LUMEN ET VIRTUS
ISSN: 2177-2789

# LEAN MANUFACTURING AND THE APPAREL INDUSTRY: AN ASSESSMENT MODEL FOR SUSTAINABILITY

https://doi.org/10.56238/levv16n46-069

**Submitted on:** 21/02/2025 **Publication date:** 21/03/2025

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## ABSTRACT

Lean manufacturing is a management model not directly focused on the study of work (Taylorism), but a management that focuses on analyzing the relationship of employees with their work and their purpose with the company. Thus, the research has a general objective to identify the application of lean manufacturing in the activities of the clothing manufacturing industries and to understand the level of execution that companies are carrying out of lean. For this, a descriptive qualitative methodology was developed with content analysis, carried out through semi-structured interviews to analyze the work experiences of employees about lean. Therefore, the results showed that the industries have applied lean manufacturing, but in a still flawed way, because they do not have an administration by objectives, training of employees continuously, as well as environmental criteria such as requirements for hiring suppliers; however, modern technologies applied to LM for production control (software and machinery) remain one of the biggest challenges for entrepreneurs because they have a high acquisition value.

**Keywords:** Lean Social. Lean Economic. Lean Environmental.

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## INTRODUCTION

The search for better working conditions and industrial spaces are factors of search and modifications to reach an ideal and sustainable scenario, especially when such changes require organizational transformations.

The lean manufacturing *management model* - hereinafter LM - has been an effective and solid alternative for production processes and organizational changes, especially in its applicability in the activities developed in the clothing manufacturing industries in favor of the permanence of a sustainable evaluation model.

According to Cintra and Oliveira (2021), clothing manufacturing companies are relevant in their representativeness in industrial spaces because they have a high production demand and meticulous processes, circumvented by several bottlenecks with high consumption of raw materials and excess labor from human force.

The authors Henrique and Gonçalves (2008) state that *lean manufacturing* has been acting in these spaces to establish balance in the use of infrastructure such as machinery, inputs and other derivatives, as well as in the use of human labor, organizing in separate stages the production of clothing activities for better performance, with sequential collection and product planning, material storage, modeling development, fabric spreading, cutting, sewing preparation, cleaning and finishing, ironing, packaging, finished product stock and order shipping.

As it is a production management model that seeks production without waste and with value in the production chain, *lean manufacturing* or *green manufacturing* establishes strategies that guide sustainable standards from the strategic, tactical, to operational levels, circumventing vertical and horizontal alignments in the organizational structure.

Thus, the present work seeks as a general objective to evaluate a possible relationship between *lean manufacturing* and sustainability from the point of view of employees of clothing industries. Seeking to meet the general objective, a new evaluation model was created to analyze the level of maturity of the *LM* with regard to sustainability in the industries, involving the business levels, the sustainable dimensions, and the variants of the production system.

Given the dimension of action of the ML model, the present research works in an on-site study with 06 small clothing companies based in Santa Cruz do Capibaribe -PE, considering the inclusion and exclusion criteria according to the methodological criteria.

However, for greater veracity of the data, qualitative research was considered with interviews and semi-structured questionnaires, as it is understood that culture and behaviors cannot be measured through palpable means (Bardin, 2011).

Therefore, the research is fully justified by the need to show and understand the behavior of *lean manufacturing* within the industrial structure through the culture of the organization, in addition to the maturity to identify through the members of the company for the development of production processes and strengthening of industrial sustainability through daily practices and behaviors.

## LEAN MANUFACTURING AND ITS RELATIONSHIP WITH THE APPAREL INDUSTRY

The clothing industry is one of the main activities for the economic development of a country, therefore, Mcdonald and Van (2002) consider that even though there are detailed processes of transformation activities in the clothing industry, companies permeate the search for new paradigms or even the change of productive attitudes that are directly influenced by market fluctuations, And for such a problem, lean manufacturing has emerged as a new paradigm for possible solutions and industrial competitiveness for garment factories, through the elimination of waste.

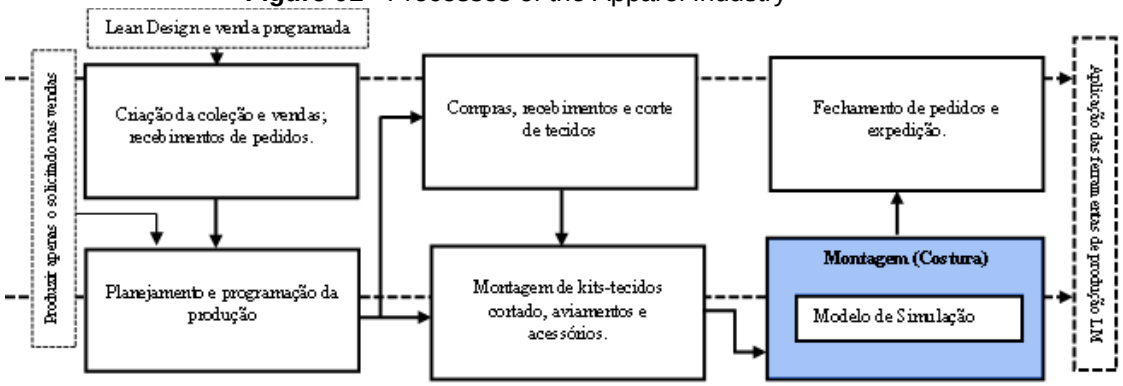
In this perspective, the production of waste from the activities arising from the manufacture of clothing, becomes a research factor for the development of industrial solutions to reduce the impacts generated through the various pollutants and balance between the dimensions of sustainability, which through lean production, *lean manufacturing* management or *green manufacturing* In the clothing production chain, sustainable standards and styles are achieved through infrastructure, machinery, culture and work philosophy, providing opportunities for the search for corporate sustainability through the "ability of the company to remain competitive and profitable over time, through the offer of products and/or services with quality and price compatible with the market, and the fair remuneration of its workforce, investors and/or owners." (Barata, 2007, p. 71).

However, even with the search for sustainability in production systems, sewing activities provide opportunities for numerous varieties of processes and bottlenecks that make it difficult to control scheduled operations (Akçagün; Dal; Yilmaz, 2015), where with the execution of the LM it is sought for better management of these processes, to achieve more effective results and operational performance with greater quality contour, minimum stock, delivery times, among other activities. (Chen *et al.,* 2019).

From this perspective, the authors Henrique and Gonçalves (2008) show that the clothing industries, to meet the standards of lean production and have "adequate" performance for sustainability, organize themselves in processes interconnected to each other to structure a production that eliminates any type of waste to remain competitive and

with a level of production balanced to that requested by the consumer; Thus, the production processes are separated by stages, namely:

**Figure 01 -** Processes of the Apparel Industry




**Fonte:** adaptado de Chan *et al*, 2018 e Henriques e Gonçalves, 2008.

Thus, it is necessary to understand that the procedures of clothing production are sequential steps that follow the pull cycle, where each step leads to a sequence of activities in series, which when performed correctly generate survival for the industry, because with the applicability of LM management, organizations are subjected to a reduction and reduction of margin of error or waste, where consequently the marginal cost is close to zero. (Nallusamy, 2016).

In this way, companies organize themselves in a standardized way, to strengthen sustainable standards that are conducive to the life cycle in organizations, seeking combinations of *lean manufacturing* tools for greater work flexibility and achievement of results (Chan, Chi; Tay, 2018); thus, from this organization, the clothing manufacturing industries, through their complexity, follow an operational sequence as described by Biermann (2007), namely:

**Figure 02 -** Production Sequence of Apparel Industry


**Source**: adapted from Biermann, 2007.

As shown in figure 02, the production sequences of the clothing manufacturing industry are structured in standardized procedures and with paradigms that enable operational control of each activity to be developed, where through the tools of the *lean/green manufacturing management model* the possibility of production with more maturity is achieved, with the elimination of waste, continuous quality and a production system according to the requested demand. (Nallusamy, 2016).

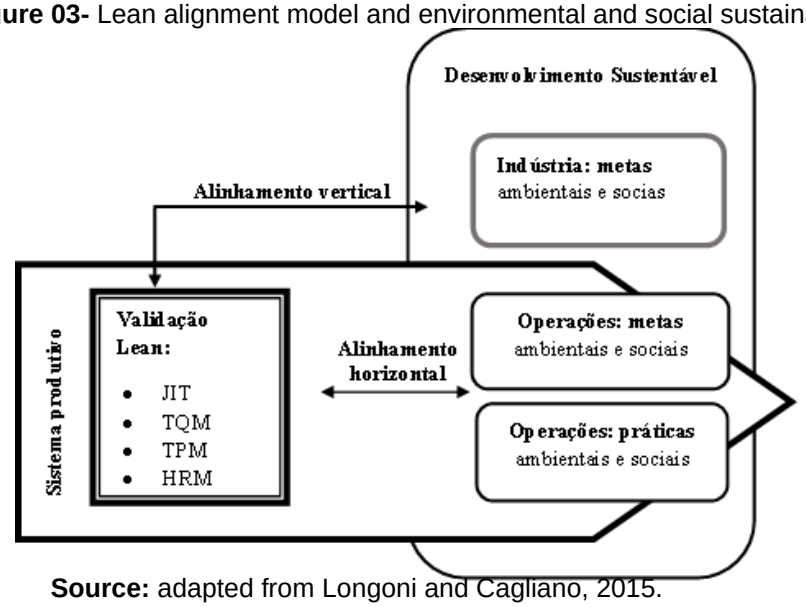
Therefore, the authors Abranches and Brasileiro (1996) consider that every industry must have its activities, departments and people connected, because every company must know its processes, to organize them, and that through this, the results are seen in the reflections found in the demand for requested service, in the correct execution of all stages of the production process and the synergy deposited in the operating system.

## LEAN MANUFACTURING: EVALUATION MODEL FOR SUSTAINABILITY IN INDUSTRY

Lean *manufacturing* or *green manufacturing* is a production management model that starts its process at the strategic, tactical, and finally the operational level of an industry, seeking to establish sustainable standards in the activities developed. (Ballé, 2019).

For Longoni and Cagliano (2015), through the organization of the LM, vertical and horizontal strategic alignment is achieved, interconnecting with the social and environmental dimensions of sustainability, perceiving such results through the involvement of the executive and the relationship with employees through the *lean* methodology with environmental and social practices, as shown in figure 03:

**Figure 03-** Lean alignment model and environmental and social sustainabi




**Source:** adapted from Longoni and Cagliano, 2015.

Through the lean alignment model with sustainability (figure 03), it can be seen that the contributions that the LM operations systems perpetuate in interfaces with social and environmental expertise, considering a sustainable development for the industry by contexts of financial survival, market stability, and social maturity by vertical and/or horizontal alignment.

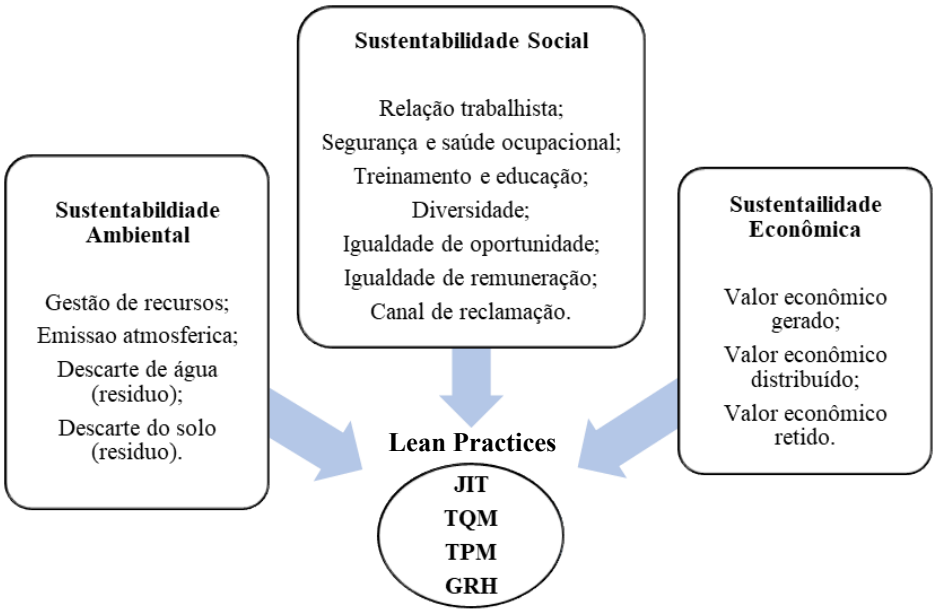
It is pertinent to consider that even though the LM permeates the dimensions of sustainability by horizontal and vertical forms, it is admitted that the research of Martínez Leon and Calvo-Amodio (2017) is more enlightening and offers greater maturity of study between the LM being sustainable for the industry from the integrations of six propositions, where: the first two prepositions are directed to the necessary adjustments between *lean manufacturing* practices with the dimensions of sustainability; prepositions three and four are related to environmental situations, directed to lean production, waste and tailings; while preposition five emphasizes the conditions of the human component, through its social relations and psychosocial well-being; and preposition six, which is structured as a large dimension for the system, as it addresses the need to implement *lean manufacturing* in a systemic and structured way.

Thus, the prepositions of the aforementioned author with the assumptions arising from Longoni and Cagliano (2015) when placing *manufacturing management* as sustainable allow us to identify that the current management model is already in constant adaptations, even though there is resistance from some industries that choose to remain with archaic production processes.

Therefore, Resta *et al* (2017) considers that to implement or measure the sustainability that a management model can offer, the Global Reporting Initiative (GRI - 2015) should be used as a reference, structuring 14 categories divided into the three dimensions of sustainability as an evaluation, namely: Environmental Sustainability; Social Sustainability; Economic Sustainability.

Through the studies of Resta *et al.* (2017), an adaptation of the relationship model of *lean manufacturing* with industrial sustainability is constructed, as shown in figure 04 below:

**Figure 04 -** Model of the relationship between *lean manufacturing* and




**Source:** adapted from Resta *et al*, 2017.

It can be seen that LM production practices are concentrated in four extensions, namely: Total Preventive Maintenance (TPM), Just-in-Time (JIT), Total Quality Management (TQM) and Human Resources Management (HRM). The relationships of these practices are interconnected in all categories of the GRI – 2015, and allows a reading of where each lean production action will intervene to offer sustainable support to the industry, therefore, the possibility of working on other joint strategies to submit better industrial performance cannot be excluded, considering that no management model supports the various activities developed in a company.

However, from this perception, it becomes pertinent to establish standards for the evaluation of ML and its maturity as a sustainable management model for the industry, considering that through bibliographic studies, it is possible to structure a questionnaire model proposed for the evaluation of *lean* and its relationship with sustainability for the industry. Thus, to evaluate *lean manufacturing* as sustainable, a questionnaire is developed on a literature review of the works of the authors Resta *et al*. (2017) and Ballé *et al* (2019), where the model proposed for the evaluation of the strategic level is composed of four parts, namely:

**Table 01 -** Proposed Model for Strategic Level Assessment

| Guidelines on the Evaluated Item | Questionnaire Template to be Applied |
|---|---|
| **PART I - Knowledge and implementation of *lean manufacturing*** | **Questionnaire for knowledge and implementation of *lean manufacturing***<br><br>1. How did you learn about lean manufacturing? |

| | |
|---|---|
| It is observed that the search for a structure of knowledge investigation and implementation of *lean manufacturing* in the industry studied, therefore, enabling questions aimed at motivating the implementation of LM in the company, forms of training the staff, and temporal evolution of the company before and after the implementation of *manufacturing management*. | 2. What motivated you to implement Lean Manufacturing in your company?<br>3. What is the biggest challenge encountered in the business strategy for implementing lean manufacturing?<br>4. How is training carried out in your company on a monthly, semi-annual, annual basis, etc.?<br>5. What criteria does management consider when hiring a new employee in view of the execution of the lean philosophy?<br>6. How would you define lean manufacturing?<br>7. In your view as a strategic position of the company, do you consider that the company has a lean manufacturing culture and methodology?<br>8. What could you point out as an improvement for LM? |
| **PART II - *Lean manufacturing*: Social Sustainability**<br><br>It is directed to structuring a questionnaire to study employability, salary level, union adjustments and job and career plan of the staff, as well as perception of health care, sports, leisure, safety and well-being; In addition, it also extends to knowledge of the existence of independent social projects carried out by the company for the community. | **Questionnaire for *Lean manufacturing*: Social sustainability**<br><br>1. How do you evaluate your company's employability level?<br>2. Does the company have policies to increase the level of salary remuneration of its employees by union adjustments, by job and career plan?<br>3. How often is the improvement of the company's work environment for employees?<br>4. Does the company have a leisure area for employees during breaks?<br>5. Does the company have health, sports, leisure, or other activities for the health, safety, and well-being of employees? Talk about.<br>6. Does the company have independent social projects for the community? (independent or partnership projects). Justify. |
| **PART III - *Lean manufacturing:* Economic Sustainability**<br><br>It provides the opportunity to produce questionnaires for study aimed at reducing operating costs and increasing revenue through improved performance of production processes. In a way, offering knowledge about the waste eliminated, and the moment that the industry empirically realized through the report of operational results. | **Questionnaire for Lean Manufacturing: Economic Sustainability**<br><br>1. Has the company been reducing its operating costs and increasing revenue?<br>2. With the implementation of LM, did the company improve the performance of its production and support processes?<br>3. Can you see that the company has increased its turnover volume? Talk about.<br>4. What waste found in production has been eliminated? Talk about.<br>5. How did you realize whether or not the company started to reduce its operating costs? Empirically or operating results report. |
| **PART IV - *Lean Manufacturing*: Environmental Sustainability**<br><br>It focuses on the production of a questionnaire to know the strategic level of the solid, liquid, and/or gaseous industrial waste produced by the researched actor. It also enables knowledge about the *manufacturing culture* involved in environmental projects or activities carried out for the community. However, the Lean | **Questionnaire for *Lean manufacturing*: Environmental Sustainability**<br><br>1. Has the company reduced its solid, liquid, and/or gaseous industrial waste? Talk about.<br>2. What is the destination of the factory's solid waste?<br>3. From a lean manufacturing perspective, how do you evaluate the company's environmental projects or activities? What improvements have been made for the community? |

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| manufacturing parameter, Environmental Sustainability, for evaluation in a questionnaire is also maintained for the analysis of economic criteria, logistics chain, reverse activities, implementation of renewable energy sources, and circular economy practices through reuse, customization, and/or recycling of end-of-life products. | 4. In meeting lean manufacturing, what economic criteria has the company been implementing within the lean culture in its logistics chain with an environmental emphasis? (conditions for purchasing material, selection of suppliers, investment in technology, means of transport, etc.)?<br>5. Has the company increased collaboration in its logistics chain with partners who follow an environmentally friendly policy? Justify.<br>6. With the implementation of lean manufacturing, has the company implemented other renewable energy sources that can reduce its energy consumption (savings, cost reduction) from non-renewable sources per unit produced?<br>7. Does the company develop circular economy practices through the reuse, customization, and/or recycling of end-of-life products (unsold and stocked collections)?<br>8. How do you work with industrial production? Do you first "capture" the sale to produce, or does the factory produce and then sell? (demand forecast). |

**Source:** Prepared by the author, 2023.

To evaluate the tactical and operational level, five criteria must be evaluated, as shown in table 02:

**Table 02** - Proposed Model for Evaluation of the Tactical and Operational Level

| Guidelines on the Evaluated Item | Questionnaire Template to be Applied |
|---|---|
| **I Criterion: Quality**<br><br>The level of culture of the employee towards *manufacturing* management is known through the self-assessment of the operational body on the quality of the work developed in its daily production, the contribution with the company's actions with the application of *lean manufacturing tools.* In addition to offering evaluation of product quality, strategies for correcting failures in production and quality of work. | **Questionnaire for the Criterion: Quality**<br><br>1. How do you evaluate the evolution of your work in the continuous improvement activities of the products?<br>2. How do you contribute to the company's actions in the application of the Lean Manufacturing tool?<br>3. How did you have access to the lean manufacturing work method?<br>4. How is the product quality process evaluated?<br>5. How often do you seek to correct failures in production?<br>6. How do you evaluate the quality of your work? |
| **II Criterion: Human Resources**<br><br>It makes it possible to learn how the people management department is training employees on the *manufacturing* culture, periodicity, investments, and training. In a way, it provides the opportunity to know through self-assessment what level of importance the LM offers to the company. | **Questionnaire for the Criterion: Human Resources**<br><br>1. When you started your activity in the company, did you undergo training to learn about lean manufacturing?<br>2. Currently, do you undergo continuous training to update your knowledge to perform your function?<br>3. How do you evaluate the application of LM in the company? Does it help to combat waste, or should it not be implemented? |

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|---|---|
| **III Criterion: Client**<br><br>This criterion makes it possible to know how mature the employees' knowledge is about the clientele, the condition of JIT distribution, the organization of demand and supply, and the expansion of production over production on demand. | **Questionnaire for Criterion: Customer**<br><br>1. What is the status of JIT distribution to the customer?<br>2. How are customer engagement levels with current and future product offerings?<br>3. Has the lean form of production, where you work on demand and then execute production, become viable for the factory floor and the delivery time of the product to the customer? |
| **IV. Criterion: Supplier**<br><br>The study of this criterion as an evaluation item provides the opportunity to understand the strategic maturity of the company if it allows employees to participate in meetings to choose suppliers and develop new products and goals to be achieved. An evaluation is submitted to verify whether there is knowledge on the part of the employees about the level of JIT delivery and criteria for choosing the main suppliers; in addition, it offers conditions to observe whether the employee can define what the LM is and what it is for, in a certain way to identify its contribution to sustainability (social, economic and environmental). | **Questionnaire for Criterion: Supplier**<br><br>1. Do you participate in the meetings and choice decisions that involve suppliers in the development of new products?<br>2. Would you know how to answer what level JIT delivery is by the main suppliers?<br>3. For you, what criteria should be taken into account when choosing suppliers in meeting Lean Manufacturing?<br>4. Would you know how to define what Lean Manufacturing is and what it is for?<br>5. For you, does lean manufacturing contribute to sustainability (social, economic, and environmental)? Talk about each item. |
| **V Criterion: Production System**<br><br>This evaluation criterion makes it possible to know the cultural maturity of the employees' knowledge about the company's Production System, directing them to know the LM tools and their functions. In addition to evaluating, from the perspective of the employees, the development and improvement of a lean product, the flexibility of activities among the workers, and the destination of solid waste from the company's production**.** | **Questionnaire for the Criterion: Production System**<br><br>1. How are the 5S being applied?<br>2. Can you identify the importance of using Kanban (a tool that uses indicators through green, yellow, and red cards) for the control and distribution of products in production? Is it viable?<br>3. In the company, is the time value standardized for the pace of production to meet the requested demand (Takt time tool)?<br>4. How do you evaluate Value Stream Mapping (VSM) in the enterprise?<br>5. Does the company make use of Kaizen and PDCA for the continuous improvement process for all activities in order to create more value with the elimination and reduction of waste? In what way?<br>6. Do you consider the factor of Visual Management that offers visualization of information on activities, production, products, and performance indicators, among other |

| | |
|---|---|
| | variables, to be important? Where do you identify this in the company?<br>7. What is the status of knowledge about equipment setup times? Talk about.<br>8. Are the lead times of each raw material and product known?<br>9. How is the Andon tool organized for visual management in operations that require interference in production?<br>10. How is the balance of the type and quantity of production calculated over a stipulated period of time for process stability, elimination of wasted time, elimination of excess inventory, reduction of costs and labor, in addition to production lead time?<br>11. Regarding the company's total productive maintenance, how is corrective and preventive maintenance carried out in the production sector? Assistance from internal or external professionals.<br>12. How do you consider lean product development and improvement?<br>13. How is the flexibility of activities among workers evaluated?<br>14. What is the destination of solid waste from the production of the company you work for? |

**Source:** prepared by the author, 2023.

Therefore, as shown in table 02, the *lean manufacturing* evaluation model for industrial sustainability interconnected to the tactical and operational levels, five criteria can be considered for the evaluation of the LM through a structure that starts from the perceptions of employees, with the assumption that the "*lean* thinking It does not focus exclusively on the study of work or the study of people (such as motivational programs). [...] Instead, lean thinking lies in specifically analyzing employees' relationship to their work. (Ballé, 2019, p. 239).

## METHODOLOGY

In order to reach answers to the object of study of this work, a qualitative descriptive study research was developed, through content analysis techniques and also the application and validation of a new evaluation model for the analysis of the relationship between *lean manufacturing* and sustainability in the industry, with approval by the Research Ethics Committee through CAAE 59296322.5.0000.5187.

It is pertinent to consider that the choice of content analysis was due to being "[...] a range of equipment; or, more accurately, it will be a single instrument, but marked by a great disparity of forms and adaptable to a very wide field of application: communications". (Bardin, 2011, p. 37).

Through the literature of Bardin (2011), the analysis was divided into three phases: i) pre-analysis; ii) exploitation of the material, categorization or coding; iii) treatment of results, inferences and interpretation. Thus, the validation of the research findings was provided through coherent and systematic results between these phases, with the rigor of the organization of the entire methodological process and the investigative maturity that inhibits any ambiguities, constituting a pioneering premise.

To carry out the study, a model was created to evaluate ML and sustainability in the industry, and its effectiveness was applied and proven throughout the results presented in this research. In a way, data collection instruments were semi-structured interviews and observations that took place in person, from July to October 2023. It is noteworthy that voice recorders were used in order to capture all the interviewees' speeches so that the collection would be more reliable.

Therefore, the universe of the research had the participation of six clothing industries based in the city of Santa Cruz do Capibaribe/PE. The participants were professionals belonging to the strategic, tactical and operational levels of the organization. The study had as a criterion for choosing small industries belonging to the Sebrae Caruaru database in the services between the years 2011 and 2021. The criterion for choosing the city as the geographic area of the companies was based on its high representativeness in Latin America, because for Silva *et al* (2015) it is one of the largest producing cities of clothing in Pernambuco.

Therefore, to represent the results, the recommendations of Bardin (2016) were met, where the data were transfigured into six factory owners, six managers/supervisors, twelve seamstresses/sewing assistants, twelve fabric cutters/weeders, twelve finishing operators/label operators, as shown in table 03 below:

**Table 03 -** Structure of the Interviewees' Coding

| Coding Industries | Industry tracking | Coding of respondents – by Organizational level | Date of interview | Average duration per respondent | LM Execution |
|---|---|---|---|---|---|
| **IN1** | Fitness Fashion Apparel Making | **IN1. EST –** 01 participant<br>**IN1. TAT –** 01 participant<br>**IN1. OPE –** 06 participants | 26/07/2023 | 00:18:21 | 06 years |
| **IN2** | Clothing Manufacturing for Beachwear | **IN2. EST –** 01 participant<br>**IN2. TAT –** 01 participant<br>**IN2. OPE –** 06 participants | 14/08/2023 | 00:17:10 | 05 years |

| | | | | | |
|---|---|---|---|---|---|
| **IN3** | Fitness and Beach Fashion Apparel | **IN3. EST –** 01 participant **IN3. TAT –** 01 participant **IN3. OPE –** 06 participants | 28/08/2023 | 00:20:08 | 08 years |
| **IN4** | Underwear Clothing | **IN4. EST –** 01 participant **IN4. TAT –** 01 participant **IN4. OPE –** 06 participants | 11/09/2023 | 00:19:17 | 08 years |
| **IN5** | Clothing Manufacturing Casual Fashion an Infantile | **IN5. EST –** 01 participant **IN5. TAT –** 01 participant **IN5. OPE –** 06 participants | 25/09/2023 | 00:18:05 | 06 years |
| **IN6** | Clothing Making fc Casual Fashion | **IN6. EST –** 01 participant **IN6. TAT –** 01 participant **IN6. OPE –** 06 participants | 10/10/2023 | 00:19:03 | 07 years |

**Source:** prepared by the author, 2023.

Thus, when arriving at the final results of the codifications, the recommendations of Creswell (2010) regarding the inclusion and exclusion criteria that were adopted in this work were considered where: of the 36 companies, 15 industries were included as suitable for selection because they have *mature lean manufacturing* and with implementation in production for more than 05 years; for the other 21 industries with LM implementation time of less than 05 years were excluded from the selection. Thus, for the refinement of the sample, the 15 factories were registered in the *Randomizer* application and 06 small industries were randomly selected for the composition of the final sample (N1, N2, N3, N4, N5 and N6).

Therefore, considering the participation of six industries, the general contribution of six representatives from the strategic and tactical levels was obtained, in addition to thirty-six operational representatives, divided equally by the number of participating industries, respectively.

## RESULTS

The presentation of the results is organized following the following structure according to the bibliography analyzed by Resta (2017) and Ballé (2019): initially, the relationship between *lean manufacturing* tools and sustainability was identified according to the samples studied, then the analyses continue according to the proposed evaluation model, through the structure of research carried out.

## RELATIONSHIP OF LEAN MANUFACTURING TOOLS WITH SUSTAINABILITY DADE

To identify the practices of applying *lean manufacturing* with sustainability and their contributions directly linked to the production system of clothing manufacturing, six industry owners (N1, N2, N3, N4, N5 and N6) respectively were interviewed.

These actors are the main responsible for strategic decision-making about the products produced and the application of the LM model, as can be confirmed by the interviewees' discourses. Therefore,

> The entire production process of the company runs according to the lean circle. From decision-making to the finished product, we prioritize the realization of all the system's tools and environmental contributions. (IN1. EST)
> On a daily basis, we do lean and run our operations in a way that is as possible and close to sustainable. You can see that our entire operation is structured in preventive maintenance and quality control, something that our competitors do not do. The appreciation that we tell the HR team to follow is our request to improve the lives of employees, and this reflects on the good work they [employees] do in meeting goals and in the operations of the pieces. (IN2. EST)
> I believe that the practices we do with lean in the area of sustainability are more found within my company, especially in the production sector. The daily activities and demands we have with everyone in our daily routine about the lean philosophy is arduous. Abroad, it depends a lot on other people doing the sustainable part, but here at the factory, lean helps us throughout the processes. (IN3. EST)
> [...] Lean tools have a sustainable relationship. The practices are all interconnected with production and people. When I installed lean in the factory, I realized that we live in constant good changes, in the quality of the part, in production, in the return of employees, in preventive actions and in the control of our waste. There are things we don't do, in this case recycling, but we initially control the process of delivering this material for use by other people. (IN4. EST)
> When I put lean in the factory, everything changed. Today we have a safe environment, productive employees, disposal of waste used and appreciation of teams with training and respect. In addition to the factory, we have the store at the Moda Center that also follows lean standards to help with our entire company culture. (IN5. EST)
> In my view, lean tools are in every corner of the factory, even in our daily lives. My company has greatly reduced energy consumption by moving facilities. Today we no longer have as much waste as before, because today we even send the remnants to the association's use. The model is very sustainable in everything. He helps with all demands. (IN6. EST).

It is noted through the discourses that the owners (directors) of the factories are able to identify that the *lean manufacturing management model* has a sustainable relationship, in addition to being noticeable that its tools are interconnected to promote sustainability.

On the other hand, it was noticed that the owners are not able to classify the dimensions of sustainability, but when provoked, they identify in the activities developed in the company those that are related to the social, economic and environmental dimensions. The perceptions are based on the identification of activities, and this became seen through the statements of the interviewees' statements, where there is *"valuing employees for*

*salary, training, opportunity to change functions, occupational safety and openness to dialogue with the head. (IN5. EST)"*

In a way, it is understood that the environmental actions developed by manufacturers are impacted by third parties, but that *lean manufacturing* is what offers the conditions for the factory to do its part with the environment and that with this condition, it is directly reflected in the company's economic guidelines, whether in the value generated or in the value distributed. Increasing production qualitatively and in the right proportion for distribution.

However, it is necessary to analyze such evidence of the actors' discourses with the perceptions of Longoni and Cagliano (2015), considering that throughout the interview the manufacturers make it clear that the LM was their decision to implement in the production of the factory, where in their statements one can perceive the whole context involving the extensions of *lean manufacturing* such as JIT, TQM, TPM and HRM being proposed first by vertical alignment and then perpetuated by horizontal alignment.

## ISSUES RELATED TO THE KNOWLEDGE AND IMPLEMENTATION OF LEAN MANUFACTURING

Deciding which production management model is most efficient for manufacturing processes is challenging for a manufacturer. With this as a presupposition, it is necessary to have knowledge about *lean manufacturing* and its extensions, in order to implement a work philosophy that generates positive results and is appropriate to organizational structures.

In view of this, in conducting the interviews with the strategic level, it was identified in the speech of the actors that the knowledge acquired from *lean* came through outsourced consultants who suggested the implementation of the model in the company, having this as an incentive, the owners consider that it motivated the most in the implementation of *lean* was the conditions that the company was in, such as disorganization in JIT, in production control and especially in the high waste arising from the high rate of wrong parts as identified in the statement: "*the first step was to hire a training course on lean, after we understood the model, we started in small steps to implement it in the company, in addition to the replacement of labor that resisted the changes in our philosophy for JIT, TQM, TPM and HRM tools" (IN5. EST).*

From this perception, the entrepreneurs were asked if the implementation of LM solved the problems found in the company, and in a way, the manufacturers recognized that *lean* organized the entire production system in six months, and in order to continue at this

pace, the factory continuously conducts annual training for employees. Thus, among the participants' speeches, they consider *lean* as:

> It is a production management model that helps us in all processes here at the factory. Today everything we produce comes from the application of the lean system. When we hire new employees, we conduct training with them through consulting with the S system. For me, lean is a production model that sustains the industry and also helps sustainability. (IN3. EST).

In this way, *lean* reaches the industries through consultancies contacted for the production area, and through this contact, training courses are held at all levels of work in the factory. However, there are perspectives that the entrepreneurs reported in the interview that even managing to implement the model in factories, modern technology becomes inaccessible to their economic conditions. According to the entrepreneurs , *"digital technologies such as production control software are too expensive for us to buy the operating license, and we have to work with traditional lean tools, manually annotating them on boards (diagrams), or papers for my general manager to later transcribe to the computer. (IN2. EST)"*

The report of N2. EST represents the thinking of the other directors interviewed, because as it was noticed, software is not yet a reality on the factory floor of these companies, and the main impact factor is the high value of technological tools that become inaccessible to small producers.

## LEAN MANUFACTURING: SOCIAL SUSTAINABILITY

According to Resta (2017), *lean manufacturing* should be seen as sustainable in the parameters of the social sustainability dimension through employability levels, which reflects the permanence of employees influenced by wages, health care, safety, hygiene and leisure, in addition to projects external to companies that offer support to the population. In view of this, through the discourses of the interviewees at the strategic level, it is noted that they value and seek ways to improve their conditions of employability and permanence of the workforce so " *we preserve the well-being of our employees, as this influences the levels of proactivity in the company and contributes to the permanence of our quality. (IN6. EST)".*

And this record of valuing employees and social conditions is emphasized when *"we carry out social project actions with our waste for the production of handicrafts, and this moves the community and external associations. When we can, we include our employees in these actions. They feel proud to get involved with social practices and value humanized activities. (IN4. EST)"*

Thus, it can be seen that when industries work with *lean* they are able to develop internal actions in the company, mainly linked to the permanence of the worker with wages, leisure, safety and hygiene; as well as the owners use the flaps to boost local commerce for the production of handicrafts carried out by the community or local associations.

## LEAN MANUFACTURING: ECONOMIC SUSTAINABILITY

When diagnosing or evaluating *lean* as sustainably economical, it is a necessity for industries to know their financial health. With this as a presupposition, it is appropriate to consider from the point of view of Resta (2017) and Ballé (2019) that for this to happen, there needs to be a reduction in operating costs and an increase in revenue, with the elimination of waste and analysis of operational reports.

Under these conditions, it was perceived through questions aimed at reducing costs and increasing revenue that the entrepreneurs asked in their statements that *"[...] We use serial production strategies, with the use of renewable energy at fifty percent of the company's capacity, as well as reducing waste in the finishing and making of the piece [...]. (IN1. EST)".* In addition, because they had been working with LM for more than five years, they realized that it was more feasible to carry out all product operations in the company and not outsource some of the steps, so *"[...] When we stop outsourcing we can save time in delivering from one operation to another, respecting the JIT, as well as no longer having expenses with third parties. (IN5. EST)"*

It should be noted that in order to visualize these results, owners are able to have greater security through the analysis of the reports, which allows more fidelity to the operational numbers, where the size of these reports,

> [...] We can see where we have decreased in the purchase of raw materials and continue to produce the same amount or even more, because we have stopped having waste of fabrics, fuel to get the pieces from outsourced workers, and even the time of the seamstresses who stopped having pieces to sew. By partially deploying renewable energy, we save time and money, as well as improve our revenue and be able to invest in comfort and infrastructure. (IN1. EST)"

In this certainty of establishing strategies for economic and sustainable purposes, entrepreneurs find in LM guidelines to be followed and stipulated in their production and daily work routine through reports and revenue generated by the company.

## LEAN MANUFACTURING: ENVIRONMENTAL SUSTAINABILITY

The involvement of the strategic level of the industries with LM and environmental sustainability are still carried out in a small way, but with remarkable initiatives in the

company. Second speech by actor IN1. EST *"We develop environmental practices in the company, such as planting trees and participating in events that we can take this idea and planting. In addition to selective waste and re-education of employees for common water, hygiene and cleaning measures [...].*

In view of the discourses, it is clear that there are still actions that industries do not carry out, such as reverse logistics or reuse of finished products for customization. It is understood according to the actor IN4. EST that *"we do not carry out the reverse logistics of products here at the factory, because our customers are from other states and they do not have the practice of returning products that they no longer use in our stores."* In addition to that "*today we do not work with the customization of the parts of our models. When the part comes out with a factory defect, we sell it to our employees at the production cost price, avoiding discarding this defective part. I believe that what we do is positive because it avoids eliminating the model of clothing unnecessarily. (IN6. EST)*

From these discourses of IN6. EST and IN4. It is clear that they are committed to some environmental practices, but not to the entire product life process, emphasizing that many of the initiatives depend on other agents to be implemented, as in the case of customers who need to return the product that is no longer used to be inserted in the reverse logistics cycle.

However, *"our tailings are taken to a landfill in Caruaru so as not to harm the environment, and the energy from the factory runs on half the solar energy that we installed a few years ago. (IN4. EST).* In this way, it is perceived that the owners have knowledge about waste and tailings and are concerned by the way they dispose of the materials. However, there are no social projects structured by the industries, but they contribute financially to philanthropic associations or community movements in favor of social projects, because *"unfortunately we cannot maintain a social project of our own, but I feel represented by contributing to social projects of associations or to the community that help people in need. (IN5. EST)*

## LEAN MANUFACTURING AND THE QUALITY CRITERION

In the analysis of the participants' discourse, answers were sought about proactivity for the development of improvement activities; the contributions they make in the application of LM tools, in addition to the level of involvement they have with the company's training or if they are aware of the training that the company offers.

Thus, through the testimony of the tactical and operational levels of the company about the forms of involvement in the activities for quality criteria, it was obtained that,

> When I joined the company, I didn't have lean training. Now, talking to colleagues, I know that the company takes courses for us to improve our activities. After about six months, the most recent people and I had a lean course with the consultant here at the company. (IN1. OPE).
> When I took over the HR sector, I didn't have a lean course. They [entrepreneurs] only enroll the sewing team, finishing, cutting operator and the rest of the operation personnel. Our knowledge of lean comes in a very superficial way, aimed only at part of people. (IN2. TAT).

In view of the speeches, it is clear that the focus of the entrepreneurs is mainly on the operational team, as they are developing activities directly linked to the development of products and handling of raw materials. In a way, even though there is training of the team at the tactical level and in an agreed way, it is perceived that managers emphasize the *lean philosophy* directed to the activities by departments that each team is allocated, that is, according to the speech of the manager of the human resources department *"we in the human resources department do not do training for the development of lean tools performed in the sewing sector or other activities on the shop floor, Not even to know what these tools are. (IN6. TAT).*

Thus, it is understood that employees do not have knowledge of all lean tools, emphasizing only those that can be applied in their sector of activity. However, these actions do not interfere with *lean* performance, because the activities performed in the company's departments are different from each other, not compromising the efficiency of *manufacturing management* (Araújo, 2006).

## LEAN MANUFACTURING AND THE SUPPLIER CRITERION

Lean *manufacturing* , because it is sustainable, tends to admit specific supply criteria from the conception of the raw material to the finished product. Thus, the interview considered employees' perceptions about such acquisitions of inputs that they handle on a daily basis in the company's production sector, having as criteria the origin of the supply, participation in meetings to choose the supply, delivery time for its raw material, which criteria the employees consider as important in the choice of suppliers in meeting the LM, as well as their perception of the contributions of *Lean Manufacturing* to sustainability. With this as a script, the main speeches were obtained, as shown in table 04 below:

**Table 04 -** Interview with the Employees

| |
|---|
| I do not participate in the meetings of raw material purchases or in the decisions for suppliers and the selection criteria. That is only with the bosses. But I believe that they only take into account the price and delivery time of the fabrics. (IN3. OPE) |
| The part of purchases and meetings with suppliers is the responsibility of the owner and sometimes with the general manager. The only thing I know is that he considers the issues of the quality of the products, the delivery time and the price of the goods if they are in |

| |
|---|
| "account." But unfortunately, there is no meeting with anyone from the sectors, only with the production manager. (IN2. TAT). |
| I believe that *lean* does help with sustainability, because today I see that we don't have so much material waste in the operation of the parts. We always leave the machines clean and organized for the next day, in this case the 5s, in addition to the company taking care of us with occupational health control programs such as overweight, diabetes, high blood pressure. (IN2. OPE) |

**Source:** prepared by the author, 2023.

In view of the analysis of the interviewees' statements (table 04), it can be seen that the decisions are not made through an Administration by Objectives, involving suggestions or evaluations through the employees, and this becomes an aggravating factor through lean evaluation criteria, as the participation of the employees is necessary to collect information about the conditions of the product that is handled in the operations of the products or even the contributions in the decisions of the company. Conclusively for this item, it is clear that there is no collaboration of the other sectors in decisions, leaving one of the characteristics of the *lean* philosophy that seeks collaboration as an "ability to exchange ideas, absorb different perspectives, take them forward and establish brief dialogues until something difficult works [...]. (Ballé, 2019, p. 59).

## LEAN MANUFACTURING AND THE HUMAN RESOURCES CRITERION

In order to understand the human resources area of the factories about the LM and the education and training in the organization, it was identified in the employees' statements that there is a deficit in the companies in the training of employees, because they do not go through refresher courses on the *lean* methodology, as expressed:

> We do not train employees. We carry out the recruitment and the entire selection process, and after hiring the owners are the ones who decide whether to hire a consultancy for lean training for employees. (IN1. TAT)
> Regarding training for lean manufacturing, training is offered the same to everyone on the team. The general manager of production, because he is already trained in lean, teaches the other novice employees who enter the factory. But so far they [owners] have not recycled our training. (IN2. TAT)

In this scenario, it becomes seen that there is only an introductory training of *lean* and for the strengthening of new courses and training does not exist in the factories, so it becomes contradictory with the LM philosophy, because when companies withdraw access to new training on *lean*, it limits itself to "giving employees cognitive skills so that they can see their work differently." (Ballé, 2019, p. 240).

## LEAN MANUFACTURING AND THE PRODUCTION SYSTEM CRITERION

The interest of the analysis by this criterion was due to the need to see the maturity of the LM culture through the knowledge that employees have through their activities.

Therefore, it was noticed in the interviews that the employees do not know the dimensions of the LM, nor the tools for using the management model, because when asked about the use of these tools, the actor IN1. OPE reported "that we use the 5s here at the factory, we leave everything clean and organized when we arrive or leave the factory".

It is pertinent to consider that the operational groups of the factories studied carry out all the LM tools, but because they do not undergo continuous training on *lean thinking,* unfortunately, the employees are unaware of what they are practicing in the activities carried out on a daily basis, that is, they practice the LM, but they are unaware of the technical description of the process.

In addition to the analysis of the discourses of the groups of employees, it was noticed in the dialogues that,

> We work with the production of parts with goals per shift. In the morning we receive the amount to be produced throughout the day, then the supervisor slaughters the total. (IN2. OPE)
> We do do LM, but I don't know the name of the tools or the dimensions, but I know we do. Everyone's work here is standardized and timed, and we have daily production goals whether here in sewing or with the cut boys. The pressure we suffer is often stressful. (IN6. OPE)
> I only know the 5s, which is the organization and cleaning part, but I know that there is more we do, because the supervisor always guides the staff on how to do it, time, see the quality of the piece and we always have demands for improvements. It becomes stressful, because we even have few cell supervisors and it overwhelms them, and so stresses everybody out. (IN4. OPE).

In the discourse of the actors, it is perceived that there is a lag of activities in the attributions, overloading the tactical level and this developing levels of stress with a cascade effect, that is, passing from one group to another. In a way, in the statements of the interviewees, it is possible to find evidence of the extensions of *lean manufacturing* as found in Resta et al (2017) as shown in table 05 below:

**Table 05** - The impact of the lean package on the dimensions of sustainability

| | | Strengths in the Discourse of the Interviewees | | |
|---|---|---|---|---|
| | | Economical | Environmental | Social |
| **Lean Extensions** | **JIT** | Low cost due to poor product management. Inventories aligned with manufacturing time, but with space occupied | Low waste and efficient use of resources | High levels of safety and ergonomics, reduction of accidents; muscle aches and high levels of stress by most employees |

| | | | | |
|---|---|---|---|---|
| | **TQM** | High quality with low cost and high turnover | Low use of energy consumption and replenishment of renewable energy | Reduced risks for employees and high employee satisfaction |
| | **TPM** | Near-zero marginal cost and high quality | Low energy loss and increased energy consumption | Low risk level for employees and reduced stress level |
| | **HRM** | Direction for the long term | Not evidenced | High commitment/satisfaction and low stress level |

**Source:** author adapted from Resta *et al.,* 2017.

In the export in table 05, it can be concluded through the views of Resta *et al* and Ballé (2019) that from the dimensions of lean manufacturing JIT, TQM, TPM and HRM there is in fact a cultural maturity of employees in maintaining the paradigms of the industries in which they are inserted, considering that even for JIT it is necessary to study ways to reduce the stress load of the work team, Because even though companies perform workplace gymnastics, medical control and leisure care, these initiatives reported by employees in the interviewee are not enough to reduce the stress arising from highly repetitive and standardized activities.

## LEAN MANUFACTURING AND THE CUSTOMER CRITERION

The lean management model has several criteria that make up its way of managing, however, one of the main approaches of the philosophy is focused on the clientele. Having this as an item for interview, it sought to understand if the employees belonging to the tactical and operational level have knowledge about the distribution jit, customer profile, the levels of relationship of customers with the products and the understanding of lean production that influences the final process of customer satisfaction. Thus, we obtain these results in the interview:

> The factory has a very good relationship with the clientele, because we produce a high demand for orders and this production we follow through the diagram our operational level of each piece, but we do not know the profile of these people who buy the parts from the factory. (IN1. OPE)
> Our focus is only restricted to factory employees and store employees. The clientele does not have access to profile information, which products are most consumed, in short, this is for the sales people. (IN4. TAT)
> The information about customer consumption, types of pieces sold and the entire structure of our sales niche is in my commercial sector and with the owners. This information is not shared so as not to generate noise or enter into issues in other different sectors. In sectors outside of production, we also have time control to return with the demands and feedback on the activities that the immediate supervisor communicates. (IN6. TAT)

It is identified in the employees' statements that the profile and satisfaction of the clientele is totally restricted to the sales sector and the owners, on the other hand, there is a subjective analysis of the operational employees who believe that the high production rate of the products implies that the customers are liking the product for its quality, price and value.

## FINAL CONSIDERATIONS

The achievement of sustainability is a challenge for producing institutions to achieve, even though there are debates on the subject and their emphasis on such importance. In a way, debating the existence of sustainability in the industrial processes of clothing becomes necessary to understand the production flow of the clothing industries and their structures that are organizationally formed by a paradigm of standardized stages.

Considerably, Nallusamy (2016) revealed a clear and solid discussion of the current scenario of clothing production in the midst of the various failures and bottlenecks that have been faced in industrial activities, where even with these complications the factories seek to organize themselves through 14 steps necessary to reduce waste and generate expenses.

Working through 14 stages, from collection planning to order shipping, has become a discipline for the clothing production industries thanks to *lean manufacturing* or *green manufacturing,* because with the implementation of this management model, stability in production and greater synchrony in manufacturing processes were achieved, with better use of inputs and higher quality achieved.

The execution of LM does not become the solution to the impacts arising from the clothing industry, because as shown in the results, entrepreneurs do not actually master the concept of LM, in addition to not disseminating such a culture to their employees, thus leaving management or *lean manufacturing* culture totally weakened and poorly executed.

It is relevant to consider that it is concluded that the failures in the maturity of the LM culture arise because of the bad involvement of those involved in the executions and in the way of disciplining the tools, without knowing how to define them; from this, we can see that the disciplinary culture is a reflection of strategic management that does not remain faithful to its own principles and also to the principles of the lean management model .

The relationship that lean manufacturing has with the industry is not only linked to industrial processes, but also to connections with the existing work philosophy between employees and the activities developed, therefore, it is proven by the findings in the application of the new model of evaluation of LM and sustainability, that employees recognize the need for permanence of LM and its relevant sustainable contributions to the

production system,  as well as the changes that come with the current situation of green manufacturing.

Therefore, it is up to researchers, students and consultants to offer a more present and participatory approach in the "factory floor" spaces to, if possible, mature the commitment of entrepreneurs to follow the principles of lean manufacturing, as they were the ones who implemented it in their factories; in addition, showing that the lean model alone without the involvement of all organizational levels does not work, thereby weakening the manufacturing culture that must be strong and present inside and outside the industry, as ML only works through people, who "are autonomous beings who think, decide and act, influenced by their emotional states and the context in which they find themselves" (Ballé, 2019, p. 239).

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