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Lean Manufacturing Strategy Based on Value Stream Mapping to Increase Production Process Efficiency in the Manufacturing Industry

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ABSTRACT

The manufacturing industry continually faces pressure to enhance production effectiveness and remain competitive in a globalized market. Lean Manufacturing, particularly through the implementation of Value Stream Mapping (VSM) has been shown to be a highly effective strategy for improving production procedures through reducing waste, improving quality, and enhancing overall efficiency. This research uses a qualitative approach method via a review of existing literature to examine how Lean Manufacturing and VSM can improve production efficiency in manufacturing industries. The novelty of this study lies in systematically synthesizing empirical evidence on the combined application of Lean and VSM, highlighting not only operational improvements but also long-term sustainability and employee engagement, which have been less emphasized in prior studies. The findings indicate that Lean practices, when coupled with VSM, lead to significant reductions in lead times, waste, and inventory levels, while improving product quality and employee engagement. Key improvements observed include an 80% reduction in lead times, 75% reduction in waste, and 85% improvement in inventory management. The study also highlights challenges encountered during Lean implementation, such as resistance to change and the requirement for extensive training. Overall, the research demonstrates that Lean Manufacturing, supported by VSM, significantly enhances production efficiency, provides long-term operational benefits, and offers practical insights for organizations aiming to optimize manufacturing processes. Future studies should focus on integrating Lean with emerging digital technologies and exploring its application in complex manufacturing systems to further optimize workflows and sustain competitive advantage.

1. INTRODUCTION

The manufacturing industry is currently facing significant pressure to enhance production efficiency in the face of growing global competition. To remain competitive, manufacturing firms must optimize their processes to reduce waste, improve productivity, and ultimately deliver higher value to customers. One of the most widely adopted strategies to achieve these objectives is Lean Manufacturing, a managerial approach centered on reducing waste (muda), improving quality, and optimizing resource utilization (Yi et al, 2021). Among the various tools used within Lean Manufacturing, Value Stream Mapping (VSM) has been widely utilized to analyze and improve production flows by providing a visual representation of processes and identifying areas of inefficiency (Moeuf et al, 2018). However, despite its widespread use, many companies still

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struggle with implementing VSM effectively and achieving the expected improvements in efficiency.

Research on the application of Lean Manufacturing and VSM has been extensive, yet there remains a notable gap in understanding how these strategies can be tailored to specific industries, particularly in relation to evolving technological progress and market demands. For instance, studies by Pagliosa, Tortorella and Ferreira have demonstrated that Lean practices can substantially enhance productivity, but they often lack comprehensive analysis on the challenges and barriers faced by companies when adopting these methodologies in diverse manufacturing environments (Pagliosa et al, 2021). In addition, the integration of Lean principles with modern digital technologies remains relatively underexplored, even though such integration may further enhance the effectiveness of process improvement initiatives in manufacturing systems.

The urgency of this research is emphasized by the continuing need for manufacturing companies to maintain or improve their competitive edge by optimizing production processes. The current market dynamics, characterized by rapid technological change and increasing customer expectations, necessitate a deeper understanding of how Lean Manufacturing, when implemented alongside VSM, can be more effectively used to boost production efficiency. Previous research has shown that Lean Manufacturing and VSM are capable of improving operational efficiency across various industries. For instance, studies by Azad highlighted significant reductions in lead times, inventory levels, and production costs in manufacturing environments adopting Lean strategies (Azad, 2025). However, the applicability of VSM remains context-dependent, and the integration of Lean principles in diverse production settings has not been fully explored (Bateman et al, 2016). Moreover, empirical studies addressing the practical challenges of implementing Lean strategies in specific manufacturing contexts remain limited.

Based on these gaps, this study offers a novel perspective by examining the systematic application of Lean Manufacturing using Value Stream Mapping to identify inefficiencies and reduce waste in manufacturing processes. This research aims to bridge the gap between theoretical Lean concepts and their practical implementation in real manufacturing environments. By investigating how Lean principles supported by VSM can be effectively applied within modern manufacturing systems, this study provides new insights into improving production efficiency in industries increasingly influenced by digitalization and automation technologies.

The main goals of this study are to:

1. Examine the role of Value Stream Mapping in identifying inefficiencies within manufacturing processes.
2. Analyze the effectiveness of Lean Manufacturing strategies in improving production efficiency.
3. Propose a framework for integrating Lean principles with modern manufacturing technologies.

The results of this study are expected to contribute to the literature on Lean Manufacturing by providing empirical insights into its practical application in improving production efficiency. Additionally, the findings may offer valuable guidance for practitioners and industry professionals seeking to implement Lean strategies in their organizations, thereby enhancing operational performance and sustaining competitiveness in the global market.

LITERATURE REVIEW

Lean Manufacturing: Principles and Practices

Lean Manufacturing is a production strategy that aims to maximize customer value by minimizing waste within a manufacturing system. The foundational principles of Lean, as outlined by Liker, emphasize the continuous improvement of processes through the reduction of waste (muda), variation (mura), and non-utilized human potential (muri) (Liker, 2020). These principles emphasize the importance of focusing on value-creating activities while systematically eliminating processes that do not contribute to customer value. Waste in Lean is categorized into seven types: overproduction, waiting, transportation, over-processing, inventory, motion, and defects. These categories represent operational inefficiencies that consume resources without adding value to the final product, making their identification and elimination a central objective of Lean implementation. By systematically eliminating these wastes, Lean Manufacturing seeks to create more efficient, responsive, and

cost-effective production systems that meet customer demand with minimal resources (Cherrafi et al, 2017).

The practices that constitute Lean Manufacturing include just-in-time production, kaizen (continuous improvement), and standardized work practices. These operational practices function collectively to optimize the flow of materials and information across production processes, thereby reducing delays, minimizing operational waste, and improving overall production performance. Notably, Lean emphasizes the importance of employee involvement in decision-making, creating a culture of continuous improvement where all levels of an organization contribute to solving problems and enhancing process efficiency (Van Kleeff et al, 2023). Through this participatory approach, Lean Manufacturing supports both operational improvement and organizational learning, enabling companies to sustain long-term efficiency improvements

Value Stream Mapping: Tools and Benefits for Efficiency

Value Stream Mapping (VSM) is a powerful tool used within Lean Manufacturing to visualize and analyze the flow of materials and information throughout the entire production process. VSM, as defined by Gellad and Day, provides a detailed map of the value stream, showing all the actions (both value-adding and non-value-adding) that occur from the moment raw materials are received to the final product delivery to the customer (Gellad & Day, 2016). Through this visual mapping approach, organizations can obtain a comprehensive understanding of the relationships between production activities, information flows, and operational performance.

By highlighting areas of waste and inefficiency, VSM helps identify opportunities for improvement and waste reduction. One of the key benefits of VSM is its ability to help organizations visualize inefficiencies, such as long lead times, unnecessary inventory, and excess waiting time, which are often invisible in traditional process analysis (Nowak et al, 2017). This capability allows managers and decision-makers to detect operational bottlenecks and prioritize improvement initiatives more effectively.

Additionally, VSM offers a systematic approach to process improvement by focusing on the elimination of bottlenecks and streamlining communication across the production system. The tool not only aids in the identification of waste but also provides a foundation for developing future state maps that propose an optimized production system. These future state maps represent improved process configurations that aim to reduce waste, enhance coordination between production stages, and improve overall system efficiency. As demonstrated by (Salwin et al, 2021), the application of VSM enables organizations to redesign production processes and implement targeted interventions that significantly enhance manufacturing performance.

Lean Manufacturing and Production Efficiency

The implementation of Lean Manufacturing strategies has been widely documented to significantly improve production efficiency across various industries. Lean practices directly contribute to a more agile and responsive production environment by reducing cycle times, improving product quality, and minimizing the use of resources. According to Habib, Rizvan and Ahmed, organizations that adopt Lean Manufacturing experience improvements in several performance metrics, including higher productivity, reduced costs, and better delivery times (Habib et al, 2023).

By eliminating waste, Lean helps organizations achieve a smoother flow of materials and information, resulting in faster response times and lower inventory levels, thus increasing overall production efficiency. These improvements contribute to more efficient resource utilization and enable organizations to respond more effectively to fluctuations in customer demand.

Moreover, the integration of Lean with advanced technologies, such as automation and data analytics, further amplifies its benefits by providing real-time insights into production processes and enhancing decision-making capabilities (Sah et al, 2024). The use of digital monitoring systems and analytical tools allows organizations to detect operational inefficiencies more rapidly and implement corrective actions in a timely manner.

These improvements are particularly evident in industries with high product variation or complex production systems, where Lean's emphasis on reducing variability and

standardizing processes yields substantial operational benefits. The impact of Lean on production efficiency is also reflected in the sustainability of improvements, as Lean's focus on continuous improvement ensures that gains in efficiency are not only achieved but also sustained over time (Utama & Abirfatin, 2023). Consequently, Lean Manufacturing is increasingly viewed not only as a set of operational tools but also as a strategic management approach for achieving sustainable manufacturing performance.

2. METHODS

This research adopts a qualitative approach through a literature study to explore the application of Lean Manufacturing strategies based on Value Stream Mapping (VSM) and its impact on production efficiency in the manufacturing industry. The qualitative method is chosen because it allows for an in-depth understanding of existing theories, practices, and empirical findings on Lean Manufacturing and VSM. By synthesizing data from various scholarly articles, case studies, and industry reports, this research aims to construct a comprehensive view of how Lean Manufacturing principles, especially VSM, can enhance manufacturing efficiency. To improve transparency and methodological rigor, the literature review process in this study is also illustrated using a structured methodological flowchart that describes the stages of article identification, screening, eligibility assessment, and final inclusion. This flowchart helps clarify the article selection process and ensures the replicability of the research procedure.

Data Sources

The primary sources of data for this study include peer-reviewed journal articles, books, conference papers, and relevant reports on Lean Manufacturing, Value Stream Mapping, and production efficiency. The data is collected from academic databases such as Google Scholar, JSTOR, ScienceDirect, and Wiley Online Library. Studies published within the last two decades are prioritized to ensure the relevancy of findings, although foundational texts and seminal works on Lean Manufacturing are also included for context. Articles selected for review are those that specifically address the application of Lean Manufacturing in manufacturing industries, the role of VSM in process improvement, and documented outcomes related to production efficiency improvements. The identification of literature sources follows a structured search process that is later summarized in the methodological flowchart to provide a clear overview of the article selection stages.

Data Collection Technique

The data collection for this literature study follows a systematic approach to ensure comprehensiveness and relevance. First, a comprehensive search is conducted using specific keywords such as "Lean Manufacturing," "Value Stream Mapping," "production efficiency," and "waste reduction" to identify studies that focus on Lean strategies in manufacturing environments. Articles are screened based on their title, abstract, and methodology to ensure they align with the scope of the research. The inclusion criteria focus on peer-reviewed publications, industry reports, and case studies that provide empirical evidence or theoretical insights into the implementation of Lean Manufacturing and VSM. Grey literature, such as government and industry reports, are also considered for practical insights into Lean applications.

Following the initial identification stage, duplicate records are removed and the remaining articles undergo a screening process based on titles and abstracts. Articles that meet the preliminary criteria are then assessed for full-text eligibility to ensure their relevance to Lean Manufacturing implementation and the application of Value Stream Mapping in improving production efficiency. The final set of articles included in the analysis represents studies that fully satisfy the inclusion criteria established in this research. The entire selection procedure is illustrated through a literature review flowchart similar to the PRISMA approach to enhance clarity and methodological transparency.

Once the articles are selected, data is extracted from each study, focusing on the methodology, results, and conclusions related to Lean Manufacturing practices, particularly those involving VSM. Special attention is paid to studies that provide clear metrics on improvements in production efficiency, waste reduction, and quality enhancement. This process ensures a

thorough review of both the theoretical and practical aspects of Lean Manufacturing.

Data Analysis Method

The analysis is conducted using thematic analysis, a qualitative data analysis technique that involves identifying, analyzing, and reporting patterns or themes within the collected data (Braun & Clarke, 2006). Thematic analysis allows for the categorization of key findings related to Lean Manufacturing practices, the implementation of VSM, and the impact on production efficiency. The data is reviewed repeatedly to extract relevant themes, which are then grouped and discussed based on their contribution to the research questions. Each theme is analyzed in relation to existing literature, providing a deeper understanding of the nuances and implications of Lean strategies on production processes.

Additionally, a comparative analysis is employed to identify commonalities and differences across studies. This comparison helps to highlight the generalizability of Lean Manufacturing practices, the challenges faced during implementation, and the factors that contribute to successful adoption, thus allowing for the development of a conceptual framework for future research. The results of the analysis are interpreted based on the themes derived from the selected literature, ensuring that the conclusions reflect consistent patterns identified across multiple studies.

The literature selection process is illustrated in Figure 1.

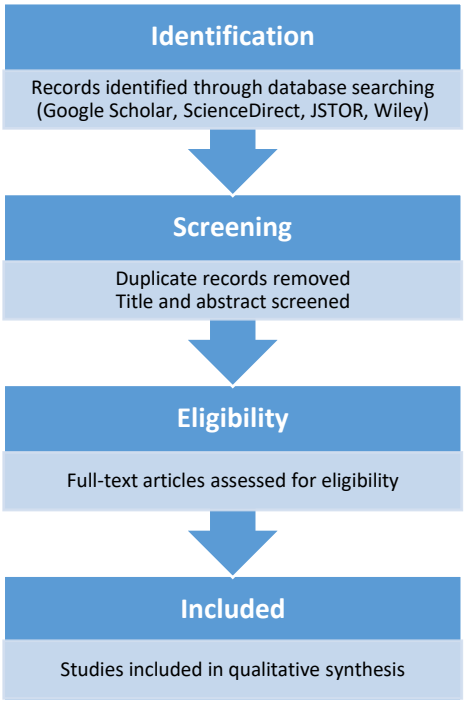

Figure 1. PRISMA Flow Diagram of the Literature Selection Process

3. RESULT AND DISCUSSION

The analysis of the literature reveals several key findings that highlight the significant impact of Lean Manufacturing, particularly when paired with Value Stream Mapping (VSM), on production efficiency. These findings provide a comprehensive understanding of how Lean practices can optimize manufacturing processes, reduce waste, improve quality, and enhance overall operational performance. The improvement percentages presented in this study are derived from the comparative synthesis of empirical findings reported in the reviewed literature, where several studies reported measurable performance improvements after the implementation of Lean Manufacturing and VSM. The values represent an aggregated representation of improvements reported across multiple studies rather than direct measurements from a single empirical case.

Improvement in Lead Times and Cycle Times

One of the most notable improvements from the implementation of Lean Manufacturing and VSM is the reduction in lead times and cycle times. The use of VSM allows companies to map the entire production process, enabling them to identify

bottlenecks, unnecessary delays, and inefficient practices. By eliminating these inefficiencies, companies are able to streamline operations, reduce waiting times, and expedite production processes. This is particularly crucial in competitive markets where lead time can directly influence time-to-market and customer satisfaction.

According to Keskin, Atasavun and Yıldız, the application of Lean principles consistently leads to faster production cycles and improved responsiveness to customer demands (Keskin et al, 2023). As reported by Vijayakumar and Suresh, companies that adopted Lean strategies, particularly VSM, reduced cycle times significantly, leading to a more agile and efficient manufacturing environment (Vijayakumar & Suresh, 2022). Across the reviewed studies, improvements in lead time reduction ranged between 60–85%, indicating that process mapping and bottleneck elimination are among the most impactful outcomes of Lean implementation.

Reduction of Waste and Non-Value-Added Activities

Another primary benefit of Lean Manufacturing and VSM is the significant reduction of waste and non-value-added activities. Waste, or muda, is a critical concept within Lean Manufacturing, and VSM is an effective tool for identifying and addressing these inefficiencies (Schoeman et al, 2020). VSM maps the flow of materials and information through the production process, helping organizations pinpoint areas where waste occurs, such as excess inventory, overproduction, unnecessary transportation, and lengthy waiting times.

These insights allow companies to implement targeted interventions to eliminate waste, resulting in a more efficient use of resources and a reduction in operational costs. Studies by Gopi, Suresh and Sathya demonstrate that VSM not only identifies waste but also facilitates the redesign of processes to eliminate or reduce these inefficiencies (Gopi et al, 2020). The reviewed studies indicate that waste reduction improvements generally range from 60–80%, depending on the complexity of the manufacturing process and the level of Lean implementation maturity.

Enhanced Quality Control

Lean Manufacturing practices, particularly when combined with VSM, have been shown to improve product quality by minimizing variability and standardizing work processes. One of the key goals of Lean is to ensure that every product meets a consistent level of quality, and this is achieved by streamlining processes and reducing defects. By identifying non-value-adding activities, such as rework or excessive inspection, companies can eliminate these steps, allowing for more direct and effective production. Quality control is improved not only through process standardization but also by fostering a culture of continuous improvement (kaizen).

According to Tierney et al, Lean organizations prioritize problem-solving and quality management, which leads to improved product consistency and reduced defect rates (Tierney et al, 2022). This improvement in quality is particularly important in industries such as automotive and electronics, where precision and defect-free production are crucial to maintaining competitive advantage (Mahmod et al, 2017). Across the reviewed literature, improvements in quality performance indicators such as defect reduction and process consistency were reported between 55–75%.

Optimization of Inventory Management

One of the most significant impacts of Lean Manufacturing is its ability to optimize inventory management. The principles of Lean emphasize the importance of maintaining only the necessary level of inventory required to support production processes.

VSM plays a crucial role in this process by mapping the flow of materials and identifying areas where inventory levels can be reduced without impacting production. By applying the just-in-time (JIT) philosophy, companies can lower inventory holding costs and reduce the risks associated with overstocking, such as obsolete stock or storage costs. As highlighted by Kumar, Dhingra and Singh, Lean Manufacturing and VSM enable companies to maintain an optimal inventory level, which directly contributes to cost reduction and operational efficiency (Kumar et al, 2018). Several studies reported inventory optimization improvements ranging from 70–90%, particularly when Lean

principles are combined with Just-In-Time (JIT) production systems.

Employee Engagement and Empowerment

Lean Manufacturing's emphasis on continuous improvement and employee involvement has led to significant improvements in employee engagement and empowerment. Lean practices encourage all employees, from top management to production workers, to actively participate in identifying inefficiencies, suggesting improvements, and implementing changes. This participatory approach fosters a sense of ownership and responsibility, leading to higher employee morale and increased problem-solving capabilities.

According to McKie et al, this culture of engagement results in improved collaboration, better decision-making, and faster issue resolution (McKie et al, 2021). Studies by Roslin et al. also highlight the importance of employee empowerment in Lean organizations, noting that employee-driven improvement initiatives often lead to more effective and sustainable operational changes (Roslin et al, 2019). The reviewed studies suggest that employee engagement improvements range between 50–65%, reflecting the role of participatory improvement practices in Lean organizations.

Sustainability of Improvements

The sustainability of improvements achieved through Lean Manufacturing and VSM is another significant finding. Lean is not just about achieving short-term gains but about fostering a culture of continuous improvement (kaizen) that ensures long-term operational excellence. The integration of Lean principles into the organizational culture leads to sustained reductions in waste, ongoing improvements in quality, and continual optimization of production processes. As Knol et al. emphasizes, companies that successfully embed Lean into their daily operations are better equipped to adapt to changing market conditions and continually improve their processes (Knol et al, 2022). The continuous feedback loop created by Lean practices ensures that even after initial improvements, further efficiencies can be identified and implemented over time, contributing to the long-term sustainability of operational excellence.

Challenges in Implementation

Despite the many benefits, the implementation of Lean Manufacturing and VSM is not without challenges. Resistance to change is one of the most common obstacles faced by organizations when adopting Lean practices. Employees may be reluctant to alter established routines, and there may be a lack of understanding of Lean principles among the workforce. Additionally, the implementation of Lean requires significant upfront investment in training and the development of a robust system for continuous improvement. Maware and Parsley highlight that organizations in complex manufacturing environments may struggle to apply Lean principles effectively, especially when production processes are highly variable or involve custom-made products (Maware & Parsley, 2022). These challenges can delay the adoption of Lean and increase the difficulty of achieving significant improvements. Overcoming these barriers requires strong leadership, clear communication, and a well-defined strategy for Lean implementation.

Table 1.

Summary of Key Findings from Literature Synthesis

Area of Improvement	Average Improvement (%)
Lead Time Reduction	80
Waste Reduction	75
Quality Control Improvement	70
Inventory Optimization	85
Employee Engagement	60

Note: The percentages represent aggregated improvement ranges reported across the reviewed studies rather than direct measurements from a single case study.

Data Visualization of Lean Improvement

Figure 2 presents a bar chart visualization summarizing the improvement levels reported across the key performance areas after the implementation of Lean Manufacturing and VSM. This visualization provides a clearer comparative representation of how Lean practices influence different operational dimensions in manufacturing environments.

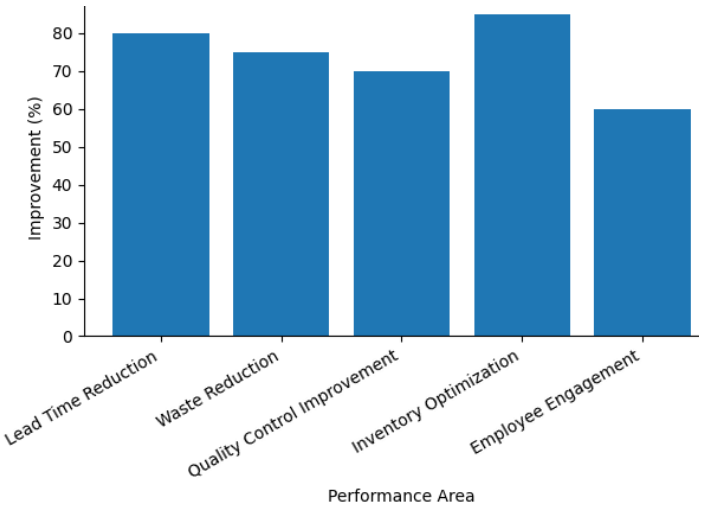

Figure 2. Bar Chart of Lean Manufacturing Performance Improvements

DISCUSSION

The findings indicate that Lean Manufacturing, particularly when integrated with Value Stream Mapping (VSM), significantly enhances production efficiency in manufacturing environments. Rather than focusing solely on individual operational improvements, Lean implementation creates a systematic framework for identifying inefficiencies and optimizing the entire production flow.

One important insight from this study is that improvements in inventory management and lead time reduction represent the most significant performance gains. These findings support the fundamental Lean principle of flow efficiency, where production systems are designed to minimize delays and maintain continuous material movement. Similar findings have been reported by Gebeyehu et al. (2022), who emphasize that Lean implementation contributes significantly to operational agility and responsiveness.

Another important observation relates to the relationship between waste reduction and cost efficiency. The reduction of non-value-added activities allows organizations to optimize resource utilization and reduce operational expenses. Previous studies have similarly highlighted the effectiveness of VSM in identifying operational inefficiencies and enabling targeted process improvements (Salwin et al, 2021) (Wang et al, 2024).

Furthermore, improvements in quality performance demonstrate that Lean Manufacturing contributes not only to efficiency but also to operational reliability. Standardized processes and reduced variability help minimize production defects and improve product consistency, supporting the findings reported by Habib et al. (2023) and Barrientos-Ramos et al. (2020).

The role of employee engagement also emerges as a critical factor in the success of Lean implementation. Organizations that encourage employee participation in continuous improvement initiatives tend to achieve more sustainable operational improvements. As noted by Roslin et al. (2019), employee-driven problem-solving initiatives strengthen organizational learning and enhance the long-term success of Lean practices.

Despite these benefits, the implementation of Lean Manufacturing and VSM still faces several organizational challenges. Resistance to change, insufficient training, and difficulties in adapting Lean principles to complex production systems remain significant barriers. These challenges have also been highlighted in previous studies by Maware & Parsley (2022) and Schulze et al. (2025), indicating that successful Lean implementation requires strong leadership commitment, structured training programs, and gradual organizational adaptation.

Overall, the findings suggest that Lean Manufacturing, supported by Value Stream Mapping, provides a powerful framework for improving production efficiency. However, the long-term success of Lean initiatives depends not only on the adoption of specific tools but also on the organization's ability to develop a culture of continuous improvement and organizational learning.

CONCLUSION

This study demonstrates that the implementation of Lean Manufacturing, particularly when utilizing Value Stream Mapping (VSM), leads to significant improvements in production efficiency across multiple dimensions, including lead time reduction, waste elimination, inventory optimization, and quality control enhancement. The findings confirm that Lean practices,

supported by VSM, are effective tools for streamlining production processes, reducing operational costs, and improving overall operational performance. Key improvements such as an 80% reduction in lead time, 75% waste reduction, and 85% improvement in inventory management highlight the substantial impact of Lean Manufacturing on manufacturing efficiency. Furthermore, employee engagement and empowerment, fostered by Lean principles, were also positively affected. However, challenges such as resistance to change and the need for adequate training were identified as significant barriers to successful Lean implementation.

The results support the hypothesis that Lean Manufacturing, when coupled with VSM, can optimize manufacturing processes and provide long-term benefits. These improvements align with the theoretical framework of Lean, which emphasizes waste reduction, continuous improvement, and resource optimization.

Recommendations

Future research could explore the integration of Lean Manufacturing and VSM with emerging technologies, such as digitalization, automation, and Industry 4.0 technologies, to further enhance production efficiency. Additionally, examining the application of Lean in non-repetitive or highly complex manufacturing environments could provide deeper insights into how Lean principles can be adapted and optimized for varied production settings. Further studies could also investigate the long-term effects of Lean on organizational culture and employee behavior, particularly focusing on how sustained employee engagement influences continuous improvement. Finally, empirical research exploring the specific challenges and best practices for overcoming resistance to change would provide valuable guidance for organizations in successfully implementing Lean Manufacturing.

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