

World Class Manufacturing: A Systematic Review

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Abstract: This article presents a systematic literature review on the World Class Manufacturing (WCM) model. The objective is to explore how its adaptation and customization occur in different industrial contexts. WCM is a strategic management methodology focused on continuous improvement, waste elimination, and efficiency optimization at all organizational levels, covering areas such as quality, autonomous maintenance, people development, and supply chain management. To achieve this objective, the research was conducted using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology, which guided the identification, selection, and synthesis of relevant publications. The methodological process included the analysis of indexed articles and the application of eligibility criteria to ensure the relevance of the selected sources. The results reveal that, although WCM is widely used, its adaptation still faces considerable challenges. The literature analysis showed that most studies focus on technical aspects, neglecting a deeper analysis of the organizational and managerial factors that are crucial for effective implementation. Furthermore, the review points to a significant gap in the model's application in small and medium-sized enterprises (SMEs), suggesting the need for new approaches to adapt WCM to resource-constrained contexts. In conclusion, the customization of the WCM model is essential for its successful implementation across different industries. Future research should move beyond the technical focus, exploring how organizational culture and leadership influence the process. It is imperative that new studies develop and validate adaptation frameworks that ensure the model's applicability to a broader spectrum of companies, aiming to increase their competitiveness and sustainability.

Keywords: World Class Manufacturing; Systematic Literature Review; Operations Management; Continuous Improvement; Customization

1. Introduction

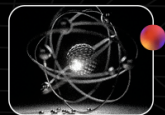
World Class Manufacturing (WCM) is an operational management model aimed at transforming organizations into global leaders through the continuous optimization of processes, elimination of waste, and promotion of efficiency and excellence across all operations (PETRILLO; DE FELICE; ZOMPARELLI, 2019).

The primary goal of this model is the constant pursuit of improvements, which are essential for ensuring competitiveness in both domestic and international markets. In this regard, the objective of this article is to conduct a systematic literature review on the World Class

Manufacturing (WCM) model, focusing on the adaptation and customization of this methodology in different industrial contexts, aiming to identify gaps and suggest directions for future research. It is expected that the results of this review will provide insights for the adaptation of WCM in various contexts, with an emphasis on the development of practical solutions that promote greater efficiency, cost reduction, and continuous improvement.

2. Methodology

To analyze the implications of adapting the World Class Manufacturing (WCM) model, a systematic literature review was conducted on



WCM and its specific applications across various sectors.

2.1 PRISMA Method

This article, focused on World Class Manufacturing (WCM) for toolmaking, will follow the review methodology the guidelines of PRISMA 2020 (Page et al., 2021).

The process will be divided into five stages: planning, scope, research, evaluation, and synthesis and analysis. The first stage of the systematic review, planning, focused on defining the databases for the research. The objective was to identify the most relevant publications on WCM and its customization across various industrial sectors.

For this, the online databases Scopus and Web of Science were selected. The second stage of the systematic review focused on defining the research scope through guiding questions. The scope was defined based on two main questions: Q1 - What WCM models are described in the literature?

Q2 - How has WCM been adjusted for different industrial sectors, and what are its gaps and strengths?

The search methodology was adapted from the review method of Henriques and Winkler (2021). The search strings were formulated to identify articles on the WCM methodology and its adaptations. The strings used in the databases were:

Web of Science: 'WCM' AND 'methodology' AND 'metalworking' AND 'customization' Scopus: 'WCM' AND 'methodology' AND 'metalworking' AND 'customization'. Initially, 262 results were obtained from Scopus and 398 from Web of Science. After refinement, 7 publications were selected based on the eligibility criteria.

During the evaluation, the articles were analyzed based on the following eligibility criteria:

C1: Indexed journal articles (peer-reviewed)

C2: Works focused on WCM models or their application in sectors

C3: Publications from 2015 onwards (last 10 years, considering 2025)

C4: Only academic articles, theses, and dissertations

C5: Works in English or Portuguese

During the evaluation stage, it was observed that many works containing the acronym "WCM" in the title and abstract did not address World Class Manufacturing but rather Working Capital Management. Given this, the following results were obtained: Scopus: 7 results Web of Science: 8 results

In the final stage, the results were validated to select the works that would be included in the article. It is important to note that the validation was based only on the key elements of the texts. Thus, the title and abstract of the 16 works were evaluated under the scope of questions Q1 and Q2.

As a result, 6 works were selected, listed below:

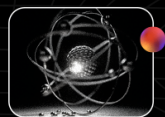


Table 1 – Selected Articles Based on PRISMA

Author(s)	Title	Summary
Oliveira, Paulo et al (2018)	World Class Manufacturing Operations Management: Scale Development and LHEMI Model Proposition	Develops and validates a quantitative LHEMI model of WCM.
Pérez et al (2020)	Design of a methodology to generate a maintenance plan through the integration of RCM, WCM and Lean Manufacturing in wire drawing processes	Applies the technical pillars of WCM in maintenance planning for drawing processes.
S. Kukla (2016)	Quality and Safety Assurance of Iron Casts and Manufacturing Processes	Applies the principles of WCM to optimize iron casting, aiming for high quality..
Mróz (2020)	The Role of Product Cost Deployment in the Early Product Management Methodology Within the WCM System – A Case Study	Uses WCM as the central framework for cost management and product launch.
Hassan e Kadhum (2023)	Application of the environmental pillar within the world-class manufacturing methodology for the purpose of achieving	Applies the environmental pillar of WCM to promote sustainability.

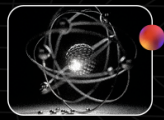
	environmental sustainability.	
Oliveira, Ana et al (2015)	Study of the Implementation of the Pillar of Focused Improvement Methodology World Class Manufacturing (WCM) in a company of automotive sector of interior of São Paulo	Describes the implementation of the WCM Focused Improvement Pillar.

To conduct this systematic literature review, we applied the five stages of the PRISMA methodology. This rigorous process allowed us to identify 6 relevant publications that served as the foundation for this review.

3. Systematic Review

The systematic literature review covered the 7 articles on World Class Manufacturing (WCM) in different industrial sectors. Below, the objectives, methodologies, results, contributions, and limitations of each study are presented, providing a foundation for understanding WCM in various contexts.

The article by Oliveira, Paulo et al. (2018) proposes a quantitative model for World Class Manufacturing (WCM), called LHEMI, which evaluates the key dimensions of WCM: Lean Manufacturing, Human Resource Management (HRM), Environmental Practices, Marketing Integration, Cost Reduction, and Flexibility. The study used a quantitative approach, with 180



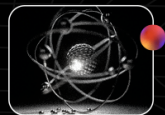
valid responses from professionals, and was conducted through Structural Equation Modeling (PLS-SEM). The results indicate that the integration of Lean Manufacturing and HRM practices improves operational efficiency and environmental sustainability in companies. The research contributes by proposing a measurement scale to assess companies in terms of WCM, allowing an analysis of the degree of compliance with system practices. The main limitation of the study is its focus on Brazilian companies, which limits the generalization of the results. The study also suggests that future research adopt a longitudinal approach and validate the model in other industrial contexts.

The article by Pérez et al. (2020) proposes an integrated methodology to generate a maintenance plan using RCM, WCM, and Lean Manufacturing in wire drawing processes. The objective is to improve operational efficiency and reduce maintenance costs. The research was conducted in a wire drawing industry, combining both qualitative and quantitative approaches. The WCM pillars applied include Autonomous Maintenance (AM), Professional Maintenance (PM), and People Development (PD), focusing on machine efficiency and worker training. The integration of these methodologies resulted in a reduction of failures, optimization of assets, and increased productivity. However, the study is limited by its focus solely on technical aspects, which restricts the generalization of the results. Additionally, the integration may be challenging

for companies with fewer resources or experience.

The article by S. Kukla (2016) focuses on the application of WCM principles to ensure quality and safety in the manufacturing processes of cast iron parts, with an emphasis on reducing labor intensity and improving production quality. The study was conducted in an iron foundry and utilized a qualitative approach, including data analysis and direct observation of the manufacturing processes. The results indicated a 45% reduction in non-value-added activities and significant improvements in safety and ergonomics in the work environment. The use of WCM principles, particularly Workplace Organization, contributed to waste elimination and improved efficiency in the casting production process. The article contributes to the practical application of WCM, demonstrating how quality and safety management can be enhanced in challenging industrial environments such as foundries. However, the research is limited to a single pillar, which restricts the generalization of the results to other industries.

The article by Mróz (2020) explores the application of Early Product Management (EPM) and Cost Deployment (CD) in the World Class Manufacturing (WCM) system, focusing on cost management in the early stages of new product development. The research, conducted in an agricultural machinery plant, utilized a case study with a qualitative approach. The results show that the combination of EPM and CD helped identify problems early, resulting in



reduced losses and improved operational efficiency.

The application of these methodologies allowed for preventive corrective actions, improving cost control and competitiveness. Despite its contributions, the study has limitations, such as an emphasis on technical issues without considering managerial and organizational aspects. It also relied on data estimates, which compromised the accuracy of the results.

Mróz (2018) suggests further research based on actual investments to validate the findings and expand the application of these tools in other industrial contexts.

The article by Hassan and Kadhum (2023) investigates the application of the environmental pillar in the World Class Manufacturing (WCM) system in a hydraulic cylinder factory, focusing on environmental sustainability.

The study adopted a quantitative approach based on environmental performance indicators. The results indicate improvements in waste management, energy consumption, and environmental impact, highlighting the importance of environmental training programs and compliance with ISO 14001. Environmental practices such as recycling and emission reduction were implemented, contributing to the factory's sustainability. The main limitation of the study is its focus on a single WCM pillar. Hassan and Kadhum (2023) suggest that further research be conducted in different contexts to validate the effectiveness of WCM's environmental practices.

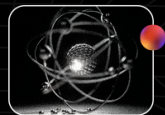
The article by Oliveira, Ana et al. (2015) investigates the implementation of the Focused Improvement (FI) pillar of WCM in an automotive company in São Paulo. The study uses a qualitative approach, with document analysis and direct observation, to assess how waste elimination and efficiency improvement were achieved. The results showed a 35% reduction in costs and a 55% decrease in machine setup time, improving the company's competitiveness.

The study highlights the importance of leadership and human factors in the success of WCM implementation. The main limitation is that it focuses on a single pillar, which restricts the generalization of the results. Additionally, the analysis focused more on technical aspects and did not deeply address managerial and organizational factors.

3.1 What are the WCM models described in the literature? What are their gaps and strengths?

The analysis of the reviewed articles, aligned with the PRISMA methodology, reveals clear patterns and trends in the application of World Class Manufacturing (WCM). While the model's relevance is evident, the review also exposes critical gaps that point toward a future research agenda.

One of the most notable patterns is the integration of WCM with other management methodologies. The literature indicates that the model is rarely applied in isolation; it's frequently combined with approaches like Lean



Manufacturing and Reliability-Centered Maintenance (RCM). This synergy has proven effective in maximizing results, as shown in studies that focus on optimizing maintenance plans, leading to fewer equipment failures, greater asset optimization, and increased productivity. However, the same literature points to a challenge: integrating these methodologies can be complex for companies with limited resources or experience.

The review also highlights WCM's effectiveness in solving specific problems through the isolated application of its pillars. Case studies across various sectors demonstrate how focusing on a single pillar can generate significant results. For example, the Focused Improvement pillar has been effective in reducing costs and setup times in the automotive industry, while the environmental pillar has contributed to sustainability in a hydraulic cylinder factory. It's important to note that most of the analyzed studies are case studies. This nature limits the generalizability of the findings to other contexts. While they validate the model's contribution, the main limitation identified is that their conclusions cannot be widely applied.

Finally, the literature analysis reveals a predominant focus on technical and operational aspects, with little attention paid to managerial and organizational factors. Many studies concentrate on process optimizations, cost management, or environmental aspects but tend to neglect how company culture and leadership impact the success of WCM. This is a gap that

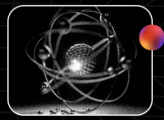
deserves to be explored in future research, as human and cultural factors are essential for a successful implementation.

4. Conclusion

The systematic review presented in this article confirms the versatility and efficacy of the World Class Manufacturing (WCM) model in advancing efficiency and sustainability across diverse industrial sectors. Our analysis of the literature demonstrates that the successful implementation of WCM is critically dependent on its adaptation and customization. Its integration with other methodologies, such as Lean, Reliability-Centered Maintenance (RCM), and specifically the Focused Improvement pillar, reinforces the model's capacity to significantly enhance operational efficiency, environmental performance, and corporate competitiveness.

Despite these established benefits, the review also identified notable research gaps. The majority of studies are characterized by an overly technical focus and rely on isolated case studies, which inherently limits the generalizability of their findings. Furthermore, a dependency on contexts with abundant resources overlooks the complexities of WCM implementation within small and medium-sized enterprises (SMEs), which often face constraints in financial resources and specialized expertise.

Accordingly, this study's primary contribution is to guide future research toward a more holistic approach. We propose that subsequent



investigations should explore how organizational culture and leadership critically influence the successful implementation of WCM. It is also imperative to develop and empirically validate specific adaptive frameworks for resource-constrained environments, thereby ensuring the model's applicability to a broader spectrum of companies.

In conclusion, the WCM literature would significantly benefit from studies that not only validate technical outcomes but also comprehensively address the managerial and contextual complexities essential for more robust and sustainable implementation.

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