation. Additional research considering the impact of diverse leadership responsibilities and lean implementation might prove insightful for implementing lean in small- to medium-sized companies.

Participants referred to their lean efforts calling it “lean manufacturing.” In addition, participants discussed the challenge of expanding lean outside of manufacturing and into various ancillary departments such as purchasing, engineering, sales, and accounting as well as administrative areas. A research study seeking to identify whether calling efforts “lean manufacturing” affects an organization’s ability to expand lean to ancillary departments may provide insight that will help organizations adopt lean philosophies across their organizations.

In this research study, a qualitative approach was used to gauge the opinions and feelings of leaders in participating companies to understand the strategies and barriers for sustainable lean manufacturing implementation. This study did not have a quantitative measure of each organization’s lean implementation success. A mixed-method study that evaluated both opinions and feelings of success strategies in implementing lean might validate the degree of success. Such an approach might provide additional insight for leaders regarding the degree of success related to their strategies and barriers as it relates to implementing lean manufacturing in small- to medium-sized companies.

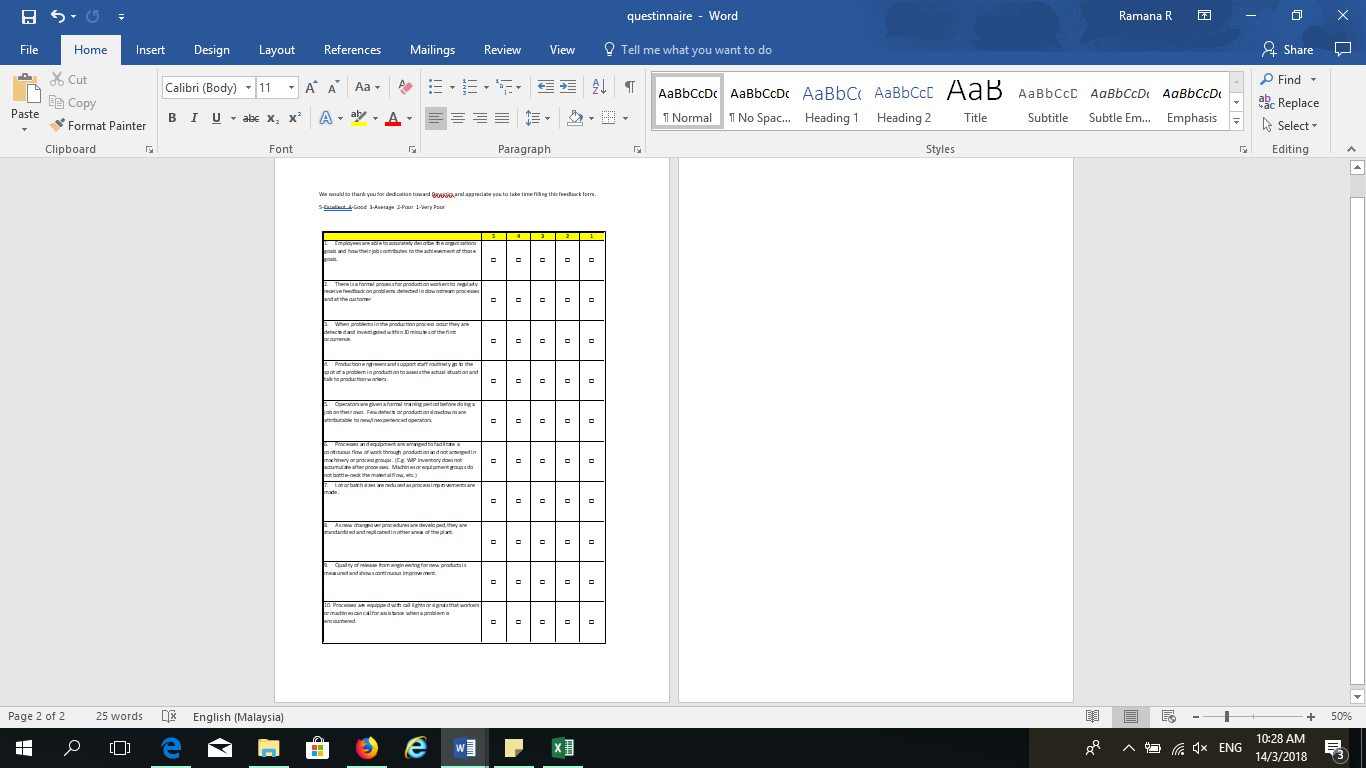
Finally, another area of recommended research is the dynamics of using outside consulting firms to assist small- to medium-sized companies in implementing lean manufacturing. A qualitative study that identifies key attributes of consultants and what information outside consultants need to be successful in supporting lean implementation in small- to medium-sized manufacturing companies could provide insight that helps companies sustain improvements from their lean efforts.

# REFERENCES

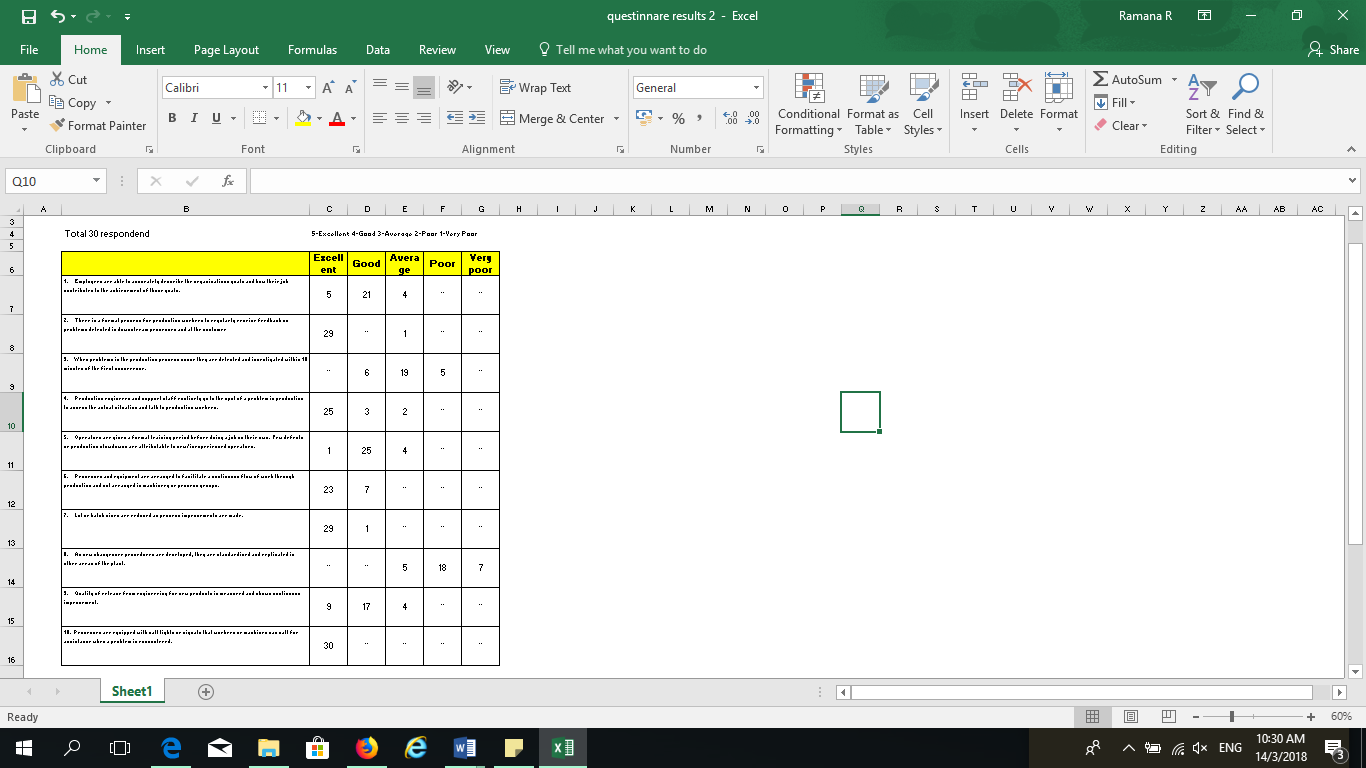
1. American Society for Quality. (2011). *Fishbone Diagram*. Retrieved from http://asq.org/learn-about-quality/cause-analysis-tools/overview/fishbone.html
2. Arthur, J. (2008, August 29). Overcome the barriers to lean six sigma results. *Business Journal, 22*(35), Retrieved from MasterFILE Premier.
3. Atkinson, P. (2010). ‘Lean’ is a cultural issue. *Management Services,*Retrieved from Business Source Complete.
4. Berg, B. L. (2008). *Qualitative research methods for social sciences* (7th ed.). Boston, MA: Pearson Higher Education.
5. Black, J. (2009, March/April). Lean manufacturing. *T & P: Tooling & Production,* *75*(3/4). Retrieved from Business Source Complete.
6. Bloomberg, L. D., & Volpe, M. (2008). *Completing your qualitative dissertation: A roadmap from beginning to end*. Thousand Oaks, CA: Sage Publications, Inc.
7. Bou-Llusar, J. C., Escrig-Tena, A. B., Roca-Puig, V., & Beltran-Martin, I. (2009). An empirical assessment of the EFQM excellence model: Evaluation of TQM framework relative to the MBNQA model. *Journal of Operations Management.*
8. Cattani, K., Dahan, E., & Schmidt, G. (2010). Lowest cost may not lower total cost: Using “spakling” to smooth mass-customized production. *Production and* *Operations Management.*
9. Christensen, L., Johnson, R., & Turner, L. (2011). *Research methods design and analysis* (11th ed.). Boston, MA: Pearson Education, Inc.
10. Conti, R., Angelis, J., Cooper, C., Faragher, B., & Gill, C. (2006). The effects of lean production on worker job stress. *International Journal of Operations &* *Production Management.*
11. Cooper, D. R., & Schindler, P. S. (2008). *Business research methods* (10th ed.). New York, NY: McGraw-Hill Irwin.
12. Creswell, J. W. (2008). *Educational research: Planning, conducting, and evaluating* *quantitative and qualitative research* (3rd ed.). Upper Saddle River, NJ: PearsonEducation, Inc.
13. Creswell, J. W. (2009). *Research design: Qualitative, quantitative, and mixed methods approaches* (3rd ed.). Thousand Oaks, CA: Sage Publications, Inc.
14. Crosby, P. (1979). *Quality is free*. New York, NY: McGraw-Hill Companies. Cusumano, M. A. (1985). *The Japanese automobile industry, technology and management at Nissan and Toyota*. Cambridge, MA: The Harvard UniversityPress.
15. De Feo, J. A. (2010a). Strategic planning and deployment: moving from good to great. In S. Chapman (Ed.), *Juran’s quality handbook* (6th ed). New York, NY: The McGraw-Hill Companies.
16. De Feo, J. A. (2010b). Using international standards to ensure organization compliance. In S. Chapman (Ed.), *Juran’s quality handbook* (6th ed.). New York, NY: The McGraw-Hill Companies.
17. Deming, W. E. (1975, August). On some statistical aids toward economic production. *Interfaces, 5*(4), 1–15. Retrieved from Business Source Complete.
18. Deming, W. E. (1982). *Out of the crisis*. Cambridge, MA: Massachusetts Institute of Technology.
19. Deming, W. E. (1985, May/June). Transformation of western style of management. *Interfaces, 15*(3), 6–11. Retrieved from Business Source Complete.
20. Dennis, P. (2006). *Getting the right things done: A leader’s guide to planning and execution*. Cambridge, MA: Lean Enterprise Institute.
21. Dennis, P. (2007). *Lean production simplified* (2nd ed.). New York, NY: Productivity Press.
22. Dobson, J. (2010). A comparison between learning style preferences and course performance. *Advances in physiological education, 34.*
23. Dura, C., & Isac, C. (2009). Using Taguchi methods to improve the production process quality, A case study. *Total Quality Management, 20*(11). Retrieved from Business Source Complete.
24. Emeliani, M. L., & Stec, D. J. (2005). Leaders lost in transformation. *Leadership &* *Organization Development Journal, 26,* 370–387. Retrieved from ProQuest.
25. Emiliani, M. L. (2006). Origins of lean management in America. *Journal of Management* *History.*
26. Evans, J. R., & Linday, W. M. (2009). *The management and control of quality* (8th ed.).
27. Feigenbaum, A. V. (1991). *Total quality control*. New York, NY: McGraw-Hill, Inc. Fisher, N., & Nair, N. (2009). Quality management and quality practice—perspectives on their history and future. *Applied Stochastic Models in Business and Industry.*
28. Fujimoto, T. (1999). *The evolution of a manufacturing system at Toyota*. New York, NY:Oxford University Press.
29. Gerring, J. (2007). *Case study research, principles and practices* (Kindle ed.). New York, NY: Cambridge.
30. Ghosh, A., & Federowicz, J. (2008). The role of trust in supply chain governance. *Business Process Management Journal.*
31. Hallgren, M., & Olhager, J. (2009). Lean and agile manufacturing: External and internal drivers and performance outcomes. *International Journal of Operations &* *Production Management.*
32. Harkin, D. (2008). A balanced approach to lean manufacturing. *Engineers Journal, 62,* 252–254. Retrieved from Academic Search Complete.
33. Herkness, D. F. (2005). *A study of transformational and transactional leadership and its* *relationship to successful lean manufacturing deployments*. (Doctoraldissertation). Retrieved from ProQuest Dissertations and Theses.
34. Hesse-Biber, S., & Leavy, P. (2011). *The practice of qualitative research* (2nd ed.). Thousand Oaks, CA: SAGE Publications, Inc.
35. Holweg, M. (2007). The genealogy of lean production. *Journal of Operations* *Management, 25.*
36. Hoyte, D. S., & Greenwood, R. A. (2007). Journey to the north face: a guide to business transformation. *Academy of Strategic Management.*
37. Imai, M. (1997). *Gemba kaizen*. New York, NY: McGraw-Hill Irwin.
38. Ishikawa, K. (1991). *What is total quality control*. Englewood Cliffs, NJ: Prentice Hall, Inc.
39. James, T. (2006, April). It’s all in the mind. *Manufacturing Engineer, 85*. Retrieved from Academic Search Complete.
40. Joosten, T., Bongers, I., & Janssen, R. (2009). Application of lean thinking to healthcare: Issues and observations. *International Journal for Quality in Healthcare.*
41. Juran, J. (1962). New life for staff departments. *Management of Personnel Quarterly.*
42. Juran, J. (1993, August 15). What Japan taught us about quality; making it management’s job—and part of the business plan—led to an export edge. *The Washington Post.*
43. Juran, J. (1995). How top executives improve performance. *Leadership Excellence.*
44. Juran, J., & De Feo, J. (2010). *Juran’s quality handbook* (6th ed.). New York, NY: The McGraw-Hill Companies.
45. Kallage, R. G. (2006, July). *Lean implementation failures*. Retrieved from http://www.thefabricator.com/article/shopstrategies/lean-implementation-failures.
46. Kamhi, A. G. (2011). Balancing certainty and uncertainty in clinical practice. *Language,* *Speech, and Hearing Services in Schools.*
47. Keim, E. (2011). Change . . . not again!! *The Journal of Quality and Participation*
48. Keller, R. (2006, December). Are you reinventing wheels? *IndustryWeek,* , 11. Retrieved from ProQuest.
49. Keyes, J. P. (2006). *The effect of lean manufacturing on a high-mix low-volume metal* *fabrication manufacturer*. (Doctoral dissertation). Retrieved from ProQuestDissertations and Theses.
50. Knapik, M. (2006). The qualitative research interview: Participants’ responsive participation in knowledge making. *International Journal of Qualitative Methods*. Retrieved from Academic Search Complete.
51. Krafcik, J. F. (1988, Fall). Triumph of the lean production system. *Sloan Management* *Review, 30*(1), 41–52. Retrieved from ProQuest.
52. Levinson, W. A. (2009). Henry Ford’s proven lessons for American industry. *IndustryWeek, 258*(7), 16–17. Retrieved from ProQuest.
53. Liao, I. H. (2005). *Designing a lean manufacturing system: A case study*. (Master’s thesis). Retrieved from ProQuest Dissertations and Theses.
54. Liker, J. K. (1998). *Becoming lean*. Portland, OR: Productivity Press.
55. Liker, J. K. (2004). *The Toyota way*. New York, NY: McGraw-Hill.
56. Macdonald, J. (1998). The quality revolution in retrospect. *TQM Magazine.*
57. Maguad, B. A. (2011). Deming’s “profound knowledge”: Implications for higher education. *Education*. Retrieved from ProQuest.
58. Maleyeff, J. (2011). Factors impacting innovation in new service offerings. *Journal of* *Service Science and Managemen.*
59. Mann, D. (2009). The missing link: Lean leadership. *Frontiers of Health Service* *Management, 26,* 15–26. Retrieved from MEDLINE.
60. Mann, R. (2008). Revisiting a TQM project: The quality improvement activities of TQM. *Total Quality Management*. Retrieved from Business SourceComplete.
61. Manta. (2011). *Manufacturing companies in the U.S.* Retrieved from http://www.manta.com/mb\_33\_E7\_000/manufacturing?refine\_company\_emp=E0 1&refine\_company\_emp=E02&refine\_company\_emp=E03&refine\_company\_em p=E04&refine\_company\_emp=E05&refine\_company\_emp=E06&refine\_compan y\_emp=E07
62. 132
63. Martinez-Lorente, A., Dewhurst, F., & Dale, B. (1998). Total quality management: Origins and evolution of the term. *The TQM Magazine*. Retrieved from ProQuest.
64. Maskell, B., & Baggaley, B. (2004). *Practical lean accounting*. New York, NY: Productivity Press.
65. Masterman, J. R. (2009, May). *Manufacturing innovation*. Retrieved from http://www.scienceprogress.org/2009/05/mep
66. Mathaisel, D. F., Cathcart, T. P., & Agripino, M. F. (2005). Meeting the competitive challenge. *Industrial Engineer*. Retrieved from MasterFILE Premier.
67. Mazumder, B., Bhattacharya, S., & Yadav, A. (2011). Total quality management in pharmaceuticals: A review. *International Journal of PharmTech Research, 3*(1), 365–375. Retrieved from http://www.sphinxsai.com/Vol.3No.1/pharm\_jan-mar11/pdf/JM11(PT=63)%20pp%20365-375.pdf
68. McLeod, A. A. (2010). *An assessment of small to medium size manufacturers practicing* *lean manufacturing in Indiana*. (Doctoral dissertation). Retrieved from ProQuestDissertations and Theses.
69. Merriam, S. B. (2009). *Qualitative research: A guide to design and implementation*. San Francisco, CA: John Wiley & Sons, Inc.
70. Moore, M. (2007, November 30). *The seven basic tools of quality*. Retrieved from http://www.improvementandinnovation.com/features/article/seven-basic-tools-quality/
71. Ndahi, H. B. (2006, November). Lean manufacturing in a global and competitive market. *The Technology Teacher*. Retrieved from Academic SearchComplete.
72. Oakland, J. (2011). Leadership and policy deployment: the backbone of TQM [Abstract]. *Total Quality Management & Business Excellence, 22*(5), 517–534.doi:10.1080/14783363.2011579407
73. Ohno, T. (1988). *The Toyota production system: Beyond large-scale production*.Portland, OR: Productivity Press.
74. Pashler, H., McDaniel, M., Rohrer, D., & Bjork, R. (2008). Learning styles: Concepts and evidence. *Psychological science in the public interest.*
75. Pay, R. (2008, May). Being taken for a lean ride. *Industry Week*.
76. Phelps, L., Parayitam, S., & Olson, B. (2007). Edwards Deming, Mary P. Follett and Fredrick Taylor: Reconciliation of differences in organizational and strategic leadership. *Academy of Strategic Management Journal*. Retrieved from Business Source Complete.
77. Pidgeon, R. (2002, November). Manufacturing is key to economic success. *Packaging* *Magazine,* 8. Retrieved from Business Source Complete.
78. Pinheiro, R. E. (2010). *Organizational change and employee empowerment—A grounded theory studying lean manufacturing into a traditional factory environment*.(Doctoral dissertation). Retrieved from ProQuest Dissertations and Theses.
79. Pirraglia, A., Saloni, D., & Van Dyk, H. (2009). Status of lean manufacturing implementation on secondary wood industries including residential, cabinet, millwork, and panel markets. *BioResources*. Retrieved from Academic Search Complete.
80. Pricewaterhousecoopers. (2007). *Manufacturing barometer*. Retrieved from http://http://www.barometersurveys.com/store/docs/Manufacturing%20Barometer %20Operational%20Effectiveness.pdf
81. Raja, M. I. (2011). *Lean manufacturing—An integrated socio-technical systems approach* *to work design*. (Doctoral dissertation). Retrieved from ProQuest Dissertationsand Theses.
82. Roth, G. (2006). Distributing leadership practices for lean transformation. *Reflections, 7,* 15–29. Retrieved from Business Source Complete.
83. Rothstein, J. (2007). Rethinking the role of teamwork and employee participation: A comparison of GM auto plants. *American Sociological Association Annual* *Meeting*. Retrieved from SocINDEX.
84. Sayer, N. J., & Williams, B. (2006). *Lean for dummies: Eliminate waste, add value, and improve performance!* Hoboken, NJ: Wiley Publishing, Inc.
85. Schneider, H. (2010, April 1). *The Washington Post*. Retrieved from htttp://www.washingtonpost.com/wp-dyn/content/article/2010/03/31/AR2010033104134.html
86. Schonberger, R. J. (1982). *Japanese manufacturing techniques*. New York, NY: Free Press.
87. Schonberger, R. J. (2007). Japanese production management: An evolution with mixed success. *Journal of Operations Management.*
88. Seddon, J., & O’Donovan, B. (2010, Summer). Rethinking lean service. *Management* *Services*. Retrieved from Business Source Complete.
89. Selko, A. (2009, June 12). *Industry Week*. Retrieved from http://http://www.industryweek.com/articles/manufacturing\_ranked\_1\_industry\_f or\_economic\_prosperity\_19355.aspx
90. Shimizu, T. (2008). *Application of lean manufacturing in the machine tool industry*. (Master’s thesis). Retrieved from ProQuest Dissertations and Theses.
91. Shingo, S. (1985). *A revolution in manufacturing: The SMED system*. New York, NY: Productivity Press.
92. Sim, K. L., Rogers, J. W., & McQuilkin, J. (2008). *Challenges and frustrations of* *implementing lean manufacturing*. Paper presented at the 2008 NortheastDecision Sciences Institute Proceedings. Alexandria, VA. Retrieved from Business Source Complete.
93. Soltani, E., Lai, P., Javadeen, S., & Gholipour, H. (2008). A review of the theory and practice of managing TQM: An integrative framework. *Total Quality* *Management*. Retrieved from Business Source Complete.

1. Southworth, T. (2011, January/February). Visual Controls. *Printing Lean*
2. Spears, S., & Bowen, H. K. (1999). Decoding the DNA of the Toyota Production System. *Harvard Business Review*. Retrieved from Business SourceComplete.
3. Standard, C., & Davis, D. (1999). *Running today’s factory: A proven strategy for lean manufacturing*. Cincinnati, OH: Hanser Gardner Publications.
4. Thomson, L. B. (2010, January 11). U.S. lost 47,000 manufacturing jobs per month over the last ten years. Retrieved from http://www.lexingtoninstitute.org/us-lost-47000-manufacturing-jobs-per-month-over-last-ten-years?a=1&c=1171
5. Turesky, E. F., & Connell, P. (2010). Off the rails: Understanding the derailment of a lean manufacturing initiative. *Organization Management Journal, 7*.
6. U.S. Census Bureau. (2008, December 1). *Business dynamic statistics*. Retrieved from http://webserver03.ces.census.gov/index.php/bds/bds\_database\_list
7. Wilson, J. (2009, April). Directions to discovery. *Industrial Engineer*. Retrieved from ProQuest.
8. Wilson, J. M. (1995). Henry Ford’s just-in-time system. *International Journal of* *Operations and Production*. Retrieved from ProQuest.
9. Woehl, J. (2011). *How leadership styles reflect on lean manufacturing practices and* *culture*. (Doctoral dissertation). Retrieved from ProQuest Dissertations andTheses.
10. Womack, J. P., & Jones, D. T. (1996). *Lean thinking: Banish waste and create wealth in your corporation*. New York, NY: Simon & Schuster.
11. Womack, J. P., Jones, D. T., & Roos, D. (1990). *The machine that changed the world*. New York, NY: Free Press.
12. Wood, G. R., & Munshi, K. F. (1991). Hoshin Kanri: A systematic approach to b10reakthrough improvement. *Total Quality Management,*
13. Worley, J. M., & Doolen, T. L. (2006). The role of communication and management support in a lean manufacturing implementation. *Management Decision.*
14. Yin, R. K. (2009). *Case study research: Design and methods* (4th ed.). Thousand Oaks, CA: Sage Publication, Inc.

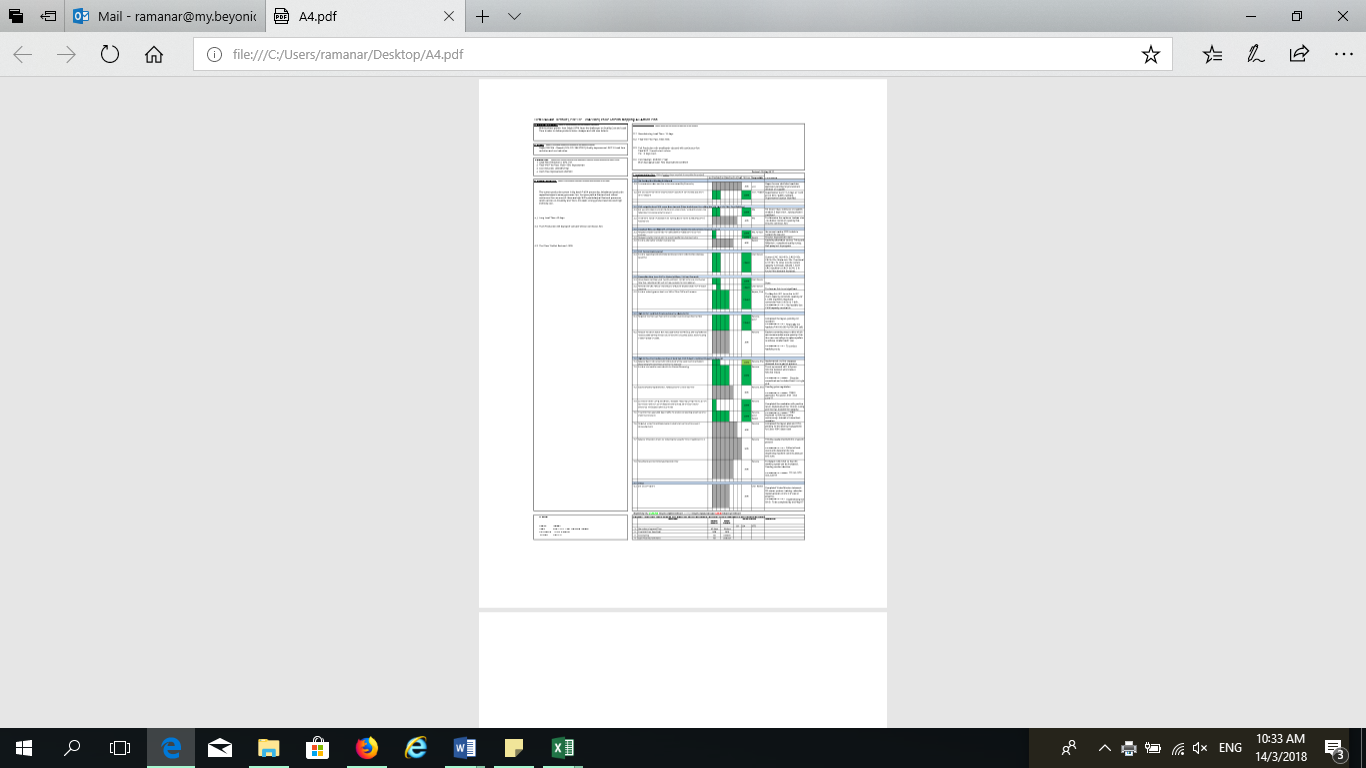
**Appendix**



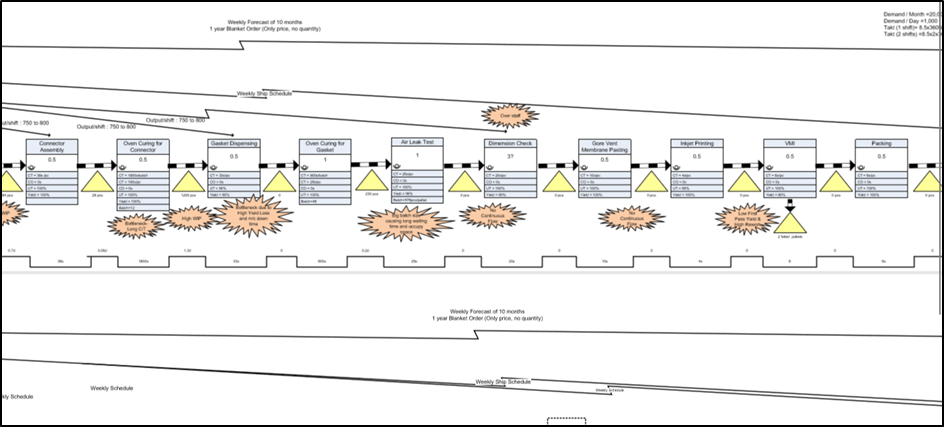
Appendix A: Sample of questionnaire

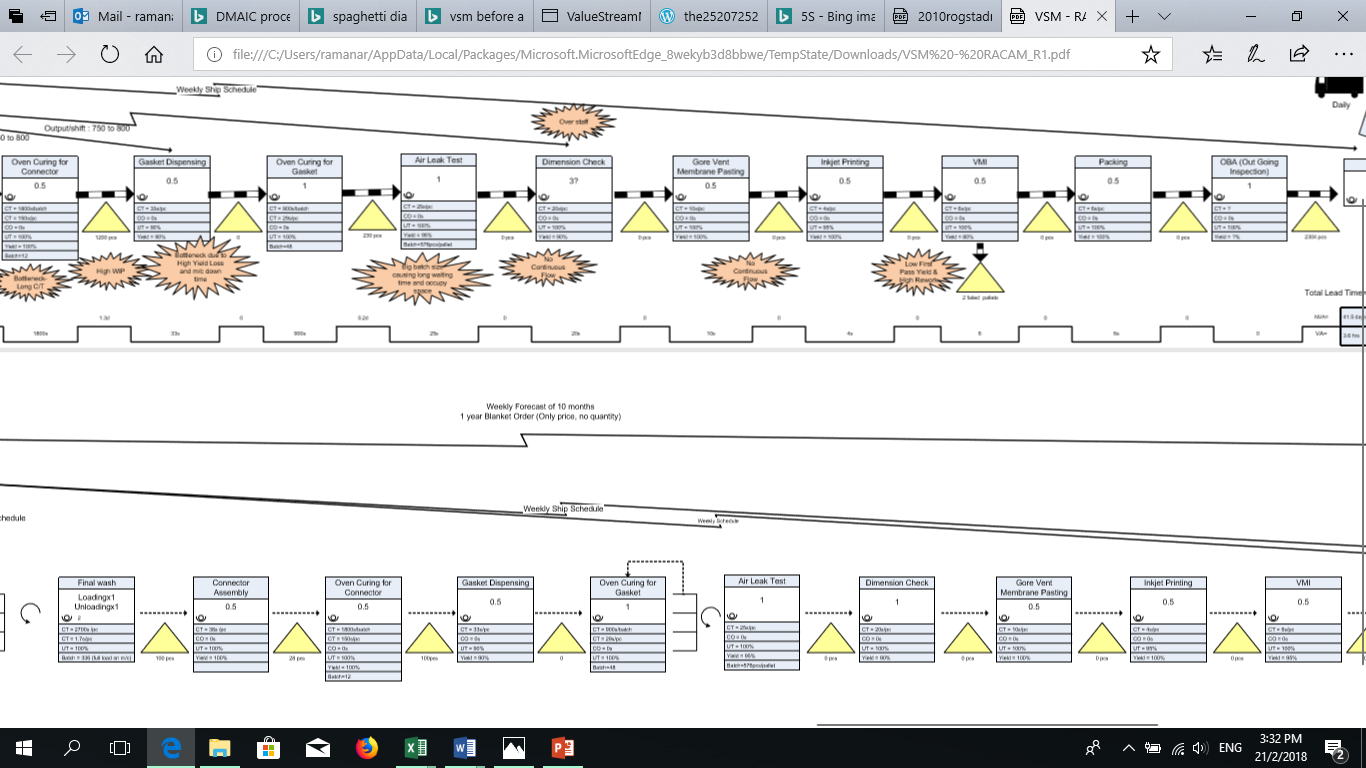


Appendix B: Questionnaire result

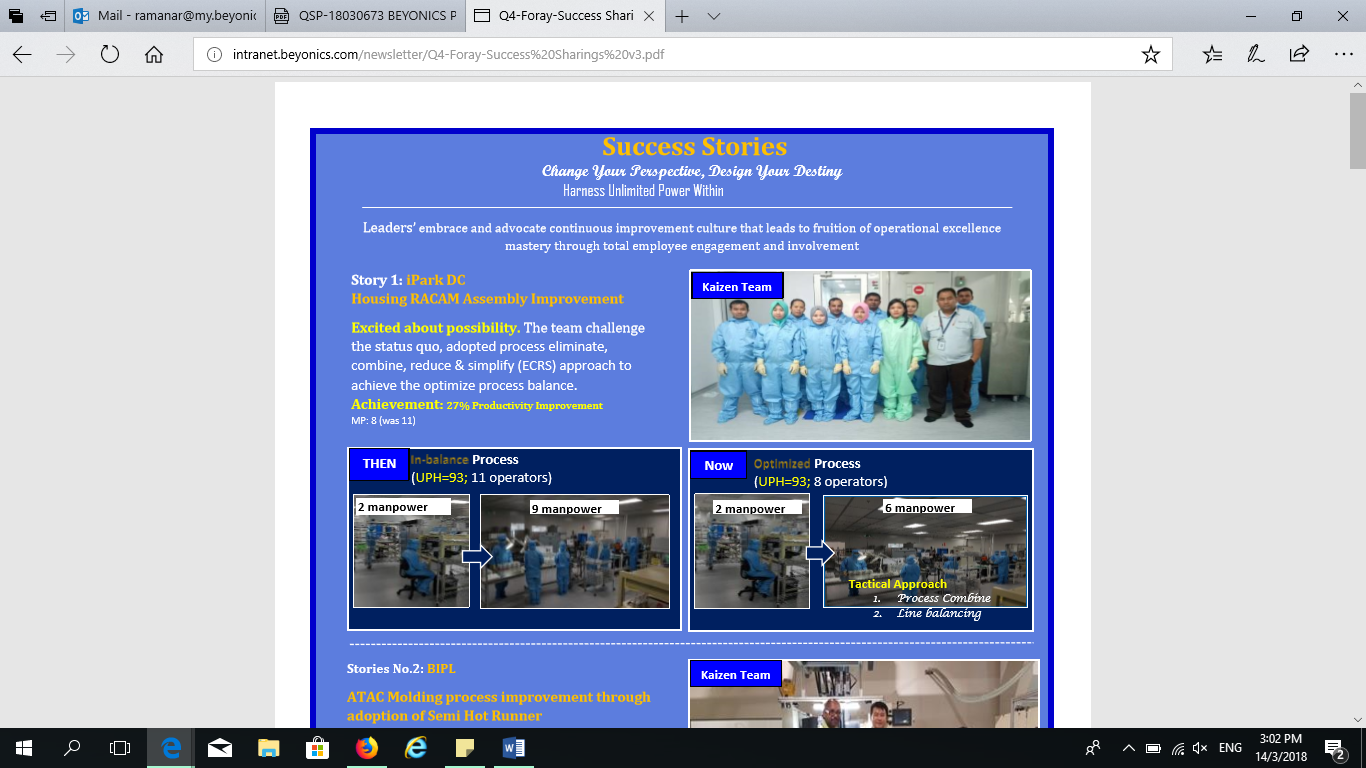


Appendix C: A4 sample





Appendix D: VSM Before and after



Appendix E: Beyonics news latter regarding the Racam line improvement.