Human-centric lean self-assessment model: driving organizational performance enhancement in the era of Industry 5.0

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Abstract: This paper presents the design, implementation, and analysis of a lean self-assessment model, developed in collaboration with employees of a manufacturing company to measure performance across different departments. The proposed tool, with a human-centric approach, focuses on active participation of organizational members, ensuring significant involvement in the development and evaluation process. In the era of Industry 5.0, where the convergence between technology and humanity is crucial, the self-assessment model not only emphasizes operational efficiency but also on the human experience and contribution. Through design research, we developed an assessment tool within a mechanical manufacturing company specializing in Blowers, Pumps, and Fans. The involved functions encompass Corporate Marketing, Sales, Back Office, Accounting Department, Management Control, Procurement, Operations, Technical Office, and Human Resources. The developed model considered three primary areas: people, process, and technology following the socio-technical system theory. Following the inclusive construction phase involving every function, data were systematically collected through the model's application, illuminating critical areas and specific strengths within each business function. The analyzed results formed the basis for initiating targeted continuous improvement projects for improve critical areas while concurrently promoting best practices to fortify existing strengths. The human-centric approach has demonstrated to foster greater adherence and acceptance of improvement initiatives, consolidating a corporate culture oriented towards the enhancement of human resources. By presenting a human-centric lean self-assessment model tailored to the manufacturing industry, offering both theoretical insights and actionable strategies for managerial decision-making this study is situated within the context of Industry 5.0, reflecting on the importance of a lean approach in the assessment of corporate performance.

Keywords: Lean, Self-Assessment, Human-centric Manufacturing, Industry 5.0, Lean 5.0

1.Introduction

In the complex and rapidly evolving landscape of Industry 5.0 (I5.0), organizations face the challenge of aligning with this new paradigm where the synergy between humans and machines takes center stage (Leng *et al.*, 2022). While Industry 4.0 (I4.0) is characterized by the integration of digital technologies and automation in manufacturing processes (Sajadieh and Noh, 2024), I5.0 emphasizes the reintegration of human intuition, creativity, and values into the manufacturing process (Maddikunta *et al.*, 2022). Despite the technological maturity of I4.0, organizations have identified the need for a more inclusive and human-centric model to navigate the complexities of modern manufacturing environments effectively (Humayun, 2021). To navigate these challenges, understanding one's current position within the technological and competitive landscape is essential. This is where the need for assessment tools becomes evident (Brozzi *et al.*, 2018). These tools, inspired by established maturity models, serve as a foundation for improvement plans, offering a mechanism for self-evaluation and benchmarking against others (Roeglinger *et al.*, 2012). Self-assessment emerges as a crucial model in this context, primarily because it fosters awareness (Baloch *et al.*, 2019) and avoids the perception of external judgment, which can be pivotal for encouraging employee engagement and buy-in (van Loon, 2019). The use of self-assessment tools, rooted in the socio-technical systems theory, enables organizations to navigate these challenges effectively by providing a structured approach to understanding their current state. This introspective approach is critical in a time when businesses must adapt to the integrated and human-centric demands of I5.0. This realization marks the genesis of our research into developing a human-centric lean self-assessment model that prioritizes human experience and contribution, aligning with I5.0. This paper presents the development, implementation, and analysis of a novel self-assessment tool, created in collaboration with employees of a mechanical manufacturing company, and

tailored to measure performance across various departments. Our approach is characterised by its emphasis on the active participation of members of the organisation in both the development and evaluation processes. This involvement ensures that the model not only reflects organisational realities, but also builds a sense of ownership and commitment to continuous improvement initiatives. By weaving together, the threads of lean methodology and human-centric principles, our model offers a comprehensive framework for assessing and improving corporate performance in the era of I5.0. Through this study, we aim to contribute both theoretical insights and actionable strategies for managerial decision-making, underscoring the pivotal role of human-centric approaches in the future of manufacturing. The paper is structured as follows, in section 2 the theoretical background is provided, in section 3 we outlined the research methodology, in section 4 results and discussion are presented and at the end some conclusions are outlined.

2.Literature Review

In today's competitive production landscape, manufacturing enterprises must adapt and evolve by reducing costs, enhancing quality, and shortening time to market (TTM). Maturity models are believed to help organizations address these challenges (de Bruin *et al.*, 2005). Maturity models assess company's strengths, weaknesses, and compare with others (Caggiano *et al.*, 2023). They define maturity stages, identify capabilities, benchmark, and address critical issues, offering standardized roadmaps for evolving domain culture and management (Sajjad *et al.*, 2023). They help understand the current state and achieve repeatable improvements (Sajadieh and Noh, 2024). Maturity models aim to gauge the level of maturity in terms of capability, competency, and sophistication within predefined criteria. Maturity is commonly evaluated using a five-point Likert scale, with the highest score indicating the highest level of maturity. Proposed framework assesses organization's best practices in capability levels (Shi *et al.*, 2019). As stated, the highest level defines full maturity in the area under consideration, conversely the lowest level represents an initial state (Becker *et al.*, 2009). A comprehensive knowledge management assessment model integrates key elements from various studies and emphasizes the importance of data, information, and knowledge (Bougoulia and Glykas, 2023). Organizations aiming for knowledge management maturity should consider critical success factors and KM standards (MAI and NGUYEN, 2022). Additionally, the relationship between knowledge management and innovation highlights the transition from knowledge assessment to capacity assessment (Razmi *et al.*, 2020). Knowledge-oriented organizations lead in implementing knowledge management practices (Saulais, 2023). By synthesizing these insights, a holistic knowledge management assessment framework can be developed, ensuring effective knowledge utilization and organizational learning. A knowledge management maturity model is a structured approach for implementing knowledge management, aiming to evaluate an organization's knowledge management practices (Kuriakose *et al.*, 2010). Various models have been developed by practitioners and researchers, each with its strengths and weaknesses. These models typically consist of criteria or dimensions that need to be assessed at different levels to determine the organization's maturity in knowledge management (Feng, 2006). Kırmızı and Kocaoglu, (2022), after conducting an extensive literature review, define maturity model dimensions as Strategy & Governance, Corporate Culture & Organizational Structure, Smart Processes & Integration, Employee Skills, and Customer Integration & Value. These dimensions encompass a variety of sub-dimensions, such as Digital Vision & Roadmap, Investment Planning, IT Cyber Security, Data Collection and Analytics, and Digital Collaboration, among others. Each dimension and its associated sub-dimensions are crafted to provide organizations with a structured framework to assess and enhance their digital transformation maturity, covering strategic, operational, cultural, and technological aspects. Lin *et al.*, (2020) identify technology, process, and organization as key dimensions. A socio-technical system is a concept that describes the interaction between the social and technological aspects of a complex system. These aspects influence each other and are interdependent (Morgan and Liker, 2020). A business function is like a socio-technical system. The success and effective functioning of a system depend on understanding and managing the complex interactions between social and technological aspects (Sony and Naik, 2020). To implement an assessment model, areas and sub-areas of the system in question have to be defined. Such models help organizations understand their current state in managing knowledge and provide a roadmap for continuous improvement towards more effective knowledge utilization and sharing. Continuous improvements is a pillars of lean management, with its roots in maximizing value while minimizing waste, provides an ideal framework for enhancing organizational performance (Shi *et al.*, 2019). Furthermore, the promotion of a bottom-up ideology is a fundamental aspect of Lean methodology (Angelis *et al.*, 2011), where improvements in processes arise from the commitment and active involvement of employees (Ainul Azyan *et al.*, 2017) and could catalyse the progression from Industry 4.0 to Industry 5.0 context (Alves, 2022). However, maturity levels measure capabilities and offer strategic competitive advantage (Kırmızı and Kocaoglu, 2022). For companies, especially those adopting Lean logic, they prove to be fundamental for implementing continuous improvement. Despite this, there is a significant gap when considering the human centric aspect of these models.

3.Research Methodology

This section describes the methodology used to develop and implement the human-centric lean self-assessment model. The first step was defining the unit of analysis. The authors selected the mechanical manufacturing company FPZ specializing in blowers, pumps, and fans since this company is considered best in class in terms of lean application and is also highly attentive to employee

engagement and empowerment. Therefore, there was a need to implement a self-assessment tool that was lean in terms of usage, considering it fast and understandable and human-centric in implementation. Indeed, the tool was developed in collaboration with employees to avoid top-down imposition of self-assessment, thus making it a tool for employees, by employees. The methodology ensured the assessment model reflected organizational realities and human-centric lean practices. The study followed several key steps: semi-structured interviews, feedback collection, formal questionnaires, standard definition, compilation, and data analysis, structured using a single-case design methodology (Yin, 2009). The initial stage of our methodology involved conducting semi-structured interviews with employees across various departments, including Corporate Marketing, Sales, Back Office, Accounting, Management Control, Procurement, Operations, Technical Office, and Human Resources. These interviews aimed to gather insights into the daily practices, challenges, and perceptions of knowledge management practices from a lean human-centric viewpoint. The flexible nature of semi-structured interviews allowed us to explore topics in depth and respond to new ideas brought up by interviewees. Following the initial interviews, a series of follow-up meetings were held to discuss the preliminary findings and clarify topics. These meetings were crucial for validating the information gathered and ensuring alignment with the objectives of the self-assessment model. During the follow-up meetings, the categories, topics, contents, questions, and responses of the four levels of the self-assessment tool were validated, with three categories and ten topics proposed, starting from literature contributions. The detailed explanations of the levels, categories, and topics are provided later in the paper in subsection '3.1. The Application Case'. Feedback from participants was systematically collected after interviews and follow-up meetings to refine the assessment tool, ensuring it remained lean and human-centric. A formalized questionnaire, developed from earlier insights, quantitatively assessed knowledge management practices, focusing on critical aspects highlighted by employees. To standardize the assessment process across departments, a standard definition for compilation was established, essential for comparing results across teams and periods. The completed questionnaires were compiled by each function involved to create a comprehensive dataset that represented the various dimensions within the organization. The final step involved a detailed analysis of the compiled data. The analysis focused on how well the functions are classified relative to the class and topic, which allows for a snapshot of the company's performance perspective. It helps to understand the strengths and weaknesses of each business function and the organization's average level compared to various classes. The insights gained from the data analysis were used to initiate targeted improvement projects. These projects aimed to address the critical areas identified during the assessment while reinforcing and expanding upon the existing strengths. The continuous improvement process was guided by the principles of lean management, with a strong emphasis on enhancing the human experience and contribution within the manufacturing environment. For our methodology, we adopt a general approach that integrates socio-technical system models tailored specifically to the realities of individual companies. Recognizing that pre-existing models are often not well-received by companies due to their lack of customization, our methodology emphasizes the development of bespoke models that reflect the unique dynamics and needs of each organization. We initiate this process by drawing from existing literature to define broad thematic areas. This initial proposition is followed by meetings and discussions with people from various departments, facilitating a dynamic feedback loop. This iterative process allows us to refine our tools and language continually, ensuring that they are both effective and user-friendly. Central to our methodology is the engagement of organizational members in every step of the design and evaluation phases. This involvement is crucial in fostering a human-centric approach, as it directly influences the development of the three macro-areas: people, processes, and technology. Through this participatory method, we not only create tools that are finely tuned to the company's context but also enhance buy-in and the effectiveness of the self-assessment model.

3.1 The application case

FPZ is a leading company in the production of air compressors and vacuum pumps, with a solid reputation built on quality, reliability, and innovation. Through a commitment to excellence and ongoing improvement, FPZ remains a benchmark in the industry, providing customized solutions and comprehensive technical support to meet the specific needs of customers. In the analysed branch, FPZ has implemented lean manufacturing and human-centric principles in a profound manner, demonstrating a strong connection to issues of employee engagement and empowerment. Through the adoption of lean practices, the company optimizes production processes to eliminate waste and maximize efficiency, while ensuring a safe and stimulating work environment. The human-centric approach translates into a particular focus on the well-being and professional growth of employees, fostering a corporate culture based on trust, collaboration, and active involvement of all team members. This commitment to engagement and empowerment is reflected in the motivation of employees and their ability to contribute significantly to the company's success. To evaluate the maturity level of business functions, specific categories and topics were identified to formulate the questions for the self-assessment tool. The classes identified were three: People, Technology, Process. Starting from literature contributions and from socio-technical systems theory (Morgan and Liker, 2020), as stated Lin *et al.*, (2020) considering People instead of Organizational, and Rossi and Terzi, (2017), considering Knowledge Management integrated in each section and Tool as Technology. For each category "People," "Technology," and "Process," specific sub-classes and contents were systematically outlined. These contents serve as the core elements that the assessment model evaluates, ensuring that each aspect

of the organization's operations is thoroughly considered. The defined contents include critical factors like competencies mapping, training management, role definitions, collaborative practices, technology adoption, and knowledge management among others. Once the contents for each topic were established, a targeted question was crafted to guide the assessment. These questions are designed to probe the effectiveness, efficiency, and maturity of practices within each topic area. The questions aim to elicit detailed responses that reflect the actual practices and perceptions within the organization, allowing the assessment to capture a realistic picture of how each topic is managed. This structured approach ensures that the assessment model not only evaluates the current state but also pinpoints areas where targeted improvements can be made, facilitating a strategic pathway toward enhanced lean and human-centric practices.

Table 1: Structure of self-assessment model

Class	Sub-class	Contents
People	Competencies	Competency mapping, gap identification, personal training objectives, and individual plans, competency profiles.
	Training	Management and responsibilities of training, budget, evaluation methods, training incentives, training events.
	Roles	Definition of roles and responsibilities.
	Collaborative Work	Collaboration and verification of collaboration, conflict management, engagement.
Technology	Corporate Know-how	Valuation of skills as a corporate asset, knowledge transfer, standardized knowledge storage.
	Knowledge Management	Capture, cataloguing, standardization, storage, and sharing of knowledge and lessons learned, database management.
	Technological Assets	Innovation, effectiveness, and improvement of technologies; tool evaluation.
Process	Value (Stakeholders)	Procedure and value creation through flows and processes, expected and generated value for stakeholders.
	Effectiveness	Quality and accuracy (effectiveness) of processes and support assets, updating of flows and tools.
	Continuous Improvement	Innovation and continuous improvement, communication of value.

As illustrated in Table 1, each of the classes—Process, People, and Technology—has been subdivided into subclasses, with four for People, three for Technology, and three for Process. For each subclass, a series of specific contents were defined, which then informed the formulation of the respective questions. To address each question, four levels have been defined. These levels descriptively articulate what each practice signifies for the company, ranging from worst practice at Level 1 to best practices at Level 4. Consequently, Level 2 is defined as a practice that represents a slight improvement over Level 1, while Level 3 indicates a stage where good practices are implemented but have not yet reached the best practice standard. Level 3 represents a state where the implementation is sound but not yet exemplary. Due to privacy concerns, only a sample description of these four levels is provided in Table 2, this example refers to the response levels for the question corresponding to the sub-class Roles within the People class.

Table 2: Example of Levels

Level	Description
1	There is no clear organizational chart associating roles and responsibilities with personnel. Job descriptions are missing. Managers are unclear about their roles, often relying on common sense for interpretation. Confusion and lack of coordination are the norm in daily interactions.
2	There is an organizational chart outlining roles and responsibilities, but job descriptions are absent. Managers have an idea of their team's roles and responsibilities, but they are not clearly defined, and work is based on individual common sense. When a new employee joins, there is a lack of initial job description outlining the company's expectations.
3	There is a clear organizational chart accessible to employees. Clear job descriptions exist for each role but are not shared with other functions. Activities are fairly coordinated, although doubts occasionally arise about who does what (tasks). The roles and responsibilities of a new employee

	are formally defined through job descriptions.
4	There is a clear, updated organizational chart accessible to all employees, within which responsibilities and roles are properly interconnected. Clear and shared job descriptions exist for each role, starting from those of function managers, who consistently exercise their coordinating role. Work and interactions flow in an organized manner, constantly aiming for improvement.

During the follow-up meetings, if two adjacent levels appeared very similar for a specific business function, efforts were made to reformulate or further elaborate the responses. This refinement aimed to identify clear differences between the levels, allowing employees to accurately identify with one specific level. This approach ensures that respondents can more precisely determine their position within the development spectrum, thereby enhancing the accuracy and utility of the self-assessment tool.

4.Results and Discussion

In the pursuit of a refined human-centric lean self-assessment model, the development process engaged every company function, creating a platform for comprehensive participation and constructive dialogue. Such a collaborative approach allowed the participants to provide valuable input, evolving the tool into a bespoke solution that was both adaptable and perfectly scaled to the company's unique requirements. The active engagement throughout the process was not merely a procedural step; it was a strategic initiative to ensure that the tool encapsulated the multifaceted nature of the organization's functions. The methodology's deployment saw direct involvement from 16 participants, representing a cross-functional swath of the corporate landscape. The participant matrix included Corporate Marketing (2 employees), Sales (3 employees), Back Office (1 employee), Accounting Department (1 employee), Management Control (1 employee), Procurement (2 employees), Operations (1 employee), Technical Office (2 employees), and Human Resources (2 employees), with the Innovation Manager playing a pivotal role. The role of the Innovation Manager was crucial during the execution of the human-centric lean self-assessment process, actively engaging from the organizational perspective. Support was offered to employees in a vital manner during the feedback stage, enabling the identification of enhancement initiatives, and playing a key role in promoting widespread participation and commitment. The diversity in the participant group ensured that the self-assessment could capture a wide range of perspectives, thus facilitating a nuanced and detailed evaluation of operational practices. The level of engagement observed during the assessment process was remarkable, denoted by the swift 10-day response time for feedback, reflective of the participants' keen involvement and the efficient feedback mechanisms in place. The initial phase of the methodology, involving four comprehensive meetings, laid the groundwork for a questionnaire that was both relevant and reflective of the operational subtleties within the various departments. Subsequent phases of feedback exchange were marked by a series of additional meetings and direct communication channels, emphasizing the iterative nature of the tool's refinement. The Innovation Manager's role was central during the four intermediary meetings, which were crucial for aligning the assessment process with the company's strategic direction and innovative objectives. Upon completion of the data collection and initial analysis, a further set of four meetings with the corporate functions was convened to deliberate on the findings. These discussions not only facilitated tailored feedback but also provided a platform for each department to contextualize their performance within the larger organizational framework. The subsequent intermediary meetings, led by the Innovation Manager, were critical for translating the assessment's results into actionable strategic initiatives. These meetings segued into four additional discussions with the various functions to define and articulate continuous improvement projects tailored to the assessment's insights. Targeted improvement initiatives, identified during these strategic planning sessions, were designed to address the critical areas of development highlighted by the assessment. These initiatives aimed to capitalize on strengths and mitigate identified weaknesses, forming part of a long-term strategy to foster organizational growth and adaptability. The self-assessment method has thus been instituted as a standard, annual process, underscoring the organization's dedication to continuous self-evaluation and enhancement in alignment with the dynamic requisites of I5.0. This iterative, human-centric approach to operational excellence has instilled a culture of active participation and has cemented the self-assessment model as an integral component of the organization's strategic planning toolkit. Through this extensive process, the organization has not only developed a robust lean assessment framework but has also reinvigorated its commitment to fostering a culture where continuous improvement and innovation are the hallmarks of its ethos.

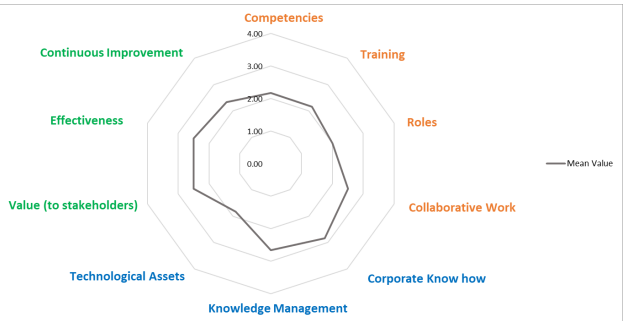

Figure 1: Mean Radar Chart

In Figure 1, the results that reflect the average values obtained from the various functions for each subclass were presented, as depicted in the radar chart. This visual representation indicates that, on average, the subclass 'Technological Assets' scored the lowest, whereas 'Corporate Know-how' scored the highest. It's important to note that the chart illustrates aggregate data; individual function results are not disclosed to maintain corporate

confidentiality. Each function, based on its unique impact on the radar chart, has identified a particular subset where it falls behind and has commenced a dedicated improvement initiative aimed at boosting performance in that specific domain. As a result of the self-assessment, several targeted improvement initiatives were implemented. For example, Management Control focused on enhancing employee competencies, Corporate Marketing prioritized improving corporate know-how, and the Sales and Accounting departments concentrated on advancing their knowledge management practices. Additionally, the Back Office and Procurement teams worked on upgrading technological assets, while Operations, the Technical Office, and Human Resources aimed to increase the value created for stakeholders through process improvements. On the contrary, for the subclasses where functions are performing closer to best practice standards, the goal is to draft a standard of best practice unique to that function. This standard will serve as a benchmark, aiming to guide other functions towards achieving excellence by emulating the successful practices that have been established. This dual approach ensures that while weaknesses are being systematically addressed, strengths are harnessed to raise the overall performance bar across the organization. Following the development of the tool, a standard process has been established to conduct the human-centric lean self-assessment on an annual basis. While the questions and response levels have been clearly defined, the process is designed to be adaptive. If, upon review of the results, it is found that the corporate functions consistently achieve Level 4 (best practices), the response levels will need to be recalibrated. This implies that what is currently considered best practice may evolve into the new norm, effectively becoming Level 3. This shift will create room for the introduction of an updated Level 4, thus raising the bar for best practices and continuously driving the organization towards greater excellence.

5.Conclusion

The core objective of this research was to design a custom lean self-assessment methodology that would be both repeatable and sensitive to the specific needs and nuances of a contemporary manufacturing company. This goal has been realized through the creation of a standardized model that can be readily adopted by similar enterprises seeking to undertake a lean 5.0 transformation journey, integrating lean principles with I5.0 and emphasizing a human-centric approach. The model's content has been precisely crafted to reflect the unique attributes of the organization, ensuring that the evaluation is as relevant as it is insightful. This balance between a standardized approach and tailored content lays a solid foundation for sustainable lean advancement, allowing for iterative refinements in response to the evolving organizational environment. The model's success is highlighted by the commitment it has engendered within the company, embodying the principles of I5.0. It has actively engaged employees in both the iterative development and the ongoing application of the assessment tools, embedding a shared ethos of continuous enhancement throughout the organization. This study has effectively closed the loop between the practical aspects of the lean processes and the individuals who drive them, fostering a culture where continuous improvement is not only a corporate strategy but a collective endeavour. A limitation of this study is its reliance on a single-case design methodology. Conducting the research within FPZ company, while providing valuable insights, inherently limits the generalizability of the findings. The unique characteristics and specific context of this company may not fully represent other organizations, even within the same industry. Additionally, focusing on a company already deeply engaged in lean practices might limit the applicability of the self-assessment tool to environments where lean principles are not as firmly entrenched. To address this limitation, future research should include multiple case studies across various industries, including those not practicing lean methodologies. This approach will help validate and refine the model's generalizability and ensure the human-centric lean self-assessment tool is robust and effective across diverse organizational contexts. Looking ahead, the methodology paves the way for tracking the evolution of improvement initiatives via key performance indicators (KPIs). These KPIs serve as quantifiable benchmarks that will enable the organization to precisely monitor and document the impact of lean practices on performance outcomes. Consequently, this will complete the feedback loop of assessment, action, and review, thus establishing the model as a dynamic instrument that not only evaluates but actively stimulates corporate excellence. The proposed model, therefore, does not represent the culmination but the commencement of an ongoing journey toward excellence. It is an instrument poised for annual application, designed to evolve with the company it serves. The model's flexibility to update response levels ensures that the benchmark for best practices remains a moving target, reflecting the organization's progressive aspirations. It is an approach that recognizes achievement while constantly redefining what is possible, pushing the company toward ever higher echelons of operational and innovative prowess. In this way, the organization is well-positioned to continue thriving in the fast-paced, human-centric era of I5.0, setting new standards for what it means to be lean, adaptive, and fundamentally human in the modern manufacturing landscape.

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