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Warehouse Management: Codification of Lean School

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ABSTRACT

This study aims to propose a coding system for the boxes and storage positions of the Lean School of the University of Valladolid. The approach used was the Case Study with direct observations and documentary analysis of the environments and based on the theoretical foundation, solutions were suggested such as the implementation of individualized barcodes and visual standardization through colors in one of the positions. Although the system has not yet been physically implemented, all the coding logic has already been defined. The proposals aim to improve control, location and operational efficiency in the environment by aligning with the principles of Lean philosophy and offering a practical application of industry.

Keywords: Lean Manufacturing, Standardization, Codification, Addressing, Storage.

INDEX

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

Storage organization directly influences production efficiency and waste reduction. In the context of Lean Manufacturing, standardization in the coding of boxes and storage locations is essential to ensure material traceability, speed up processes and eliminate unnecessary movements.

The Lean Manufacturing methodology is applied in industries with the aim of improving profitability, market share and customer satisfaction, reducing problems and consequently increasing quality through statistical tools (Bostelmann, 2019). Industrial coding is the identification of a product that is converted into letters, numbers and other characters. This type of identification helps companies and customers to have greater product traceability, in addition to knowing data such as expiration dates, supplier product data, among others (Calzado-Mesa, 2022).

According to Dias (2012, apud Tomasi et al., 2015), there is a need for an item classification and coding system, because without it, there cannot be efficient control of inventories in a production line or logistics center. Furthermore, other procedures such as storage and operationalization will not occur properly. When this item identification procedure is carried out, all their information is available.

The research will be conducted at the Lean School of the University of Valladolid and will involve analyzing the manufacturing process, identifying and classifying existing boxes, considering their different sizes and shapes, and strategically organizing storage positions. This will help develop a code that best adapts to the production process and the layout of the boxes, optimizing the management and efficiency of the system. Implementing this proposal could result in reduced time spent searching for materials, greater control over existing inventories, traceability, and improved student experience through real-world practices in industrial management.

Furthermore, as argued by Souza (2009, cited by Silva, 2021), it is in this context that organizations must promote internal adaptations, to direct management towards the elimination of elements considered surplus — with an emphasis on stocks, which concentrate a significant portion of financial resources.

In this context, to achieve its specific and general objectives, the chosen approach was Case Study, which aims to investigate the phenomena that occur in the organization. Document analysis and direct observation were used to collect data to obtain maximum information about the processes.

2 LITERATURE REVIEW

2.1. Toyota Production System

The Toyota Production System was developed in Japan after the Second World War and is a model focused on improving a company's production processes and reducing waste. Based on two pillars – Just In Time (production only necessary) and Jidoka (machine downtime autonomy) – according to Ghinato (1995). Also, the system is based on standardization, which is essential for process consistency and facilitating continuous improvement, like figure 1 below:

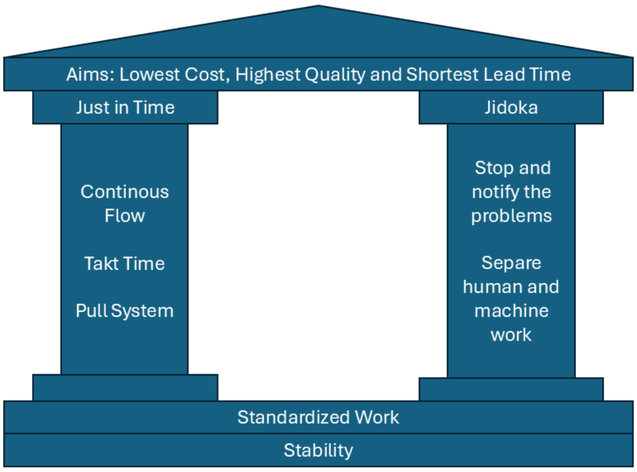


Figure 1 – Toyota Production System

This system was used as the basis for the creation of the Lean Manufacturing philosophy, which expanded beyond the concept of the automotive industry and aims the same principles, reduce costs, increase quality and reduce lead time. This philosophy aims to eliminate waste using various tools and methodologies that were primarily developed in Japan at the Toyota Factory production plant (Guevara et al., 2022). According to Palange & Dhatrak (2021), companies adopt this practice as a strategy to remain competitive, seeking to increase the productivity of manufacturing systems and raise the level of product quality.

According to Woomack and Jones (2008 apud Papandrea et al., 2020), to eradicate waste, Lean thinking is necessary, which can be applied to any type of process and organization, standardization is the basis of this system. In this context, two essential Lean tools that directly relate to the theme of box and warehouse position coding are the Seven Wastes and the 5S methodology.

2.1.1. Seven Wastes

One of the fundamental principles of Lean Manufacturing is the systematic elimination of waste at all stages of the production process. According to Ohno (apud do Rosario Vieira, 2014), there are seven types of waste identified in the Toyota Production System. These types are further described and categorized by Harish & Selvam (2015) as follows:

- Overproduction: manufacture an item in a quantity greater than that required by customer.
- Inventory: excess is a consequence of the overproduction and hide problems of the plant floor.
- Waiting: when the items are not processed or moving.
- Motion: unnecessary worker movements that do not add value to the product, these jobs should be analyzed and redesigned.
- Transportation: excessive movement between processes that adds no customer value, must be mapped to facilitate visualization and proposal of improvements.
- Rework: quality problems that generate the need to reprocess or discard materials, resulting in reinspection, reprogramming, inventory costs and loss of production capacity.
- Over Processing: processing beyond that the required, using expensive equipment for processes that are not necessary or that can be done with simpler tools.

As well as Seven Wastes, some contemporary authors consider two more types: Unused Employee Creativity that happens when the organization does not use the skills, knowledge and suggestions of labor and Environmental Waste that refers to the negative impact that does not add value to the product itself and can be avoided. Although, this project focuses on the classic seven wastes, because they are directly related to the logistical and operational issues in coding materials.

With the codification of materials in the Lean School, it will be possible to control and have immediate visibility of the inventory, avoiding unnecessary purchases, knowing where each item is, the search time is minimized and the processes flow better, since the transportation will also be improved, making the flow of materials logical and efficient. In addition, the people involved will go straight to the right point, reducing unnecessary walks throughout the process.

2.1.2 5S + 1S

The 5S tool is a methodology used for continuous improvement of quality and productivity, which consists of 5 elements (Piñero et al., 2018): Seiri (selection), Seiton (ordering), Seiso (cleaning), Seiketsu (standardization) and Shitsuke (self-discipline). And other authors incorporate a sixth element – safety – that reinforces the importance of integrating safety measures into enterprise practices and contributes to the prevention of accidents and the promotion of a safe worker environment that is called by 6S.

The project itself is directly related to the Seiketsu principle, which deals with standardization to maintain organization and efficiency in the work environment. By establishing codes, rules and standardized visual formats for the boxes and their positions, a solid foundation is created to maintain order in a consistent way. This standardization also contributes to the application of the other pillars of 5S in an integrated manner: by facilitating the identification of the items that are really necessary for the production line (obsolete or useless items are eliminated) in accordance with Seiri; by defining fixed and logical locations for each item, search time is optimized and Seiton is promoted; and, finally, the effectiveness of the system will depend on the constant discipline of those involved in following the defined standards, line in with Shitsuke. Although, the codification system can also support safety by reducing risks associated with disorganized storage and inefficient material handling.

2.2 Inventory Management

Inventory management is related to the planning and control of inventory materials or products that will be used in the production or commercialization of goods and services, as defined by Bertaglia (2006 apud Oliveira & Silva, 2014).

According to Oliveira & Silva (2014), inventory control is the procedure adopted to record, monitor, and manage the inflow and outflow of goods and products in an industry or business, and it should be applied to raw materials, manufactured goods, and/or sold merchandise. With the growing number of items with different demand patterns and specific characteristics, the difficulty in inventory management increases due to the need for differentiated control, as each organization is unique and requires adaptation in management models (Santos, 2006 apud de Carvalho et al., 2018).

In this context, the main challenge of this study is related to the lack of visibility and control of stored items, resulting from the absence of standardized coding for all materials. Without this system, it becomes difficult to accurately identify what is available in inventory, the lack of this standardization compromises traceability and planning. Additionally, the lack of control can generate unnecessary costs, such as material losses, excess inventory, or stockouts at critical moments. From the Lean perspective, poor inventory management is directly related to several of the Seven Wastes, including overstocking, unnecessary motion, and waiting time, standardizing the identification and location of items is essential to reducing these inefficiencies.

With these challenges, tools such as the Warehouse Management System (WMS) emerge to improve solutions related to control and operational efficiency. These are warehouse management systems used to manage a company's daily operations to ensure better use of resources (Ortiz & Paredes-Rodríguez, 2021). To implement this resource, item coding is necessary, and its function is to improve warehouse management, integrating the activities of all sectors of the company (Assis et al. 2018 apud Silva, 2021).

According to Wozniakowski et al. (2018), the program allows agile access to the location of products in the warehouse, controlling them in terms of quality and quantity, automatically choosing the storage location, that is, it assists with greater precision in operational issues within the warehouse. Furthermore, the integration of this system with Enterprise Resource Planning (ERP) ensures coherence between strategic planning and operational execution, allowing decisions made in the ERP to be executed in the best possible automatically by the WMS, that is, using this system not only reduces labor costs but also reduces human errors.

2.3 Coding Systems

The purpose of coding is to standardize and facilitate communication within the company, assigning unique codes to each product and position to prevent companies from not having control over their assets. In this way, identification is the starting point for a good materials management system (Costa, 2023). The most used coding systems by companies are alphabetical, alphanumeric, and numerical and decimal systems. Their selection depends on achieving clear and precise coding that avoids confusion and prevents ambiguous interpretations (Nara et al., 2013):

- Alphabetical system: consists of a set of letters from the alphabet, sufficient to identify the material. However, due to difficulties in memorization, it is becoming obsolete (Dias, 1993, apud Nara et al., 2013). It was widely used in book coding through a combination of letters (de Carvalho et al., 2018). A practical example is the name of departments within a company (Figure 2):

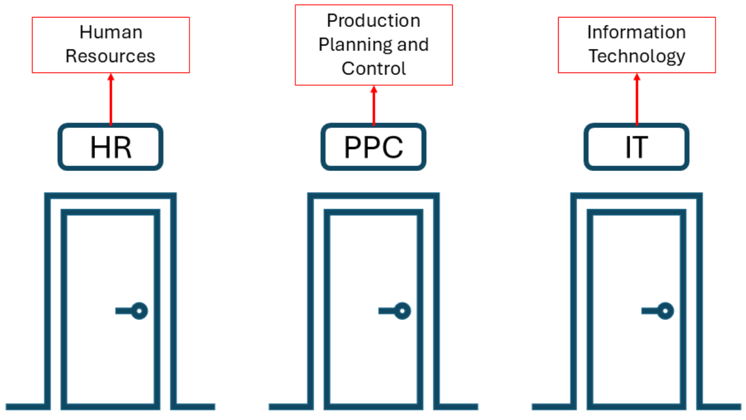


Figure 2 - Departments of a Company

- Alphanumeric system: a combination of letters and numbers, allowing for a greater number of items compared to the first system (Dias, 1993, apud Nara et al., 2013). An example is a car license plate, as shown in figure 3:

Figure 3 - Mercosur Model Car Plate

- Numerical and decimal system: used for its simplicity, it consists of a combination of numbers (Pereira, 2009, apud de Carvalho et al., 2018). In this regard, it is the most widely used by companies, as it allows for extensive variation (Dias, 1993, apud Nara et al., 2013), an example would be the EAN code (European Article Number) (Figure 4):

Figure 4 – European Article Number

2.4 Addressing

Addressing is a method used to assist in locating items within a warehouse. This system involves dividing the warehouse into areas, blocks, aisles, columns, and levels (Cáceres et al., 2019). According to Dias (1993 apud dos Santos et al., 2017), the purpose of the addressing system is to identify the exact location of materials stored in the warehouse or stockroom. While coding allows for the standardization and identification of materials, addressing complements this process by defining their physical location, ensuring greater agility and precision in logistics operations.

Inventory location systems can be divided into three categories (Moura, 1997 apud Silva, 2021):

- Memory: a system used for a small mix of products in which the people using it must simply memorize where the products are, with no formal control. An example would be a small warehouse in a family-run auto repair shop, where few people work.
- With a fixed location: regardless of whether there is material in each location, it has already been declared, meaning that the space will remain empty until the same material is placed again. An example would be a pharmacy where position X in the cabinet is reserved for a specific type of medicine and the space will remain empty until it is replaced.
- Random location: items do not have fixed positions previously assigned and their location is recorded in a system that allows tracking where each one is. An example would be a large supermarket logistics center, when a palette of tomato sauce arrives, it will be stored wherever there is available space.

Therefore, according to Jacinto et al. (2011), to optimize the picking and movement of products, it is essential to consider variables such as the type of product, the physical structure of the warehouse, and the flow of inbound and outbound goods.

Following these ideas, addressing contributes directly to waste reduction by minimizing unnecessary movements, waiting times, and errors in product retrieval, which are part of the seven wastes identified by Ohno. Furthermore, this concept is strongly aligned with the 5S methodology, more specifically with the sense of order (Seiton), as it organizes and standardizes the work environment so that everything has a designated place, making it easier to find materials.

3 METHODOLOGIES

The methodologies used to develop this project were bibliographical research and case study approach. The first was conducted with the objective of understanding the different types of coding used in logistics environments, which is essential for theoretical basis and choosing the most appropriate coding method. The second, a case study, was conducted at the Lean School, where it was possible to analyze the stocks and boxes available in practice. Based on this observation, the most efficient coding system for each item was defined, considering the operational needs and organizational reality.

3.1 Box Logic

For the coding of the boxes, the choice was made to use the numerical and decimal system, which according to Dias (1993 apud Nara et al., 2013), is the most used among companies for structuring items, as it allows a wide range of combinations, facilitating interpretation.

The code structure follows a clear logic, where each digit represents specific information about the box:

- The first one refers to the color (for example, 1 equals blue, 2 equals red).
- The second one indicates the size (for example, 1 equal small, 2 equals medium).
- The third one indicates whether it has a foam or not (for example, 0 would be without foam and 1 with).
- The last four digits represent the box's own code, used for tracking and controlling.

1210001

Figure 5 – Example Codification Box

The code shown in Figure 5, 1210001, is an example of the coding format, that: the number 1 indicates the color (blue), 2 represents the size (medium), 1 indicates that there is foam, and the last four digits (0001) correspond to the individual code of the box.

3.2 Storage Positions Logic

For the coding of storage positions, the alphanumeric system was used, according to Dias (2006 apud Jacinto et al., 2011), an alphanumeric code is used to indicate the positioning of each stored material, facilitating handling and storage operations.

The code structure follows a clear logic, in which each part of the number and letter represents specific information about the position in which it is inserted, totaling nine characters:

- The first three characters (letters) correspond to the main storage area, such as storage or specific areas designated by codes such as "ABC", "DEF" exemplified by letters.
- The first digit represents a subdivision within this main location, made up of rack, for example, it could be the rack on the right or the rack on the left, and this will be represented by its respective number.
- The second numeric digit refers to the column of the rack.
- The third numeric digit represents the level (height) within the storage structure, for example, first, second or third level.
- The last three numeric digits are intended to accurately identify the space within the bay, by measuring in centimeters the exact horizontal position.

As can be seen visually in figure 6:

Figure 6 – Addressing Method

Moreover, error prevention systems are implemented to avoid confusion in the transmission of this code, as in these examples, according to Courtois, et al. (2007 apud Lemos et al., 2018):

- Avoiding letters that can be confused with the numbers 0 and 1, for example, “O, i, I, Q”.
- Avoiding zeros that begin fields and numbers.
- Avoiding consonants with similar sounds in the code, such as “B” and “P”.
- Avoiding segmented and small fields, such as “123 456”.

AFL – 132060

Figure 7 – Example Codification Position

The example code shown in figure 7, AFL-132060, fits within the stipulated parameters. It does not contain letters that can be confused with numbers or phonetically similar consonants, the numerical section does not start with zero and the code is continuously formatted with the help of the hyphen, which is good for the visual organization, separating the storage area from the positional coordinates.

4 RESULTS AND DISCUSSION

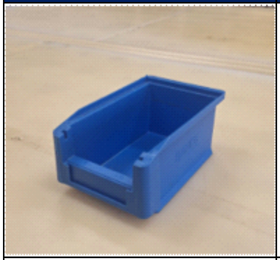
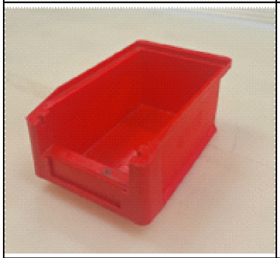
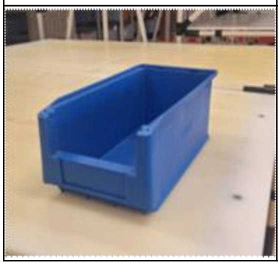
4.1 Box Coding

After the coding structure was defined, it was possible to organize and classify the boxes in the Lean School in a systematic way. To clarify the interpretation of the codes, Table 1 below presents the meaning of each digit that composes it:

Digit Position	Meaning	Possible Values
1	Color	1 = Blue 2 = Red 3 = Gray 4 = Black
2	Size	1 = Small 2 = Medium 3 = Big 4 = Strech
3	Foam	0 = Without 1 = With
4 - 7	Individual Code	Sequential Number (0001, 0002, 0003...)

Table 1 – Types of Box

Based on this logic, the boxes physically observed during the visit were catalogued; table 2 below shows how the coding was applied based on the photos taken:

Image	Color	Size	Foam	Individual Code	Final Code
	1	1	0	0001	1100001
	2	1	0	0001	2100001
	1	1	1	0001	1110001
	1	2	0	0001	1200001
	1	2	1	0001	1210001
	1	3	0	0001	1300001

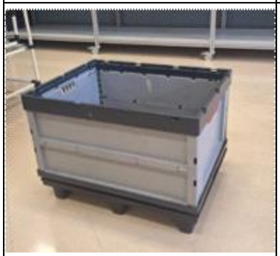
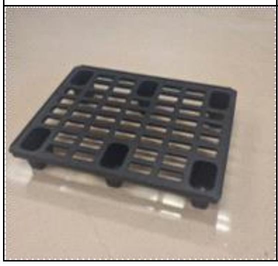
	1	4	0	0001	1400001
	3	1	0	0001	3100001
	3	2	0	0001	3200001
	3	3	0	0001	3300001
	4	3	0	0001	4300001

Table 2 – List of Coded Boxes

Regarding the coding of the size of the boxes, all were made using their colors as a basis, figure 8 visually demonstrates how the structure works:

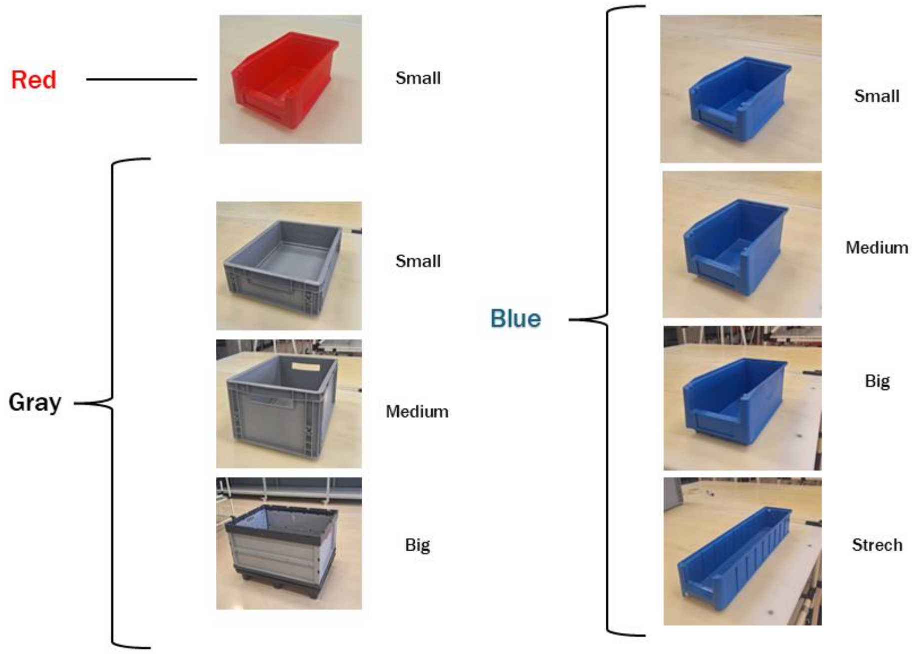


Figure 8 - Color Correlation with Size

This standardization will contribute to the control of records of existing boxes in the laboratory and their traceability.

4.2 Coding of Storage Positions

Initially, the different storage areas relevant to the Lean School of the University of Valladolid were identified, considering that each one has specific characteristics and needs. The locations were named according to their references in Spanish and associated with a standardized set of initials that serve as the basis for the code.

Table 3 presents a summary of the areas identified, the correspondence in Spanish and the corresponding initials used:

Storage Name	Spanish Reference	Initial
Bellows Storage	Almacén Fuelle	AFL
Car Parts Storage	Almacén Piezas Coche	ACO
Finished Product Storage	Almacén Producto Terminado	APT
Bases and Wheels Storage	Almacén de Bases y Ruedas	ABR
Mobile Pipe Storage	Almacén Móvil de Tubos	AMT
Mobile Parts Storage	Almacén Móvil de Piezas	AMP
Mobile Rails Storage	Almacén Móvil de Railes	AMR
Manufacturing Station Storage	Puesto de Montaje	PDM
Recycling Station Storage	Puesto de Reciclage	PDR

Table 3 – Initials Storage

4.2.1 Bellows Storage

Figure 9 shows the physical layout of Bellows Storage, highlighting the positions of the shelves and the numbering of each rack, thus facilitating the understanding of the structure:

Figure 9 – Bellows Storage

Furthermore, below is Table 4 which details the meaning of each part of the code in a systematic way.

Digit Position	Description	Value
1 - 3	Main Storage Area	AFL
4	Rack number	1 = Left rack 2 = Right rack
5	Rack Column	1 = First 2 = Second
6	Rack Level	1 = First 2 = Second 3 = Third 4 = Fourth 5 = Fifth
7 - 9	Exact horizontal position (in cm) within the bay	000 015 030 045 060

Table 4 – Bellows Storage Coding

4.2.2 Car Parts Storage

Figure 10 shows the physical layout of Car Parts Storage, highlighting the positions of the shelves and the numbering of each rack, thus facilitating the understanding of the structure:

Figure 10 – Cars Parts Storage

Furthermore, below is Table 5, which details the meaning of each part of the code itself.

Digit Position	Description	Value
1 - 3	Main Storage Area	ACO
4	Rack number	1 = Unique
5	Rack Column	1 = First 2 = Second 3 = Third 4 = Fourth 5 = Fifth 6 = Sixth 7 = Seventh 8 = Eighth 9 = Nineth
6	Rack Level	1 = First 2 = Second 3 = Third
7 - 9	Exact horizontal position (in cm) within the bay	000 015 030 045 060 075 090 105 120 135 150

Table 5 – Car Parts Storage Coding

It is important to highlight that not all columns in this stock have the same measurement, and the value may vary between spans. In this case, the exception, which is larger and goes up to 150, is column 7, and columns 4 and 6 are smaller than the standard, and can go up to measurement 105. All the others are standardized and can go up to measurement 135.

4.2.3 Finished Product Storage

Figure 11 shows the physical layout of Car Parts Storage, highlighting the positions of the shelves and the numbering of each rack:

Figure 11 – Finished Product Storage

Furthermore, below is Table 6, which details the meaning of each part of the code.

Digit Position	Description	Value
1 - 3	Main Storage Area	APT
4	Rack number	1 = Unique
5	Rack Column	1 = First 2 = Second 3 = Third
6	Rack Level	1 = First 2 = Second 3 = Third 4 = Fourth
7 - 9	Exact horizontal position (in cm) within the bay	000 015 030 045 060 075 090 105

Table 6 - Finished Product Storage Coding

In practice, this storage has the capacity to store up to 120 centimeters between the spans, however, it will not be used daily. The boxes that are in this stock are part of the assembly production process, are 15 centimeters wide and are stored in multiples of four.

4.2.4 Bases and Wheels Storage

Figure 12 shows the physical layout of the Bases and Wheels Storage, highlighting the positions of the shelves and the numbering of each rack:

Figure 12 – Bases and Wheels Storage

Also, below is Table 7 which details the meaning of each part of the code.

Digit Position	Description	Value
1 - 3	Main Storage Area	ABR
4	Rack number	1 = Unique
5	Rack Column	0
6	Rack Position	1 = Front 2 = Back
7 - 9	Exact horizontal position (in cm) within the bay	000 060 120 180 210 240 300 360

Table 7 - Bases and Wheels Storage Coding

In this type of stock, the spacing variations are 60 centimeters apart, as only the largest boxes will be stored there, unlike other storages.

4.2.5 Mobile Pipe Storage

Figure 13 shows the physical layout of the Mobile Pipe Storage, highlighting the positions of the shelves and the numbering of each rack:

Figure 13 – Mobile Pipe Storage

Also, below is Table 8 which details the meaning of each part of the code.

Digit Position	Description	Value
1 - 3	Main Storage Area	AMT
4	Rack number	1 = Unique
5	Rack Column	0
6	Rack Level	1 = First 2 = Second 3 = Third 4 = Fourth
7 - 9	Exact horizontal position (in cm) within the bay	000

Table 8 - Mobile Pipe Storage Coding

This storage does not have separation by specific measurements, since the stored objects do not have standardized spacing.

4.2.6 Mobile Parts Storage

Figure 14 shows the physical layout of the Mobile Pipe Storage, highlighting the positions of the shelves and the numbering of each rack:

Figure 14 – Mobile Parts Storage

Also, below is Table 9 which details the meaning of each part of the code.

Digit Position	Description	Value
1 - 3	Main Storage Area	AMP
4	Rack Part	1 = Blue 2 = Yellow
5	Rack Column	1 = First 2 = Second
6	Rack Level	1 = First 2 = Second 3 = Third 4 = Fourth
7 - 9	Exact horizontal position (in cm) within the bay	000 030

Table 9 – Mobile Parts Storage Coding

The strategy adopted for coding this mobile rack was based on color identification, with blue being assigned to one side and yellow to the opposite side, this facilitates fast visual identification and systematic organization of the stored materials, especially considering the bilateral nature of the equipment. Furthermore, this rack was designed to exclusively hold small gray plastic boxes, 30 cm wide. Thus, the spacing between the positions was standardized at 30 cm intervals, ensuring uniform distribution appropriate to the size of the boxes different from the other storages.

4.2.7 Mobile Railes Storage

Figure 15 shows the physical layout of the Mobile Wheels Storage, highlighting the positions of the shelves and the numbering of each rack:

Figure 15 – Mobile Wheels Storage

Also, below is Table 10 which details the meaning of each part of the code.

Digit Position	Description	Value
1 - 3	Main Storage Area	AMR
4	Rack number	1 = Unique
5	Rack Column	1 = First 2 = Second
6	Rack Level	1 = First 2 = Second 3 = Third
7 - 9	Exact horizontal position (in cm) within the bay	000 020 040

Table 10 – Mobile Wheels Storage Coding

In this storage, boxes are not used to organize the items. Instead, the materials — specifically wheels — are stored directly on the structures, being grouped according to their characteristics. As a result, the spacing criterion between positions also changes: a fixed interval of 20 cm was adopted, corresponding to the average width of the wheel groups.

4.2.8 Manufacturing Station Storage

Figure 16 shows the physical layout of Car Parts Storage, highlighting the positions of the shelves and the numbering of each rack:

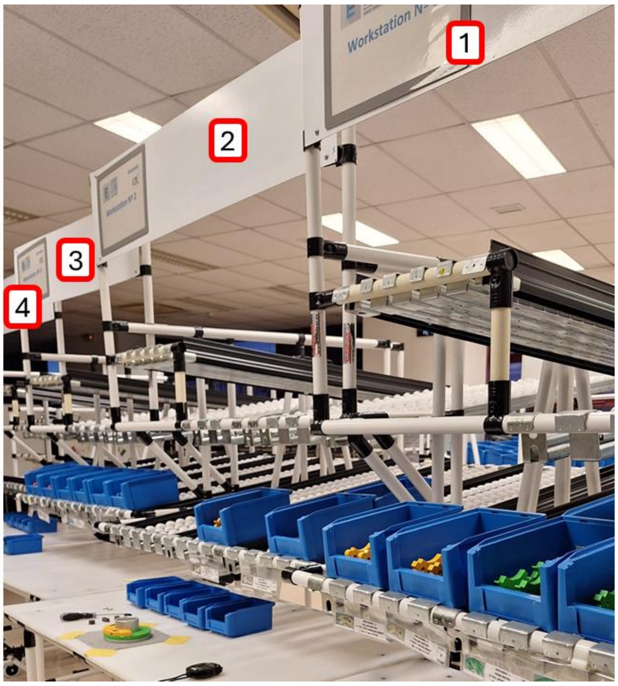


Figure 16 – Manufacturing Station Storage

Also, below is Table 11 which details the meaning of each part of the code.

Digit Position	Description	Value
1 - 3	Main Storage Area	PDM
4	Rack number	1 = First 2 = Second 3 = Third 4 = Fourth
5	Rack Column	0
6	Rack Level	1 = First 2 = Second 3 = Third
7 - 9	Exact horizontal position (in cm) within the bay	000 015 030 045 060 075

Table 11 - Manufacturing Station Storage Coding

4.2.9 Recycling Station Storage

Figure 17 shows the physical layout of Recycling Station Storage, highlighting the positions of the shelves and the number of each rack:

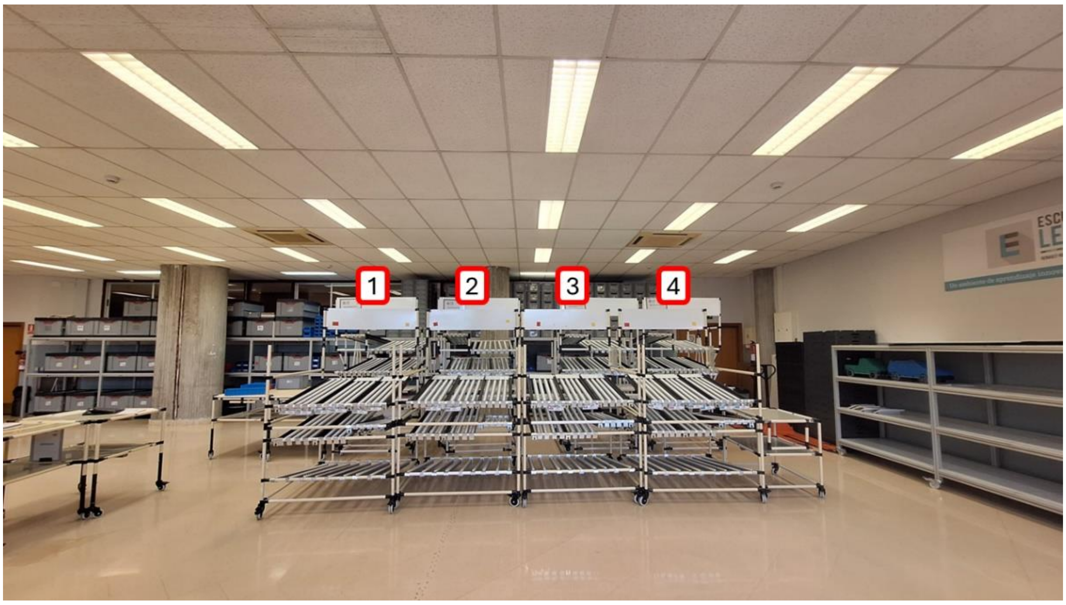


Figure 17 – Recycling Station Storage

Also, below is Table 12 which details the meaning of each part of the code.

Digit Position	Description	Value
1 - 3	Main Storage Area	PDR
4	Rack number	1 = First 2 = Second 3 = Third 4 = Fourth
5	Rack Column	0
6	Rack Level	1 = First 2 = Second 3 = Third
7 - 9	Exact horizontal position (in cm) within the bay	000 015 030 045 060 075

Table 12 - Recycling Station Storage Coding

5 FINAL CONSIDERATIONS

The project aimed to deepen the theoretical bases related to standardization and coding processes, to create a logic for identifying both the different types of boxes present in the laboratory and their storage positions. The proposal developed successfully met the established objectives, resulting in a standardized and comprehensive coding system tailored to the specific context of the Lean School, bringing clarity to the storage structure, organizing the positions in a logical and consistent way with Lean principles. However, there are still opportunities for improvement.

During the process, some difficulties were identified, they are related to the lack of standardization of items in some specific stocks. In the case of Mobile Pipe Storage, the types of materials stored are not definitively known, making coding, traceability and organization of the location difficult. In addition, similarly, Mobile Parts Storage does not have the indicated blue and yellow signs on the physical surface, making it necessary to implement this visual identification.

Although the 9S methodology was not applied – this concept incorporates elements such as team spirit, economy and discipline –

eventually, this can be included in future analyses, bringing a more comprehensive view of the organization and inventory management, especially in learning environments.

As a recommendation for general improvement in future projects, the adoption of barcodes applied individually to both the boxes and the positions is proposed, since the absence of this mechanism prevents control of the quantity of materials available in the laboratory and their efficient location, this method is widely used in the industrial context. In the context of the Lean School, the application of barcodes can be carried out progressively, since this work has developed the necessary theoretical and structural logic.

The first phase may involve generating the codes, considering the available positions in each warehouse; applying them to boxes would be more complex, since their exact quantity is still unknown. Next, it would be necessary to physically make and apply the labels, in addition to starting to use barcode readers to test the functionality of the identification in the physical environment. This second phase can be implemented initially in just one storage, functioning as a pilot project, and later expanded to the others.

After this stage is completed, it will be essential to develop a specific program for reading, counting and tracking the boxes, allowing the exact identification of each item in the warehouse. With this gradual approach, the laboratory will not only have a functional tracking and control system but will also provide students with practical experience of industrial operations, thus fulfilling one of the main pedagogical objectives of the Lean environment.

The development of this project provided a practical opportunity to explore the challenges of applying Lean principles to real-world scenarios, particularly within an educational environment. The process required not only technical knowledge, but also adaptability and critical thinking to propose viable solutions to organizational problems.

REFERENCES

Bostelmann, M. D. S. (2019). *Proposta de implementação da metodologia lean manufacturing em uma montadora de veículos* (Bachelor's thesis, Universidade Tecnológica Federal do Paraná). http://repositorio.utfpr.edu.br/jspui/handle/1/16315

Cáceres, A. M. G., Colombo, S. G., & Barra, B. N (2019). Endereçamento de estoque em uma indústria de tintas: uma proposta de melhoria. https://aprepro.org.br/conbrepro/2019/anais/arquivos/08272019_170842_5d658d52df793.pdf

Calzado-Mesa, Z. (2022). Proyecto de codificación industrial en la gestión de inventarios. *Ciencias Holguín*, *28*(3). http://www.ciencias.holguin.cu/plugins/generic/pdfJsViewer/pdf.js/web/viewer.html?file=http%3A%2F%2Fwww.ciencias.holguin.cu%2Frevista%2Farticle%2Fdownload%2F246%2F43%2F363

Costa, C. R. (2023). *Revisão do Sistema de Codificação de Uma Unidade de Produção Têxtil* (Master's thesis, Universidade do Minho (Portugal)). https://www.proquest.com/openview/3614f7366d659ed46c29fb294a275ad8/1?cbl=2026366&diss=y&pq-origsite=gscholar

de Carvalho, C. S. B., Ramos, G. D. M. E., da Cunha, J. M. S., Gonçalves, M. F. S., & Barbosa, F. B. M. H., 2018. CODIFICAÇÃO DE MATERIAIS PARA GESTÃO DE ESTOQUES: UM ESTUDO DE CASO NO SEGMENTO DE BIJUTERIAS. https://www.researchgate.net/publication/325745857_CODIFICACAO_DE_MATERIAIS_PARA_GESTAO_DE_ESTOQUES_UM_ESTUDO_DE_CASO_NO_SEGMENTO_DE_BIJUTERIAS

do Rosario Vieira, A. M. P. (2014). Implementação do Toyota Production System–Standard Work na secção de soldadura (Master's thesis, Universidade de Coimbra (Portugal)). https://estudogeral.uc.pt/handle/10316/39062

dos Santos, D., Schlickmann, F., & De Nez, J. (2017, August). ENDEREÇAMENTO DE ESTOQUES EM UMA INDÚSTRIA DE IMPLEMENTOS RODOVIÁRIOS. In *Anais Congresso Sul Catarinense de Administração e Comércio Exterior* (Vol. 1). https://periodicos.unesc.net/ojs/index.php/admcomex/article/view/3676/3412

Ghinato, P. (1995). Sistema Toyota de Produção: mais do que simplesmente just-in-time. *Production*, *5*, 169-189. https://www.scielo.br/j/prod/a/bRXLyrMFFK6WZGCvYNxC8sR/?lang=pt

Guevara, J. A. M., Urquijo, C. A. Z., & Varela, P. D. M. (2022). *Lean Manufacturing Modelos y herramientas*. https://www.researchgate.net/profile/John-Munoz-Guevara/publication/359604417_Lean_Manufacturing_Modelos_y_herramientas/links/67362b6468de5e5a30772517/Lean-Manufacturing-Modelos-y-herramientas.pdf

Harish, K. A., & Selvam, M. (2015). Lean wastes: A study of classification from different categories and industry perspectives. The Asian Review of Civil Engineering, 4(2), 7-12. https://doi.org/10.51983/tarce-2015.4.2.2220

Jacinto, J., Heil, L., de Souza, M. F., & Rodrigues, S. (2011). Logística: o endereçamento como ferramenta fundamental na armazenagem e estocagem. Faculdade de Tecnologia de Santa Catarina. Brusque. https://www.academia.edu/13175919/Log%C3%ADstica_o_endere%C3%A7amento_como_ferramenta_fundamental_na_armazenagem_e_estocagem

Lemos, C., Pereira, M. T., Ferreira, L. P., & Silva, F. J. G. (2018). A codification system roadmap: case study in a metalworking company. *Procedia Manufacturing*, *17*, 688-695. https://www.sciencedirect.com/science/article/pii/S2351978918312368

Nara, E. O. B., Moraes, J. A. R., Kipper, L. M., Furtado, J. C., Silva, A. L. E., Iserhard, F. Z., & Hoffmann, F. (2013). Sistema de codificação e sua relação com controle de projetos: um estudo de caso. *Exacta*, *11*(2), 213-224. https://periodicos.uninove.br/exacta/article/view/4343/2590

Oliveira, M. M. E. P., & SILVA, R. M. R. D. (2014). Gestão de estoque. *Cuiabá: Instituto Cuiabano de Educação*. https://portalidea.com.br/cursos/dce3372185d4fb07e9abc6b854e0baf3.pdf

Oliveira, P. M., Souza, R. da S., Silva, F. M. C., Lacerda, V. S. S., & Pereira, D.H. (2016). Os desafios para a gestão de estoque em micro e pequenas empresas: Um estudo de caso. *Proceedings of the 13th SEGeT – Symposium of Excellence in Management and Technology.* https://www.aedb.br/seget/arquivos/artigos16/20324192.pdf

Ortiz, S. J., & Paredes-Rodríguez, A. M. (2021). Evaluación sistémica de la implementación de un sistema de gestión de almacenes (WMS). Revista UIS ingenierías, 20(4), 145-160. https://doi.org/10.18273/revuin.v20n4-2021012

Palange, A., & Dhatrak, P. (2021). Lean manufacturing a vital tool to enhance productivity in manufacturing. *Materials Today: Proceedings*, *46*, 729-736. https://doi.org/10.1016/j.matpr.2020.12.193

Papandrea, P. J., Paiva, D. M., de Cássia Baisso, A., das Chagas, C. A. G., & da Silva, R. G. (2020). Lean Manufacturing: redução de desperdícios e a padronização do processo. *Journal of Open Research*, *1*(1), e4-e4. https://journals.stellata.com.br/jor/article/view/4

Piñero, E. A., Vivas, F. E. V., & de Valga, L. K. F. (2018). Programa 5S s para el mejoramiento continuo de la calidad y la productividad en los puestos de trabajo. Ingeniería Industrial. Actualidad y Nuevas Tendencias, 6(20), 99-110. https://biblat.unam.mx/pt/revista/ingenieria-industrial-actualidad-y-nuevas-tendencias/articulo/programa-5ss-para-el-mejoramiento-continuo-de-la-calidad-y-la-productividad-en-los-puestos-de-trabajo

Silva, K. S. L. (2021). Proposta de melhoria sobre endereçamento e codificação no estoque de uma empresa familiar de utensílios de alumínios. https://repositorio.ufu.br/bitstream/123456789/33299/1/PropostaMelhoriaEndere%C3%A7amento.pdf

Tomasi, T., De Oliveira, R., & Kuiawinski, D. L. (2015). Armazenagem de materiais: um modelo para endereçamento e separação de itens em uma empresa atacadista de produtos agropecuários. https://www.academia.edu/44376165/ARMAZENAGEM_DE_MATERIAIS_UM_MODELO_PARA_ENDERE%C3%87AMENTO_E_SEPARA%C3%87%C3%83O_DE_ITENS_EM_UMA_EMPRESA_ATACADISTA_DE_PRODUTOS_AGROPECU%C3%81RIOS_Material_storage_a_model_for_addressing_and_separating_items_in_a_wholesale_company_of_agricultural_products

Woźniakowski, T., Jałowiecki, P., & Zmarzłowski, K. (2018). ERP systems and warehouse management by WMS. *Information systems in management*, 7. https://yadda.icm.edu.pl/baztech/element/bwmeta1.element.baztech-6b126c03-0754-40b6-b602-d56731b3aada/c/ERP_SYSTEMS_AND_WAREHOUSE_MANAGEMENT_BY_WMS.pdf