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Lean Application: An Assessment of 5S on Employee Attitudes and Productivity

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LEAN APPLICATION: AN ASSESSMENT OF 5S ON EMPLOYEE ATTITUDES AND PRODUCTIVITY

by

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ABSTRACT

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This study examines the effect of the implementation of 5S on employee attitudes and productivity in an Asian based facility of a global manufacturing company. Utilizing an assessment of the 5S implementation in various areas of the facility and organizational performance data for each of those areas, a non-experimental, causal comparative approach is used to analyze the impact. The study concluded that statistically significant improvements from the implementation of 5S were found both in quality and product cost for this facility; however, the study also found statistical significance where the implementation of 5S led to a decrease in performance and an increase in maintenance costs.

Additionally, the study identified non-statistically significant relationships between 5S implementation and management attitudes. Conversely, the study identified statistically significant relationships between 5S implementation and employee attitudes. The data for the management respondents indicated higher scores than the employee respondents.

The study provided insight by offering additional knowledge on the effects of the implementation of 5S on attitudes and productivity. It expanded on previous research by also considering the relationships between groups with the outcome showing several groups having statistical significance. This enhances and allows future researchers and practitioners to understand the underlying influences that may have greater impacts on both attitudes and productivity.

While going through the process of completing my dissertation I almost lost my father. It was a humble reminder of the importance of family. Growing up a first-generation Greek-American, I was always able to see the many sacrifices my father and mother made for my Sister and me. My Grandmother always told my father, "Just do a little more for your children than I did for you." My Wife, Amanda, and I, as well as my sister, Kiki and her husband George, will do everything we can to continue that legacy. This work is dedicated to my family and the continuous improvement of each generation.

-N. D. Karvounis

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CHAPTER I

INTRODUCTION

The body of knowledge surrounding lean manufacturing has been researched for over 30 years through an evolution that has created increasing interesting in academia and with practitioners who want to understand effective organizational transformations (Hoss & ten Caten, 2013). In the simplest terms, lean manufacturing can be defined as a systemic approach of continually improvement through waste elimination (Womack, et al., 1990). Despite budding societal needs in the post "Great Recession" era, how to best implement lean is still an ominous endeavor being researched by an increasing number of academics and business practitioners (Randhawa & Ahuja, 2017).

The divergent and challenging aspect of lean is that unlike mass production, which views individuals as interchangeable parts of a mechanism, lean manufacturing principles establish individuals as symbiotic elements of the process, critical to sustainable growth in a dynamic environment (Womack, et al., 1990). With lean, the expectation is not only to do more with less, but also to improve through a search for waste-free, highly repeatable processes (Delisle & Freiberg, 2014). A great deal of effort has been focused on transitioning traditional organizations with "fat" business models into lean organizations sufficiently equipped for sustainable progress.

One instrument utilized to accelerate lean initiatives is the application of the lean manufacturing tool, 5S (Liker & Meier, 2006). This tool is a foundational lean initiative developed by Toyota in order to facilitate process standardization (Jaca, et al., 2014). It has been referred to as one of the "easiest" and "simplest" lean tools to implement (Randhawa & Ahuja, 2017). It has also been referred to as the key to establishing a total quality environment (Osada, 1991). As Toyota rapidly expanded their Toyota Production System (TPS), which has become the golden standard for lean practitioners, this fundamental tool has become a cornerstone to continuous improvement (Liker & Meier, 2006). Toyota's continued success explains why organizations across the globe have shifted to standardizing their own systems with mechanisms for continuous improvement (Chiarini, 2011).

5S stands for the Romanization of five Japanese words: seiri, seiton, sesio, seiketsu, and shitsuke (Jaca, et al., 2014). Those five words have been translated respectively to sort, stabilize, shine, standardize, and sustain (Liker, 2004; Hirano, 1995; Osada, 1991). Although some attest 5S was started by Takashi Osada (Jimenez, et al., 2015), and others argue it was developed by Hiroyuki Hirano (Patel & Thakkar, 2014), most accept Toyota as the organization best known for its implementation (Jaca, et al., 2014).

Global relevance is attained through the ability to be applicable across cultures (Leotsakos, et al., 2014). A consultant group collecting data in Europe on 107 companies found that 100 percent of the companies studied utilizing 5S and 99 percent of them utilized robust documentation systems to support their 5S efforts (Chiarini, 2011). As a result of Toyota's successes, the lean operating system approach spans several cultures, regions, and even industries (Liker & Meier, 2006). With the sustained success Toyota and their cohorts have been able to accomplish, robust confirmation indicates lean operating systems enable the management of organizations to continually evaluate and improve (Delisle & Freiberg, 2014).

In the beginning, it was critical for Toyota to develop an approach for standardizing processes in order to allow them to continually improve (Womack, et al., 1990). During their post-war origins, the dire situation prompted extreme frugality to produce high quality with the least number of resources. Simultaneously with their efforts in prudence and quality, streamlining efforts on waste elimination birthed a process focus openly embraced as a working organizational model (Liker & Meier, 2006). This lean focus helped Toyota to sufficiently meet the demands of a rapidly expanding company, as well as with significant increases in customer demand. It also inspired other major organizations like Volkswagen, General Motors, and General Electric to pursue waste elimination in their own operating systems (Liker & Meier, 2006).

Toyota has quickly become the fifth largest company in the world (Fortune, 2019). As a result of their successes with lean, other organizations are attempting to replicate their approach (Liker, 2004). Their revolutionary system of lean manufacturing has prompted other organizations to rapidly self-evaluate the necessary requirements so they can also transform into organizations of continuous improvement (Womack, et al., 1990). The concept of improvement is one that entails both efficiency and effectiveness in the overall productivity of organizations (Gapp, et al., 2008). Both efficiency and effectiveness are paramount to an organization's ability to stay both competitive and relevant. Simply put, lean initiatives of continuous improvement diminish costs, which many see as a clear long-term strategy to produce improved profits (Ondiek & Kisombe, 2013).

Efficiency is generally a topic limited to an operational focus where effectiveness transcends to various different aspects of management; however, both are ultimately required throughout organizations for sustained improvements (Gapp, et al., 2008). 5S is one of the best-known lean manufacturing methodologies that actively engages both (Gapp, et al., 2008); however, there are only a few studies analyzing its relationship with performance (Bayo-Moriones, et al., 2010). Although research indicates 5S will affect behavior (Sari, et al., 2017), the impact remains unclear; in particular, when behavior is measured in conjunction with performance. This research aims to further the body of knowledge to better understand the impact of the 5S system in a major manufacturer's facility, as well as the effects it has on employee attitudes and productivity. In doing so, it may offer insight to what steps can be prioritized to expedite improvements and trigger long-term success.

Statement of Purpose

Considering the economic instabilities of the current economy, the need to adopt lean approaches of proactive, long-term strategies and quickly discard reactive styles of management has intensified rapidly (Bozickovic & Maric, 2013). Compounded by economic globalization, the rapid organizational improvements essential for surviving have heightened the focus on benchmarking and operational excellence (Toma & Naruo, 2017). Pressure to be more effective and efficient has triggered organizations to focus their efforts on transformative cost-saving initiatives like 5S with urgency (Albert, 2004). The dynamic environment of the post-recession era has compounded this urgency and forced organizations to operate with a heightened level of consciousness, particularly regarding their resources (Taylor, et al., 2013).

Globally, many major organizations have adopted lean for systemic transformation to enhance their focus and seek improvements along their whole value stream (Liker & Meier, 2006). Academia and industry alike are continually searching for the best methods to improve productivity (Nicholds, et al., 2018). This fervor to adopt lean systems has also included external pressures from agencies, legislation, and government organizations (Iranmanesh, et al., 2019).

Studies focused on properly addressing the needs of the customer through the effective performance improvement of quality, cost, and delivery are leading priorities for manufacturing (Amasaka, 2008). It is also critical to further develop connections between practices and performance for organizations in an ongoing pursuit of world-class recognition (Davies & Kochhar, 2002). Assertions on the benefits of 5S have been made; however, there is little evidence available to verify these claims (Hutchins, 2006). The purpose of this study is to assess if the implementation of 5S can influence employee attitudes and productivity in an Asian based facility of a global manufacturing company. This study aims to assess the results of an adopted 5S system to determine if the anticipated impacts have been realized and to help better understand the strengths and weaknesses.

Research Questions and Hypotheses

This study will examine the effect of the implementation of 5S in facilities of a global manufacturing company on area productivity and employee attitudes. The following research questions will be utilized to achieve this goal:

Research Question 1: Is there a significant difference in productivity in operating units before and after the implementation of 5S?

H_{01}: The implementation of 5S in operating units will increase productivity as measured by weekly operations reports compared to reports before the implementation of 5S.

Research Question 2: Is there a significant difference in employee attitudes as measured by employee survey results and the rate of 5S implementation?

H_{02}: The implementation of 5S in operating units will improve employee attitudes as measured by employee survey results compared to the level of 5S implementation.

Background and Significance

People within organizations have gone through a dramatic change from being previously looked at as tradable, replaceable equipment to now having evolved into human assets who are critically responsible for both the failures and successes of their respective organizations (Vijayabanu & Amudha, 2012). In order for continued success to be sustainable, the employees within organizations must be able to adapt to changes. In this document, the word employees and team members are frequently used interchangeably. Lean manufacturing is the approach many organizational leaders have chosen to enable their employees to adapt to change, but precisely how to successfully implement this system remains unclear. 5S is a specific philosophy and methodology being applied internationally.

In Toyota, all processes, not just 5S, are established to enable operating routines, team relationships, and team cultures as self-fulfilling “knowledge creating” entities (Lam, 2000). This knowledge growth is not limited to the workplace, and despite focused efforts on learning and training internally, Toyota also focuses efforts externally through conferences and case studies (Toma & Naruo, 2017). These actions provide evidence that emphasis in lean organizations is placed on an on-going pursuit of growth and development. As such, organizations showcasing a learning culture can be used to exemplify transformational behavior for transitioning organizations as they shift to prepare for the future.

A learning organizational structure is favored, as the main features of functional flexibility and teamwork are associated with widespread skills, organizational participation, and enhanced empowerment (Wood, 1993). Different organizations implement strategies like 5S differently, sometimes starting in small operating units (OUs) and eventually making it through entire organizations (Pojasek, 1999). Making it through an entire organization is difficult and requires changing the organizational culture; however, the benefits of 5S are best realized as an integrated holistic management perspective with a high level of autonomy in a well-planned environment (Gapp, et al., 2008). These attributes are favorable to organizations, particularly when the dynamic and shifting market demands require expedient adjustments to services.

5S can be considered a method of training through practice, as it involves direct exposure to lean tools by requiring participants to have on-going focus on standardization and continuous improvement. Through constant reflection on the actual, the standard, and the gap, participants are directly exposed to lean in a visual environment conducive to forcing thought. This sort of systemic process is an implemented methodology used to modify, change, or develop skills and/or behaviors to improve performance (Milhem, et al., 2014).

Established 5S systems require robust feedback to ensure operators are properly developing skills to maintain and achieve the minimum standard. In terms of lean manufacturing, the standard is the defining point and platform for all processes (Liker & Meier, 2006). In order for the feedback to be effective, one must measure against this standard and effectively communicate results with a follow-up to address and document deficiencies for all improvements (Jimenez, et al., 2015). Similarly, any investment of time and resources requires a measurable improvement in performance. A failure to do so fails to develop cause and effect relationships for improvement (Davies & Kochhar, 2002). In other words, the focus must be placed on a strict adherence to the goals and targets with follow-up and learning when the goals and targets are not met.

The significance of this research is to improve the understanding of the effectiveness of 5S in manufacturing. This is important because 5S has been labeled as a foundational tool for improving quality among other key factors of success (Kanamori, et al., 2016). Studies have illustrated 5S impacts quality and, more accurately, have indicated the implementation of 5S has led the way to advancement in other continuous improvement endeavors (Kanamori, et al., 2016). In addition to the previously mentioned quality and safety impact of 5S, the approach can also enrich Total Production Maintenance (TPM), which is an approach utilized to maximize uptime and stabilize production (Lokunarangodage, et al., 2015). With the successful implementation of 5S, maintenance should transition from a fixing mode to a preventive and even predictive approach (Pojasek, 1999).

Although there is much left to explain regarding ways to improve the engagement and involvement of individuals in 5S, this research allows for movement closer to grasping an understanding of the impact of 5S in the workplace. The Great Recession has changed how organizations operate, but as the world economy continues to adjust, it is imperative to note shifts towards long-term planning (Liker & Meier, 2006). In the lean manufacturing context, the long view approach is typically a defining principle in making organizational decisions (Liker & Meier, 2006). As such, organizations with implemented concepts like lean manufacturing, six-sigma, and continuous improvement continue to gain ground and notoriety. The purpose of any lean endeavor is to ensure the customers' needs are being sufficiently fulfilled. This study furthers the understanding of 5S to arrive at that end.

Definition of Terms

The following definitions and table (Table 1) have been included to ensure the reader is familiar with the specialized terms and acronyms often utilized in facilities utilizing lean manufacturing:

1. 5S: an acronym utilized to abbreviate sort, set, shine, standardize, and sustain. It is a method of stabilizing processes through repeatability and structure.

2. After process audit: an audit to measure production quality after all production processes have been conducted, prior to customer delivery.

3. Cycle time: the time required to complete a process.

4. Employee satisfaction: an individual's collection of positive or negative feelings regarding his or her job (Robbins & Judge, 2013).

5. First time through (FTT): a quality metric measuring the number of units produced that require no further processing.

6. First time quality (FTQ): a quality metric measuring the number of units produced with issues that are repaired and delivered without requiring further processing.

7. Gemba: the actual location where the work or processing takes place.

8. Hours per unit (HPU): a key process indicator (KPI) used to explain the efficiency of a process. It is mathematically calculated by (Working Hours*Employees/Units Produced).

9. Jishuken: a Japanese word that translates to deep dive. It is a method of accelerated improvement that utilizes project work as a training tool while also improving the areas in which they are utilized.

10. Jobs per hour (JPH): is an engineering metric often utilized for equipment to determine the number of units produced during a set time period.

11. Key process indicator (KPI): a metric used to gauge and explain a process or components of a process.

12. Lean manufacturing: a strategic business model focused on waste elimination through the entire value stream to add value for the customer and reduce throughput time.

13. Line-balancing: restructuring to ensure all processes are loaded to the "load" line of a takt.

14. Per thousand units: a quality metric used to measure the number of defects incurred during the production of one thousand units.

15. Productivity: units produced per work hour measured by the number of units produced by a specified time (Hutchins, 2006).

16. Rate of production: a measurement of production that compares the actual number of units produced to the number of units planned.

17. Recordable injury: any type of injury incurred during the workday that requires treatment.

18. Safety: the frequency of employee injuries as measured by the rate of incidence (Hutchins, 2006).

19. Tactical implementation plan (TIP): a graphic representation of all the activities with tasks, assigned responsibility, and expected start, duration, and completion dates.

20. Takt time: the time allotted to a process to meet customer demand.

21. Yamazumi: a graphic representation of the cycle times of various processes as they relate to the takt time of the facility.

Table 1

Frequently Used Acronyms in Lean Operations Management

Acronym	Full phrase
5S	Sort, set, shine, standardize, and sustain
BU	Business unit
CT	Cycle time
DIB	Diversity, inclusion, and belonging
EE	Employees
FTE	Full time employee
FTT	First time through
FTQ	First time quality
ISO	International organization for standardization
HPU	Hours per unit
JPH	Jobs per hour
KPI	Key process indicators
OSHA	Occupational safety and health administration
OU	Operating unit
PTU	Per thousand unit
SQDCME	Safety, quality, delivery, cost, morale, & environmental
TT	Takt time
TIP	Tactical implementation plan
TPM	Toyota production system

Overview of Study

This study incorporates an underlying theoretical construct around the concept of creative tension. As described, creative tension is prevalent when there is a clear vision prescribed for an organization, the gap between the current state and the vision is clearly understood, and this gap between the two creates a natural tension to move in the direction of the vision (Senge, 1990). In lean organizations, the endless pursuit of standards and improving standards has pushed towards organizational needs and how organizations move to achieve those needs (Senge, 1990).

A system of key process indicators (KPI) focused on quality, delivery, and cost has been utilized in successful lean organizations (Imai, 1986). These various KPI are important as they measure whether organizations are able to produce the best quality at the lowest costs while enhancing on-time delivery, which is critical for organizations to remain competitive (Ahls, 2001). In that direction, research has concluded 5S benefits include improved safety, higher quality, lower costs, improved floor space utilization, improved changeover time, reduced maintenance issues, and even improved employee job satisfaction (Albert, 2004). Understanding the gaps between productivity, KPI contributes to the need to study 5S as an influencing approach for improvement.

Metrics are often confusing; however, it is important to ensure the best metrics are used when measuring performance (Ahls, 2001). When considering the widely accepted KPI, production facilities typically have an abundance of data internally related to the metrics of quality, delivery, and cost (Imai, 1986). It is important to consider various elements for performance evaluation rather than focus on one because an item could be beneficial in one area, all the while being detrimental to others (Davies & Kochhar, 2002). In that regard, after safety, stable quality in production is the quintessential measure essential to be successful in global manufacturing systems (Amasaka, 2008). Similarly, in an assessment of several companies, quality, cost, and delivery metrics are most frequently prioritized and utilized by organizations seeking to improve and, ultimately, be considered world-class (Dale & Asher, 1989).

The data used in this study are regularly available internally and allow for non-experimental, ex post facto (causal comparative) research, as seen in the Hutchins (2006) study. In the Hutchins' (2006) study, the data for productivity, safety, quality, product cost, and maintenance cost identified limited statistically significant ($p < 0.05$) differences before and after the implementation of 5S. The results of the previous study are briefly summarized to help build context for this study.

The data of the Hutchins' (2006) study indicated a decrease in productivity with statistical significance in three out of six of the cost centers studied. The data also identified a decline in safety in the experimental cost centers and a slight improvement in control cost centers; however, none of them were statistically significant (Hutchins, 2006). The data identified slight improvements in quality in the experimental groups with a decline in control groups, but none were statistically significant (Hutchins, 2006). Both product and maintenance costs also indicated lower performance, but they too were not statistically significant. Lastly, when looking at the attitudes of employees and management, the previous study found employee attitudes to have slight improvements, while it was identified that management had a lower perception, but again the data for both were not significant (Hutchins, 2006). This study aims to better understand these relationships and seeks to see if other organizations also identify non-significant influences of 5S on productivity and attitudes.

In order to maintain industry anonymity and protect against anti-trust infractions, the data in the study are presented in a manner to maintain industry confidentiality. This type of confidentiality and anonymity is required in specific industries as a result of the high level of competiveness associated with potential advantages in market position, competitive resources, and even organizational learning (Elmoselhy, 2013).

Despite the need to maintain confidentiality, the KPI studied in this dissertation are able to replicate the model from Hutchins (2006) study of another production facility. Performance measures, such as those used to study the effects of 5S, are continually used in organizations to monitor stability, as well as establish potential growth and follow-up with potential achievement regarding pursued initiatives (Nicholds, et al., 2018). In doing so, the KPI analyzed includes metrics directly related or derived from the standard quality, delivery, and cost models.

Additional internal organizational data is utilized from longstanding 5S audits in order to effectively gauge the 5S implementation rate. Qualitative and quantitative data is also collected utilizing employee surveys. Descriptive statistics are used for the area KPI, 5S audits, and survey results to analyze the data and identify trends. The KPI and 5S audit results are to be compared to assess the data to clarify the effect of 5S on performance. This study helps both researchers and organizations better understand if 5S helps achieve improvement and addresses why this was or was not accomplished (Hutchins, 2006)**.**

Delimitations

This study is an ex post facto study. In part, this is directly related to the fact most organizations have already implemented some degree of lean (Chiarini, 2011). As such, this research provides insight to an environment where a more defined experimental approach is not possible (Cohen, et al., 2011). In this situation, elements of lean have already been implemented and it is not possible to properly conduct a direct experiment, as most organizations would not be willing to implement inefficient processes after improvements have already been adopted. Nonetheless, ex post facto research is a valuable exploratory approach and allows for insight to information concerning the nature of phenomena, in particular in relationships where the study assists with an improved understanding of what goes with what and under what conditions (Cohen, et al., 2011).

Limitations

The limitations of the study include the following:

1. This is an ex post facto study in a facility owned and operated by a global manufacturing company in Asia. This means the "experience," in this case 5S implementation, occurred prior to the study (Leedy & Ormrod, 2013). In that regard, it is both unreasonable and unrealistic to remove already integrated elements of 5S or improvements in order to study their impacts. As a result, this methodology is best suited for such situations where those factors cannot be controlled (Cohen, et al., 2011).

2. In ex post facto research, it is virtually impossible to isolate and control all potential variables or to truly identify critical variables (Cohen, et al., 2011). With an inability to control for other possible contributing variables, and being limited to observed effects, this type of research cannot be used to explain causal relationships (Leedy & Ormrod, 2013). Moreover, when relationships are identified, it is difficult to decide which is the cause and which the effect; reverse causation must be considered (Cohen, et al., 2011). Without a true control for the variables, the results of additional studies could yield different results (Cohen, et al., 2011).

3. Ex post facto studies start with groups that are different in some regard. The analysis retrospectively examines contributing factors in an attempt to explain what brought about the differences (Cohen, et al., 2011). Other studies have identified the difficulty in isolating specific causal relationships to 5S (Kanamori, et al., 2016). Part of this is associated with the inability to control the independent variable; however, perhaps more importantly, randomization is also not

possible (Cohen, et al., 2011). As a result of the inability to control or randomize, when a relationship is identified between two variables, it must be recognized there is a possibility both are individual results of a common third factor rather than the first being necessarily the cause of the second (Cohen, et al., 2011).

In short, with this limitation one cannot know with certainty whether or not the causative factor has been included or even identified in the current study (Cohen, et al., 2011). For example, when it comes to lean, there are great difficulties in distinguishing what leadership approach is most effective and how critical it is to be able to shift and adopt when necessary (Senge, 1990). This study cannot strictly control any particular leadership approach and, thus, does not evaluate the different approaches.

4. As in Hutchins (2006), this study is limited to one 5S program as it compares to a particular organization's internal performance and, therefore, the findings are not typically generalizable. The metrics used by each organization have varying levels of customization and research indicates academia has difficulty identifying and recognizing the importance and selection of various performance measures utilized in organizational research (Richard, et al., 2009).

Likewise, the 5S model in this study has been developed within the organization studied and one can find differences between the reliability and effectiveness of the 5S audits each organization uses. In that regard, it should be noted other studies have developed 5S audits for reliable 5S testing (Whitman, et al., 2014). This study is not focused on the 5S implementation directly; instead, it focuses on how 5S impacts attitudes and productivity using these internally established measures.

5. As in Hutchins (2006), this study has population limitations where the responses are limited to a single facility with a "unionized" workforce. The fact the research is limited to one facility can potentially make the research less generalizable. In that regard, one facility can have a different perspective than another. In addition, the fact the location studied is unionized means the union can create an unidentifiable impact and inhibit the randomness of the participants, as well as potentially inhibit the responses of the participants. This means there are no means to prevent the union from influencing who participates in the survey, especially since the survey is completely voluntary. Similarly, the answers of the workforce can potentially be influenced by the union leadership.

6. As in Hutchins (2006), this study is unable to randomize which groups are the experimental and comparison groups. In this situation, there are not enough groups being studied to be effective in randomly selecting groups for each condition. Since 5S has already been introduced, the methodology of the Hutchins (2006) study will be followed as close as possible. For example, an unavoidable difference is Hutchins (2006) included six different cost centers for comparison; however, this study only had five total operating units to study.

7. Key process indicators are often not transferable between operating units within organizations, let alone between different organizations. In that regard, many indicators are essentially customized to specifically measure the desired outcomes of the processes for which they have been developed (Jimenez, et al., 2015). Often, these indicators are the products of evolution and are not easily identified for developing organizations (Jimenez, et al., 2015).

The fact that different organizations may not have achieved the same levels of maturity with their own internal data limits the ability of transferring expected outcomes to other organizations. Complex organizations, such as manufacturing, operate in environments where variables frequently change, highlighting concerns regarding data maturity, in particular when studying the impacts of practices and their measurable benefits in the data (Davies & Kochhar, 2002). Although the study replicated also shares the same KPI, there are significant chances the measurement of those KPI are not wholly standardized between the two different organizations. For example, an identified potential gap in this study is the measurement of the KPI, such as product cost. In Hutchins (2006), no explanation of how the “product cost” was measured and therefore, this study also utilizes internal data to measure the impacts of improvements.

8. There is a potential gap between the perceived and actual reality when it comes to lean implementation (Rose, Deros, & Rahman, 2013). In studies where it was possible to examine both, the data indicated there were significant differences between perception and practiced scores (Rose, Deros, & Rahman, 2013). In that regard, the organizational 5S audits, as well as how the surveyed teams perceived their area was doing can potentially indicate two completely different understandings of successes or failures in the implementation of 5S.

Summary

The purpose of this study is to determine if it is beneficial to implement 5S to improve facility attitudes and performance. In doing so, the goal is to further the body of knowledge on what performance improvements can be identified and related to 5S. Using the Hutchins (2006) study as a baseline, this study specifically compares KPI to actual plant audit scores and conducts surveys with team members and management.

Lean manufacturing is the method most widely selected by organizations to help transitions and adjustments required to stay competitive in the unstable economic environment of the Post Great Recession era. In establishing this approach, organizations have already accepted a role of learning and development requirements at the workplace (Senge, 1990). With ingrained lean concepts being the focus moving forward, the expectations of organizations will be to continue down these paths of improvement.

To conduct this study, it is assumed organizational trends will continue down the path of lean manufacturing. It is also assumed organizations will continue to seek new ways to enhance organizational learning. In order for this research to gain traction, it is assumed others will seek to build upon the research produced in this study.

Key terms and acronyms were described in order to provide a solid foundation to build upon the research as described in the document. This was done to eliminate any confusion of unfamiliar terms and concepts, as well as to ensure alignment with how terms are utilized in this study. It is imperative the results of the study are not lost in unfamiliar terminology and the key definitions are utilized for clarifications.

CHAPTER II

REVIEW OF LITERATURE

Chapter II will provide a review of literature pertinent to a thorough understanding of 5S and how it has been incorporated. The literature review is established in order to provide the reader with a history and evolution of manufacturing to facilitate an understanding of how and why the various tools were developed. Gaining a general insight into lean and continuous improvement can provide a sufficient understanding of the identified evolution of organizations, in particular with a focus on 5S, as well as further clarifying the importance and goals of the research.

To accomplish this, the chapter will start with the origins of lean, beginning with influential contributors including Ford, Deming, Toyoda, and Ohno and then evolve into conceptual definitions of lean after the Great Recession. This transition into recent lean practices will include an overview of the prescribed lean principles and the “lean house,” which is the foundation of all continuous improvement. For this research, the 5S component is the paramount feature of this house. The focus will then shift to an understanding of the evolution. Much of the currently available research on 5S is limited to practical and informative literature instead of research from an academic perspective (Hutchins, 2006).

Organizational Culture

There are four defined categories used to describe basic organizational knowledge requirements including Japanese-Form Organizations, Machine Bureaucracies, Professional Bureaucracies, and Operating Adhocracies (Lam, 2000). Although there are no right or wrong types of organizations, the cultural shift has been towards a Japanese-Form Organization, exemplifying lean manufacturing techniques. Japanese-Form Organizations ensure learning is embedded as part of organization processes to promote cumulative learning and incremental innovation (Lam, 2000). This type of learning is entrenched in the processes, but also indicates conditions support a learning culture. Prerequisites for organizations to successfully adopt lean philosophies including literacy and numeracy, among other factors (Black, et. al, 2014).

A key component of lean is the ability to generate ideas from the people performing the processes (Rother, 2010). As a precondition for lean development and progression, it is necessary to understand local meanings and support transitions in a manner that different locations can understand and effectively respond (Black, et. al, 2014). This goes beyond the ground level tacit knowledge described in Liker and Meier (2006) and stretches into elements of organizational culture, which directly impacts how the organization functions, learns, and transitions (Bortolotti, et. al, 2015).

Even if transitions are supported with language translators, there is still the potential for language barriers and fundamental requirements for cultural understanding (Black, et. al, 2014). Still, the implementation of lean can surmount various obstacles and, nevertheless, develop the labor force (Bozickovic & Maric, 2013). Extensive research indicates connections between organizational culture and lean transitions; however, there are still many questions to be answered (Bortolotti, et. al, 2015). Noting the importance of organizational culture, previous research states 5S can influence employees' mindsets and behaviors (Chadha, 2013); however, the extent of which is unclear. Nonetheless, organizational behaviors impacting organizational KPI offer boundless improvement opportunities (Ahls, 2001).

Prevailing successful lean cultures require leaders who are willing to engage team members and actively seek to develop their team based on the actual needs of their team members and the processes they perform (Dombrowski & Mielke, 2014). These leaders must be supportive of the learning, but also must be patient with the team members while not directly intervening with problem-solving (Dombrowski & Mielke, 2014). Problems and mistakes are inevitable; however, their consequences and the ensuing results, can dramatically change the culture of how teams engage those problems (Dombrowski & Mielke, 2014).

Studies show successful organizations adopt learning cultures; however, this learning attribute is not naturally occurring and must be nurtured and cultivated (Hussein, et al., 2014). It is important to address issues, not people, directly and work with the teams to find reasonable and acceptable solutions (Chaneski, 2004). It is also imperative to note that while this initiative focuses on adding lean and continuous improvement efforts, normal work responsibilities must also be managed and completed (Harris & Harris, 2010). In other words, in addition to traditional responsibilities, new process requirements dictate lean and continuous improvement work is actually part of each employee's responsibilities. In addition to the aforementioned organizational culture topics, it is also critical the teams are flexible (Harris & Harris, 2010).

Several indicators link the successes of lean manufacturing to the cultures of the organizations that are implementing lean philosophies and techniques (Kull, et. al, 2014). Unassertive and cooperative approaches among team members in order to navigate through the uncertainty are prevailing values in organizations with successful transitions to lean (Kull, et. al, 2014). Organizational cultures existing in unstable situations, e.g., poor and fast-growing economies, are more receptive to lean as they are more reactive to short-term changes and are typically more willing to adjust in order to maintain employment (Kull, et. al, 2014). On the other hand, cultures with concrete performance targets and goals of relatively stable situations have incredible difficulties in adjusting to the "moving target" of transitioning economies and demands (Kull, et. al, 2014). This aspect of an increasing level of responsibility can be difficult to overcome.

All countries have their own national culture; therefore, it is important to understand how leadership and team members within organizations are impacted by the national culture in terms of how they work and adapt lean strategies (Kull, et. al, 2014). Research supports lean can improve performance in all nations, and although some cultures are more or less likely to adapt quickly, all can improve with extensive practice (Kull, et. al, 2014). In order to do so, it is necessary the organizational culture encourages job security, safe experimentation for learning, and most importantly, mutual trust, particularly between management and team members (Manotas Duque & Rivera Cavadid, 2007). Such actions establish a more trusting environment. This element of trust is crucial as organizational lean philosophies need to be developed internally and grown within an organization’s culture and not simply be imposed (Atkinson, 2010). In that sense, the teams understand the changes as integral parts to their development and implementation.

Adopting lean requires significant organizational change involving understanding various factors influence success, as well as how to properly address them (Martinez-Jurado, et. al, 2014). It is particularly important to make note of the transition phase and utilize pilot areas with opportunities to troubleshoot initial problems identified in the small areas before expanding into larger areas (Martinez-Jurado, et. al, 2014). Sometimes a great pilot area can be a break area, which not only touches many, but also can show strong points in an effective manner by improving something team members really care about (Manos, et al., 2006). The key point of such activities is to ensure the most opportunities to allow individuals to take part in the transition rather than only being affected by the outcomes (Martinez-Jurado, et. al, 2014).

Transitions to lean often require reinventing the previously established operating systems employed by organizations, which typically requires a change in the established culture (Ndahi, 2006). Leaders initiate this change. In doing so, it is critical to always remember “people are boss watchers,” so for initiatives to be successful, leaders must lead by example (Atkinson, 2010, p. 40). Toyota leadership emphasizes the importance of every leader directly developing the next generation of leaders (Balle, et al., 2015). Similarly, it can be said these leaders also develop the organizational choices with the directions and development of their teams.

Too often, managers do not focus on, or sufficiently consider, cultural topics (Ahls, 2001). Regardless of the prevailing organizational cultures, for any transitions to be effective, it is necessary for leaders and managers to be “culture carriers” and lead by example, coaching and developing behaviors towards a lean culture (Poksinska, et. al, 2013). Lean initiatives should not only improve processes, but also support the culture by guiding behaviors and thinking towards the lean transformation (Poksinska, et. al, 2013). The absence of a nurturing lean culture can prohibit all lean tools and lean applications from helping the organization achieve their potential results (Searcy, 2012). Ultimately, in congruence to the prevailing, existing culture, it is necessary to establish an evolving corporate culture emphasizing teamwork and robust communication (Day, 1995).

Lean Manufacturing

There are several contributors who helped develop and establish what is now known as lean manufacturing. Precursors to lean include Eli Whitney’s interchangeable parts, Frederick Taylor’s Scientific Management, Frank Gilbreth’s process charts and motion studies, and Edward Deming’s concept of Total Quality Management (Ndahi, 2006). With lessons of the past, one can argue lean’s origins truly started with Henry Ford in the Highland Park manufacturing plant when he combined the assembly line, interchangeable parts, and standard work (Manotas Duque & Rivera Cavadid, 2007). In particular, Ford, Deming, Ohno, and Toyoda stand out as true lean champions with many of their ideologies in regard to molding the transition from batch production to pull production (Womack, et al., 1990). With such guiding ideologies toward customer needs, the pinnacle of lean implementation results from a balanced and smooth flow of production (Elmoselhy, 2013). This section is designed to introduce lean manufacturing as an integral part of continuous improvement and an encompassing ideology to which 5S is a foundation.

Major transitional Japanese industrial leaders including Toyoda, Shingo, and Ohno took a hardline process-oriented system focus to eliminate waste, reduce inventory, and primarily improve throughput time (Abdulmalek & Rajgopal, 2006) in order to make processes more efficient and more effective while meeting customer demands as fast as possible. The substantial differences from what Ford was doing in the Unites States to what Toyoda and Ohno were doing in Japan was primarily a focus shift from machine and workstation optimization to product flow through the entire value stream (Manotas Duque & Rivera Cavadid, 2007). A main focus of lean is to optimize costs and quality, while ensuring an overall excellent experience for the customer (Alsmadi, et. al, 2012). Ford had all the foundations covered; however, Toyoda and Ohno were improving much faster.

An overall business model with an emphasis on lean helps businesses to better compete (Alsmadi, et. al, 2012). The speed at which Toyota was able to grow as an organization truly illustrates how their approach quickly brought them from a "start-up" auto manufacturer to a global player. This can be evidenced by Toyota Motor Company still being a top ten company on the Global Fortune 500 list while Ford is no longer even in the top twenty (Fortune, 2019).

Organizations in the United States are rapidly trying to adopt lean manufacturing in an attempt to keep competitive in the global market (Abdulmalek & Rajgopal, 2006).

Clearly defining lean manufacturing is difficult, as the philosophy is often misunderstood, understated, and mostly incomplete (Alsmadi, et. al, 2012). Many definitions are focused on practical lean tools instead of the philosophy; however, this still tends to be a generally accepted approach as the lean practices have produced positive results (Alsmadi, et. al, 2012). One way lean has been defined is the “setting of standards aimed at continuous improvement by all team members” (Scaffede, 2002, p. 16).

Lean can also be summarized as decreasing lead times, removing waste, and focusing directly on the wants of the customer (Andersson et. al, 2014). The adaptive and customer-centric approach of lean has also provided it with the nickname “demand-based manufacturing” (Lebow, 1999). Regardless of the various definitions applied to lean manufacturing, the overall similar themes make them all generally compatible (Lebow, 1999).

In the spirit of the constant change of lean, it has been described as a “revolution through evolution" (Atkinson & Nicholls, 2013, p. 12). In that regard, it is best to understand lean manufacturing as all of the above, but also as a strategic approach to finding the best way to develop a competitive advantage by listening to the voice of the customer with effective and efficient delivery (Atkinson & Nicholls, 2013). To be more succinct, lean is a strategic business model focusing on waste elimination through the entire value stream to add value for the customer and reduce throughput time.

Under current models, it is unclear if lean practices cause better performance, better performance causes an increase in lean practices, or if both are being caused by an unidentified third factor (Alsmadi, et. al, 2012). This can be attributed to the difficulty in defining lean for study. For example, to broaden the idea of lean, many also include reducing unnecessary capital investments as a characteristic to lean organizations (Black, et. al, 2014). Nevertheless, with extensive successes in Japan, the United States of America, South Korea, and Europe, rapid implementation of lean manufacturing is growing in China, India, and Malaysia (Dubey & Singh, 2015). The empirical effect of lean on performance requires far more focus from academics and scholars alike, as the research is still underdeveloped (Alsmadi, et. al, 2012); however, the widely adopted use of 5S can catapult organizations in the direction of becoming lean (Albert, 2004).

The Origin of 5S

Hiroyuki Hirano and Takashi Osada have been attributed with the most credit in developing 5S (Jimenez, et al., 2015). Since Osada and Hirano are both from Japan, it is typically uncontested that 5S is the product of the continuous improvement (kaizen) culture of Japan (Jimenez, et al., 2015). The differences between Hirano and Osada are how they define 5S as being strictly a tool for eliminating waste versus a conceptual vision for growth, respectively (Jaca, et al., 2014). This dichotomy is one that pigeonholes 5S into a practical tool focused primarily on the removal of waste for business superiority over competitors rather than an approach focused on integrated learning and development (Jaca, et al., 2014). Although this study does not delve into that argument, it can be useful to understand the difference.

5S is often called the commonsense approach to management (Imai, 1986). It is recognized as the most widely adopted lean workplace methodology to achieve continuous improvement (Jaca, et al., 2014). It has been defined as a methodology, philosophy, a policy, a process, a technique, and a tool (Jaca, et al., 2014).

It has also been defined as a set of techniques to standardize housekeeping and workplace organization (Henderson, 2019). The primary function of 5S is "maximize the level of workplace health and safety in conjunction with increased productivity" (Gapp, et al., 2008, p. 567). Despite the varying cultures of organizations housed in different countries, many have found success with 5S (Casey, 2013). This is noted because areas outside of Japan seeking to adopt 5S often have different cultural dynamics that could impact its implementation. Regardless of the aforementioned impacts, lean ideals continue to spread, as does the concept and practical use of 5S.

The 5S Words

5S is more than a simple list of five words beginning with the letter S about how to keep the workplace clean (Albert, 2004). Academics and practitioners frequently interchange the S words, which are translated from the original Japanese words, used in 5S (Albert, 2004). However, the most used definitions are derivatives of sort, store, shine, standardize, and sustain (Osada, 1991; Hirano, 1995; Liker, 2004). Osada (1991) translates the Japanese words: seiri, seiton, seiso, seiketsu, and shitsuke to the English words: organization, neatness, cleaning, standardization, and discipline, while Hirano (1990) translates them in a similar manner to organization, orderliness, cleanliness, standardized cleanup, and discipline (see Table 2). This section clarifies what the individual S words mean and how they function in greater detail, as well as the order in which they should be implemented.

Table 2

The Prevailing Translations of 5S

Number	Japanese	Japanese (English Letters)	Hirano (1995)	Osada (1991)	Liker (2004) (Common version)
1	整理	Seiri	Organization	organization	sort
2	整頓	Seiton	Neatness	orderliness	store
3	清掃	Seiso	Cleaning	cleanliness	shine
4	清潔	Seiketsu	standardization	standardized clean-up	standardize
5	躾	shitsuke	discipline	discipline	sustain

The first S to be introduced is Sort. Sorting requires separating unnecessary items from the required items and is a building block for the ensuing items in 5S (Chadha, 2013). Osada (1991) simply describes organization as the "art of throwing things away" (p.45). The sentiment is to sift through what is needed and discard what is not needed, i.e., separating the necessary from the unnecessary (Osada, 1991). To truly achieve this step, one must not only eliminate unnecessary items, but also move to a state where one can prevent a return to the previous condition (Osada, 1991). Sort and organization in this context have also been defined as stratification management where the key to successful stratification management is differentiating between need and want while ensuring what is needed is in its proper place (Ho & Cicmil, 1996).

The second S is store. Storing is essential in order to establish new storage locations for the required items remaining after the sorting exercise (Chadha, 2013). Neatness and orderliness mean there is a place for every required item to eliminate the need for anyone looking for items

(Osada, 1991; Hirano, 1995). In that sense, items are not only easily found, but are also easily returned to their idle locations when not in use (Osada, 1991). It is paramount everyone is involved and continually practices imagination to develop superior locations and presentation methods (Osada, 1991). Store and neatness in this context have been described as a study in efficiency where the measure of success is how quickly one can use what is needed and return them as fast as possible (Ho & Cicmil, 1996).

The third S is shine; however, shine means much more than cleaning, it also means inspection (Osada, 1991). Every piece of equipment necessary to complete tasks is essential to work and, therefore, it is understood the person who uses the equipment is best prepared to keep the basic parts of the equipment clean for its function, as they are best able to identify minor issues while they are still minor (Osada, 1991; Hirano, 1995). Some argue, the discipline of proper housekeeping is a prerequisite to effective quality (Dale & Asher, 1989). In that regard, by seeking to ensure individuals who use the various pieces of equipment the most also clean it, the team members are then additionally capable of broadening their perspective of the equipment to proactively identify safety and quality threats (Osada, 1991; Hirano, 1995). This aspect of cleanliness contributes to the atmosphere of the environment, whereas a cleaner environment is more harmonious with team members and thus more comfortable (Dale & Asher, 1989).

Knowing lean initiatives are centric to standards and improving standards, the fourth S of standardization is also positioned towards visualization (Osada, 1991). One way standardization has been described is as an approach to illustrate the current state of affairs (Osada, 1991). This can be accomplished in a wide variety of ways, but the most common strategies include visualization through images, maps, and diagrams, but also include written down procedures and manuals (Osada, 1991). Hirano (1995) similarly defines the fourth S as a means to standardize the three previous activities from action to a new state of conformance (Hirano, 1995). Related and unifying concepts of visual management and transparency clarify this step as an approach to quickly contain deviations before they become major problems (Ho & Cicmil, 1996).

The final S is often translated as sustain, but Osada (1991) and Hirano (1995) translated the last S as discipline. The reason for this is because in describing the definition, it not only means following the rules, but also reflecting on previous mistakes and how one could improve in order to eliminate the possibility of repeating the same mistakes (Osada, 1991). According to Hirano (1995), the element of 5S transcends the previous four steps as an overarching pivotal factor for the system as a whole, where discipline sets social and safety conventions and establishes overall work environments.

5S has been utilized in a wide array of organizations and industries. Ranging from offices and industrial facilities, the successes of 5S have even been evident in the food service industry, where results have shown improvements in flow, equipment management, material storage, and even work routines (Engelund, et al., 2008). Understanding the meanings and purposes of the 5S words helps explain how important each is, how they build on one another, and reemphasizes the importance of the standard.

The Standard

Organizations, processes, and even quality are defined through standards. Whether it is standard processes or standard measurements, the standard is the basis for systemic improvement. Therefore, it is necessary to better understand the standard to illustrate how one knows they are successful, how performance can be measured, and what actions within an organization ensure continued success. 5S philosophy and practice can help; however, before any improvement can be made a standard, stabilization must come first (Liker & Meier, 2006).

The standard can be defined as an implemented and agreed upon standard, process, design, or practice (Leotsakos, et al., 2014). In order to be a true standard, it must be supported with instructions in a consistent and measurable way (Leotsakos, et al., 2014). As a process, the standard must be sufficiently communicated and detailed in order to be reproduced and replicated by multiple operators that can produce the same verifiable results (Leotsakos, et al., 2014). In lean organizations, team members are well-versed about variation, particularly when considering losses (Dale & Asher, 1989). As a result, they are encouraged to adhere to standards as closely as possible to effectively reduce variation through strict control over processes (Dale & Asher, 1989). When applied to specific processes, this repeatable set of standards is called standard work instructions.

Standard processes have one key function: control the process to control the output. Often referred to as the driving force to lean management, standard work instructions focus efforts away from people and shift towards processes (Mann, 2015). In other words, standard processes ensure the actions produce the desired results. As the safest and most efficient ways to perform activities, standards are evolving as organizations evolve. Consequently, standards serve as a starting point for continuous improvement, but also as a gauge and measurement for success. They are also focal transitions for Deming's Plan-Do-Check-Adjust cycles.

Standard measurement is necessary for organizational development and understanding potential opportunities. That is to say, the standard is one of the key aspects of lean practices connecting lean to the scientific method. Targets are used as standards to be met and should be treated as such (Rother, 2010). When looking to trigger problem solving, the inability to achieve specific, measurable, attainable, realistic, and time bound (SMART) goals is also an opportunity, much like a deviation from the process (Rother, 2010). Both have been developed with thought and rigor and, therefore, striving for their attainment and achievement is necessary for organizational success.

5S requires a process that not only builds cleaning into the daily activities (Patel & Thakkar, 2014), but one that identifies problems (Gapp, et al., 2008). Building on this concept of solving problems, detailed processes have led to systemic visualization tools for “minute management.” Minute management, or at-a-glance management, means one can identify deviations in just a few moments. For example, some production facilities may use visual indicators like green or red colors to indicate they are on target or below target. These visualization tools exist for emphasized production topics like hour-by-hour production and safety crosses, but they also exist for 5S (Mann, 2015). For example, a 5S map indicates the standard of how an area is supposed to look with individuals assigned to maintain the area. Simply looking at the map allows minute management to see if the 5S is being maintained in the area.

Once standards exist, the development and growth of an organization should drive necessary training to enforce and support those minimal acceptable levels (Gold & Thorpe, 2008). A deviation from the standard is a problem and, in this context, an improvement to the standard is continuous; also frequently referred to as kaizen. Understanding when things are out of place or out of standard allows individuals to trigger the need for action (Baes, 2017). Sometimes, it may not be clear what changes are necessary; however, the trigger for the need can still help change behaviors. In that way, one can see how 5S can be considered a foundation to build upon.

5S as a Foundation

5S has been labeled a foundational element to the implementation of lean manufacturing (Liker & Meier, 2006). It has also been identified as the starting point to Total Quality Management (TQM) in the arrangement of 5S, lean, and TPM (Kanamori, et al., 2016). Expanding on this foundational aspect, the quality shift has more recently become the primary purpose of 5S (Gapp, et al., 2008). Some would even argue the absence of a robust 5S system can render all other systems ineffective (Chapman, 2005). For these reasons, it is helpful to review previous research pertaining to 5S as a precursor for various ensuing initiatives.

As a technique, 5S is described as a structured program developed to establish both total cleanliness and standardization in the workplace (Patel & Thakkar, 2014). Cleanliness and standardization are prefaces to future activities but are also methods to better identify current deficiencies and opportunities in the workplace. 5S is said to be systematic and organic with results from utilization allowing organizations to use less effort, time, and resources while producing with fewer defects (Chapman, 2005). It is applied to reduce waste, eliminate non-value-added work, and if used in congruence with International Organization of Standards (ISO), it also helps assure a safe work environment (Boca, 2015).

5S impacts quality by confirming the right equipment is properly maintained to produce the expected results (Nakajima, 1989). It does so by ensuring a desired state exists and the appropriate team members are assigned to maintain this state. When work areas and equipment are properly maintained, individuals are able to identify anomalies before failures occur in order to prevent production losses (Chapman, 2005). By constantly being involved with the equipment, operators are also able to help identify further improvements to the equipment like guards to keep them safer and better maintained (Becker, 2001).

In addition to functioning better and being more organized, a clean work environment creates the feeling of better quality and provides an overall image of the institution conducive to excellence (Sari, et al., 2017). On the contrary, poor housekeeping, machine breakdowns, and substandard work environments contribute to poor productivity (Chadha, 2013). Success breeds success and an area with successful 5S integration can show a clearer path to future endeavors with enhanced employee engagement through improved working conditions.

With 5S offering potential improvements in quality, cost, downtime, and inventory (Pojasek, 1999), 5S endeavors can also be a precursor to implementing ISO into organizational systems (Lokunarangodage, et al., 2015). ISO initiatives continue progress by systemically adopting and monitoring standards and applying actions to deviations (Gapp, et al., 2008). Often, this is done in a manner to better harmonize other initiatives and improve synchronized efforts (Lokunarangodage, et al., 2015). Organizations with successful ISO typically have robust lean initiatives and have found ways to combine their efforts (Chiarini, 2011). 5S helps establish a general direction towards those standardization improvements.

All standardization is focused on reducing and eliminating variability (Leotsakos, et al., 2014). As a foundational element, 5S can help signal variation, and or deviation, from the standard to signal a problem exists; however, in an advanced system, this can trigger problem solving in order to establish countermeasures, eliminating the causes for the need to clean (Sobek & Smalley, 2008). Correspondingly, research indicates organizations with advanced ISO implementation have also further developed 5S integration (Bayo-Moriones, et al., 2010). However, research raises caution to connecting causal relationships between 5S implementation and other variables (Bayo-Moriones, et al., 2010).

5S is intended as a holistic perspective in both management and decision making (Gapp, et al., 2008). It is a key link in its role with developing the capabilities of both management and the overall organization (Gapp, et al., 2008). Some have even argued in order for 5S to be most effective many of the improvement initiatives should be driven from the bottom up and involve every organizational role from janitors to top executives (Abramovitch, 1994). The absence of leadership involvement has been viewed as a danger, particularly when leadership does not clearly see related benefits of 5S and views it only as an exercise in cleaning and, thus, a waste of time (Abramovitch, 1994).

When 5S strategies are extended beyond cleaning or simple housekeeping initiatives and are utilized to focus efforts on the systemic elimination of variations in organizations, they have also led to advanced safety cultures (Leotsakos, et al., 2014). As a result, 5S has been often extended or associated to 6S, where the sixth S is safety (Jimenez, et al., 2015). Typically, a clean work environment will improve safety (Becker, 2001). In the first two S of 5S, the focus is to eliminate searching and "prevent the use of the wrong tools or parts," which can inevitably lead to unsafe situations (Becker, 2001, p. 29). In a proper 5S system, out of place or missing items are easy to identify (Bullington, 2003) and, therefore, easier to eliminate and isolate from improper usage.

In addition to being successfully applied across cultures, 5S has also been applied in various fields outside of manufacturing (Kanamori, et al., 2016). Research has shown employees spend in excess of one quarter of their time looking for information with associated labor cost estimates approaching 10% (Markovitz, 2012). Such tremendous impacts can help one understand why and how 5S has crossed into other industries. Although different industries may have difficulties identifying what, specifically, their customers are willing to pay for, understanding the use of 5S can help organizations identify and address waste and abnormalities (Markovitz, 2012). With a low-cost initial implementation impact, 5S can be successful in different economic environments (Kanamori, et al., 2016). Reducing variation and creating value for the customer has allowed a transition from organizing shop floors to streamlining information and keeping flow maintained in the absence of the same personnel (Markovitz, 2012).

With regards to a deeper understanding of the foundation of the word, 5S can mean much more to certain individuals. To many Japanese 5S practitioners, 5S is an approach not just to clean physical environments but also to thinking processes (Ho & Cicmil, 1996). Practicing 5S can be a way of purifying the spirit and changing both thinking and behavior (Osada, 1991). Transformation and continuous improvement require a foundation of thinking and practice as daily routine (Rother, 2010).

When an apprentice starts with cleaning, the purpose is to develop respect for the work and all of the interacting tools required to complete the work (Osada, 1991). When workers come together in such a way, the ensuing results allow for situations where working together is not only about making the work better, but also making each other better (Osada, 1991). Some would argue this lack of team involvement is one of the biggest differences between 5S in Japan and 5S in the West (Ho & Cicmil, 1996). In that regard, the foundational element is to start by doing each step of 5S, which can contribute to an awakening process and change how the organization views daily activities (Osada, 1991).

Cultural Understanding

When considering cultural differences between Japan and other nations in regard to the successful adoption of 5S, different cultures can be either beneficial or harmful. In Japan, conformity and structure is celebrated, while other cultures in other countries openly embrace rebellious behavior and individualism (Casey, 2013). In a system where it is crucial to have cooperation, rebellious behavior can be quite detrimental to systemic endeavors. Due to this, it is important to understand what cultures best allow 5S to thrive towards long-term sustained improvement and success and in which cultures extra efforts could potentially be required.

Japan has roots promoting a focus on the community and is also the country that housed both of the individuals credited with inventing 5S. With an emphasis on mutual assistance, reverence, dependence, and harmony, the Japanese culture is conducive to integrating 5S into operational practice (Jaca, et al., 2014). This is not only in the workplace, but also in the general public. In support of unity and sustenance, the Japanese have integrated visual aids throughout their communities where mantras and positive imagery reinforce altruistic behaviors and ideals (Jaca, et al., 2014). In fact, Japanese companies replicate those efforts in the workplace and are more capable of capitalizing on those initiatives based on familiarity (Jaca, et al., 2014).

In addition to a common practice of community focus, the Japanese also hold specific social characteristics like orderliness and cleanliness in reverence and often partake in social activities to maintain their local environments (Jaca, et al., 2014). This further emphasizes social norms in the workplace and the related desires of organizations. It is said the Japanese believe they are cleaning their minds when they clean their homes and environments (Pojasek, 1999). In that regard, one could see how the process is further linked to positivity for the Japanese.

The Japanese culture also has strong foundations to loyalty and cooperation, which helps reinforce individuals within an organization should adopt the organizational goals as their own (Jaca, et al., 2014). This advances aforementioned connections between improvements being continually sought after in both work and life. Goal alignment between personal goals and organizational goals can improve the attainment of both.

Thinking is a key component to lean. A lack of utilizing an organization's thought is defined as a waste (Liker & Meier, 2006). To that point, many Japanese organizations reward any and all suggestions for improvement to enhance the value of every minor improvement contributing to the overall success of the organization and the attainment of goals (Jaca, et al., 2014). Many Japanese organizations utilize continuous improvement as a means of communication to encourage employee contribution by illustrating their impact (Jaca, et al., 2014). This can further the contributions by keeping the attention on those improvements.

In regard to cleanliness in Japanese organizations, everyone is responsible for their own area (Jaca, et al., 2014). 5S helps identify what adds value for the customers (Baes, 2017), but does so by embedding "values of organization, neatness, cleaning, standardization and discipline in the workplace" (Bayo-Moriones, et al., 2010, p. 217). This is accomplished without boundaries and scope, in an effort to translate it into an embraced culture for team members (Bayo-Moriones, et al., 2010).

The Japanese also quickly identify excess as a result of cultural efficiencies including smaller homes and scarce extra space (Casey, 2013). In contrast, in places like America, individuals are not focused on societal improvement and can often overlook efficiency as a result of an abundance of resources and vast spaces available (Casey, 2013). In many ways, this can explain how the Japanese transfer societal behaviors into their work environment, whereas other cultures have to develop these values entirely (Jaca, et al., 2014). The need is simply not engrained in daily life making the need for specific actions difficult for some to identify.

After a brief overview of the Japanese reasoning to 5S, it is understandable the processes for 5S integration in different countries vary tremendously (Jimenez, et al., 2015). In fact, researchers suggest it is much better "to avoid a 'one-size-fits-all" approach utilized by many consultants (Pojasek, 1999, p. 100). An element of lean and lean tools as a whole is that they have often been created as solutions resulting from identified issues addressed through robust and systemic problem solving (Rother, 2010). In many ways, this is why "meaningful change does not require in-depth expertise or the need for outside consult" (Delisle & Freiberg, 2014, p. 12). Problems can be solved internally. As well, the solutions others have used to address their problems might not be the best solutions for the problems experienced by other teams. Lean embraces the use of best practices; however, there is no "silver-bullet" and organizations should be cautious to blindly follow other organizations' best practices. It is wise to look at what can stimulate internal problem-solving and thought.

When looking to the West, the competitive nature associated with Americans allows the visual management component of 5S to trigger behavioral changes (Casey, 2013). It does so by clearly highlighting performance for everyone to see through the use of visual management tools like scoreboards. 5S and lean initiatives are often managed through the use of scoreboards to clearly indicate the current status of the activities being conducted (Liker & Meier, 2006). These boards can facilitate feedback quickly to keep individuals informed (Jimenez, et al., 2015).

In addition to scoreboards, lean organizations frequently utilize management centers with constant updates of notices and improvements, which are typically displayed with charts and photographs to highlight wins (Pojasek, 1999). The implemented standards allow for practice sharing and the rapid sharing of information allows for both competition and cooperation to flourish under healthy leadership (Leotsakos, et al., 2014). Whereas other cultures like the Japanese might have intrinsic motivation from the benefits of 5S, Western cultures could instead find motivation from the showcasing of "winning" scores.

To further look at different Western cultures, it is helpful to also consider other situations that can influence the cultures. Research indicates Spanish plant Unions typically favor the adoption of 5S, while American plants as a whole seem almost entirely indifferent (Bayo-Moriones, et al., 2010). This dynamic may exist as a result of rigid contractual agreements pertaining to work content; nonetheless, 5S contributes to how the visual workplace is supported within organizations (Bullington, 2003). Maps and plans are readily updated and supported through metrics to help keep employees up to date with the current standards and results of the facilities (Jusko, 2002). With work content being rigidly assigned, visualizing 5S places successes in plain sight while highlighting opportunities.

The visual aids used to support 5S can also be a method to evaluate and monitor behavior (Pojasek, 1999). By documenting results, organizations have reference points to evaluate performance and provide a sense of organizational improvements made over time (Pojasek, 1999). More importantly, these functions “keep everyone abreast of what is happening … to spot concerns before they develop into major problems” (Pojasek, 1999, p. 102). Nonetheless, one must understand efforts to change the organization, the culture, and physical appearance are long-term commitments requiring tremendous attention from all levels of the organization (Scaffede, 2002).

Understanding the importance of the organizational culture and the impact it has on success is vital to making progress. If leadership frequently shifts focus and tries to change cultures too quickly, continuous improvement efforts can be seen as whimsical approaches that will leave just as quickly as they were initiated (Medinilla, 2014). In the West, the “what have you done for me lately” approach can be incredibly detrimental. Due to this, it is important to establish a functional strategy, to work through the growing pains, and to allow the culture to evolve with guidance.

In respect to organizational culture, it is critical to identify the starting organizational culture, as some cultures are toxic, riddled with politics and blame, before making significant changes towards a desired condition (Medinilla, 2014). In that regard, it is difficult to expect a Japanese-like culture overnight. It is also important to understand abrupt changes could potentially make situations worse by having organizational goals misaligned with personal goals.

Keys to Success

Establishing a plan to move forward with any transformation is critical. One of the most widely utilized and accepted approaches requires the individual or group to understand the current status, the desired state, and the gap, and to then develop plans to address obstacles identified in the gap (Rother, 2010). After completing this cycle, the organization is expected to meet targets or identify what else must be done to meet them through organizational learning (Rother, 2010). This process is an approach to success, but there are several additional components to be addressed, which are essential to successful integration and 5S transformation.

As mentioned from Rother’s (2010) process, learning is essential for organizations. This is why others have identified workspaces requiring a learning culture in order to successfully adopt 5S (Jimenez, et al., 2015). Organizations and individuals alike have to constantly reflect on what is going well and what is not going well to be able to learn from mistakes and improve on successes (Liker, 2004). Systemically designed configurations with defined time frames offer the best potential to achieve significant productivity improvements (Nicholds, et al., 2018). Keeping things time bound allows for reflection and keeps organization focused on a target completion date.

Keeping things on schedule requires some level of effective communication. To truly be successful, organizations must have strong communication and be willing to commit to education and coaching when necessary (Delisle & Freiberg, 2014). 5S has been adopted in different sectors globally because as a continuous improvement system, it is easy to understand and apply (Jaca, et al., 2014). Several clear precursors to successful implantation of 5S include getting the entire organization involved, integration into daily work, detailed communication with consistency and follow-up, senior leadership involvement, and a direct link to improvement initiatives (Albert, 2004). Likewise, it is important to express the expectations and desired outcomes of the activities upfront to the team members, as previous studies have shown team members negatively impact certain processes when they have not been properly engaged (Muthuveloo, et al., 2013).

With strong plans, schedules, and effective team involvement, organizations must also make sure to follow-up and see things through. Although 5S may be “easy” to implement, 5S is difficult to maintain. As a result, it is necessary to conduct 5S audits (Chadha, 2013). Additionally, from these audits, it is also beneficial to reward top performers (Chadha, 2013). These rewards require approval from management, thus, to be successful, leadership must support these initiatives. In various continuous improvement processes, leadership is one aspect that shows a substantial influence on sustainability (Dombrowski & Mielke, 2014).

It is also critical to have leadership and management backing, in particular when it comes to commitment, empowerment, leading by example, and even monetary support (Manotas Duque & Rivera Cavadid, 2007). That said, as an organizational requirement, it is necessary every individual in the organization understands, follows, and takes leadership seriously (Searcy, 2012). The relationship between the top and bottom must be aligned towards goals and initiatives and the outcomes should be mutually beneficial.

It is highly important to clearly identify to team members the direct benefits of how their jobs can improve (Chaneski, 2004). On the whole, unions and work-councils tend to accept lean initiatives, as they typically improve jobs and work to stabilize employment (Lebow, 1999). For 5S to work, everyone truly needs to be involved, organization wide (Chaneski, 2004).This is only achievable if team members are properly informed and protected from losing their jobs as a result of improvements (Day, 1995).

Successful implementation of lean requires training and sensitizing employees to the organizational changes in a manner which allows team members to practice and learn (Kreimeier, et al., 2014). Some attest 5S is simple and can be successful with only "conventional discipline" and "high commitment" (Patel & Thakkar, 2014, p. 776). It requires an aligned, concerted effort and belief from management it can effectively produce the necessary results from the successful changes of 5S (Gala & Wolniak, 2013). Similarly, these efforts must engage and involve all members of the organization from the floor to top management (Leotsakos, et al., 2014). Area leaders in support of the transitions are responsible to identify weaknesses, monitor the processes, and help prepare the organization for necessary changes (Filip & Marascu-Klein, 2015). This is paramount, as research shows people believe it is impossible for groups to function without leaders (Carroll, 2001). As such, this effort and commitment are vital to success (Patel & Thakkar, 2014).

Adopting lean as a set of transferable tools designed to fit every organization is one of the biggest misconceptions about lean (Atkinson, 2010). Understanding lean is more than a technique allows one to see how the approach changes perspectives on labor, changes perspectives on tasks, and therefore changes how one measures successes (Manotas Duque & Rivera Cavadid, 2007). One of the biggest obstacles to successful implementation of lean is team member rebellion (Kreimeier, et al., 2014).

Lean requires training, communications, and empowerment as qualifications to successful transitions in organizations (Marin-Garcia & Bonavia, 2015). Likewise, 5S requires extensive communication to ensure it is successful (Chaneski, 2004). Previous experiences illustrate communication is not only necessary to provide information, but also to ensure information is understood and agreed upon (Osada, 1991). To that point, it is important for management and team members to truly understand and accept why certain transitions should occur before expecting others to simply follow suit (Osada, 1991).

Behavioral and Training Transitions

Research pertaining to employee performance management illustrates performance is a process of continuous improvement, and education and training are needed to increase employee performance (Khan, 2012). The fact some studies have shown at least 70% of organizations offer some sort of training, illustrates how important organizational development has become (Waddoups, 2011). Moreover, there must be consistency with the message and patience with the results, which are built on leadership development that enhances the professional development of workers (Jaca, et al., 2014). When it comes to 5S integration, there is no difference. It is important to understand the behavioral and training aspects in an organization for successful 5S integration.

All organizations are composed of different people who in turn contribute and require different and unique knowledge. Consequently, it is beneficial to identify and study methods with abilities to cross barriers for the purpose of achieving improvements in safety, quality, knowledge, and even participation (Jimenez, et al., 2015). Organizational knowledge is different between organizations, which also requires different avenues to pursue improvement of them. Nonetheless, common key attributes of high performing organizations include efforts focused on skill acquisition, opportunities to showcase acquired skills, and an endless pursuit of continuous improvement (Stewart, et al., 2010).

A significant focus has been placed on ensuring organizations understand why things are being done, as well as overall purposes to any transformation (Sinek, 2011). Alasadi and Al Sabbagh (2015) determined that training is perceived as positive by owners and managers, but when this training is followed with stark process changes, those positive views could be different. This means that people are typically happy with gaining knowledge and skills but are not so eager to use these items to change their daily life. Some studies have introduced merit to this thought by illustrating a potential for employees to resist changes, especially when top management is disengaged in the transition (Gala & Wolniak, 2013). Therefore, the purpose and the expectations of projects and transformations should not only be communicated but should also be supported.

Again, it is important to connect efforts to the actual business. Education and training must effectively utilize current knowledge and skills to build upon them in a manner that allows one to continuously create and expand new knowledge to ensure specific needs are sufficiently addressed to meet organizational objectives (Vijayabanu & Amudha, 2012). It is critical to note organizational knowledge is composed of explicit knowledge and tacit knowledge, which both require development and honing (Zhao, et al., 2014). Sometimes, this organizational knowledge needs to be properly dispersed throughout the organization and the skill to do so is what needs to be further developed (Gala & Wolniak, 2013). As processes and demands change, so too must individuals adapt with the knowledge and skills required to be successful.

Sometimes problems dictate behavioral changes, while others are triggered by opportunities. During a State of the Union address, the American President John F. Kennedy once reminded society, “the time to fix the roof is when the sun is shining” (Kennedy, 1962). This idea emphasizes that even though an organization has been successful, they must continue to solidify their presence. Similarly, education and training that develops human capital not only improves the resiliency of an organization to recover during a recession, but it also allows organizations to better react to growing issues (Kim & Ployhart, 2014). Of course, in a lean organization, the roles of leadership vary and tend to focus more on empowering leadership (Carroll, 2001).

In situations of cultural change, the leadership must be incredibly capable of coaching and guiding the teams through these potentially unclear transitions (Gala & Wolniak, 2013). Transitioning to coaching from the traditional command style approach of leadership is difficult because by nature coaches develop people and ultimately let go some of their control (Carroll, 2001). The people best suited for improvement are the process experts; the people performing the tasks (Liker & Meier, 2006). They are most often the ones who identify the issues, and under the coaching model, leaders must ensure they are empowered and enabled to fix those issues (Carroll, 2001).

Pitfalls to 5S Implementation

5S is often misused as a synonym for good housekeeping; however, 5S is not just a cleaning system (Gapp, et al., 2008; Jaca, et al., 2014). It is much more than physical cleanliness, but it is a critical improvement in the thinking process (Pojasek, 1999). Researchers have described it more like a value driven business model; organization wide strategies for improving decision making and performance (Gapp, et al., 2008). Similarly, it has been described as underutilized when not embraced as a quality management and improvement framework (Delisle & Freiberg, 2014). At any rate, variations to organizations introduce risk to otherwise stable systems. Therefore, it is important to be cognizant of obstructions to the organization's traditional operations (Nicholds, et al., 2018). This means if normal processes are not properly adjusted in the introduction and implementation, 5S could not only become ineffective, but it could also become an inhibitor to success. This section introduces pitfalls to the implementation of 5S.

5S is not a self-sustained system; it requires significant leadership involvement and cannot be implemented through delegation (Gala & Wolniak, 2013). When the standards exist and tasks have been delegated, it is critical for those standards to be monitored, assessed, and confirmed for basic 5S to exist (Filip & Marascu-Klein, 2015). Critical to sustainability, there needs to be a robust feedback system, allowing detailed performance results with huddle meetings to discuss barriers and sometimes trigger problem-solving meetings for more complex issues (Delisle & Freiberg, 2014).

The post-recession economy, although not entirely predictable, can be navigated with the proper processes. That said, being lean is not the summation of a series of projects (Liker & Meier, 2006). Moreover, successful 5S is also not the results of projects (Jimenez, et al., 2015). To be successful long-term, the lean processes must evolve and become an engrained, continuous way of operating (Rother, 2010). As such, it is imperative to develop and implement improvement strategies geared toward such initiatives to keep people thinking, engaged, and empowered (Rother, 2010).

Improvement strategies and organizational plans are particularly important if consultants are used to support transitions. If external consultants are utilized, it is mandatory they are aligned with the overall organizational goals or they could take the organization in a different direction, which inevitably will not be supported by both management and team members (Scaffede, 2002). In the same way, team members and management ultimately want to please their customers, internally or externally (Scaffede, 2002). If the vision and direction do not align with achieving customer satisfaction, not only should one expect failure, but one can expect the morale of the team to quickly dissipate as a result of their wasted efforts (Scaffede, 2002).

Learning, control, and maintenance of the involved resources can ensure things are more effectively and quickly completed to help maintain progress in a continuously evolving and dynamic environment (Jimenez, et al., 2015). As conditions change, so too must organizations adapt and be flexible to meet customer expectations (Bullington, 2003). Those improvements can lead to multiple outcomes including visible results, improved long-term discipline, focused attention, safety improvements, and an increase of professional training though improved organization activities (Patel & Thakkar, 2014).

Research shows many organizations adopt the first three S steps, but typically fail on the last two (Chapman, 2005). In those situations, 5S is implemented only at a superficial level with foot printing, posters, and even slogans, but not in a cultural change embracing key items like safety and quality (Becker, 2001). In some regard, this explains why researchers state 5S typically fails as a result of a lack of management support. If progress is to be sustained, it may often involve some degree of forward thinking. Ultimately, this forward thinking can lead to innovation. Knowing that innovation requires the interactive application of knowledge, learning, and use further emphasizes the value of education and training (Santiago, 2013).

Summary of Literature Review

The literature review provides an introduction and discusses information pertinent to understanding this study. The elements included a generational span of evolution from lean beginnings to more recent behavior and cultural points. To focus attention on points of interest, this section provides a summary for further clarification and review of each sub-section, beginning with organizational culture and ending with the potential pitfalls of 5S implementation.

Organizational culture is a key element to lean and 5S alike. One of the conditions for a successful and fruitful transformation is for prevailing cultures to be those of learning organizations (Lam, 2000). A thriving environment is often associated with empowering leadership and driving initiatives (Dombrowski & Mielke, 2014). Although leadership is paramount, the achievement of true transformation involves extensive cooperation between all levels of the organization (Kull, et. al, 2014). This concerted effort ensures the prevailing organizational culture works in congruence with the identified and sought out transformation (Ndahi, 2006). This is important, particularly when successful, because the organizational culture is synchronized and meshes well with the local cultures (Ahls, 2001). Nevertheless, the culture is still unique and emphasizes teamwork (Day, 1995).

Organizations are continuously demanded to be improved and one method is lean manufacturing. Lean manufacturing is the umbrella topic under which 5S falls. The major efforts of lean are to eliminate waste, reduce inventory, and primarily reduce throughput time to better achieve the needs of customers (Abdulmalek & Rajgopal, 2006). The transition of lean in history is identified by the change from batch production to pull production (Womack, et al., 1990). Being lean is more than a summation of projects and, instead, requires a concerted transition to continually seek ways to improve established standards (Liker & Meier, 2006). There are many tools and philosophies that have sprouted from lean thinking and 5S is one of the most frequently pursued.

Developed in Japan by lean innovators Hirano and Osada, the concept of 5S has become one of the most widely adopted lean concepts (Jimenez, et al., 2015). With relatively simple and easy to understand emphasis and goals, some conclude 5S is a commonsense approach (Imai, 1986). As an integral part of lean manufacturing and 5S alike, the standard has been the baseline for continuous improvement (Leotsakos, et al., 2014). In that regard, the precursor to growth is the standard and the most succinct way to define a problem is a deviation from the standard (Liker & Meier, 2006). This deviation can also be related to targets, such as those established for organizational KPI, measuring items including quality, cost, and delivery. Organizations must be in tune with what those variations and deviations can cause, particularly in terms of losses (Dale & Asher, 1989). In order to truly understand how variations and deviations come to fruition, it is important to emphasize a process focus (Mann, 2015). The standard is the minimum acceptable outcome for a process (Gold & Thorpe, 2008).

5S is foundational component to successful lean transformation (Liker & Meier, 2006). As previously described, 5S must be successful in order to be able to utilize and pursue additional goals and recognition. One example where 5S must exist before success can be attained is with ISO certification, where order and standards are recognized externally (Lokunarangodage, et al., 2015). The emphasis on the importance of 5S has been repeatedly illustrated in such situations where initiatives have been rendered futile without successful integration of 5S into daily activities (Chapman, 2005). Part of the reason for this is 5S becomes embedded in the organizational culture.

Different cultures, environments, and industries can produce different results, which makes it helpful to understand how the organizational culture can be impacted by the local cultures to better steer improvement efforts (Davies & Kochhar, 2002). The most successful step to integrating any sort of transformation is working towards establishing a learning organization (Senge, 1990). The Japanese have a strong model for learning organizations and by seeing what has been done, others can learn from their triumphs and tragedies to also be successful.

There are several keys to success, but the successful three-step methodology of understanding the current situation, establishing a target, and systemically bridging the gap between the two has been widely adopted (Rother, 2010). In doing so it is critical for all people involved in the processes to take responsibility for those gaps as the organizations works through closing them (Martyn & Crowell, 2012). Initial achievement is typically not enough; sustained achievement is the true measure of success. In that regard, teams must remain focused and consistently look to audit processes and successfully address identified deficiencies and opportunities (Chadha, 2013). Understandably, this involves changes in processes, but other means are also influenced.

To ultimately achieve performance improvement, changing processes occasionally requires changes in culture and changing cultures require influence on day-to-day behaviors through continuous improvement and training (Khan, 2012). Sharing knowledge and skills is the critical behavior sought out through transformation (Gala & Wolniak, 2013). This is often quite difficult. For that reason, it is imperative for leadership behavior to illustrate both the ability and talent to coach and guide teams through complications as there are many obstacles that are detrimental to progress (Gala & Wolniak, 2013).

The obstacles and pitfalls to progress with 5S integration often begin with a misguided perception that 5S is merely a system for improving housekeeping (Gapp, et al., 2008) (Gala & Wolniak, 2013). 5S can, and should, influence all processes involved. Process changes introduce variations to otherwise functioning systems, which can cause negative results without proper adjustments (Nicholds, et al., 2018). With that said, 5S alone is not sustainable and requires extensive leadership and follow-up (Gala & Wolniak, 2013). Improvement strategies like 5S must engage teams in a way to keep individuals thinking and empowered (Rother, 2010). Similarly, those strategies must stimulate the organization in a way that directly connects actions to customer needs (Scaffede, 2002). This is difficult, particularly with 5S where historically organizations struggle to follow through on all five of the 5S points (Chapman, 2005). The key failure is often a lack of a wholly engrained system, rendered only to shop floor levels and not clearly connected to organizational values (Becker, 2001).

The literature review offers information clarifying previous research to aid with the completion of this study. With a substantial amount of information presented, the summary aims to reemphasize key points for further clarification and review each sub-section. With the conclusion of the literature review, the next chapter will introduce the procedures of the study.

CHAPTER III

METHOD

Chapter III will describe the procedures of the experiment. It will explain the population, instrument design, methods of data collection, and data analysis. The explanation of these items allows the reader to connect the literature to a functional study. This study aims to provide insight into the impacts 5S has on productivity and attitudes.

This study is a causal comparative study utilizing two groups to compare the effects of a single variable (Forman, 2003); the influence being studied is 5S implementation. In a previous study, Hutchins (2006), conducted quantitative analyses on productivity, safety, quality, product cost, and machine breakdown data for comparison with experimental groups and quantitative and qualitative analyses on employee surveys. The organizational data in Hutchins' (2006) study included ex post facto data where the researcher had no impact on the independent variable, as it has already occurred prior to the study (Johnson, 2001). This study replicates Hutchins' (2006) methodology using the corresponding data from another organization.

Productivity has been measured using various methods; however, prevalent approaches typically focus on quality, cost, and delivery (Amasaka, 2008). On-going application and enhancement of quality, cost, and delivery are best utilized when they closely relate to the actual needs of the customer (Amasaka, 2008). Unrelated, but important to note, the term quality has also expanded beyond the actual products or services received, but also includes perceptions of corporate image and management (Amasaka, 2008). This study focuses on KPI utilized by the organization to best understand the former; the actual products by using internally collected data.

As a comparative point, it is necessary to understand the comparison groups. As in Hutchins (2006), the independent variable is whether or not the department implemented 5S. In the organization studied, 5S has already been introduced. During new hire orientation, every team member has also been trained on 5S, as well as various other organizational tools including overviews to other safety, quality, delivery, and cost topics. In the introduction of 5S, each employee has been exposed to a PowerPoint presentation of examples, as well as the definitions of the 5S categories.

Within the organization studied, there is a performance management team continually tracking and monitoring the various KPI of the organization. This group has a sub-section responsible for the KPI associated with 5S including auditing to ensure score alignment. Each team in production has a team leader. The organization utilizes team leaders to be responsible for the operational level of the KPI including 5S. Each team leader in the OUs is properly trained to use the 5S audits to measure 5S implementation. The sub-section responsible for 5S ensures alignment with the OUs team leaders' 5S audits by conducting monthly audits on the team and comparing their scores to the team leaders' scores.

Despite the organization's emphasis on the need for and importance of everyone's contribution to CI, each OU also has at least one Continuous Improvement Facilitator responsible for supporting CI activities. In support of CI efforts, the organization has a digital CI suggestion system to allow for all team member suggestions to be captured with established criteria for follow-up. This systemic approach allows department team members to directly identify items for improvement and keeps CI facilitators active on their initiatives. These improvements create new standards, which are then documented and turned into checklists to ensure stabilization. Suggestions and improvements, including those focused on 5S, are rewarded both with recognition and with financial incentives.

Setting

The setting of this study is a manufacturing facility housed in the northeastern region of Asia. The facility is owned and operated as a joint venture organization with investors including global production leaders and a Fortune 500 organization with facilities spanning the globe. The organization has been on their “lean journey” for over a decade and has an internal audit system used to monitor lean activity, as well as an audit specifically for 5S. The frequency of the 5S audit is weekly and typically conducted internally, with only exceptions being made for cross-team audits to maintain organizational alignment. Following each audit, there are action items associated with the opportunities identified.

The facility in this study is composed of five different operating units housed closely together in an evolving campus. These five different operating units work synchronously to create a finished product; however, they are managed independently and also produce components for usage other than the finished product. In most situations, the production activities are conducted in an assembly line fashion, where previous operating units feed into one final OU to assemble a completed product. In that regard, the outcome of the final product is also impacted by the influences of the upstream processes.

The operating units are sized differently despite being connected. Sequentially, all of the operating units work at the same takt time in order to produce the required production number based on customer demand. The upstream operating units combined are still less than the final assembly. The total number of personnel from the five teams are 680, 280, 315, 375, and 2,010, respectively, for a total of 3,660 team members. These teams are managed by 110 managers with the control groups having 14, 14, 16, and 20 and the experimental group having 45. It is important to note the units within the organization operate under the same rules and procedures; however, the different ratios of management are related to the processes performed by each team.

These shared operating processes allow for each operating unit to report and discuss the same organizational KPI at every OU meeting, as well as at every operations shop floor meeting. Each member of management is expected to know the status of their metrics and provide containments and countermeasures for each deviation from their standards. Specifically, there are detailed reactions or action items associated with each metric showing non-conformance. This is noted to illustrate how the items being researched in this facility are monitored and sought for improvement.

Data Collection

As an ex post facto causal comparative study, the vast majority of the data utilized in this study are collected from existing organizational data. Data associated with productivity, safety, quality, product cost, maintenance cost, and machine breakdown will be studied, as in the Hutchins (2006) model. Traditionally, the focus of key measures falls under the umbrella of quality, cost, and delivery (Nicholds, et al., 2018). The KPI methods are collected, although the types of KPI are not always standardized between different organizations; however, in this instance they are quite similar and provide sufficient data for a replication study.

This organization's data for each OU have been recorded and monitored as long as the business has been operational. It is continually examined by each operating unit and is readily available through the organization's internal data system. The internal data system and shop floor management allows the organizational leadership to also monitor the data and manage the OUs for improved results. In order to maintain anonymity and prevent anti-trust violations as a result of this study, the data is converted into a ratio of actual score to target score for each KPI.

As in the Hutchins' (2006) model, additional data is collected through the use of surveys. The surveys are administered through the use of a Microsoft Excel based online survey generator named Wènjuàn xīng (questionnaire star), which is accessed through the use of a mobile phone application named WeChat created by a company called TenCent. For the team members, posters with QR codes to access the survey are posted throughout the facility. For the management, similar QR codes are sent via email to ensure they receive the specific QR code associated with the needs of the study.

In this facility, individuals are allowed to use mobile phone technology and in this particular region, one must have a mobile phone in order to receive payment, as well as to make purchases. Therefore, there is a high probability all employees have access to the survey because without their mobile phones, they are unable to function. Similarly, the rampant use of QR codes for this method of data collection of other daily business activities allows for ease of use and seamless utilization of this application.

The application used for the survey has built-in features to prohibit and restrict individuals from taking the survey multiple times by associating the phone number directly with the survey. Additionally, this region requires a registration of mobile telephones to the government with specific government identification numbers, so that individuals can only be registered with one telephone at a time. Similarly, the application has a feature where it immediately rejects a team member submission as a duplicate when the same registered phone number scans the management survey. This is important to ensure opinions are not misidentified or misstated.

The participant surveys are collected to develop data for workplace cleanliness and organization, employee commitment, employee job difficulty, employee input on decisions, employee cooperation between shifts, employee control over the workplace, use of floor space, employee job frustration, and employee attitudes toward 5S. The surveys are in two parts, where the first section utilizes a Likert scale to allow the data to be quantified and the second section includes open-ended questions to capture additional information (Hutchins, 2006). Organizational data from 5S audit scores are continuously available and analyzed using quantitative methods.

The KPI data in this study (productivity, safety, quality, product cost, and maintenance cost), consist of a six-month time frame. This six-month time frame is composed of three months before 5S was implemented and three months after 5S was implemented. Based on production scheduling, the dates may not be exactly the same; however, the number of production days before and after 5S implementation will match for parity.

In terms of stable production, the industry of the facility being studied fluctuates regularly. This often occurs during different seasons. This study uses the most stable time frame captured in weeks to ensure the volume of production is constant for data collection; however, if the volume changes during the study, it will be noted. At the time of the study, the two quarters selected for analysis predict stable production and, thus, can reduce outside interference with the data. It should also be noted some of the KPI are only assessed weekly; therefore, in order to maintain useful comparisons, all other data was captured using the same time frame. Data will be collected and analyzed for each OU using an analysis of variance (ANOVA), as well as regression analyses and descriptive statistics to sufficiently answer the research questions. Similarly, the data will also be analyzed as an overall facility.

As in Hutchins (2006), the 5S data is collected using company records and with the predetermined comparative groups established prior to the study. In that regard, of the five operating units, only one has taken on a strategic implementation of 5S with on-going and continual training. Therefore, the other operating units are the comparative groups for the study, which were only subject to the initial 5S training each team member completed during orientation. The 5S audits are conducted weekly and monthly by the team responsible for 5S tracking to ensure alignment. Plant and area data is reported in monthly production reports.

Research Design

When utilizing a causal comparative study, the goal of the research is to determine whether the independent variable affected the dependent variable by comparing two or more groups (Salkind, 2010). This study employs a causal comparative research design as a result of the desire to answer the question on how 5S impacts employee attitudes and productivity. In that regard, the independent variable is 5S and the dependent variables are employee attitudes and productivity. This is different from a correlational research design, where, instead, the focus would be to study one group of individuals and research to identify the effect of one or more independent variables on the dependent variable within the same group (Salkind, 2010). Although correlational research designs and causal comparative research designs are also similar with a shared goal to determine what effect an independent variable may or may not have on dependent variables, they still have vast differences, which makes it important to highlight why a causal comparative approach is most appropriate for this study (Salkind, 2010).

Since the adoption of the organization’s production system, which occurred prior to the construction and production of the facility used in this study, 5S has been an active part of the lean implementation in this facility. In that regard, both productivity data and 5S data is already being gathered, collected, and used for performance management. Management is utilizing a structured approach with their own internal audit system to track, measure, and improve this progress. Each OU manager is responsible for their own performance and the implementation of 5S in their area.

For various reasons, the level of implementation can vary dramatically. This research will not explain the potentially proprietary audits to avoid providing any information that might be considered to be creating a competitive disadvantage, nor will it examine the different managerial roles and approaches in performance management. Instead, the study will use the verified process outlined in Hutchins' (2006) to assess the impact of 5S on employee attitudes and productivity to ensure this approach that can be replicated in future studies.

After 5S is implemented in the organization, the areas are audited. This research examines each area using the Hutchins (2006) audit and the comparative approach from the same study in order to create a causal comparative study where the level of 5S implementation is compared to the dependent variables of safety, quality, and productivity. The results of the data collected from the audits and the data collected from the system are studied using a quantitative analysis.

In the Hutchins (2006) study, the primary statistical analysis tools utilized were regression analysis and ANOVA. In general, the three most frequently applied statistical analysis tools in causal comparative studies are the chi-squared test, the paired samples and independent, t test, and analysis of variance (Salkind, 2010). As a replication study, this research will conduct the same analysis found in the Hutchins (2006) study. Additionally, this research will also offer additional analyses with the potential to build on the previous study. More specifically, the data is analyzed using IBM's Statistical Package for the Social Sciences (SPSS) statistical software to conduct the ANOVA, as well as the appropriate regression analyses and descriptive statistics to sufficiently answer the research questions from the Hutchins (2006) study.

Participants

The target population of this study is the employees of an Asian global manufacturing company's operations team. It includes both team members and management members. The comparisons are made between different areas and their different levels of 5S implementation achievement. The five areas being assessed are two component development areas, two component processing areas, and one final assembly area. These five areas are the entire operations team of this particular organization.

Ethical Protection of Participants

The purpose of the research has been fully explained to those who partake in the study. It has also been explained that their participation is entirely voluntary. Their information is strictly confidential and is collected by the researcher. For organization purposes, the mobile application associates each survey to the mobile device used to access the survey. Since it is clear the data is associated with a mobile phone number and a WeChat account, it is important to clarify the researcher never has access to the personal information of those surveyed. This study is approved by the Old Dominion University Education Human Subjects Review Committee (see Appendix C). All ethical guidelines established by the committee are maintained.

Measures

To address the research questions, the study utilizes two different data collection systems. The first is the internal data system, which provides information on 5S scores, productivity, safety, quality, product cost, and maintenance cost. The second data source is the survey conducted directly by the study. It is important to note the data is collected internally with the actual values; however, they are converted in this study to a ratio of the actual values to the target values to maintain proprietary information. That is to say, instead of providing the actual numbers, a target achievement value will be used for each datum. This section describes the KPI utilized for each research question and how they are measured for the purpose of this study.

The first research question focuses on productivity. In Hutchins (2006), the effects of 5S were measured using productivity, safety, quality, product cost, and maintenance cost. All of these variables are measured using internal data; the first of which is productivity. For this study, productivity is measured by weekly reports of jobs per hour (JPH) as related to planned versus actual. In this circumstance, the target is to match the plan as close as possible, where variance in either direction is less than favorable. The production data of JPH are readily available for each OU and are collected from daily production reports, which are then developed into the weekly reports used in this study as the standard time measurement. As in Hutchins (2006), the data is averaged across shifts to develop a standardized approach for shift differentials and to ensure consistency.

The second variable measured is safety. In this study, safety is measured by weekly safety reports (Hutchins, 2006). Safety data is readily available for each OU and are collected from safety documentation as required by the local government. In this study, safety is measured by documenting even slight injuries. For clarification, this is all injury information reported to the organization. This includes anything requiring treatment and treatment can include anything as small as receiving an adhesive bandage, such as a Band-Aid. In this facility, injury avoidance is a focal point with a target of zero injuries, forcing management and team members alike to research and immediately implement countermeasures for all injuries.

The third measured variable focuses on quality. Quality data is available for each OU in multiple measures and are collected from every unit produced. For this study, the quality is measured utilizing the metric of Per Thousand Units (PTU). Each unit produced a target for "acceptable" defects. As a result, in this measurement, the goal is to be below the target score, meaning lower scores are more favorable. It must be noted, the organization studied tracks and monitors various quality metrics including PTU, FTT, and after production audit scores. For every identified defect, the organization tracks and monitors occurrences, as well as follow-up actions to verify and validate the effectiveness of active containments and countermeasures.

The fourth variable measured focuses on product cost. In Hutchins (2006), it is not clarified what elements of product costs are included in the measurement; however, it is clear the study is using a cost KPI. How product costs are defined as a KPI can vary from organization to organization. Therefore, this study will focus on operation specific labor costs on the product through the KPI of Hours Per Unit (HPU). The goal here is to match or be lower than the targets.

Product costs are frequently collected in various locations, both inside and outside of operation facilities. Although HPU is often an efficiency metric, it also has a direct influence on the costs of products. Unlike procurement parts and raw materials, which can quickly change with market costs, the cost of labor is more closely related to how an organization is functioning. As such, monitoring the hours used to create one unit allows an organization to rightfully assess the cost of labor to produce one unit.

For example, a complex product built in multiple locations can include sub-assemblies produced in shared locations. Similarly, in large organizations, corporate procurement may control specific material costs. Both can and often do change and influence product costs, while labor costs can be more standardized. That said, all production facilities measure fixed and variable costs specific to their location. The measurement of product costs assists in determining if 5S influences the organizational efficiency to produce the product. As in Hutchins (2006), the product cost will be measured monthly and, in this situation, the best data for comparison is HPU. When measuring HPU, the goal is to meet or be below the target.

The fifth variable focuses on maintenance cost data. Maintenance cost data is available for each OU in regard to the efficiency of equipment. For this study, the maintenance costs are measured by weekly production reports. Maintenance costs can be defined as costs directly associated with equipment and equipment failures. The organization studies and monitors all maintenance efforts through an extensive TPM program, an overall preventive maintenance strategy. In this organization, there is a specific budget allotted to each operating unit based on historical data. When measuring maintenance costs, the goal is to be below the assigned target.

The next variables studied are those established by the internal 5S data provided by the 5S audits. The 5S audit is measured through a 0-5 scoring criteria in a sequential range from "unacceptable" to "world class." The assessment is utilized in all of the OUs to provide data points for each 5S category and to create a comprehensive score for each of the areas being assessed. The individual scores are loaded into a database for further analysis.

The remaining variables studied are measured using either a 1-4 Likert scale in the survey or using a simple qualitative analysis of the open-ended questions. The Likert responses 1-4 are strongly disagree, somewhat disagree, somewhat agree, and strongly agree, respectively. As in the Hutchins (2006) study, the open-ended questions are utilized to draw generalizations and points of discussion to help understand the general results of the primary aspects of the survey.

Preliminary Analyses and Assumptions

Assumptions of this study include:

1. Lean manufacturing as a production system will continue to be the methodology utilized in production facilities.

2. Individuals involved in research groups will themselves not be content experts; however, as area team members, they will have a vested interest in improving their work environment and a sufficient amount of tacit knowledge to complete tasks.

Description of Analyses

IBM's Statistical Package for the Social Sciences (SPSS) statistical software is utilized to analyze all data in this research. The questions and hypothesis for this study are tested using inferential statistics at an alpha significance level of .05 for all analyses. The analyses include descriptive statistics, including mean, frequency, and range to analyze the productivity data, as well as help clarify some of the survey data. As in the Hutchins (2006) study, primary analyses are ANOVA for relationships between the groups studied. Additionally, this study also includes paired, sample t tests to examine relationships between before and after 5S implementation outcomes among the dependent variables.

CHAPTER IV

RESULTS

This chapter will present the findings of the study to answer the research questions in regard to the initial hypotheses. The researcher will detail and illustrate data and results of the study using tables and figures while describing the findings of the study. The first research question will be explained in relation to productivity using the aforementioned KPIs of productivity, safety, quality, product cost, and maintenance cost and how they relate to 5S in the organization studied. Similarly, the second research question will be explained in connection to the survey, as it relates to attitudes and 5S in the organization. All of the data is processed utilizing reliability analysis and distribution testing before explaining the findings using a paired sample t-test for before and after implementation, as well as ANOVA testing for the effects of 5S implementation on the productivity measures. In addition, the 5S audit data was processed in relation to the productivity measures of this study in order to provide additional analyses regarding the influence of 5S on productivity by utilizing the actual level of 5S to the dependent variables.

Reliability Analysis

A reliability analysis was utilized to establish the validity of the data in the study. A reliability analysis is an assessment of the degree of consistency between multiple measurements of a variable. An example method to establish reliability is the test–retest method, which measures consistency between collected responses for an individual at two points in time. Using this method, researchers can review responses, so they are not too wide-ranging across different time periods.

Internal consistency is a second method to measure reliability, which applies to the consistency among variables in a summated scale. The logic behind measuring internal consistency suggests individual items or indicators of a scale should all be measuring the same construct and should all exhibit intercorrelation with one another (Hair, et al., 2010). This study utilizes Cronbach's Alpha analysis to validate the reliability of both the organizational data and the survey data, as seen in previous models related to 5S and productivity (Randhawa & Ahuja, 2018).

The Cronbach's alpha of Attitudes to 5S was acceptable ($\alpha = 0.974$) for the Management Data and for the Team survey data ($\alpha = 0.984$) since both values were higher than 0.7 (Hair, et al., 2010). Cronbach (1951) alpha coefficients must exceed a threshold of 0.7 in order to be considered acceptable for the internal scale reliability (Nunnally, 1978). With reliability being established, the next step was to test the distribution.

Distribution Testing

One assumption for two-way ANOVA models is the scores for dependent variables follow a normal distribution; however, ANOVA analyses are often effective tools of measurement even when the assumption of normality is violated (Hair, et al., 2010). Nonetheless, significant deviations from normality should be reviewed with caution. One method used to examine normality is to look at values of skewness and kurtosis. Both values should remain between -1 and 1 to indicate normality. As seen in Table 3 below, few values exceed this threshold, indicating no substantial deviations from normality. The Kurtosis value of 2.138 for Attitudes towards 5S (management data) indicates a considerable degree of non-normality. For tests involving the 'attitudes' variable, a non-parametric version of ANOVA (Kruskal-Wallis test) was used.

There were three instances warranting the removal of outliers. The first was identified in the “quality” data as an outlier with a value more than 3 times the maximum value of the rest of the cases. Two additional outliers were identified with values for ‘Maintenance Cost’ close to 0, while all others of the collected values ranged from 0.94 to 1.04. All three outliers were removed. It should be noted the values were calculated after those outliers were removed from the data.

Table 3

Means, Standard Deviations, and Sample Sizes for the Maintenance Cost Data

Variables		Mean	Std. Deviation	Skewness		Kurtosis	
		Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Attitudes_5S (Management)	109	3.3837	0.67633	-1.400	0.231	2.138	0.459
Attitudes_5S (Team)	3654	3.3357	0.71566	-1.107	0.041	1.047	0.081
Productivity	157	0.9821	0.02094	-0.355	0.194	-0.819	0.385
Quality	157	0.9066	0.09012	-1.283	0.194	1.492	0.385
Product Cost	157	0.9446	0.03905	-0.044	0.194	-0.330	0.385
Maintenance Cost	157	0.9773	0.01956	0.069	0.194	-0.420	0.385

Table 4 displays the frequency of values for the Safety variable. Data for Safety were compared to a target of zero. Anything above zero indicates the frequency of injuries of safety instances in a given week. A prioritization and focus on safety can be deduced from the very few instances identified during the study; however, there could be additional influences on this data. As presented, there were only five safety issues identified during the study (3.1% of the cases) and all five of those instances were single incidents identified in the “experimental group” during those respective weeks. On the other hand, 96.9% of the responses indicated zero documented safety incidents. From a statistical standpoint, this limited specific analyses will be described later.

Table 4

Frequency Statistics for Safety

		Frequency	Percent	Valid Percent	Cumulative Percent
Safety	0.00	155	96.9	96.9	96.9
	1.00	5	3.1	3.1	100.0
	Total	160	100.0	100.0	

Results and Findings to Research Question 1

The first hypothesis in this study proposed the implementation of 5S in operating units would increase productivity as measured by weekly operations reports compared to reports before the implementation of 5S. As in Hutchins (2006), specific organizational KPI based on internal data was used to measure productivity, safety, quality, product cost, and maintenance cost. Productivity data for each operating unit was collected from the weekly management reports of each operating unit.

With the onset of a pandemic, the Corona Virus Disease of 2019, the data collection period was extended from a 24-week duration to a 32-week duration due to the delayed availability to provide classroom training. Ensuring that there were matching timeframes for before and after data collection forced the project to extend to 16 weeks from the originally intended 12 weeks. This time frame closely follows Hutchins (2006) and is consistent with other models following a cycle between 9-18 months (Doolen, et al., 2008). As in Hutchins (2006), data was averaged across the number of shifts in each cost center to establish one weekly value.

Results: Paired Sample T-test

This study utilizes a paired sample t-test, as this statistical analysis tool allows the comparison of means from the same group at different times while an independent sample t-test is only able to compare the means for two groups (Gamst, et al., 2008). The paired sample t-test appropriately addresses the required analyses in this study to compare the before and after of 5S implementation in the five research groups. The findings for each are presented here for further understanding their influence in the organization studied.

Productivity

A two-way ANOVA was conducted using productivity data to examine three key points. The first point was to analyze the differences of productivity among experimental and control groups; to research the main effect of the group on productivity. The second point was to analyze the differences of productivity between "before" and "after" structured 5S implementation, which evaluates the main effect of structured 5S implementation on productivity. The last point was to determine if the before and after differences are significant among experimental and control groups to determine an interaction effect. An interaction effect can be described as existing when the pattern of means across one level of an independent variable differs from the pattern across another level of the same independent variable (Gamst, et al., 2008). This same process was used for all productivity measures with an exception to safety that was explained independently because of data constraints.

The results of the two-way ANOVA are shown in Table 5, starting with the descriptive statistics. Table 5 shows the mean values of productivity by operating unit and program status.

The mean target achievement for productivity in the experimental group is the lowest, both before and after implementation, as well as the total average with mean scores of 0.95 for each.

Table 5

Two-Way ANOVA on Productivity

Operating_Unit	Program_Status	Mean	Std. Deviation	N
Experimental Group	Before	0.9487	0.00672	16
	After	0.9536	0.00611	16
	Total	0.9512	0.00680	32
Control 1	Before	0.9994	0.01015	16
	After	0.9973	0.00193	16
	Total	0.9983	0.00726	32
Control 2	Before	1.0000	0.00000	16
	After	1.0000	0.00000	16
	Total	1.0000	0.00000	32
Control 3	Before	0.9821	0.01266	15
	After	0.9845	0.02582	16
	Total	0.9833	0.02024	31
Control 4	Before	0.9725	0.00670	16
	After	0.9832	0.01080	14
	Total	0.9775	0.01027	30
Total	Before	0.9805	0.02093	79
	After	0.9838	0.02095	78
	Total	0.9821	0.02094	157

Hutchins (2006) identified significant differences in the groups before and after implementation where the data showed three out of six groups actually decreased in productivity before and after implementation with 7%, 30%, and 15% differences. This study differed with only one observed group (Control 1) decreasing in productivity totaling a 0.3% decrease. Table 6 presents the results of the two-way ANOVA model on productivity. This study found a non-significant interaction between the effects of Program Status and Operating Unit on productivity, F (4, 157) = 1.627, p = 0.170. As a result, it can be determined the effect of implementation on different groups (if any) is relatively the same.

Table 6

Tests of Between-Subjects Effects of Productivity

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	0.051[a]	9	0.006	48.350	0.000	0.747
Intercept	151.167	1	151.167	1286632.230	0.000	1.000
Operating_Unit	0.050	4	0.012	106.131	0.000	0.743
Program_Status	0.000	1	0.000	3.454	0.065	0.023
Operating_Unit * Program_Status	0.001	4	0.000	1.627	0.170	0.042
Error	0.017	147	0.000			
Total	151.504	157				
Corrected Total	0.068	156				

Through further analysis, simple main effects coefficients, sometimes referred to as simple effects, were used to clarify or identify differences within the design. In this study, Operating_Unit and Program_Status identified a significant difference on productivity among different groups, F (4, 157) = 106.131, p < .001, while there is no significant difference on productivity when comparing before/after periods, F (1, 157) = 3.454, p = 0.065. A beneficial approach to understanding this influence is to consider how the scores on the dependent variables are affected by specific combinations of the levels identified within the independent variables (Gamst, et al.). Doing this requires isolating the levels of a variable and then comparing the means of those groups (Gamst, et al., 2008).

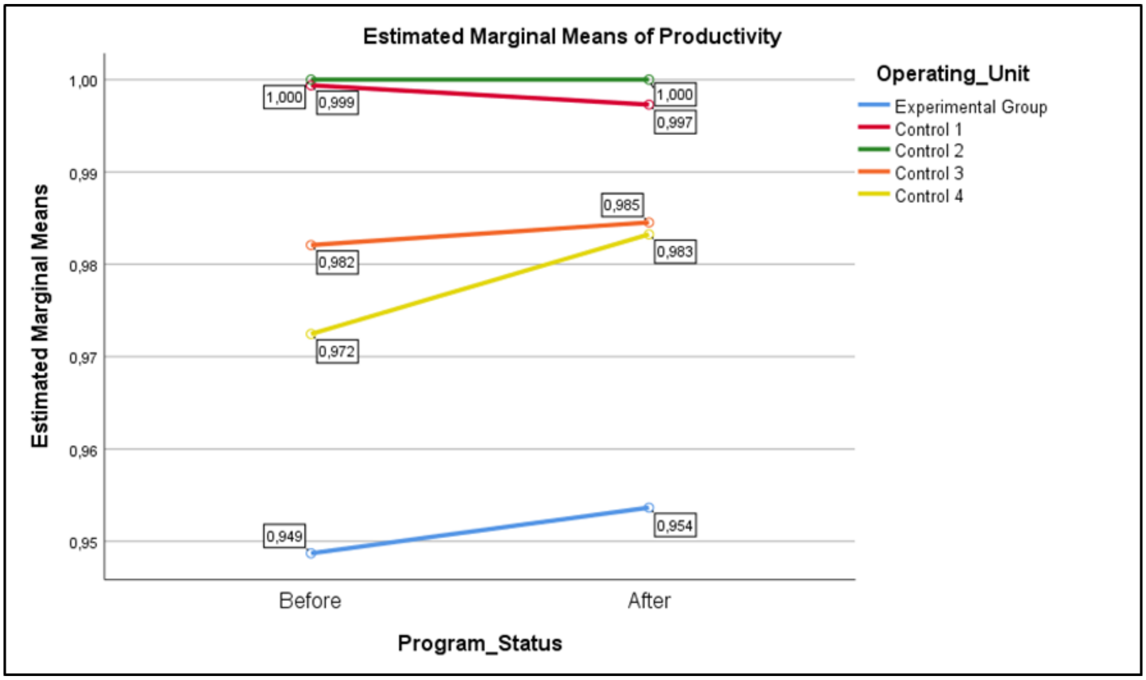
The column 'Partial Eta squared' refers to the intensity of the effect. The effect size ($\eta p2$) is categorized into effects using three thresholds small (0.01), medium (.06), and large (Cohen, et al., 2011). Table 6 presents the effect of pertaining to different groups on productivity is very high ($\eta p2 = .743$), while the interaction effect is small-to-medium ($\eta p2 = .042$).

Figure 1 is used to visualize the levels of productivity among different groups. The variation on productivity from before and after the implementation of structured 5S for different groups is depicted through the use of different lines on the graph. Overall, one can see the scores of productivity are indeed lower for the experimental group from the beginning. As noted in the limitations of this study, the areas could not be randomly assigned and, therefore, this low performance could potentially illustrate why this area was targeted for improvement.

In addition, while productivity increased for this group, it also increased for Control Groups 3 and 4. Only Control Group 2 showed a slight decrease on productivity, which may help to explain why the interaction effect was not significant, since there is no clearly significant different increase or decrease of one group compared to the others.

Figure 1

Estimated Marginal Means of Productivity



The data analysis of previous studies has repeatedly identified most organizations are able to attain significant improvements from 5S implementation in productivity through various influences not limited to an increased availability of equipment, a reduction of set-up time, and overall improvements in production time (Randhawa & Ahuja, 2017). This study, as well as Hutchins' (2006) study found this improvement to be minimal; however, this could be related to outside factors.

Safety

Safety data for each operating unit was collected in the same way as was done for each of the following productivity data, through weekly reports of each operating unit. Unfortunately, insufficient data was available during the 32-week time frame to be able to utilize the same model for statistical analysis. As depicted in Figure 2, the model for Safety did not fit according to the Omnibus Test (p > .05). This was directly related to the fact only five safety events (identified with the value of “1” for individual instances), occurred during the study, while 152 weekly reports from the different departments had no safety incidents (coded as “0”). The low sample size of safety incidents (“1”), limits the statistical power of the test.

Figure 2

Omnibus Test for Safety Data

Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
16,808	9	0,052

Dependent Variable: Safety
Model: (Intercept), Program_Status, Group, Program_Status * Group[a]

a. Compares the fitted model against the intercept-only model.

In general, organizations often have difficulties, and in some situations, they have inabilities to properly measure their process improvement initiatives towards safety requirements and targets (Schwerha, et al., 2020). Providing appropriate analysis tools to assess specific equipment hazards along with reliability issues is useful in upgrading operations and management of those operations (Tsarouhas, 2012). In Hutchins (2006), the injury data from one operating unit or cost center were more than the entire number of incidents in the facility studied; however, the previous study found no significant differences in safety (p = .703) as a result of implementing 5S. As a result of the lack of sufficient data, this study could not sufficiently provide additional insight on this particular influence.

Quality

This section and the subsequent sections for Research Question 1 will present the same analysis for the remaining measurements of productivity, as described with the first KPI studied. As noted, safety was the only exclusion as a direct result of the limited data. This section is dedicated to the Quality data and begins with a descriptive table (Table 7).

Table 7

Means, Standard Deviations, and Sample Sizes for Quality

Operating_Unit	Program_Status	Mean	Std. Deviation	N
Experimental Group	Before	0.9278	0.04615	16
	After	0.8421	0.05504	16
	Total	0.8849	0.06628	32
Control 1	Before	0.9861	0.02058	16
	After	0.9633	0.01754	16
	Total	0.9747	0.02209	32
Control 2	Before	0.9563	0.02775	16
	After	0.8187	0.12889	16
	Total	0.8875	0.11528	32
Control 3	Before	0.8397	0.10173	15
	After	0.8613	0.08700	16
	Total	0.8509	0.09346	31
Control 4	Before	0.9219	0.07064	16
	After	0.9500	0.07071	14
	Total	0.9350	0.07089	30
Total	Before	0.9274	0.07629	79
	After	0.8855	0.09828	78
	Total	0.9066	0.09012	157

As noted earlier, quality is measured with a focus to remain below the target. The data identified the lowest mean or the highest achievement for quality achievement was in control group 3 (0.8397, SD = 0.1017) for the before data and control group 2 (0.8187, SD = 0.1289) for the after. Conversely, the highest mean or lowest achievement for both the before and after data was Control group 1 (0.9861, SD = .0206) and (0.9633, SD = 0.0175).

The ANOVA model of this study, illustrated in Table 8, was used to identify significant main effects of ‘Group’, F (4, 157) = 14.671, p < .001, ηp2 = .285, and “Program_Status,” F (1, 157) = 11.875, p = .001, ηp2 = .075, on Quality. This means quality is significantly different when comparing before and after periods, as well as when comparing the different operating units categorized as groups. For example, the Experimental Group and Control groups 1 through 4 had estimated marginal means of 0.928 to 0.842 (improvement), 0.986 to 0.963 (improvement), 0.956 to 0.819 (improvement), 0.840 to 0.861 (decline), and 0.922 to 0.950 (decline), respectively. The interaction effect is also significant F (4, 157) = 7.827, p < .001, ηp2 = .176, meaning the differences are not the same across different groups.

Table 8

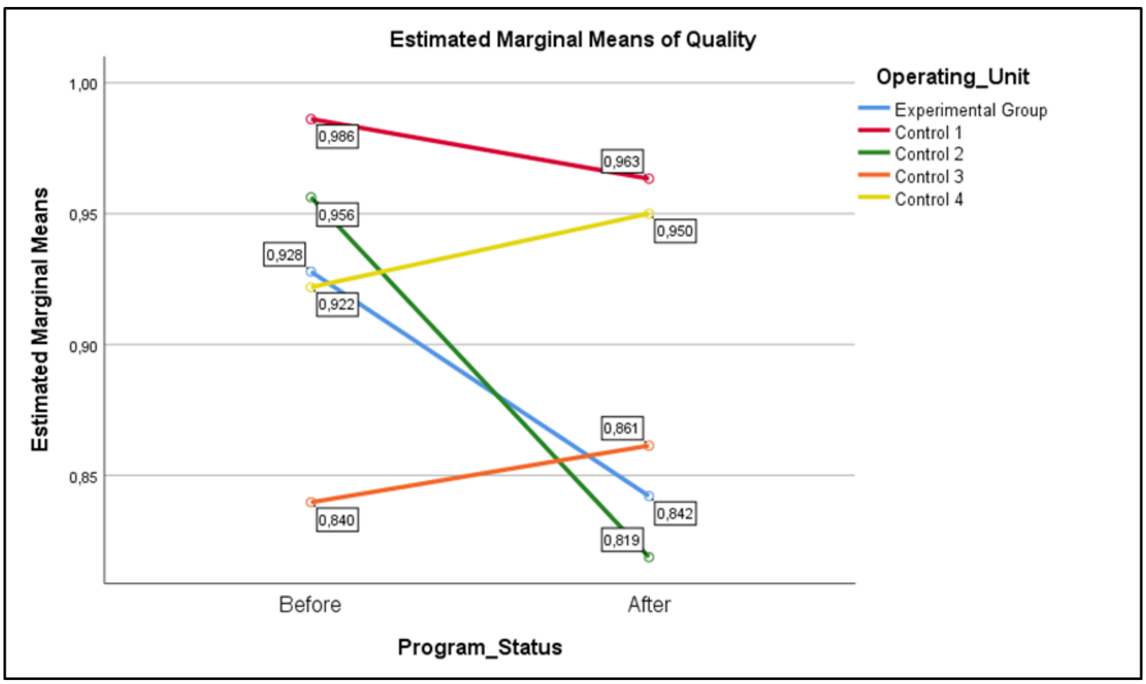
Tests of Between-Subjects Effects of Quality

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	0.519[a]	9	0.058	11.353	0.000	0.410
Intercept	128.844	1	128.844	25342.430	0.000	0.994
Operating_Unit	0.298	4	0.075	14.671	0.000	0.285
Program_Status	0.060	1	0.060	11.875	0.001	0.075
Operating_Unit * Program_Status	0.159	4	0.040	7.827	0.000	0.176
Error	0.747	147	0.005			
Total	130.309	157				
Corrected Total	1.267	156				

Figure 3 is used to visualize the differences between the groups, both before and after implementation. The quality means decreased, in essence illustrating improvements for the Experimental Group and Control Groups 1 and 2, while it increased for Control Groups 3 and 4, showing a decrease in quality. Contrarily, Hutchins (2006) found no significant differences in quality (p = .0867) before and after the implementation of 5S. The previous study identified a slight overall improvement while at least two groups saw substantial improvements.

Figure 3

Estimated Marginal Means of Quality



There can be multiple factors attributed to determining why the results differ in the two studies. To begin, quality is often one aspect of an organization with the ability to establish central values to define the actual organization culture (Ablanedo-Rosas, et. al, 2010). That said, traditional quality functions of organizations are often problematic in regard to quality control production mechanisms. Therefore, it is necessary to assess and seek improvement with the overall organization structure of the quality management systems (Guo, et al., 2020).

Identifying specific quality variables for monitoring quality data and establishing process control must be considered in order to more effectively monitor the influence of quality (Xiao, et al., 2019). A contributing factor to this problem is quality is often difficult to define and frequently based on perception and limited to the experiences of a person or organization (Ablanedo-Rosas, et. al, 2010). In short, how quality is measured both internally and between organizations has an influence on how to measure improvement.

Inconsistencies in terms of how internal measurements define quality can also compound problems with regard to practice sharing quality improvement initiatives. For example, the methods and frequency of how quality data is reported can influence outcomes, as well as how teams cooperate to resolve and address identified problems (Baird, et al., 2011). Utilizing quality data and focusing on how it is reported with an emphasis on actions, triumphs, and outcomes driven through vigorous improvement cycles with rapid follow-up has shown the highest levels of performance (Baird, et al., 2011).

In the two organizations studied, this can differ dramatically. However, it should be noted some quality practices essentially have a universal validity based on positive effectiveness across a broad spectrum of applications (Netland & Sanchez, 2014). It also needs to be considered that different organizations have different needs and motivations for the application of their continuous improvement systems, which can be a potential explanation for why different levels of quality improvements have been realized in different organizations (Netland & Sanchez, 2014). In general, implementing 5S has shown perceptions of quality improvement; however, organizations must further integrate additional strategies to achieve a total commitment to optimizing improvements (Ablanedo-Rosas, et. al, 2010).

Management and researchers both generally accept 5S as a basis for quality. As a result, in order for effective implementation and improvements to occur, it is necessary to have an organizational commitment to the philosophy to better implement advanced quality techniques (Ablanedo-Rosas, et. al, 2010). 5S has been long-established as capable of providing foundational elements of standardization and continuous improvement to facilitate environments conducive to quality (Randhawa, et al., 2017).

Product Cost

This section reviews the analyses completed to measure the impacts of 5S on product cost. Table 9 shows the means, standard deviations, and sample sizes for the Product Cost data. As previously noted for this particular statistic, the goal and objective were to stay below the target, thus lower scores are actually favorable. In that regard, Control Group 2 had the highest (worst score) of 0.9735 at the start of the study, but also remained the worst with an even higher score of 0.9875. In general, all of the operating units in this study saw an increase in product cost when compared to their target product cost.

Table 9

Means, Standard Deviations, and Sample Sizes for Product Cost

Operating_Unit	Program_Status	Mean	Std. Deviation	N
Experimental Group	Before	0.9572	0.01041	16
	After	0.9717	0.00738	16
	Total	0.9645	0.01154	32
Control 1	Before	0.8942	0.01396	16
	After	0.9078	0.01404	16
	Total	0.9010	0.01541	32
Control 2	Before	0.9735	0.01116	16
	After	0.9875	0.00638	16
	Total	0.9805	0.01144	32
Control 3	Before	0.8911	0.01372	15
	After	0.9277	0.02358	16
	Total	0.9100	0.02668	31
Control 4	Before	0.9501	0.02442	16
	After	0.9872	0.03325	14
	Total	0.9674	0.03402	30
Total	Before	0.9338	0.03732	79
	After	0.9556	0.03788	78
	Total	0.9446	0.03905	157

The data of this study, as seen in Table 10, indicated significantly different scores of product cost when comparing data from before and after implementation, $F(1, 157) = 68.508$, $p < .001$, $\eta_p^2 = .318$. The study found product cost to also be significantly different among groups, $F(4, 157) = 138.751$, $p < .001$, $\eta_p^2 = .791$. Additionally, the study found interaction was also significant, $F(4, 157) = 3.928$, $p = .005$, $\eta_p^2 = .097$.

Table 10

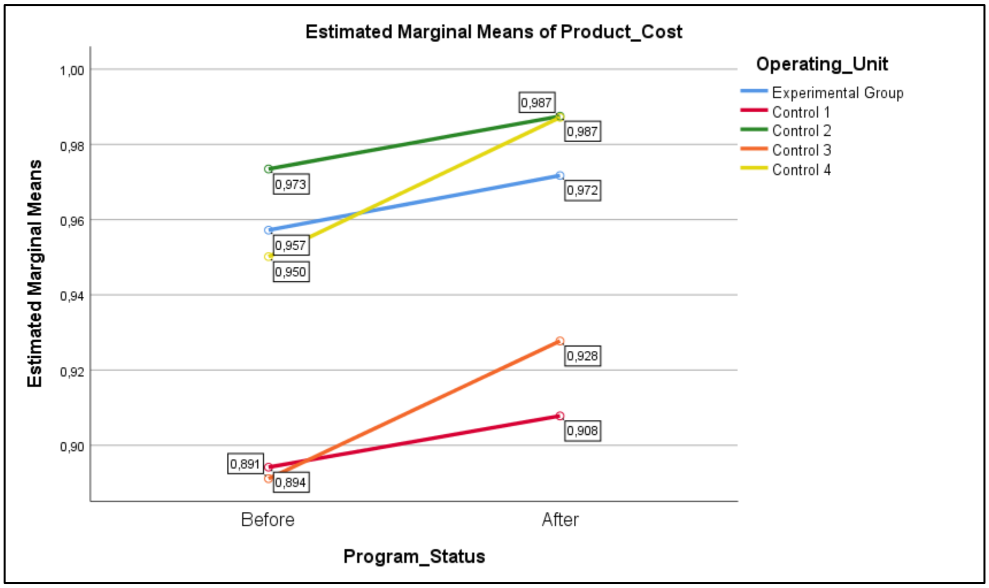
Tests of Between-Subjects Effects of Product Cost

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	0.193[a]	9	0.021	69.802	0.000	0.810
Intercept	139.894	1	139.894	455981.106	0.000	1.000
Operating_Unit	0.170	4	0.043	138.751	0.000	0.791
Program_Status	0.021	1	0.021	68.508	0.000	0.318
Operating_Unit * Program_Status	0.005	4	0.001	3.928	0.005	0.097
Error	0.045	147	0.000			
Total	140.326	157				
Corrected Total	0.238	156				

Figure 4 illustrates the mean values of product cost increased for all groups before and after implementation; however, one can see more substantial increases identified for Control Groups 3 and 4. Hutchins (2006) indicated no significant differences in product cost ($p = 0.948$), which is quite different from this study ($p < 0.001$). Additionally, the Hutchins' (2006) study found it unlikely the implementation of 5S would affect product cost, while this study found the product costs to increase.

Figure 4

Estimated Marginal Means of Product Cost



The differing results on product cost can be explained by multiple factors, as findings to support different results have been previously identified in other studies. For example, 5S programs have historically shown effectiveness in reducing costs and improving quality while also increasing the rate of delivery and reliability of the service or product (Ablanedo-Rosas, et. al, 2010). Similarly, studies have identified the majority of organizations achieved a reduction in production costs from the implementation of 5S did so through items not limited to the reduction of materials, labor, and energy (Randhawa, et al., 2017).

Maintenance Cost

This section reviews the analyses completed to measure the impacts of 5S on maintenance cost. Table 11 shows the means, standard deviations, and sample sizes for the maintenance cost data. It should be noted the experimental group had the lowest initial maintenance cost scores (0.9485), as well as the lowest scores after implementation (0.9559). Much like the previous KPI, the lower scores are more favorable for maintenance costs as well and therefore in this instance, the experimental group had the best achievement. The after score of the experimental group was still lower than the before scores of the second lowest score identified in Control Group 4 (0.9820).

Table 11

Means, Standard Deviations, and Sample Sizes for Maintenance Cost

Operating_Unit	Program_Status	Mean	Std. Deviation	N
Experimental Group	Before	0.9485	0.00669	16
	After	0.9559	0.00836	16
	Total	0.9522	0.00834	32
Control 1	Before	0.9995	0.00998	16
	After	0.9971	0.00217	16
	Total	0.9983	0.00721	32
Control 2	Before	0.9676	0.00941	16
	After	0.9855	0.00699	16
	Total	0.9765	0.01219	32
Control 3	Before	0.9824	0.01270	15
	After	0.9846	0.02588	16
	Total	0.9835	0.02029	31
Control 4	Before	0.9712	0.00824	16
	After	0.9820	0.01068	14
	Total	0.9763	0.01077	30
Total	Before	0.9737	0.01943	79
	After	0.9810	0.01913	78
	Total	0.9773	0.01956	157

As seen from the data, the maintenance cost was significantly different between groups, $F(4, 157) = 64.841$, $p < .001$, $\eta p2 = .638$. It was also statistically significant when comparing before and after implementation, $F(1, 157) = 14.625$, $p < .001$, $\eta p2 = .090$. The effect of the implementation was significantly different among groups, since the interaction effect was significant, $F(4, 157) = 3.522$, $p = .009$, $\eta p2 = .087$. The results differ here again from the results of the Hutchins' (2006) study, which found no significant differences in maintenance costs as a result of implementing 5S.

Results and Findings to Research Question 2

The second hypothesis in this study proposed a significant difference in employee attitudes, as measured by employee survey results and the rate of 5S implementation. As previously explained, as a result of the pandemic, data from four months prior to the 5S implementation and four months following the 5S implementation in each cost center were accessed and analyzed. Data was averaged across the number of shifts in each cost center.

Survey Data

The survey was collected for management and employees, and for both data sets the first step was to conduct a Kruskal-Wallis test. A Kruskal-Wallis test is utilized for the purpose of assessing whether samples originate from the same distribution. In circumstances where the data is from a normal distribution, the Kruskal–Wallis tests are frequently viewed as almost as effective as one-way ANOVA; however, in situations of non-normality or multiple outliers, the tests are often viewed as more reliable (Ramachandran & Tsokos, 2021). Several graphs and tables are utilized to clarify and visualize the results. Looking, first, at the management data, a Kruskal-Wallis test was executed. The test was non-significant, $p = 0.086$ and $0.086 \geq 0.05$

(Figure 5). The results of the study indicate there were no significant differences on management attitudes among the five groups included in the study.

Figure 5

Independent-Samples Kruskal-Wallis Test Summary for the Management Survey Data

Independent-Samples Kruskal-Wallis Test Summary

Total N	109
Test Statistic	8,154[a,b]
Degree Of Freedom	4
Asymptotic Sig.(2-sided test)	0,086

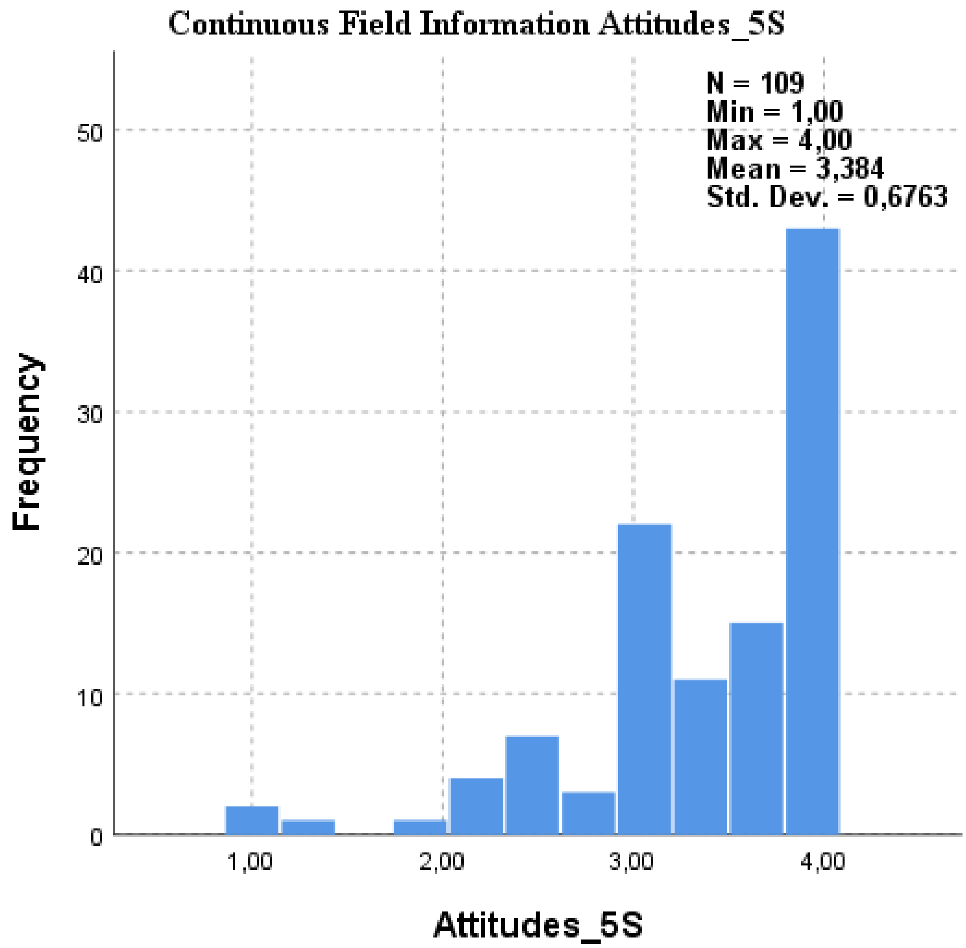
a. The test statistic is adjusted for ties.

b. Multiple comparisons are not performed because the overall test does not show significant differences across samples.

Figure 6 shows the frequency of management scores. Descriptive statistics are used for both management and employees. Additionally, the distribution of values is presented using boxplots for each group.

Figure 6

Graph of the Overall Scores for the Management



The majority of the management data from each operating unit indicated an overall positive attitude, where the majority of responses scored above "3," as slightly agree, visually depicted in Table 12. This can further be understood in the boxplot of Figure 7, which includes a visual representation of the median scores as well as the quartiles of the data of each unit. This study found the mean score for management overall was 3.384 (SD = 0.6763). It also found the mean score for the management control group to be 3.2300 and 3.4917 for the experimental group. In Hutchins (2006), the mean score for management was 2.6735 (SD = 0.8512) in the control group and 2.4898 (SD = 0.7671) for the experimental groups, but the overall was not provided.

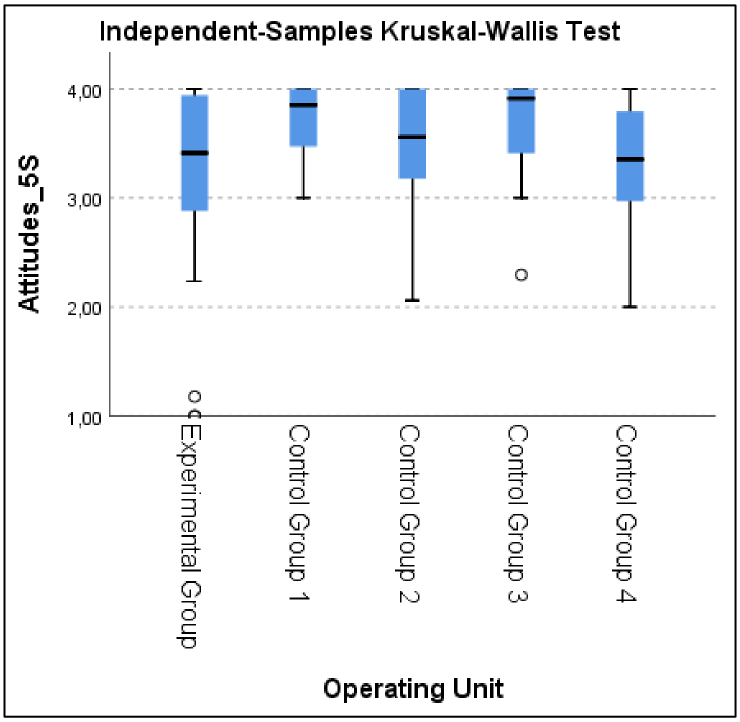
Table 12

Descriptive Statistics for the Management Survey by Group

		Attitudes_5S	
		Mean	Standard Deviation
Operating Unit	Experimental Group	3.23	0.80
	Control Group 1	3.69	0.37
	Control Group 2	3.45	0.61
	Control Group 3	3.62	0.50
	Control Group 4	3.28	0.62

Figure 7

Boxplot for Management Survey Results



When comparing the results for the team members identified as "Team," the data show contrasting results to management. In that regard, the results for team member data were significant among groups with respect to Attitudes towards 5S (Figure 8). The Hutchins (2006) study found both management and team member attitudes did not have significant differences as a result of the implementation of 5S.

Figure 8

Kruskal-Wallis Test for Team Member Attitudes

Independent-Samples Kruskal-Wallis Test Summary

Total N	3654
Test Statistic	31,444[a]
Degree Of Freedom	4
Asymptotic Sig.(2-sided test)	0,000

a. The test statistic is adjusted for ties.

Figure 9 displays the groups with the highest attitudes were identified in Control Group 2 and 4. At the same time, Control Group 1 and the Experimental Group show the lowest values. This study found the mean score for team members overall was 3.336 (SD = 0.7175). It also found the mean score for the team members in the experimental group to be 3.321 and 3.355 in the control groups, as seen in Table 13. In Hutchins (2006), the mean score for team members was 1.8571 (SD = 0.6124) in the control group and 1.890 (SD = 0.5861) for the experimental groups, but the overall was not provided.

Figure 9

Boxplot for Employee Survey Results

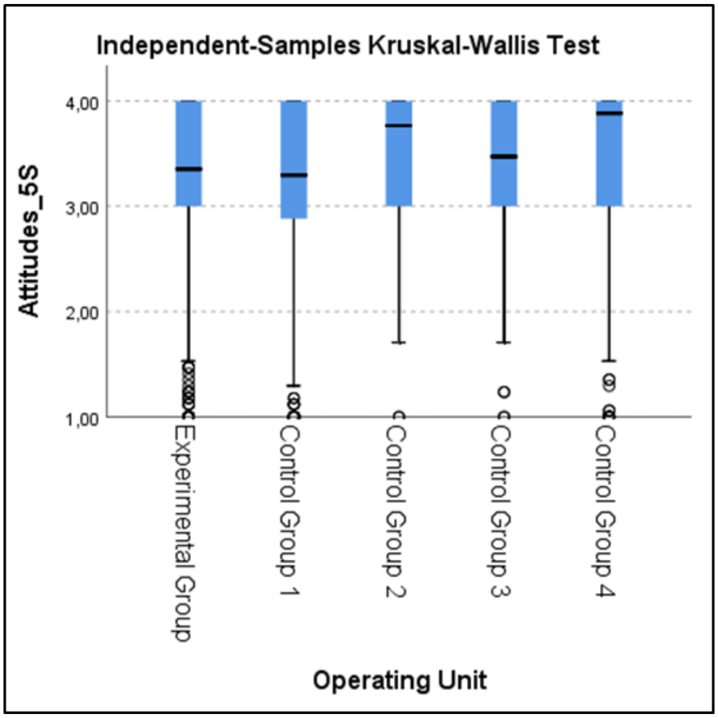


Table 13

Descriptive Statistics for the Employee Survey by Group

		Attitudes_5S	
		Mean	Standard Deviation
Operating Unit	Experimental Group	3.32	0.70
	Control Group 1	3.24	0.80
	Control Group 2	3.50	0.60
	Control Group 3	3.40	0.60
	Control Group 4	3.41	0.78

Additional Kruskal-Wallis tests were conducted to examine if pairwise differences between groups were significant (Table 14). The experimental group data identified statistically significantly different scores when compared to Groups 4 ($p < .001$) and 2 ($p < .001$). Figure 8 utilized black lines to show the median values and one can identify the Experimental group had a relatively lower value than Groups 2 and 4.

Table 14

Pairwise Differences Between Groups

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.
Control Group 1-Experimental Group	54.649	45.764	1.194	0.232
Control Group 1-Control Group 3	-139.578	70.303	-1.985	0.047
Control Group 1-Control Group 4	-277.052	66.405	-4.172	0.000
Control Group 1-Control Group 2	-295.054	73.619	-4.008	0.000
Experimental Group-Control Group 3	-84.929	62.509	-1.359	0.174
Experimental Group-Control Group 4	-222.403	58.091	-3.829	0.000
Experimental Group-Control Group 2	-240.405	66.217	-3.631	0.000
Control Group 3-Control Group 4	-137.473	78.884	-1.743	0.081
Control Group 3-Control Group 2	155.476	85.046	1.828	0.068
Control Group 4-Control Group 2	18.003	81.853	0.220	0.826

Although Hutchins (2006) did not find statistically significant relationships when seeking to understand the relationship of the implementation with employee attitudes with both management and team members, this study identified statistically significant results with team members. Previous studies have also identified a positive impact on team member attitude from the implementation of 5S, especially when considering specific work life attributes like awareness, motivation, team collaboration and enthusiasm, as well as individual impacts like self-discipline (Randhawa, et al., 2017).

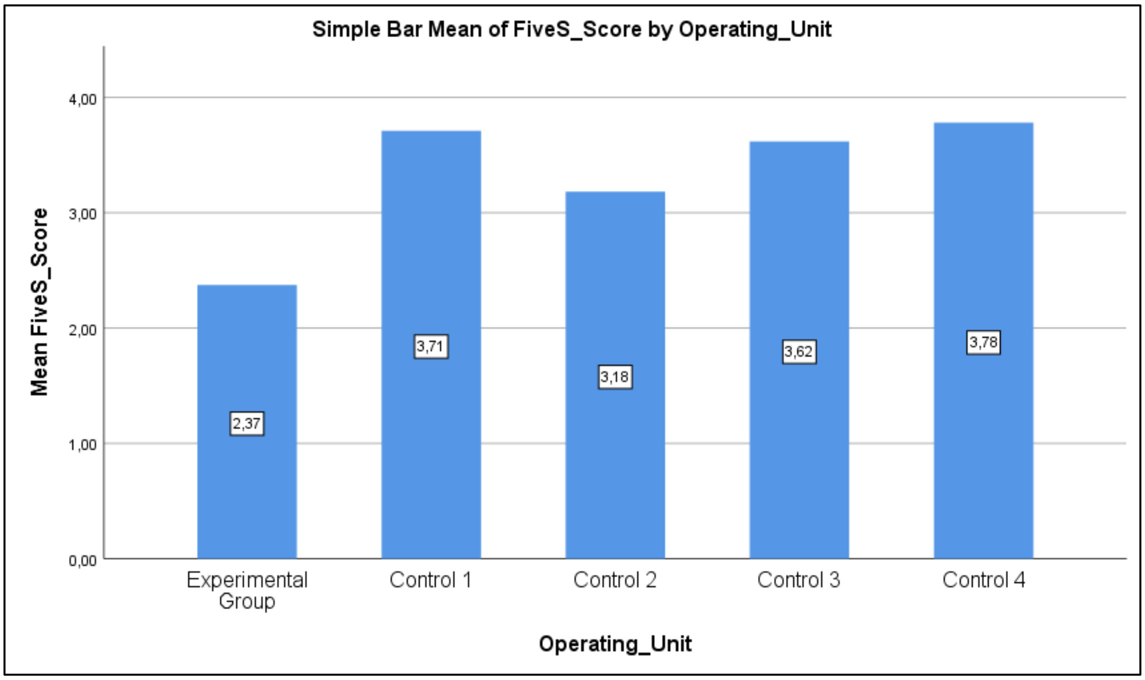
It has repeatedly been found that successful 5S implementation to be influenced by an organization’s culture, communication, and team member attitudes (Ablanedo-Rosas, et. al, 2010). For this purpose, there could be additional underlying influences on attitudes, particularly with how the 5S is implemented. In particular, manufacturing organizations with top management commitment to 5S have positively impacted organizational culture (Ablanedo-Rosas, et. al, 2010). As mentioned in Chapter 2, the influence of culture can contribute to both the success of implementing 5S as well as its resulting impacts.

5S Audit Data

Audit data for each Operating Unit were collected from weekly audit reports created for the weekly production reports for the duration of the 32-week study. To best understand the influence of the actual 5S scores in this study, a comparison analysis of the 5S scores between groups was completed. This builds on the Hutchins (2006) study by exploring the influence of 5S directly to the productivity measurements. Figure 10 visually displays the mean scores of ‘FiveS-Scores’ by group. The Experimental Group was identified to have the lowest average (2.37) while Control Group 4 had the highest (3.78).

Figure 10

Bar Chart of the Mean 5S Scores by Operating Unit



The influences of the actual 5S scores collected in this study were tested using regression analysis. Regression analysis is a technique used to explore the relationship between a continuous dependent variable and one or more independent (or predictor) variables (Pallant, 2013). In situations where only one independent variable is being tested, the technique is called a simple regression; however, in situations as seen in this study with two or more independent variables, the method is called multiple regression analysis.

The objective of regression (simple or multiple) is to utilize independent variable(s) with known values in attempt to predict single dependent values selected by researchers (Hair, et al., 2010). Each independent variable is weighted using the regression analysis procedure to ensure optimal prediction from the set of independent variables.

Assigned weights are used to denote the relative contribution of the independent variables to the overall prediction and facilitate interpretations of the influence for each variable in making the prediction. Although correlation among the independent variables complicates the interpretative process, the set of weighted independent variables forms the regression variate, which is a linear combination of the independent variables used to predict the dependent variables (Hair, et al., 2010).

This study utilized three regression models to examine the relationships between 5S scores and the productivity measurements, considering the variation between groups. The first models (Model 1) included only 5S scores as an independent variable. The second models (Model 2) included dummy variables representing each group. The third models (Model 3) included interaction terms for groups and 5S scores. The interaction terms were represented by the mathematical product between the predictor variable and the interaction (or moderator) variable.

One interaction variable was created for each group. If the interaction value presents a significant coefficient ($p < 0.05$), the effect of 5S scores on productivity is significantly different between that particular group and the reference group. The reference group is one that is omitted from the analysis, so the coefficients for other groups can be interpreted in relation to them. For the sake of this analysis, the experimental group was included as the reference group.

There are several key assumptions for regression analysis. The main assumptions include an independence of observations, which this study achieved through the sampling procedure, ensuring observations were independent. Another assumption requires an interval (or metric) level of measurement of the dependent variable, also provided through the provided dependent variables. A third assumption of regression is outliers, which refers to observations that are relatively extreme (Tabachnick & Fidell, 2018). One case, which showed a value for 'quality' more than 3 times the maximum value of the rest of the cases, was removed. Two cases showing values for 'Maintenance Cost' close to 0, when all other values ranged from 0.94 to 1.04, were also removed (same strategy as the first order).

Additional assumptions for regression analysis include the normality, linearity, and homoscedasticity of residuals (errors). One way to assess these last assumptions are through the use of scatterplots of residuals (Tabachnick & Fidell, 2018), which was the approach used in this research. The results of the tests of these assumptions are presented in the following sections.

Productivity

As previously explained, three models were executed hierarchically. The first with only 5S_Scores as predictor, the second adding the groups' dummy variables, and the third adding the interaction terms (to examine if the effect of 5S scores on productivity is different between groups). This same process was followed for all remaining productivity KPI. Table 15 shows the statistics of significance of these hierarchical models for productivity. The data indicate all three models were significant as per the F-statistic ($p < .001$).

Table 15

ANOVA Results for Model Testing on Productivity

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	0,024	1	0,024	82,937	0,000[b]
	Residual	0,045	155	0,000		
	Total	0,068	156			
2	Regression	0,050	5	0,010	84,696	0,000[c]
	Residual	0,018	151	0,000		
	Total	0,068	156			
3	Regression	0,051	9	0,006	49,524	0,000[d]
	Residual	0,017	147	0,000		
	Total	0,068	156			

a. Dependent Variable: Productivity

b. Predictors: (Constant), FiveS_Score

c. Predictors: (Constant), FiveS_Score, Control Group 2, Control Group 3, Control Group 1, Control Group 4

d. Predictors: (Constant), FiveS_Score, Control Group 2, Control Group 3, Control Group 1, Control Group 4, Control Group 2 * FiveS_Score, Control Group 3 * FiveS_Score, Control Group 4 * FiveS_Score, Control Group 1 * FiveS_Score

Table 16 depicts the statistics of model fit. The first model has an R-square of 0.349, meaning that 34.9% of the variance on productivity can be explained by 5S scores. The R^2 increases substantially on the second model, indicating productivity can be explained increasingly when groups are added to the model (productivity is highly related to groups). Significant changes to the F-statistic, found in the last column, indicate an inclusion of the variables from one model to the next, which significantly changes the explanatory power of the model.

If the change is significant from Model 2 to Model 3, this indicates adding interaction terms alters the power of the model. In other words, significantly different effects of 5S on productivity can be identified between groups. Table 16 shows R-square increased from 0.349 to

0.737 from Model 1 to Model 2 and this change was significant (p < 0.001). The R-square change for the last model, however, was not significant at the 5% significance level (p = 0.072). This indicated the effect of 5S scores on productivity did not depend on groups with a 95% confidence.

Table 16

Model Summary for Productivity

Model Summary[d]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	0,590[a]	0,349	0,344	0,01695	0,349	82,937	1	155	0,000
2	0,859[b]	0,737	0,728	0,01091	0,389	55,809	4	151	0,000
3	0,867[c]	0,752	0,737	0,01074	0,015	2,198	4	147	0,072

a. Predictors: (Constant), FiveS_Score

b. Predictors: (Constant), FiveS_Score, Control Group 2, Control Group 3, Control Group 1, Control Group 4

c. Predictors: (Constant), FiveS_Score, Control Group 2, Control Group 3, Control Group 1, Control Group 4, Control Group 2 * FiveS_Score, Control Group 3 * FiveS_Score, Control Group 4 * FiveS_Score, Control Group 1 * FiveS_Score

d. Dependent Variable: Productivity

The beta coefficients and their significance were examined (columns ‘B’ and ‘Sig.’ in Table 17). While the t-statistic is not directly interpretable, the p-value represents the results of the significance test of the variable. Values below 0.05 represent statistical significance of the predictor. That is to say, the variable significantly influences the outcome variable. The beta coefficient refers to the absolute change in the outcome variable occurring for a one-unit change on the independent variable. So, negative beta coefficients indicate an inverse relationship between the variables, whereas positive values represent the opposite.

Table 17

Parameter Estimates of the Model Coefficients for Productivity

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	0,906	0,009		106,467	0,000		
	FiveS_Score	0,023	0,003	0,590	9,107	0,000	1,000	1,000
2	(Constant)	0,914	0,019		46,989	0,000		
	FiveS_Score	0,016	0,008	0,402	1,922	0,057	0,040	25,182
	Control Group 1	0,026	0,011	0,506	2,333	0,021	0,037	27,027
	Control Group 2	0,036	0,007	0,698	5,060	0,000	0,092	10,915
	Control Group 3	0,013	0,011	0,241	1,203	0,231	0,043	23,135
	Control Group 4	0,004	0,012	0,080	0,360	0,719	0,035	28,429
3	(Constant)	0,925	0,025		36,763	0,000		
	FiveS_Score	0,011	0,011	0,283	1,044	0,298	0,023	43,656
	Control Group 1	0,075	0,121	1,442	0,620	0,537	0,000	3213,083
	Control Group 2	0,075	0,060	1,448	1,243	0,216	0,001	803,723
	Control Group 3	-0,077	0,109	-1,464	-0,706	0,481	0,000	2549,788
	Control Group 4	-0,317	0,120	-5,977	-2,637	0,009	0,000	3044,221
	Control Group 1 * FiveS_Score	-0,011	0,034	-0,817	-0,340	0,734	0,000	3413,261
	Control Group 2 * FiveS_Score	-0,011	0,020	-0,678	-0,546	0,586	0,001	914,457
	Control Group 3 * FiveS_Score	0,026	0,031	1,816	0,846	0,399	0,000	2729,132
	Control Group 4 * FiveS_Score	0,087	0,033	6,181	2,641	0,009	0,000	3247,367

a. Dependent Variable: Productivity

This data indicates 5S scores are a significant predictor of productivity according to Model 1 ($\beta = 0.023$, $p < 0.001$). The results of Model 2 show that belonging to Control Group 1 is a significant predictor of productivity (compared to the reference group – Experimental Group) ($\beta = 0.026$, $p < 0.05$). The same applies to Control Group 2 ($\beta = 0.036$, $p < 0.001$). The positive beta coefficients indicate that belonging to these groups have a positive effect on productivity, compared to the Experimental Group. With regards to Model 3, where only interaction terms should be interpreted, the table shows that only the effect of 5S scores on productivity is significantly different for Control Group 4, compared to the Experimental Group ($\beta = 0.087$, $p < 0.001$). To better visualize the differences, the following scatterplot, Figure 11, was generated and from it, one can see the relationship of productivity and 5S scores by group.

Figure 11

Scatterplot of Productivity by 5S Score and Operating Unit

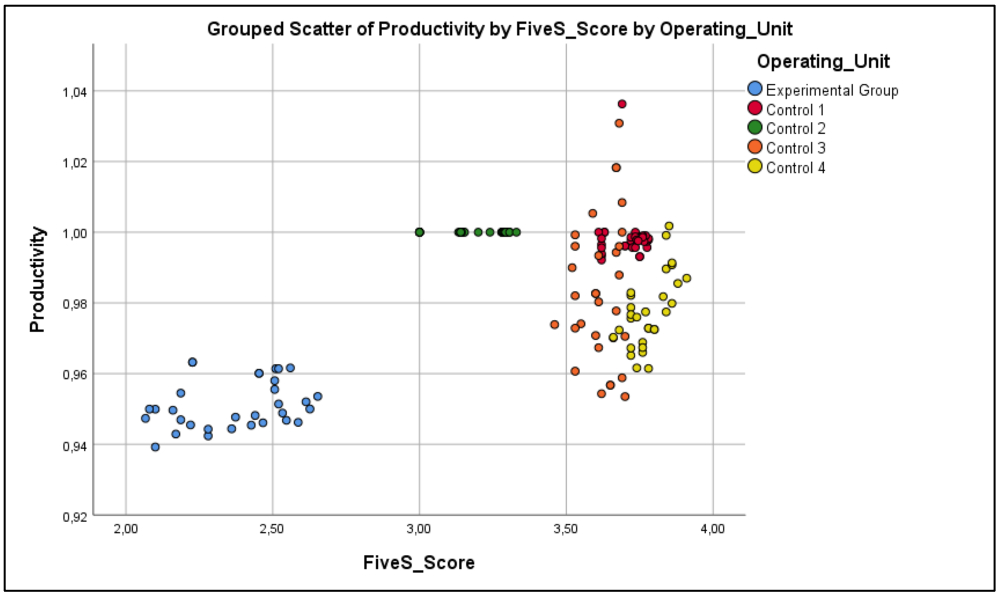


Figure 11 shows Control Group 1 and Control Group 2 do not have an increasing pattern on their values or more specifically, do not present a relationship between both variables, whereas the values of the Experimental Group do. This can help explain their significant p-values on Model 2. The graph also depicts that Control Group 4 values have an increasing pattern, where an increase in the value of 5S also increases the values of productivity. It is noticeable that the angle of the increase is substantially higher compared to the Experimental

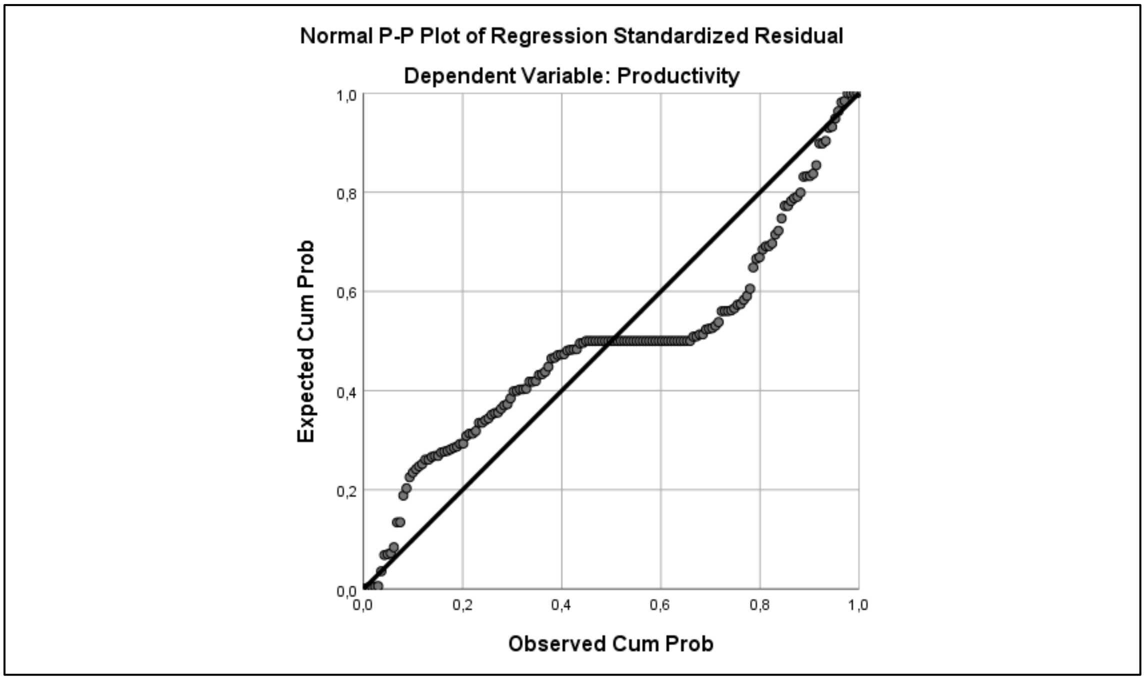
Group. This also provides further explanation of why the interaction term for this group has a significant p-value different from the Experimental Group. In this instance, a stronger effect.

Lastly, violations of the assumptions of normality, linearity, and homoscedasticity of residuals (errors) were examined for this model. Figures 12 and 13 show a P-P plot and a scatterplot of residuals. These figures are used to assess the normality of residuals through observation. The observations on the P-P plot should follow a diagonal pattern to suggest normality of residuals (Tabachnick & Fidell, 2018).

When points are well distributed along the X and Y axes on a scatterplot, they suggest homoscedasticity and linearity (Tabachnick & Fidell, 2018). Conversely, nonlinearity can be identified when most of the residuals are above the zero line on the plot at some predicted values and below the zero line at other predicted values (Tabachnick & Fidell, 2018). Lack of homoscedasticity can be identified when the values are more dispersed for a given predicted values than at other values (Tabachnick & Fidell, 2018).

Figure 12

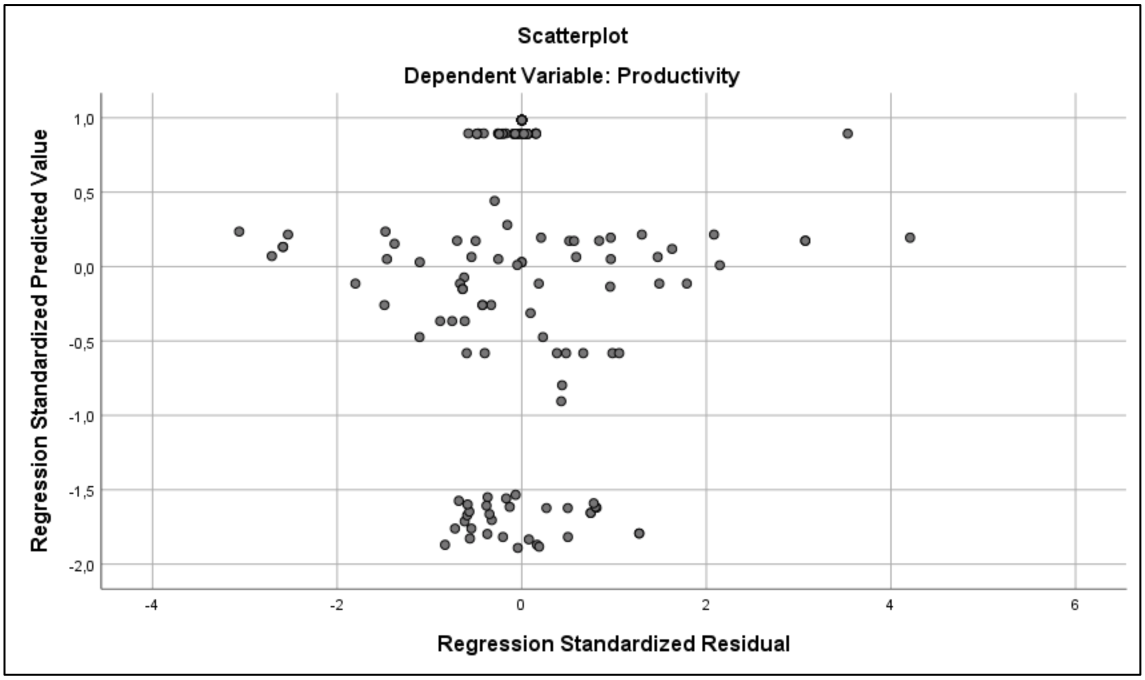
P-P Plot of Regression of Productivity as Standardized Residual Dependent Variable



The P-P plot in Figure 12 indicates some degree of deviation from normality as the points do not closely follow the diagonal pattern. This is confirmed by the scatterplot in Figure 13, showing some points grouped together instead of a nicely spread pattern. Although this does not invalidate the results of the model, it is something to be presented and taken into consideration when interpreting the results.

Figure 13

Scatterplot of Regression Standardized Predicted Values for Productivity



Safety

The models utilized for the previous and remaining productivity measurements did not fit for Safety. As seen with other data analyses attempted for safety, the inability to run specific statistical analyses was a direct result of imbalances found within the data. During the study, only five safety incidents were identified (coded as 1), while there were 152 cases with no safety issues (coded as 0). With a limited number of values, and with some of the control groups experiencing no issues at all, conducting a calculation of model coefficients was not possible (see Table 18).

Table 18

Safety, Variables in the Equation

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	FiveS_Score	-1,989	2,727	0,532	1	0,466	0,137
	Control Group 1(1)	24,194	441620,40	0,000	1	1,000	3,22E+10
	Control Group 2(1)	24,194	205180,80	0,000	1	1,000	3,22E+10
	Control Group 3(1)	24,194	395855,35	0,000	1	1,000	3,22E+10
	Control Group 4(1)	24,194	440211,96	0,000	1	1,000	3,22E+10
	Control Group 1 * FiveS_Score	1,989	119024,73	0,000	1	1,000	7,312
	Control Group 2 * FiveS_Score	1,990	64435,011	0,000	1	1,000	7,312
	Control Group 3 * FiveS_Score	1,990	109382,84	0,000	1	1,000	7,313
	Control Group 4 * FiveS_Score	1,990	116421,46	0,000	1	1,000	7,313
	Constant	-93,786	766675,39	0,000	1	1,000	0,000

a. Variable(s) entered on step 1: FiveS_Score, Control Group 1, Control Group 2, Control Group 3, Control Group 4, Control Group 1 * FiveS_Score, Control Group 2 * FiveS_Score, Control Group 3 * FiveS_Score, Control Group 4 * FiveS_Score.

Quality

This section provides study findings in regard to the influence of the actual level of implementation of 5S on quality. The interpretations for productivity, quality and the remaining variables is constant, excluding safety based on the lack of sufficient samples. When looking at quality, the first model utilized is not statistically significant (Table 19), indicating ‘5S_Scores’ are not a significant predictor of quality.

Table 19

ANOVA Results for Model Testing on Quality

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	0,025	1	0,025	3,074	0,082[b]
	Residual	1,242	155	0,008		
	Total	1,267	156			
2	Regression	0,391	5	0,078	13,498	0,000[c]
	Residual	0,876	151	0,006		
	Total	1,267	156			
3	Regression	0,502	9	0,056	10,723	0,000[d]
	Residual	0,765	147	0,005		
	Total	1,267	156			

a. Dependent Variable: Quality

b. Predictors: (Constant), FiveS_Score

c. Predictors: (Constant), FiveS_Score, Control Group 2, Control Group 3, Control Group 1, Control Group 4

d. Predictors: (Constant), FiveS_Score, Control Group 2, Control Group 3, Control Group 1, Control Group 4, Control Group 2 * FiveS_Score, Control Group 3 * FiveS_Score, Control Group 4 * FiveS_Score, Control Group 1 * FiveS_Score

The model in Table 20 shows a significant increase on the F-statistic, indicating belonging to the different groups in this study is a significant predictor of Quality. The R^2 increases substantially from the first to the second model and then again from the second model to the third. An indication of Quality can be explained as increasing when groups are added to the model (a relationship between Quality and groups exists). Significant changes to the F-statistic, also indicate an inclusion of the variables from one model to the next, which significantly changes the explanatory power of the model, especially when noting the first model was not statistically significant, ($p = 0.082$).

If the change is significant from Model 2 to Model 3, this indicates adding interaction terms alters the power of the model. In other words, significantly different effects of 5S on productivity can be identified between groups. Table 20 shows R^2 increased from 0.309 to 0.396 from Model 2 to Model 3 and this change was significant ($p < 0.001$). The R-square change for the first model, however, was not significant at the 5% significance level ($p = 0.082$).

Table 20

Model Summary for Quality

Model Summary[d]

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	0,139[a]	0,019	0,013	0,08952	0,019	3,074	1	155	0,082
2	0,556[b]	0,309	0,286	0,07615	0,289	15,810	4	151	0,000
3	0,630[c]	0,396	0,359	0,07213	0,087	5,322	4	147	0,000

a. Predictors: (Constant), FiveS_Score

b. Predictors: (Constant), FiveS_Score, Control Group 2, Control Group 3, Control Group 1, Control Group 4

c. Predictors: (Constant), FiveS_Score, Control Group 2, Control Group 3, Control Group 1, Control Group 4, Control Group 2 * FiveS_Score, Control Group 3 * FiveS_Score, Control Group 4 * FiveS_Score, Control Group 1 * FiveS_Score

d. Dependent Variable: Quality

Table 21 presents the model coefficients. The model coefficients for all groups indicated significant positive effects on Quality when compared to the Experimental Group (positive and significant beta coefficients). The effect of 5S scores on quality also becomes significant, indicating some form of moderation is occurring. This means the effect is dependent on which group is being evaluated.

Table 21

Parameter Estimates of the Model Coefficients for Quality

Coefficients[a]

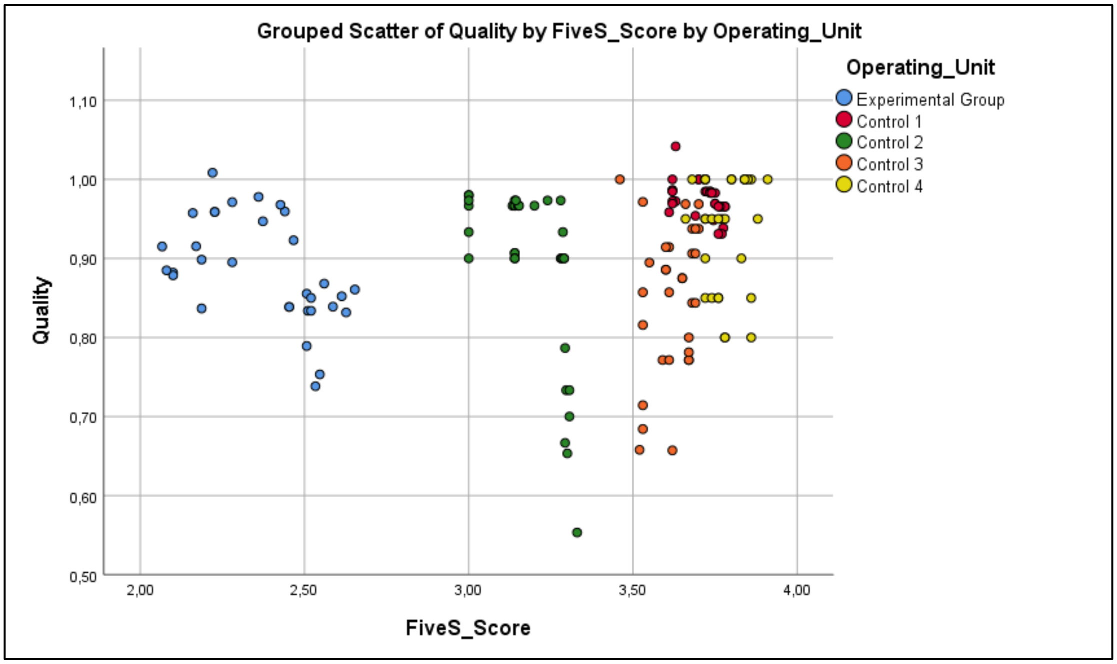
Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
1	(Constant)	0,829	0,045		18,454	0,000		
	FiveS_Score	0,023	0,013	0,139	1,753	0,082	1,000	1,000
2	(Constant)	1,433	0,136		10,559	0,000		
	FiveS_Score	-0,231	0,057	-1,378	-4,060	0,000	0,040	25,182
	Control Group 1	0,399	0,078	1,788	5,083	0,000	0,037	27,027
	Control Group 2	0,190	0,050	0,850	3,803	0,000	0,092	10,915
	Control Group 3	0,254	0,073	1,124	3,455	0,001	0,043	23,135
	Control Group 4	0,375	0,082	1,643	4,554	0,000	0,035	28,429
3	(Constant)	1,324	0,169		7,835	0,000		
	FiveS_Score	-0,185	0,071	-1,103	-2,605	0,010	0,023	43,656
	Control Group 1	0,244	0,810	1,093	0,301	0,764	0,000	3213,083
	Control Group 2	1,589	0,405	7,125	3,922	0,000	0,001	803,723
	Control Group 3	-1,473	0,730	-6,526	-2,017	0,046	0,000	2549,788
	Control Group 4	-0,573	0,808	-2,507	-0,709	0,479	0,000	3044,221
	Control Group 1 * FiveS_Score	0,025	0,225	0,419	0,112	0,911	0,000	3413,261
	Control Group 2 * FiveS_Score	-0,451	0,136	-6,447	-3,327	0,001	0,001	914,457
	Control Group 3 * FiveS_Score	0,461	0,209	7,397	2,210	0,029	0,000	2729,132
	Control Group 4 * FiveS_Score	0,234	0,221	3,865	1,058	0,292	0,000	3247,367

a. Dependent Variable: Quality

The results of the third model identified Group 2 and Group 3 as having significantly different effects of 5S on quality, compared to the effect of the experimental group. Figure 14 illustrates these differences. A decreasing pattern, or an improvement in performance, can be reasonably identified by the experimental group based on the pattern of the dots. On the contrary, the other groups visibly experienced an increase in quality scores or a decrease in performance as 5S scores increased. Similarly, the data presented another interesting observation; a contrast of the findings where the control groups are positioned on the right-hand side of the graph compared to the experimental group on the left. Where the 5S scores were higher for these groups, similarly higher quality scores and lower performance were also identified.

Figure 14

Scatterplot of Quality by 5S Score and Operating Unit



In Figures 15 and 16, the purpose is to show whether or not a normal distribution was identified. Figure 15 depicts the predicted regression line with a solid diagonal line. Small residuals can be identified using the regression line and the observations, represented by the circular dots. Additionally, a noticeable diagonal pattern indicates the residuals were close to normal.

Figure 15

P-P Plot of Regression of Quality as Standardized Residual Dependent Variable

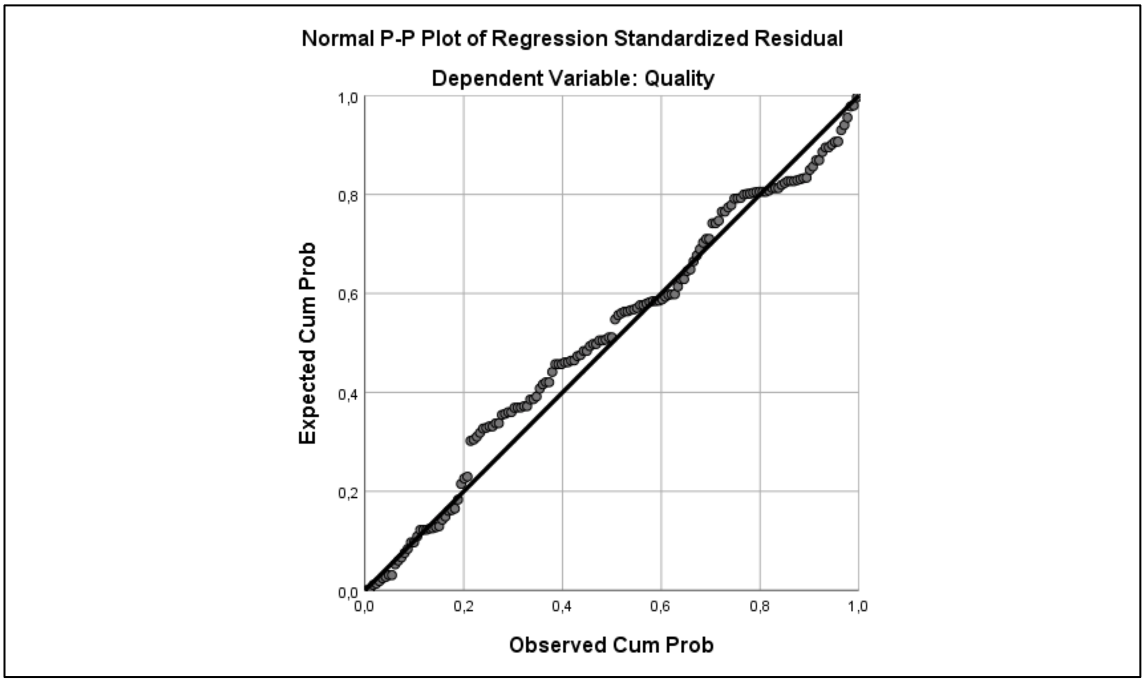
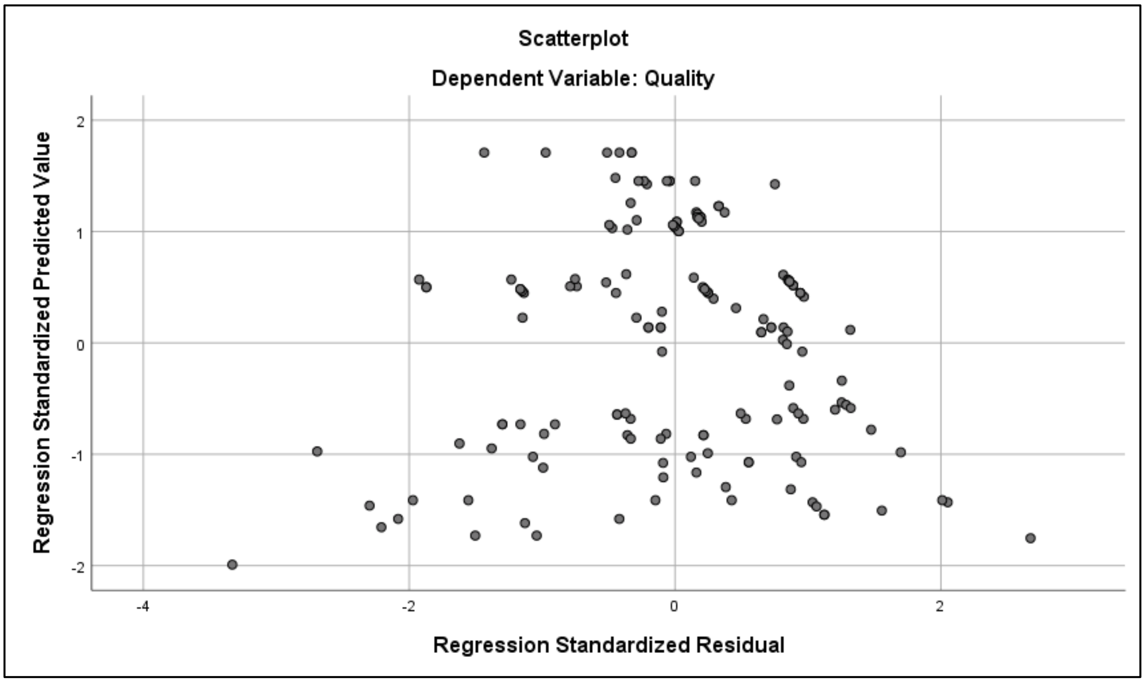


Figure 16 illustrates relatively dispersed data, with no visibly discernable pattern of the residuals plotted against the fitted values. As a result of the non-constant variance of the residuals, the data appear to be heteroscedastic. Last but not least, the data also appear to follow a relatively normal distribution.

Figure 16

Scatterplot of Regression Standardized Predicted Values for Quality



Product Cost

This section presents the study findings in regard to the influence of the actual level of implementation of 5S on product cost. Like quality, lower scores in product cost are actually more favorable. According to Table 22, all three models are statistically significant ($p < .001$).

Table 22

ANOVA Results for Model Testing on Product Cost

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	0,028	1	0,028	20,884	0,000[b]
	Residual	0,210	155	0,001		
	Total	0,238	156			
2	Regression	0,186	5	0,037	107,078	0,000[c]
	Residual	0,052	151	0,000		
	Total	0,238	156			
3	Regression	0,208	9	0,023	113,782	0,000[d]
	Residual	0,030	147	0,000		
	Total	0,238	156			

a. Dependent Variable: Product_Cost

b. Predictors: (Constant), FiveS_Score

c. Predictors: (Constant), FiveS_Score, Control Group 2, Control Group 3, Control Group 1, Control Group 4

d. Predictors: (Constant), FiveS_Score, Control Group 2, Control Group 3, Control Group 1, Control Group 4, Control Group 2 * FiveS_Score, Control Group 3 * FiveS_Score, Control Group 4 * FiveS_Score, Control Group 1 * FiveS_Score

There were significant F-changes from Model 1 to Model 2, as well as from Model 2 to Model 3. Table 23 shows a significant increase on the F-statistic. This indicates belonging to the different groups in this study as a significant predictor of product cost.

Table 23

Model Summary for Product Cost

Model Summary[d]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	0,345[a]	0,119	0,113	0,03677	0,119	20,884	1	155	0,000
2	0,883[b]	0,780	0,773	0,01861	0,661	113,473	4	151	0,000
3	0,935[c]	0,874	0,867	0,01425	0,094	27,655	4	147	0,000

a. Predictors: (Constant), FiveS_Score

b. Predictors: (Constant), FiveS_Score, Control Group 2, Control Group 3, Control Group 1, Control Group 4

c. Predictors: (Constant), FiveS_Score, Control Group 2, Control Group 3, Control Group 1, Control Group 4, Control Group 2 * FiveS_Score, Control Group 3 * FiveS_Score, Control Group 4 * FiveS_Score, Control Group 1 * FiveS_Score

d. Dependent Variable: Product_Cost

According to Model 2 for product cost, Table 24 depicts belonging to all groups as negatively related to product cost, compared to belonging to the experimental group ($p < .001$). In other words, the data indicates belonging to the control groups identified better performance in terms of product cost. The first Model indicates that 5S scores have a negative impact on product cost ($\beta = -0.025$, $p < 0.001$). The coefficients of the third model indicate the effect of 5S on product cost is significantly different for 1 ($p < .05$), 3 and 4 ($p < .001$).

Table 24

Parameter Estimates of the Model Coefficients for Product Cost

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
1	(Constant)	1,028	0,018		55,712	0,000		
	FiveS_Score	-0,025	0,005	-0,345	-4,570	0,000	1,000	1,000
2	(Constant)	0,726	0,033		21,867	0,000		
	FiveS_Score	0,101	0,014	1,386	7,234	0,000	0,040	25,182
	Control Group 1	-0,198	0,019	-2,050	-10,328	0,000	0,037	27,027
	Control Group 2	-0,065	0,012	-0,677	-5,371	0,000	0,092	10,915
	Control Group 3	-0,180	0,018	-1,839	-10,015	0,000	0,043	23,135
	Control Group 4	-0,139	0,020	-1,401	-6,885	0,000	0,035	28,429
3	(Constant)	0,868	0,033		25,998	0,000		
	FiveS_Score	0,041	0,014	0,561	2,904	0,004	0,023	43,656
	Control Group 1	-0,474	0,160	-4,907	-2,962	0,004	0,000	3213,083
	Control Group 2	-0,137	0,080	-1,421	-1,715	0,088	0,001	803,723
	Control Group 3	-1,043	0,144	-10,665	-7,228	0,000	0,000	2549,788
	Control Group 4	-1,533	0,160	-15,480	-9,601	0,000	0,000	3044,221
	Control Group 1 * FiveS_Score	0,096	0,044	3,687	2,160	0,032	0,000	3413,261
	Control Group 2 * FiveS_Score	0,038	0,027	1,246	1,411	0,160	0,001	914,457
	Control Group 3 * FiveS_Score	0,259	0,041	9,592	6,283	0,000	0,000	2729,132
	Control Group 4 * FiveS_Score	0,391	0,044	14,934	8,968	0,000	0,000	3247,367

a. Dependent Variable: Product_Cost

Figure 17 helps to visualize these differences. It can be noted the values of product cost increase sharply as the values of 5S increase for the control groups 3 and 4. This increase is significantly different from the Experimental Group, which presents a much slighter increase of values. For this reason, the p-values for the interaction terms of Group 3 and Group 4 are significant ($p < .001$). In regard to normality of residuals, Figure 18 illustrates the observations follow a diagonal pattern. This diagonal pattern closely matches the predicted regression line. With no substantial deviation, the data indicated the residuals were close to normal.

Figure 17

Scatterplot of Product Cost by 5S Score and Operating Unit

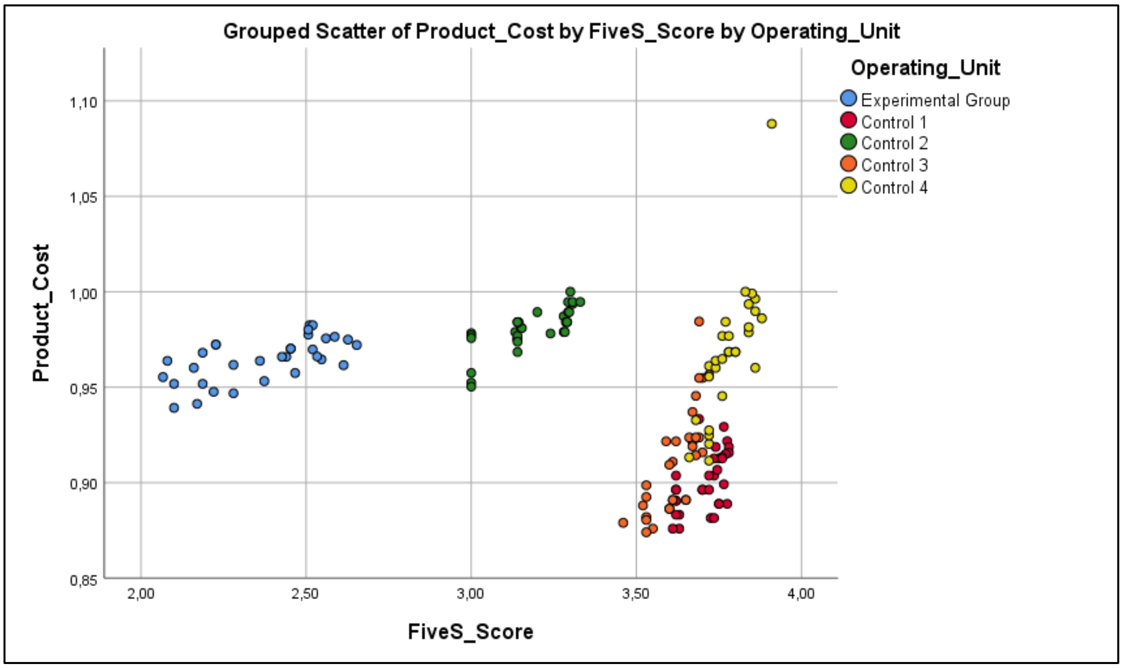
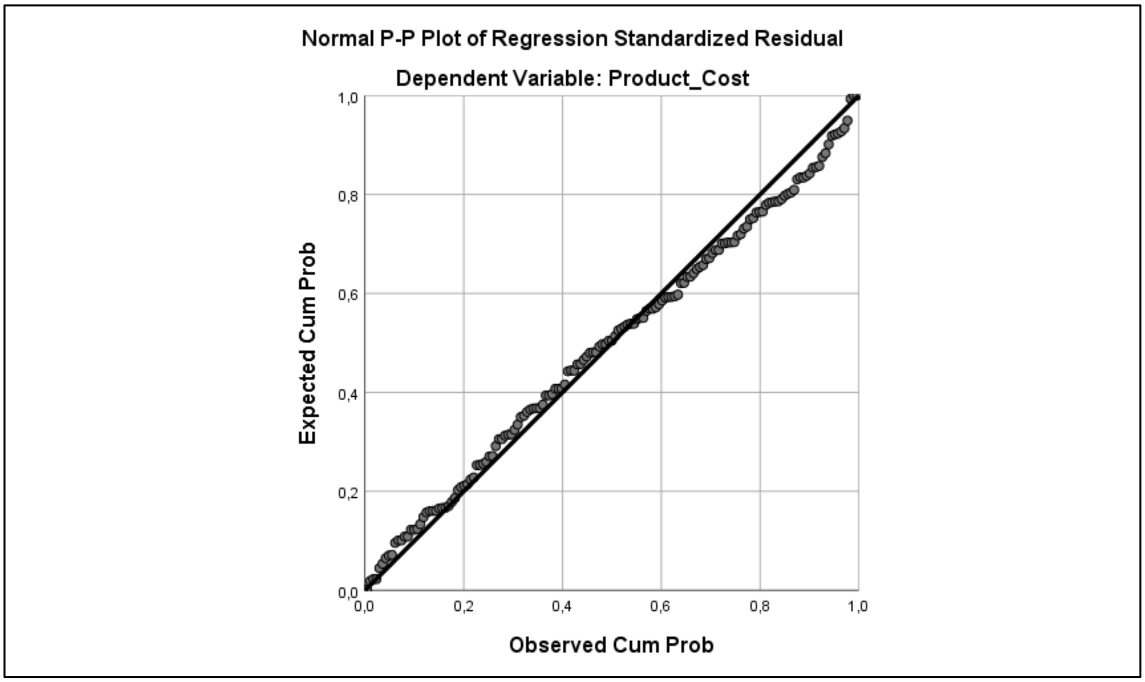


Figure 18

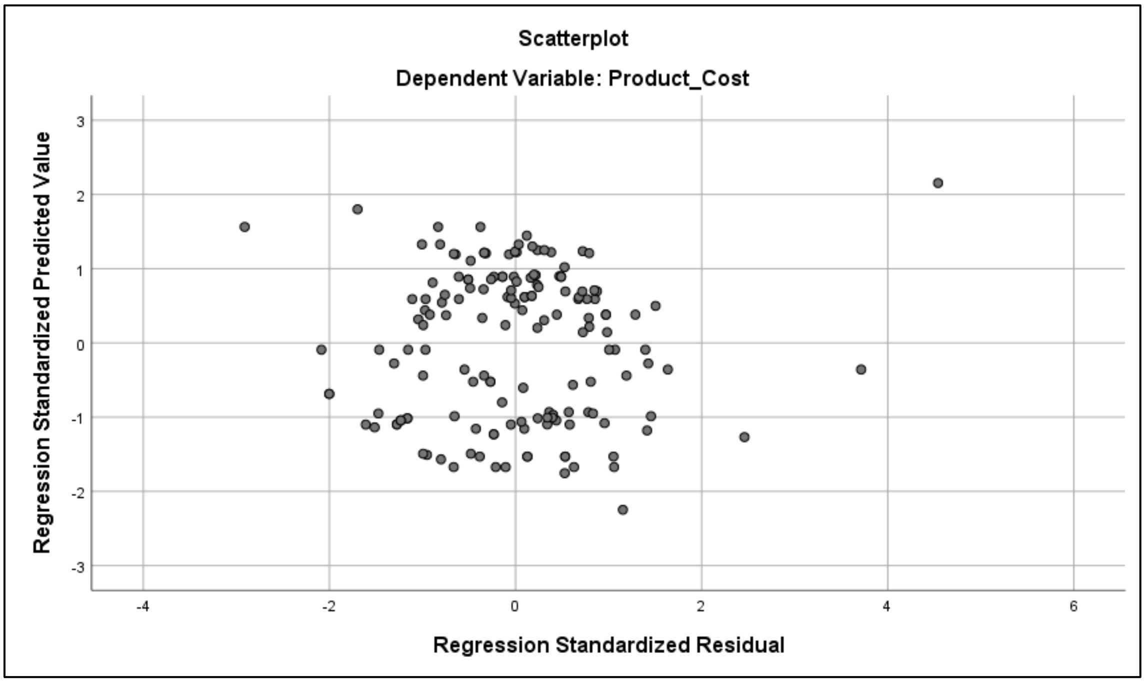
P-P Plot of Regression of Product Cost as Standardized Residual Dependent Variable



The observed data from Figure 19 appear to have some grouping. Again, this observation does not invalidate the results of the model. Instead, this is something to be presented and taken into consideration when interpreting the results. In this situation, the data is still scattered enough for the model to be helpful in interpreting results.

Figure 19

Scatterplot of Regression Standardized Predicted Values for Product Cost



Maintenance Cost

This section presents the study findings in regard to the influence of the actual level of implementation of 5S on maintenance cost. Like quality and production costs before, lower scores in maintenance cost are favorable. According to Table 25, all three models are statistically significant ($p < .001$).

Table 25

ANOVA Results for Model Testing on Maintenance Cost

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	0,029	1	0,029	142,613	0,000[b]
	Residual	0,031	155	0,000		
	Total	0,060	156			
2	Regression	0,038	5	0,008	52,737	0,000[c]
	Residual	0,022	151	0,000		
	Total	0,060	156			
3	Regression	0,040	9	0,004	32,264	0,000[d]
	Residual	0,020	147	0,000		
	Total	0,060	156			

a. Dependent Variable: Maintenance_Cost

b. Predictors: (Constant), FiveS_Score

c. Predictors: (Constant), FiveS_Score, Control Group 2, Control Group 3, Control Group 1, Control Group 4

d. Predictors: (Constant), FiveS_Score, Control Group 2, Control Group 3, Control Group 1, Control Group 4, Control Group 2 * FiveS_Score, Control Group 3 * FiveS_Score, Control Group 4 * FiveS_Score, Control Group 1 * FiveS_Score

Similarly, in regard to the model for product cost, there were significant changes on the F-statistic (and consequently in the R^2) on all the hierarchical models. Table 26 shows R-square increased from 0.692 to 0.797 from Model 1 to Model 2 and this change was significant ($p < 0.001$). The R-square change for the last model, was also significant at the 5% significance level ($p < 0.001$).

Table 26

Model Summary for Maintenance Cost

Model Summary[d]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	0,692[a]	0,479	0,476	0,01416	0,479	142,613	1	155	0,000
2	0,797[b]	0,636	0,624	0,01200	0,157	16,243	4	151	0,000
3	0,815[c]	0,664	0,643	0,01168	0,028	3,065	4	147	0,018

a. Predictors: (Constant), FiveS_Score

b. Predictors: (Constant), FiveS_Score, Control Group 2, Control Group 3, Control Group 1, Control Group 4

c. Predictors: (Constant), FiveS_Score, Control Group 2, Control Group 3, Control Group 1, Control Group 4, Control Group 2 * FiveS_Score, Control Group 3 * FiveS_Score, Control Group 4 * FiveS_Score, Control Group 1 * FiveS_Score

d. Dependent Variable: Maintenance_Cost

In contrast from most of the previous analyses, there were not many differences between groups in terms of their effects on maintenance cost. Only Control Group 4 had a significant negative (improvement) effect on maintenance cost compared to the experimental group, controlling for 5S scores and the effects of the other groups. In regard to the interaction terms, the effect of 5S on maintenance cost is significantly different for Groups 2 and 4 in comparison to the experimental group, which can be seen in Table 27.

Table 27

Parameter Estimates of the Model Coefficients for Maintenance Cost

Coefficients[a]

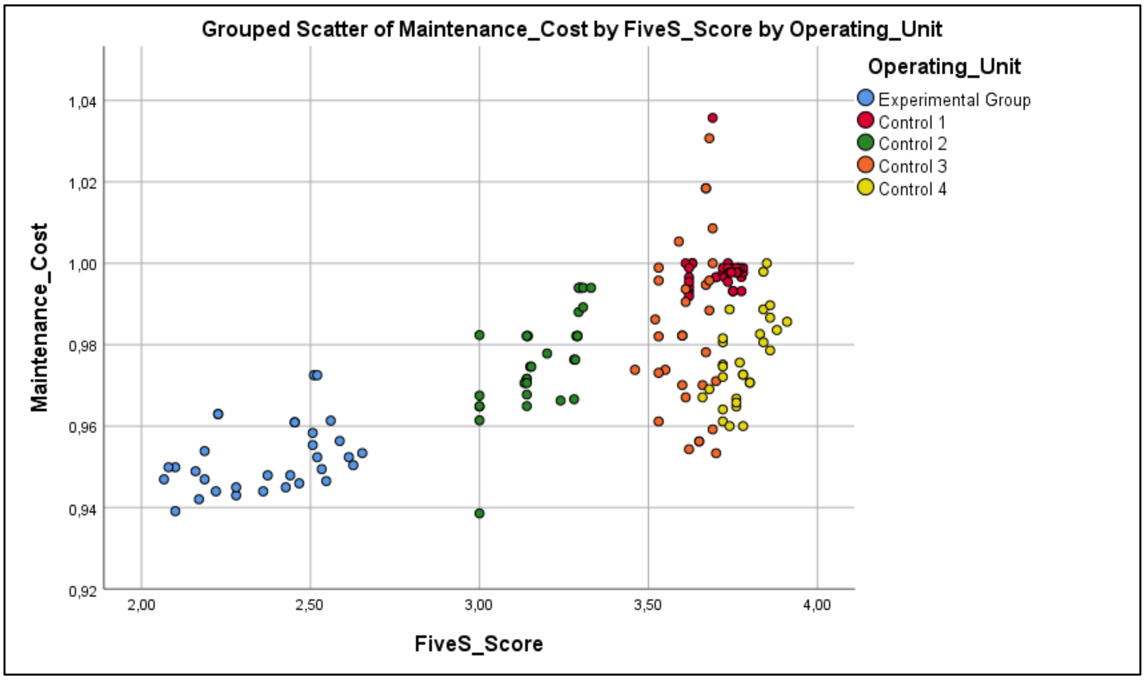
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	0,894	0,007		125,776	0,000		
	FiveS_Score	0,025	0,002	0,692	11,942	0,000	1,000	1,000
2	(Constant)	0,866	0,021		40,502	0,000		
	FiveS_Score	0,036	0,009	0,996	4,043	0,000	0,040	25,182
	Control Group 1	-0,002	0,012	-0,048	-0,188	0,851	0,037	27,027
	Control Group 2	-0,005	0,008	-0,102	-0,631	0,529	0,092	10,915
	Control Group 3	-0,014	0,012	-0,281	-1,190	0,236	0,043	23,135
	Control Group 4	-0,027	0,013	-0,543	-2,074	0,040	0,035	28,429
3	(Constant)	0,911	0,027		33,296	0,000		
	FiveS_Score	0,017	0,011	0,477	1,510	0,133	0,023	43,656
	Control Group 1	0,096	0,131	1,978	0,730	0,467	0,000	3213,083
	Control Group 2	-0,176	0,066	-3,640	-2,685	0,008	0,001	803,723
	Control Group 3	-0,074	0,118	-1,516	-0,628	0,531	0,000	2549,788
	Control Group 4	-0,321	0,131	-6,479	-2,456	0,015	0,000	3044,221
	Control Group 1 * FiveS_Score	-0,020	0,036	-1,505	-0,539	0,591	0,000	3413,261
	Control Group 2 * FiveS_Score	0,059	0,022	3,856	2,667	0,009	0,001	914,457
	Control Group 3 * FiveS_Score	0,023	0,034	1,716	0,687	0,493	0,000	2729,132
	Control Group 4 * FiveS_Score	0,085	0,036	6,473	2,376	0,019	0,000	3247,367

a. Dependent Variable: Maintenance_Cost

Figure 20 shows the effect of 5S scores on maintenance cost appears to increase for these control groups in comparison to the experimental group (dots increasing more intensely). It is interesting to note again, this means worse performance was identified in the groups where 5S scores were higher. Looking closer, Control Group 3 even identified several instances of exceeding the limit targets.

Figure 20

Scatterplot of Maintenance Cost by 5S Score and Operating Unit



The P-P plot and scatterplot of residuals indicate slight nonconformity to the requirements of normality. In Figure 21, there is a distinguishable deviation from the diagonal pattern of a normal distribution. Similarly, in Figure 22, there is noticeable grouping, thus both visuals should be considered.

Figure 21

P-P Plot of Regression of Maintenance Cost as Standardized Residual Dependent Variable

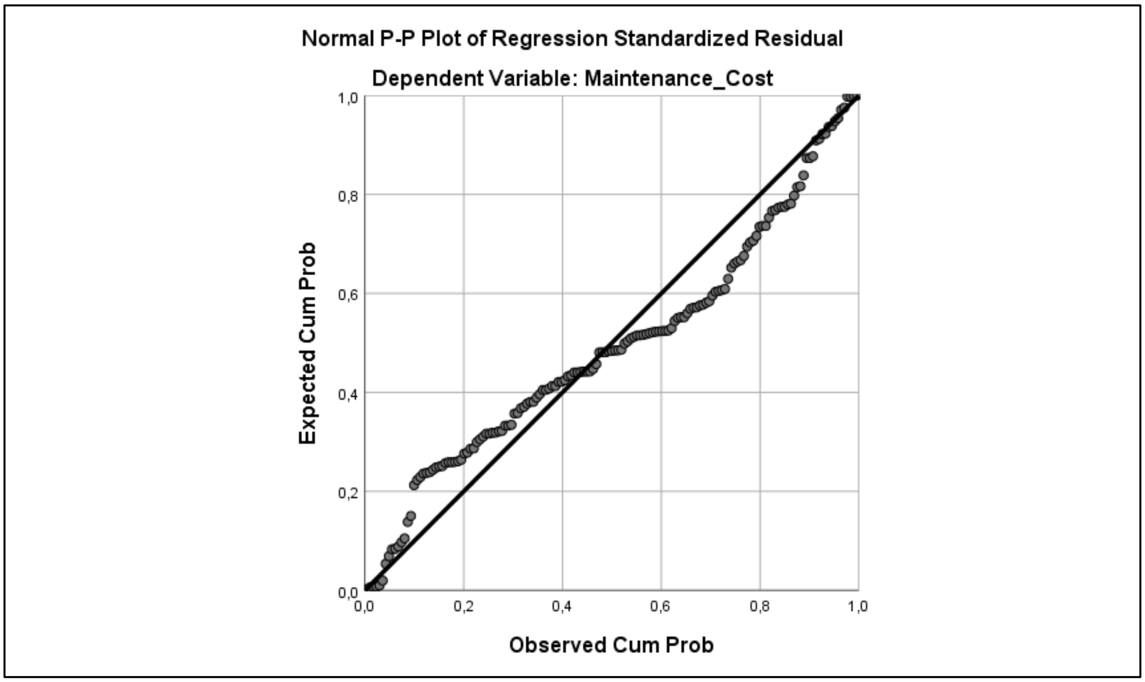
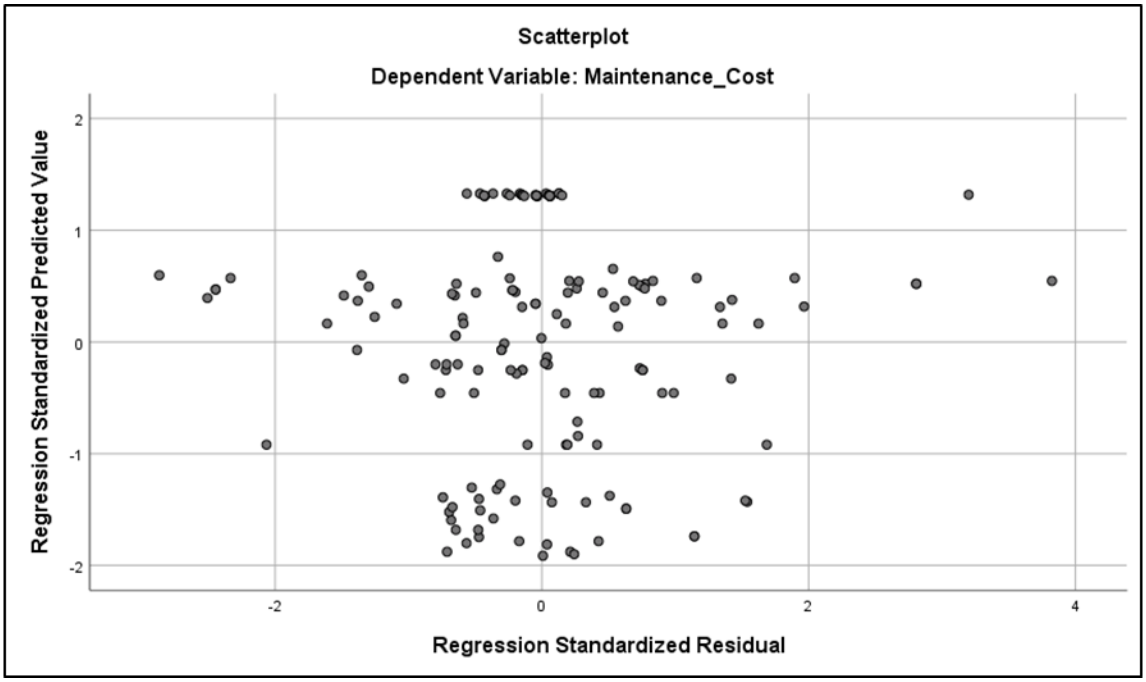


Figure 22

Scatterplot of Regression Standardized Predicted Values for Maintenance Cost



Relevance and Review

When looking at Research Question 1, the findings of this study differ from the Hutchins' (2006) study. As mentioned above and summarized in Table 28, with exception to productivity measures and safety, the remaining KPI studied identified statistically significant influences on productivity in the facility studied. With differing values and findings from the Hutchins' (2006) study, this identifies the potential for additional underlying influences, currently not properly measured. With the intent to build on previous studies, additional influences were measured by adding additional statistical analyses to the actual 5S scores of the operating units.

Table 28

Summary for Research Question 1

Focus Area	Results	Significance	Significance
Productivity	No difference	No	p = 0.065
Safety	Model ineffective	N/A	N/A
Quality	Means decreased, showed performance improvement	Yes	p < .001
Production Cost	Means increased, showed decline in performance	Yes	p < .001
Maintenance Cost	Means increased, showed decline in performance	Yes	p < .001

The data from Research Question 2 identified statistically significant results with team members, but not with the management in the facility studied. The data also indicated higher scores in the experimental group for management, 3.4917 compared to 3.2300 for control groups and lower scores for employees, 3.321 compared to 3.355 for the control groups. In that regard, it is interesting to further understand what influences in the organization or organizations in general allow for data distinguishable dichotomies between employees and management when looking at the implementation of 5S. Although the total mean scores for both groups were relatively close with a score of 3.33 for employees and 3.38 for management, the bigger gap was noticed between the groups. Concisely, the data illustrated further study is necessary with results from management and employees at odds by having the experimental groups showing different findings and the management data being statistically insignificant. The next question to better understand is what contributing factors allowed this to happen and to better understand the gap between the two. Fortunately, the study identified an overall positive attitude for this facility.

When looking at those additional analyses, it is important to note the value of the various approaches utilized in this study. For example, it has been determined the interactions of various influences take precedence over main effects as a result of the interactions integrating deeper, more complete details than main effects (Gamst, et al., 2008). Being able to make further inference from specific data allows for researchers to reduce the likeliness of generalization, particularly in situations like this study, where other influences and factors may better explain different outcomes (Gamst, et al., 2008).

As previously mentioned, the findings of these influencing effects identified a deeper understanding to the research question. These analyses provided information to raise additional questions. In terms of productivity, the influence of 5S was highly identifiable when looking closer at groups. This allows one to increasingly look for other potential variables explaining the differences between the groups, such as leadership styles, work content, environment, etc.

When looking at quality, the data indicated visibly recognizable influences based on the different groups. Visibly depicted in Figure 14, was a decreasing quality score or an improvement in performance in the experimental group with differing results in the other groups. Where the 5S scores were higher for the control groups, similarly higher quality scores and lower performance were also identified. Again, intuitively, there are additional influences impacting the effects greater than the implementation of 5S alone.

The data for product cost also offered interesting influences. The control groups, with notably higher 5S scores, also indicated lower product costs. In this situation, the results may match corresponding expectations, but also open additional opportunities for research on various levels. For example, there are additional potential influences allowing the control groups to have higher 5S scores, and it would be beneficial to understand what they are. Additionally, the product costs in general were favorable, and there are potentials for utilizing concepts like the Pareto Principle to positively influence multiple factors at the same time (Juran, 1954). Understanding such influences could possibly explain why Control Groups 1 and 3 incurred such low product costs compared to the other groups.

Lastly for productivity, the maintenance cost data illustrated an increase in the scores for the control groups compared to the experimental group, even increasing with intensity as the 5S scores increased. Again, this counterintuitively illustrated worse performance identified in the groups where 5S scores were higher. Improvements in 5S typically mean equipment, and the areas that house them, are better maintained; therefore, understanding what influences an increase in maintenance costs despite these improvements could be promising to unlock with additional performance improvement initiatives.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Being lean is not the summation of multiple activities and projects (Liker & Meier, 2006). Similarly, the impacts of lean activities and projects typically are not directly transferable or even sophistically measurable for true long-term and short-term impacts. For that purpose, it is pertinent to look holistically at situations and practice share where relevant but be sure to focus on organizational needs in order to determine what must be done in order to reach target conditions (Rother, 2010). This section focuses on the conclusions of this study and offers key recommendations for future research and practical implications.

Discussion of Findings

This study illustrated 5S implementation can produce organizational improvements in the researched facility. To accomplish this task, the research sought to identify findings for the impacts of 5S on all five measures of productivity and attitudes. In the particular facility studied, there were several contributing lessons learned, which allowed for the body of knowledge on this topic to be expanded. These lessons offer various points for discussion.

In this study, statistically significant improvements from the implementation of 5S were found both in quality and product cost for this facility; however, the study also found statistical significance where the implementation of 5S led to a decrease in performance and an increase in maintenance costs. With that said, the business impact of the non-significant findings could still be impactful. In other words, it is suggested to not immediately discredit findings that were not statistically significant.

There are various influences to consider in terms of the suggestion to take the information learned from the study in its entirety and not limit one's utilization to what is statistically significant. The first influence to consider is the duration of the study. Despite other studies sharing the time frame, it may not have been long enough to capture the real effects of the implementation.

Some people have used the phrase “base rate” to bring attention to the start conditions of the analysis, but to do so requires understanding various events may have already taken place for the given outcome to occur (Chinco, et al., 2021). Indeed, there are statistical analyses designed to attempt to consider such phenomena, but there is still much to learn (Chinco, et al., 2021). For example, other studies have found positive relationships exist between empowerment and sustainability in sustained continuous improvement efforts like 5S over time, but they often found time lag between realizing desired results (Hirzel, et al., 2017). This means if the study were extended over longer periods of time, the data could potentially change and offer different lessons. This is particularly valid when considering attitudes where change is often met with underlying resistance to change (Kegan & Laskow Lahey, 2009).

Employees and management are always related, and although this study frames team members and management separately, this is only done with the intent of understanding perception differences. In fact, people often sub-consciously protect themselves from change, often in ways that make change more difficult (Kegan & Laskow Lahey, 2009). Working together and understanding the positive relationships between management and employees is critical for any organizational initiative, particularly when examining the efficacy of change (Kegan & Laskow Lahey, 2009). It should be noted, change is not only limited to processes, but also mindsets.

Positively, research has verified mindsets can change and team members, specifically, have the ability to change their mindsets towards new behavioral patterns within an organization

(Hirzel, et al., 2017). A lot of this is influenced by team member empowerment and most team member empowerment has been identified as taking place increasingly during the initial phases of programs (Hirzel, et al., 2017). In other words, looking at the results of this study requires also considering the various influences in the literature review like organizational culture in order to highlight critical influences on specific successes.

Similarly, it should also be noted time investments at different durations could be a factor. The roll-out phases have been identified as the primary time when knowledge transfer occurs to team members, but this is only where the changes begin (Hirzel, et al., 2017). Team members often overcome time constraints when improvement activities are accepted as part of their responsibilities (Rother, 2010). They are also able to expand their capabilities in situations where they are able to maximize collective problem solving between team members, as individuals (Hirzel, et al., 2017).

The process improvement loop is strengthened as the team members perceived levels of improvement increasing with support from organizational leadership; however, there is often a gap between perceived successes and actual successes as subjective perceptions lag behind objective actual implementation (Hirzel, et al., 2017). As a result, a heightened focus on team member empowerment with leadership support can truly help behavioral change towards improvement initiatives, particularly during initial program phases (Hirzel, et al., 2017). That said, leadership must embrace and prepare themselves for long-term engagement and involvement as improvement initiatives take time to become robust (Hirzel, et al., 2017).

Looking at some of the specific productivity measurements, quality is, and should also always be, a priority (Deming, 1986). As a functional measurement of productivity, effective quality control mechanisms positively influence organizational productivity by reducing energy consumption, environmental impacts, quality losses, and increasing overall economic benefits (Guo, et al., 2020). In other words, it can be stated quality may have a Pareto principal effect, where solving quality issues can help resolve other issues (Juran, 1954).

Both practitioners and researchers can benefit from further understanding the various levels and influences of product quality, as research has shown it can heavily influence production, quality, and maintenance across all of the manufacturing processes (Bouslah, et al., 2018). After positive and well-managed 5S implementation, organizations have seen increased product quality with improvements in excess of 40%, which have likewise optimized financial savings (Hussain, 2019). Quality improvement and manufacturing costs are frequently related, and those impacts are also subjective to outside influences, such as competitive pressure and consumer demand (Li, et al., 2018). It is also important to note there are multiple process variables with different economic effectiveness when considering quality improvement (Xiao, et al., 2019).

Although the Hutchins (2006) study indicated it is unlikely for the implementation of 5S to impact maintenance costs, with insignificant influences identified before and after implementation, the topic again should not be rejected based on the statistical findings alone. This is because the influence of 5S on maintenance costs can be intuitive as a cleaner and more organized workspace allows for faster issue identification. Fortunately, this study found the experimental group was identified to have the lowest maintenance costs.

Referencing back to the rate, this study received and provided minimal information regarding the active situations regarding the equipment in the different operating units. This suggests the need for a broader perspective, particularly when monitoring equipment along a given life cycle. There are three phases to equipment life cycle: Burn-in, Useful life, and Wearout. Each is associated with its own specific failure modes, offering different solutions for those problems (Tsarouhas, 2012) and allowing faster issue identification through 5S, which can dramatically improve equipment management (Imai, 1986; Womack, et al., 1990).

Without question, many specific actions can be levers to influence various KPI. For instance, maintenance costs can be strongly associated with equipment reliability and, if production facilities operate with higher reliability, a reduction of costs associated with equipment failure can be expected (Tsarouhas, 2012). Effectively measuring the cost of a production facility using facility and equipment reliability puts costs into a clear business context for tracking and measuring (Tsarouhas, 2012). When pieces of equipment with high failure rates are identified, they must be further addressed in order to extend the equipment life cycle (Tsarouhas, 2012). This, again, strengthens the idea of a deeper understanding of base rates.

In general, the lower reliability of upstream processes negatively influences downstream processes and the ability to produce, which, inevitably, negatively influences product costs (Bouslah, et al., 2018). Preventive maintenance strategies like 5S in congruence with enhanced quality control mechanisms on both equipment and products improves both the performance of the equipment and the ability of the facility to produce (Bouslah, et al., 2018). Proactive maintenance systems are typically better than other maintenance systems; however, economic benefit may not be easily justified depending on the uniform applications utilized in the operations system (Linnéusson, et al., 2020). As a result, it is necessary to balance the complex feedback to justify when a particular type of maintenance is required (Linnéusson, et al., 2020).

Proactive maintenance can prevent failure by restoring functional usage prior to failure, which can inevitably reduce downtime, maximize production time, and potentially reduce additional costs related to damage from equipment failure (Linnéusson, et al., 2020). The ability to implement this level of process understanding is not often prevalent in operations, however, it can be done by gaining an aggregate perspective of individual processes from a systems perspective (Linnéusson, et al., 2020). To bring this back full circle, further integrating quality control between stages has the potential to both improve outgoing quality and mitigate poor quality on the reliability of downstream equipment, which also influences maintenance costs (Bouslah, et al., 2018).

In summary, there was a lot to be learned from this study, but it is evident there is still a substantial amount of research to be done in this field. Looking at KPI, it is important to measure what they are expected to measure and that they do so in a manner that is mutually exclusive and collectively exhaustive (Rasiel, 1999). It is suggested to look at the findings of this study in their entirety to both benefit practical use, as well as support future research.

Limitations of the Study

As previously noted, this study was conducted during a pandemic. This means there was the potential for unidentifiable influences to have altered the outcome of the study. It has been determined operations environments often operate under conditions where short-term situations trigger rapid responses that can hinder or slow down strategic activities (Linnéusson, et al., 2020). The problem with the pandemic is that those influences may not have yet been identified as the circumstances and lessons related to the pandemic are constantly changing as the body of knowledge on the topic grows.

Another interesting result of the pandemic was the noted contributions to the study. For example, specific time was allocated for the entire staff to receive vaccines or provide medical reasoning as to why they were unable to receive the vaccine. On the one hand, this led to an unprecedented 99.8% response rate to the survey where 3,654 of the 3,660 operating units' total staff contributed to the survey. On the other hand, the financial implications of this lull in production were not entirely scrubbed from the data as a result of a lack of an ability to do so. Therefore, there were two separate instances of two-week periods with potentially undocumented downtime through slower production speeds of the same workforce.

Implications for Professional Practice

The data of this study found relationships between attitudes, productivity, and 5S, which, in some situations, may not be considered significant. However, when this information is connected to real business or practical significance, every opportunity for efficiency savings can contribute tremendously. The concept of practical significance emphasizes a focus on the impact and usefulness in real world applications (Kirk, 1996).

When considering this sort of research, it is important to study concepts like scaling because implementation can be costly, but in large volumes, what may have been deemed insignificant could be quite the contrary (Kirk, 1996). For example, small savings per unit can create incredibly valuable savings if those items are produced in high volume. In those instances, it is important to verify the research is answering the proper questions related to the practical implementation and, if possible, to better determine if null hypothesis testing is even relevant to those incredibly high-volume situations (Kirk, 1996). Perhaps there are several other benefits identified outside of this 95% confidence interval; it is important not to reject any improvements on critical items like safety.

Similarly, it is important to consider operational impacts, which have been further studied to incorporate a utilization of small, medium, and large impacts to further measure and clarify impacts (Kirk, 1996). In this study, the value of improved 5S illustrated a higher influence on the measurements of productivity rather than the adopted method of how the 5S was promoted. With that said, it should, and must be stated, a critical element to the successes of the team can be directly associated with how the teams' function, as well as how their leaders lead.

There are risks of attributing success and failure to factors outside of what is measured, including differences between the circumstances and the leaders managing the changes (Reinertsen, 1999). For example, leaders who set the stage for improved communication with higher team participation and productive responses allow for environments of heightened psychological safety, which help stimulate changing thoughts and enhancing participation (Edmondson, 2019). Setting the stage is important, but so too is the way success is measured.

KPI have been mentioned continually throughout this study because it is incredibly important for the introduced and utilized KPI to be useful and directly linked to the pursued outcomes in order to clearly explain impacts and influences to the processes and the overall organization instead of focusing only on specific areas and equipment (Kang, et al., 2016). The developed KPI must be available directly in the workspace and must be used to continually validate and verify results, so as to also continually refine and improve the KPI (Kang, et al., 2016). In addition to the KPI, previous studies also highlighted the need to improve the audit and assessment models in order to ensure implementation of related improvement elements (Kurdve, et al., 2014).

The overall influence on both the workplace environment and the environment as a whole must be monitored and specifically assigned to operative managers (Kurdve, et al., 2014). KPI should be associated with specific stakeholders in order to validate and justify the return on investment but must also be audited and evaluated for expected achievements (Kurdve, et al., 2014). Often, lean and continuous improvement tools are developed out of necessity, used by subject matter experts and not general operative staff (Kurdve, et al., 2014).

Continuous improvement initiatives frequently require expansions on team member roles and responsibilities to ensure sustainment (Kurdve, et al., 2014). Understanding when and how to do this is critical but is certainly dependent on various factors. Some of them could even be industry or facility specific based on wide-ranging influences like collective bargaining agreements. It is necessary to constantly monitor and implement overarching frameworks for operational and strategic views in order to create an environment conducive to informed decision making (Linnéusson, et al., 2020).

Along with the Internet of Things and other advanced information systems, organizations are able to truly capitalize on better integrating performance standards as part of their operations systems (Luz Tortorella, et al., 2019). This allows for seamless integration of KPI monitoring as it relates to performance in real-time, however, it also has the potential to anticipate potential problems to maintain stable flow in the systems (Luz Tortorella, et al., 2019). Again, to best lead any organization, the best data is said to be mutually exclusive and collectively exhaustive (Rasiel, 1999).

Safety should always be a priority. This is sometimes difficult to measure (as noted from this study), but it is important not to fall into complacency from a lack of data. Items related to safety are not exclusively compliance or legal requirements so require additional focus utilizing the process improvement techniques of driving productivity and quality solutions (Schwerha, et al., 2020).

Safety is often a priority metric for organizations, and it is ideal to integrate systems that simultaneously consider safety, productivity, and quality to ensure safety is not overlooked or understated in both process management and process review (Schwerha, et al., 2020). Focusing initiatives and efforts on safety allows for improved communication, which in turn can positively influence safety, productivity, and empowerment of team members (Schwerha, et al., 2020). Topics like safety and quality are things employees can truly get excited about. Similarly, they are also topics that could have impacts or influences on other aspects of the organization.

For team members, safety is always a priority. By demonstrating a prioritization of safety to establish an injury-free environment, organizations have been shown to improve team member attitudes and commitment towards awareness and responsibility (Ablanedo-Rosas, et. al, 2010). This positive attitude could very well be transferable and could build on the successes of initiatives like 5S. The data analysis of previous 5S implementation studies show vast reductions in both the frequency of accident occurrences and incidents of injury in the workplace (Randhawa, et al., 2017).

Again, connecting initiatives with team and management is critical. With a roughly 54% increase in team member acceptability, 5S initiatives driven from identified 5S problems have shown to be far more successful (Hussain, 2019). Additionally, there have been qualitative improvements associated with improved 5S including growth with team member character, leadership, cooperation, and even self-esteem (Hussain, 2019). Qualitative relationships with waste reduction in both processes and actual dunnage, as well as energy consumption, have been linked to improved 5S implementation (Hussain, 2019). Likewise, these contribute to ecological and community impacts (Hussain, 2019).

Looking more closely at societal impacts, the costs related to neglecting safety or not prioritizing potential safety efforts continue to reach beyond high financial costs and stretch into social costs to the perspectives of team members and customers (Marria, et al., 2014). In many instances, workplace injuries and fatalities could have been avoided if processes were specifically defined, properly displayed, and strictly adhered to by organization personnel

(Marria, et al., 2014). Knowing consumers and organizations are linked so closely to such topics, it becomes clear why extra efforts should be made. Using 5S as a means to bridge these various topics makes sense, especially when improvements in 5S also leave positive impressions with visiting customers (Randhawa, et al., 2017).

Recommendations for Future Research

Different organizations have applied various approaches for continuous improvement activities, and it is useful to identify the impacts of how they affect universally prioritized KPI on safety, quality, delivery, and costs (Netland & Sanchez, 2014). It is also interesting to further study if there are any prevalent models or roadmaps to improve the implementation of continuous improvement strategies using development, deployment, management, and sustainment as efficacy measures (Netland & Sanchez, 2014). For that purpose, it is helpful for researchers to utilize standardized audits and analyses in future studies.

One way to start such a process is to utilize already identified and shared tools. For example, future studies could benefit from utilizing the same audits and building larger and longer data sets for comparative analysis. Although the organization studied was unable to share their internal audit, others have already developed useful and practical 5S audits to be shared for future studies (Whitman, et al., 2014). There have also been incredibly thorough audits and checklists established to analyze the proper behaviors and processes conducive to effectively establishing lean cultures (Mann, 2015). Using the same audits across multiple organizations could help better identify prevailing influences of more successful organizations and 5S programs.

Team members in previous studies, who were initially reluctant to participate with self-interested topics like safety, have been transformed into contributors when a clear and safe focus has been provided (Schwerha, et al., 2020). Individuals constantly make unconscious decisions based on their environment and experiences where they do not sufficiently value the future or their potential contributions to maintain a presumed image in the organization (Edmondson, 2019a). It is interesting to note, this is not limited to individuals. Often, work groups, teams, and organization act as individual units and unknowingly inhibit specific changes they desire (Kegan & Laskow Lahey, 2009). Therefore, enhancing two-way communication for improvement initiatives is necessary, as constraints on communication inhibit empowerment efforts at various levels in the organization (Ablanedo-Rosas, et. al, 2010). Organizations can capitalize on improvement initiatives by establishing specific meetings for collaborative learning through organized knowledge exchange (Glover, et al., 2015). Future research can benefit through maximizing enhanced surveys on management and team member attitudes by streamlining the survey and adding specific questions on leadership and organizational culture.

This research does not incorporate how target achievements or shortfalls are addressed, particularly in regard to their perceptions on the influence of 5S on their work. Future research could integrate how the status is handled, particularly on whether feedback is presented as appreciation, if failure is destigmatized, and if there are clear punishments for blatant violations (Edmondson, 2019b). Seeking out contradictions, as well as further circumstances of enhanced effects without identified causes or vice-versa, indicate the need for more data and repeated studies (Reinertsen, 2000).

In order to attain the changes leadership seeks to instill in their organization, the organizational culture must emphasize a developmental stance and must understand that the way in which change is perceived could further enhance transformation (Kegan & Laskow Lahey, 2009). Understanding the organization’s philosophies and leadership and how it is integrated into the organization are critical, as work orientation cannot be limited to the perceptions of one department: for example, a quality department or initiative (Ablanedo-Rosas, et. al, 2010). Elements of what the organization prioritizes must be traceable in the organizational philosophy, where items like quality are included and 5S is not minimized (Ablanedo-Rosas, et. al, 2010). Similarly, understanding the level of commitment from top management, and whether it has been considered in things like organizational strategic planning, can truly help further the understanding of how important the philosophy is in an organization (Ablanedo-Rosas, et. al, 2010). Other studies have drawn similar conclusions to further measure 5S with related success factors including the commitment from top management and team member perception on the commitment to the philosophy (Ablanedo-Rosas, et. al, 2010).

As previously noted, time and duration are longstanding attributes needing further development. Other studies emphasize the importance of maintaining efforts with commitment and follow-up as key contributors of the successes associated with 5S (Ablanedo-Rosas, et. al, 2010). In order to do so, it is important to sustain 5S culture over a long period of time and validate a relationship with strategic planning (Ablanedo-Rosas, et. al, 2010). There are various aspects, such as management engagement, learning, and stewardship, which wax and wane the effectiveness of improvements over time (Glover, et al., 2015). Moreover, a continuation of improvement events also enhances the effectiveness of follow-up improvements with a potential of compounding effects (Glover, et al., 2015).

In addition to being able to successfully complete fundamental job requirements, team members and management alike must embrace, be trained, and be expected to utilize continuous improvement techniques as part of their normal functions (Ablanedo-Rosas, et. al, 2010). In the literature review, the gap between how different geographic areas embrace 5S was introduced, but research shows further development and enrichment of the philosophy and how it is embraced as a lifestyle needs further development (Ablanedo-Rosas, et. al, 2010). More awareness of what influences allow 5S thinking to be embraced as a way of life rather than as a tool in places like Japan versus other locations can truly benefit the more appropriate spread of 5S (Ablanedo-Rosas, et. al, 2010). For this purpose, it is proposed future studies utilize 5S practice as a success factor to be measured and monitored for continuous improvement methodologies (Ablanedo-Rosas, et. al, 2010).

Previous research has shown specific leadership approaches like collaboration, consultation, ingratiation, inspiration, and rational persuasion make the commitment to continuous improvement more likely (Lam, et al., 2015). These approaches can help strengthen work relationships. Improved work relationships contribute to improved organizational outcomes (Lam, et al., 2015). Although it is easy to become preoccupied with the technical aspects of management, it is critical to also maintain a focus on the behavior aspect (Lam, et al., 2015). It is equally likely a highly motivated and engaged workforce with limited technical knowledge or a highly technical, wholly unmotivated, and non-committal workforce will fail (Lam, et al., 2015).

Although the attitudes are captured, the impacts of productive responses are missing and research has shown helping individuals understand, appreciate, and embrace specific challenges allows for a maximization of team member commitment and contribution (Edmondson, 2019b). A failure to insufficiently “speak up” or draw attention to specific items, such as safety, can be hazardous, and in many circumstances the resulting harm could have been prevented (Edmondson, 2019b). In different parts of the world, there are prevailing cultures of silence. Seeking to determine the level of psychological safety of the organization and researching the influence of psychological safety on 5S integration could be fruitful in establishing ideal conditions for 5S improvement.

Additionally, creating learning and transformative workplaces involves psychologically safe environments, often enriched with intense and uncommon levels of engagement and experimentation (Edmondson, 2019b). Seeking to research and provide a better understanding of the environment could also further explain the reasons why there are gaps in attitude and 5S in an organization. This is even more urgent of a research topic, noting quality improvement is directly linked to an organizational culture’s ability to implement such practices (Baird, et al., 2011).

Likewise, improvements to future studies could be made by understanding if the organizations seeking transformation are encouraging learning. The Toyota organization adopted a three-step methodology to safeguard organizational learning by incorporating experimentation in order to identify what works and what does not work, deriving implications and lessons from practical experience to establish knowledge, as well as by establishing measurements to distinguish facts from opinion (Balle, et al., 2019). Future studies could assess and validate whether or not such activities are taking place along with the adoption and implementation of 5S.

Learning should not be limited to individuals, but instead should focus on the ability of teams and different groups within the organization to be able to collectively share and learn through collaborations (Baird, et al., 2011). When these behaviors are maximized, organizations can truly expect to see remarkable effects driven from their most valuable resources in all improvement initiatives: the team members (Baird, et al., 2011). Operations and production are fields expected to remain within society for the foreseeable future, and although this list of future research improvements is vast it is far from exhausted. This study hopes to inspire follow-up and secondary research to further clarify the future.

Conclusions

Previous studies have repeatedly shown positive relationships between the successful implementation of 5S, particularly when looking at overall productivity related topics including safety, quality, and cost, as well as employee attitudes (Randhawa, et al., 2017). This is most especially the case when organizations are working with fully committed management and highly involved team members (Randhawa, et al., 2017). Much like with the conclusions of this study, the future is continuous improvement.

5S is a fundamental and foundational element to continuous improvement and should be included in both organizational and strategic planning to allow for more advanced philosophies, techniques, and tools to be applied in the future (Ablanedo-Rosas, et. al, 2010). The organizational implementation of 5S is applicable and worthwhile using both statistically significant metrics for validity and through perceived and real measures, which still need additional research (Ablanedo-Rosas, et. al, 2010). There is much to be done, but there will always be more to do.

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APPENDIX A

5S Survey - Employee

	Questions	Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree
1	5S has made my job easier	1	2	3	4
2	I am currently very satisfied with my job	1	2	3	4
3	5S has had a positive impact on my safety	1	2	3	4
4	5S has made setups or changeovers easier	1	2	3	4
5	5S has had a positive impact on my productivity	1	2	3	4
6	5S has improved the cleanliness of my workplace	1	2	3	4
7	5S has improved the organization of my workplace	1	2	3	4
8	5S has the commitment of department management	1	2	3	4
9	The value that I get from 5S activities is worth the effort	1	2	3	4
10	My supervisor gives regular 5S updates at monthly meetings	1	2	3	4
11	Since 5S was implemented, I have greater input on decisions	1	2	3	4
12	Since 5S was implemented, I feel less frustrated in doing my job	1	2	3	4

13	Since 5S was implemented, I feel more in control of my workplace	1	2	3	4
14	Since 5S was implemented, there is more cooperation between shifts	1	2	3	4
15	Overall, I am more satisfied with my job since we implemented 5S	1	2	3	4
16	Everyone in my area fulfills their 5S responsibilities on a regular basis	1	2	3	4
17	We have fewer machine breakdowns than before we implemented 5S	1	2	3	4
18	We have better use of floor space now than before we implemented 5S	1	2	3	4
19	Employees in my are speak in positive terms about 5S and its benefits	1	2	3	4

How do you think 5S is going in your area? Why?

How much time do you put into 5S activities each day?

What do you feel are the major benefits you are getting from 5S?

Compared to 3 months ago, 5S is going better, worse, or about the same?

What do you think should be done to improve 5S in your area?

APPENDIX B

5S Survey - Management

	Questions	Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree
1	5S has made my job easier	1	2	3	4
2	I am currently very satisfied with my job	1	2	3	4
3	5S has had a positive impact on my safety	1	2	3	4
4	5S has made setups or changeovers easier	1	2	3	4
5	5S has had a positive impact on productivity	1	2	3	4
6	5S has improved the cleanliness of my department	1	2	3	4
7	5S has improved the organization of my department	1	2	3	4
8	The value that I get from 5S activities is worth the effort	1	2	3	4
9	Overall, I am more satisfied with my job since we implemented 5S	1	2	3	4
10	Everyone in my area fulfills their 5S responsibilities on a regular basis	1	2	3	4
11	Since 5S was implemented, there is more cooperation between shifts	1	2	3	4
12	Since 5S was implemented, people don’t spend time looking for items	1	2	3	4
13	We have fewer machine breakdowns than before we implemented 5S	1	2	3	4

14	We have better use of floor space now than before we implemented 5S	1	2	3	4
15	Since 5S was implemented, production starts more quickly at shift start	1	2	3	4
16	Since 5S was implemented, employees have greater input on decisions	1	2	3	4
17	Employees in my area speak in positive terms about 5S and its benefits	1	2	3	4

How do you think 5S is going in your area? Why?

How much time do you put into 5S activities each day?

What do you feel are the major benefits you are getting from 5S?

Compared to 3 months ago, 5S is going better, worse, or about the same?

What do you think should be done to improve 5S in your area?

APPENDIX C

IRB Approval

OLD DOMINION UNIVERSITY

OFFICE OF THE VICE PRESIDENT FOR RESEARCH

Physical Address
4111 Monarch Way, Suite 203
Norfolk, Virginia 23508
Mailing Address
Office of Research
1 Old Dominion University
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Phone(757) 683-3460
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DATE: September 1, 2020

TO: Petros Katsioloudis, PhD
FROM: Old Dominion University Education Human Subjects Review Committee

PROJECT TITLE: [1632170-1] LEAN APPLICATION: AN ASSESSMENT OF 5S ON EMPLOYEE ATTITUDES AND PRODUCTIVITY
REFERENCE #:
SUBMISSION TYPE: New Project

ACTION: DETERMINATION OF EXEMPT STATUS
DECISION DATE: September 1, 2020

REVIEW CATEGORY: Exemption category # 2

Thank you for your submission of New Project materials for this project. The Old Dominion University Education Human Subjects Review Committee has determined this project is EXEMPT FROM IRB REVIEW according to federal regulations.

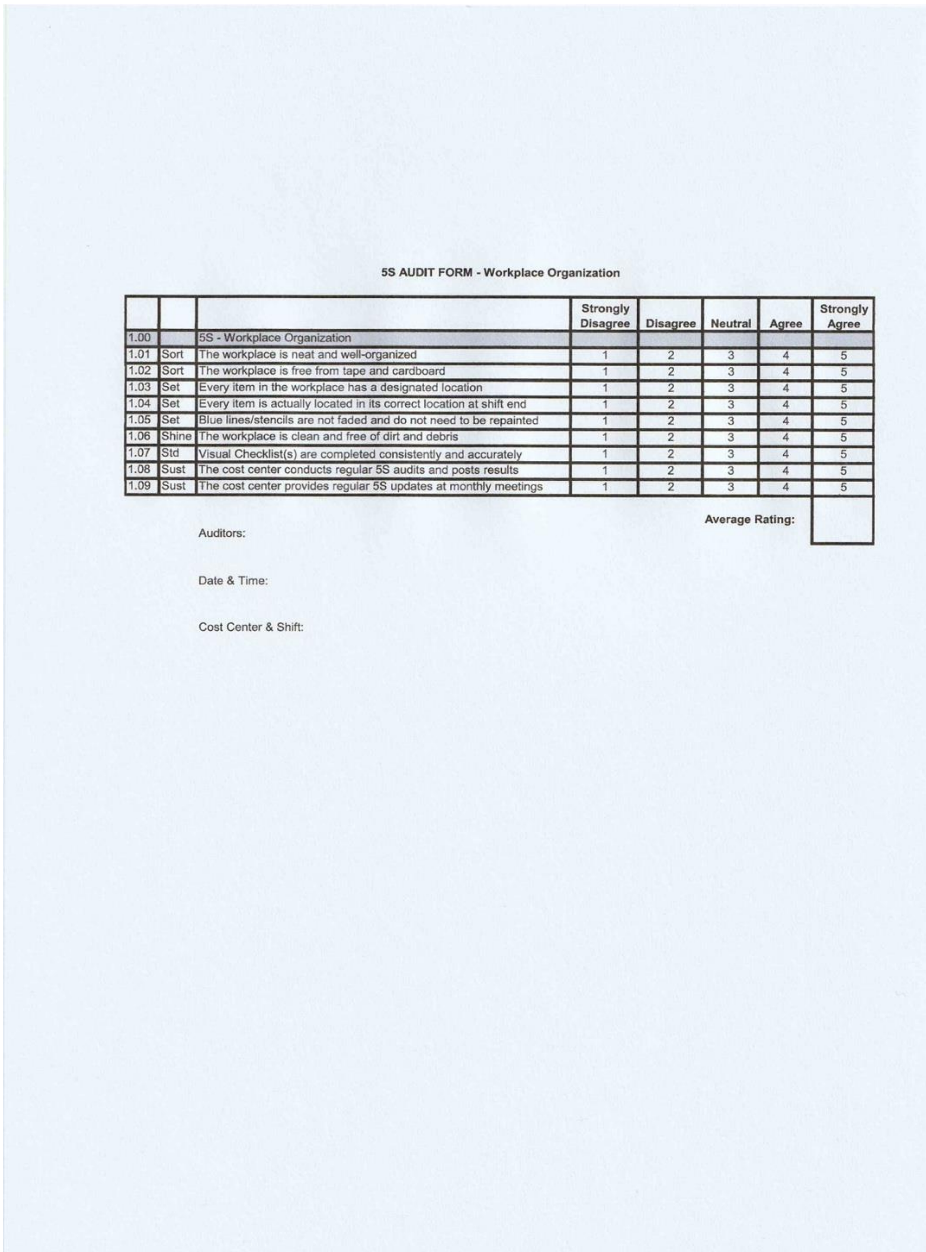
We will retain a copy of this correspondence within our records.

If you have any questions, please contact Laura Chezan at (757) 683-7055 or lchezan@odu.edu. Please include your project title and reference number in all correspondence with this committee.

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within Old Dominion University Education Human Subjects Review Committee's records.

APPENDIX D

Example 5S Audit form: As depicted in Five "S" improvement system: An assessment of employee attitudes and productivity improvements by Christopher B. Hutchins



5S AUDIT FORM - Workplace Organization

			Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1.00		5S - Workplace Organization					
1.01	Sort	The workplace is neat and well-organized	1	2	3	4	5
1.02	Sort	The workplace is free from tape and cardboard	1	2	3	4	5
1.03	Set	Every item in the workplace has a designated location	1	2	3	4	5
1.04	Set	Every item is actually located in its correct location at shift end	1	2	3	4	5
1.05	Set	Blue lines/stencils are not faded and do not need to be repainted	1	2	3	4	5
1.06	Shine	The workplace is clean and free of dirt and debris	1	2	3	4	5
1.07	Std	Visual Checklist(s) are completed consistently and accurately	1	2	3	4	5
1.08	Sust	The cost center conducts regular 5S audits and posts results	1	2	3	4	5
1.09	Sust	The cost center provides regular 5S updates at monthly meetings	1	2	3	4	5

Average Rating:

Auditors:

Date & Time:

Cost Center & Shift:

APPENDIX E

Example 5S Audit form: As depicted in Rater-Reliability of a 5S Audit by Lawrence E. Whitman, Michael Jorgensen, and Nishant Gorrepati

0	1	2	3	4	5
Unacceptable **Zero Effort** (5 or more mistakes)	**Activity Started** **Slight Effort (4** mistakes)	**Widespread Activity** **Many Opportunities For Improvement** (3 mistakes)	**Minimum Acceptable Level** **Sustained for at Least One (l) Month** (2 mistakes)	**Best in Class Results** **Sustained for Three (3) Months** (1 mistake)	**World Class Example** **Sustained for at Least Six (6) Months** (0 mistakes)

DESCRIPTION	EVALUATION CRITERIA	SCORE
lS. Sorting (Clearing Up)		
1.1 First Impression Overall	**Your general impression should tell you this is the best you have seen for a factory using similar processes.**	
1.2 Removing Unnecessary Items	**All items not necessary for performing work are removed from the workplace.**	
1.3 sorting frequency	**Sorting exercise is performed in each work area at least on monthly basis**	
1.4 Tools placement	**Only tools and products are present at the workstations.**	
1.5 Bulletin Boards	**No outdated, tom, or soiled announcements are displayed. Allbulletins are arranged in a straight and neat manner.**	
1.6 Red Tagging	**Red tagging is performed on the shop floor on regular basis, at least monthly.**	
2S. Storage (Organizing)		
2.1 Shelves, Benches, andDesks Arranged	**Items are arranged, divided, and clearly labeled such that it is**	

	obvious where things are stored and where they should be returned.	
2.2 Shelves, Toolboxes, Benches, and Desks:Control	**These are kept free of unused objects, including files and documents. Tools and fixtures are stored in dedicated shadowboxes or hanging and are cleaned before being returned to proper position after use.**	
2.3 Items on Floor	**WIP, tools, materials, and products are not left to sitdirectly on the floor.**	
2.4 items location	**Large items such as tote bins are positioned on the floor in clearly marked areas, by painted lines.**	
2.5 General Storage	**Storage of boxes, containers, and material is always neat.**	
2.6 Arrangement of items	**When items are stacked, they are never out of alignment, or in danger of falling over.**	
2.7 Equipment: Cleanliness and Organization	**Nothing is placed on top of machines, cabinets, and equipment.** **Nothing leans against walls or columns.**	
2.8 Unobstructed Aisles and Access	**Aisles are free of material and obstructions. Nothing is ever placed on the lines.**	
2.9 Aisle Markings	**Aisles and walkways are clearly marked and can be identified at a glance. Lines are straight, with no chipped or soiled paint.**	

2.10 Emergency Access	**Fire hoses, extinguishers, and other emergency equipment are unobstructed and stored at locations that are clearly markedand highly visible for easy operation.**	
2.11 Documents: Storage	**Only documents necessary to do the work are stored at workstations. Documents and binders are stored in a neat andorderly manner.**	
2.12 Equipment storage	**Tools, jigs, and fixtures are arranged neatly and stored in a way that they are kept clean and free of any risk of damage.**	
2.13 Equipment: Maintenance	**Controls for machines are properly labeled. Critical points for daily maintenance checks are clearly marked (fluid levels, etc.). Checklists are neatly displayed and kept clean and updated.**	
2.14 Tools and Gases: Arrangement	**Tools are located for easy access for changeovers and set-ups. Gages and measuring equipment used to monitor quality arealso arranged as above.**	

3S. Shining (Cleaning)		
3.1 Floor Cleaning	**All floors are clean and free of debris, oil, and dirt. Cleaning of floors is done regularly, daily at minimum.**	
3.2 Equipment: Painting	**All machines and equipment are painted and look clean. There are no places in the plant less than six feet high that areunpainted.**	
3.3 Equipment: Cleanliness	**Machines and equipment are constantly kept clean and unsoiled. Routine daily care keeps glass, work surfaces, and the general area clean and polished. Guards and deflectors areused to keep chips and waste from falling on the floor.**	
3.4 Storage of Cleaning Equipment and Supplies	**All cleaning equipment is stored in a neat manner. It is obvious where it belongs and is easily available when needed. Hazardous materials and containers are properly labeled.**	
4S. Standardize		
4.I Visual Control	**Display boards are present in each production work area and are within sight of all operators in the area.**	
4.2 Weekly Audits	**5S audits are done in each work area at least weekly with the results recorded on the work area's radar chart.**	
4.3 Status Displays	**Work area display boards include at least the weekly 5S audit**	

	checklist results (radar charts), Kaizen activities performed oridentified, layout or chart of 5S responsibilities in the plant.	
4.4 Continuous Improvement	**A document is being published at least once in every month which includes the Kaizen activities being performed in the previous cycle and Kaizen activities identified newly along** **with the person and department in which it has been identified.**	
SS. Sustaining (Training and Discipline)		
5.I Maintenance	**Maintenance and production resources are adequately deployed** **to keep equipment running properly; an effective preventativemaintenance program is in place.**	
5.2 Documents: Control	**All documents are labeled clearly as to contents. Responsibility for control and revisions is clear. No unlabeled binders /documents are present. Obsolete or unused documents** **are taken care of on regular basis.**	
5.3 Area 5S Responsibility	**Each work area of the plant should fall under the responsibilityof a person on the plant manager's staff as indicated on the plant 5S responsibility layout that shall be prominently** **displayed throughout the plant.**	

5.4 5S Control and Sustaining	**There is a disciplined system of control and maintenance to assure that each of the above items is maintained at the highestpossible level. It is the responsibility of management to maintain this system.**	
5.5 Work Area Visits	**The responsible plant manager staff person should visit each work area at least weekly and initial / date the 5S audit checklist (radar chart) results; additionally, each overdue Kaizen Newspaper action item should be initialed by this person. It is also recommended that the plant manager visiteach work area at least monthly and initial / date the radar chart.**	

2.10 Emergency Access	Fire hoses, extinguishers, and other emergency equipment are unobstructed and stored at locations that are clearly markedand highly visible for easy operation.	
2.11 Documents: Storage	Only documents necessary to do the work are stored at workstations. Documents and binders are stored in a neat andorderly manner.	
2.12 Equipment storage	Tools, jigs, and fixtures are arranged neatly and stored in a way that they are kept clean and free of any risk of damage.	
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4.3 Status Displays	Work area display boards include at least the weekly 5S audit checklist results (radar charts), Kaizen activities performed oridentified, layout or chart of 5S responsibilities in the plant.	

4.4 Continuous Improvement	A document is being published at least once in every month which includes the Kaizen activities being performed in the previous cycle and Kaizen activities identified newly along with the person and department in which it has been identified.	
SS. Sustaining (Training and Discipline)		
5.I Maintenance	Maintenance and production resources are adequately deployed to keep equipment running properly; an effective preventative maintenance program is in place.	
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