Warehouse management model integrating 5S methodology and ABC classification to optimize space utilization and search time in a commercial SME

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Abstract–Currently, large quantity of Peruvian SMEs does not count with the resources and tools to establish an adequate warehouse management. This problem results in high costs of keeping items in the warehouse, inefficient utilization of space and poor visibility of products within the warehouse. For that reason, the objective of this study is to present an accessible model than can be implemented in SMEs of the wholesale sector that are interested in improving their warehouse practices. Therefore, the contribution of this article is based on the design of a warehouse management model, that allows the areas on the warehouse to be organize and stablish a correct way of product placement. The model is composed by two classic tools for inventory and warehouse management, the 5s methodology and the ABC method. The obtained results demonstrate that it is possible to reduce searching times from 216.75 min to 148.75 min; to establish order and organization within the warehouse, with an improvement of 47% in the 5s level; to maintain the utilization at percentages greater than 95%, and reduced the space occupied by waste to 0.

Keywords-- Warehouse management, Warehouse utilization, SME, 5s, ABC Classification

I. INTRODUCTION

The pandemic caused by COVID-19 left multiple challenges for organizations, especially in terms of logistics operations [1]. Among them we see the need to implement new management methods that can deal with problems such as disruptions in global supply chains [2]. One of the most affected parts within it, is the warehouse operations, where organizations will need to adapt to larger volumes of e-commerce fulfillment and to better control their inventory in a time of supply shortages [3]. Small and medium-sized enterprises (SMEs) will suffer the most from these problems and will have to look for alternatives to tools that require large investments and resources, due to limitations in terms of knowledge, lack of specialized human resources and the limited management capacity they have to face challenges such as these [4].

The case study will focus on logistics processes related to warehouse management problems, which were identified in a small company belonging to the commercial sector in Perú. At present, this is considered one of the most important sectors in the country, due to its great contribution to the Peruvian economy. In the year 2021, it occupied 10.6% of the total Gross domestic product (GDP) [5]. Moreover, this sector is largely made up of SMEs, since it represents the 99.5% of the total number of formal companies, of which 45% were identified as part of the commercial sector [6]. In terms of employment figures, it represents 17.7% of the country's Economically Active Population (EAP) in year 2020 [7]. Despite being a sector with a large share in the Peruvian economy, it is not exempt from problems related to logistics management, and this is reflected in sector statistics, which indicate that only 28.6% of the total number of companies using logistics services in the country efficiently manage warehouse management processes [8].

A model is proposed to address the problems presented in warehouse management in SMEs. It is known that warehouse management requires a reduction of waste with respect to high costs, unnecessary quantities and non-value-added tasks [9]. Therefore, the 5s methodology is integrated, which is considered as the first step to initiate a quality and continuous improvement plan in organizations [10]. The lack of a method for the prioritization of items with higher value directly affects the operations in the warehouse, for which recommended techniques such as ABC classification are presented [11]. This model presents an innovative approach by integrating traditional tools such as ABC classification and the 5s methodology. The aim is to establish a continuous improvement model for warehouse management, which is adapted to the needs of SMEs in the sector.

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II. STATE OF THE ART

A. Warehouse management

Warehouse management is an important component of the supply chain. It is confronted daily with the rapid advance of globalization, which makes organizations look for new approaches to improve their performance. Due to the importance of the warehouse in organizations, it is necessary to implement tools to assess potential risks within the warehouse in order to create awareness of potential hazards to prioritize them, build control measures and propose mitigation actions to avoid incurring financial losses. [12].

There are different tools and models to help mitigate problems related to warehouse management. Among them, there are storage models based on the implementation of the 5s

methodology, which aims to improve operational efficiency, minimize storage costs and travel distances. [9]. Similarly, innovative models for the warehouse area, with alternatives to traditional tools, as these are usually not designed to handle large order quantities. The results of implementing warehouse management can be seen in the improvement of productivity and operations of related processes such as receiving, storage and dispatch.[13].

B. ABC classification

It is a tool used to establish inventory control based on the premise that a few items are responsible for the majority of inventory problems. This is because the classification follows the Pareto principle of 80-20, which would indicate that 80% of the value corresponds to only 20% of total SKUs in inventory [14].

The classification method proposes dividing inventory items into three categories: category "A" contains the highest inventory value concentrated in a small number of items, category "B" has an average value and share, and category "C" has the lowest inventory value, but the highest volume of items. [11]. Based on the criteria by category, the approximate percentages for the classification by category, in terms of value and participation of items in inventory, are as follows [15].

TABLE I
Approximate percentages of participation by category

Category	%Inventory value	%Inventory items
A	80%	10%
B	15%	25%
C	5%	65%

A comparison of existing ABC classification methods is also performed in order to choose the best ones for the model. The results of the literature comparison indicate that the "Annual Dollar Usage" (ADU) classification method is the simplest approach and the fastest to implement. In addition, it is considered a basic alternative for companies with smaller inventories [15]. This method can also be considered to apply improvements in a company's warehouse, by means of advanced models for the distribution of items based on the ABC classification method and a structured network. [16].

C. 5s methodology

The 5s methodology is a lean method for workplace organization, comprising five phases defined under the Japanese language: "Seiri", "Seiton", "Seiso", "Seiketsu" and "Shitsuke". These terms are interrelated and are implemented systematically [17]. For this methodology, to have a good result, the previous "S" must be correctly applied to reach the next phase. Each level of the 5s methodology has its own importance, which will be mentioned below. [18]:

- Seiri: save the necessary objects and evaluate the actions to be taken for unnecessary objects.
- Seiton: establish an order to make the workflow easier and smoother.
- Seiso: establish tools to achieve a clean and safe workplace.
- Seiketsu: verify compliance with and maintenance of the first three phases.
- Shitsuke: ensure that what was implemented in the previous phases is maintained.

Efficient use of company resources is important for a lean workplace, as well as employee motivation [19]. Companies often apply the 5S methodology to improve the performance of their operations, reduce downtime, waste and defects, in order to avoid additional costs in the warehouse. [20].

III. CONTRIBUTION

A. Foundation of the Model

This research is based on an in-depth analysis of the problems in logistics management in SMEs in the commercial sector in Peru. In which, warehouse management is of great importance, however, this usually presents problems such as: deficiencies in the use of space, workplace organization, accumulation of waste, among others. For this reason, the study seeks to propose a warehouse management model of easy access and implementation for SMEs in the country.

B. Proposed model

The proposed model is based on the application of the ABC method and the 5S methodology, in order to mitigate inefficient practices in the warehouse area. The design of the model is presented below, taking into account the inputs and outputs, as well as the interrelation between its components.

C. Components of the model

This model will be developed in two phases. The first phase consists of the ABC inventory categorization, in order to establish a priority level for the items in the warehouse. The second phase will implement the 5s methodology, where emphasis will be placed on the development of the second "S" of Order, since this is where the ABC method will be implemented for the redesign of the warehouse distribution.

1) Company: data gathering and analysis

This stage consists of gathering data on the company and its competitive environment. A review of the company's current processes and its main activities is carried out in order to identify the main problems faced by the company and to propose tools to eradicate them.

2) Structure of the model

a) Phase 1: ABC inventory categorization

The proposed model starts with the ABC classification of inventories. The ABC classification method was chosen according to the annual usage value. To implement the tool, the

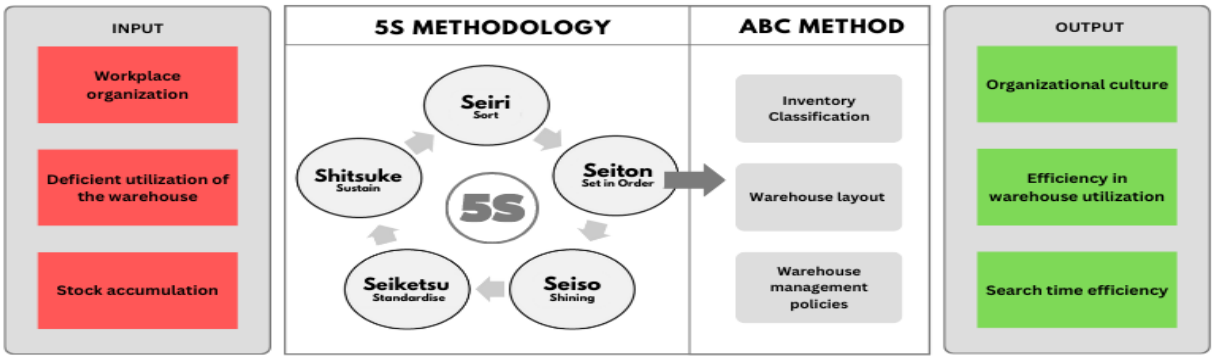


Fig. 1 Proposed model

first step is to identify the inventoried items, the units sold in a year and their unit costs, in order to calculate the total annual value. The data obtained is sorted, and the percentages of participation and their accumulated percentages are calculated. Once the information has been compiled, the results are evaluated based on the participation intervals in terms of value and quantity.

TABLE II
Inventory categorization

ABC	%Value	No. of items	%Items
A	78,37%	9	17,31%
B	16,26%	14	26,92%
C	5,37%	29	55,77%
Total	**100,00%**	**52**	**100,00%**

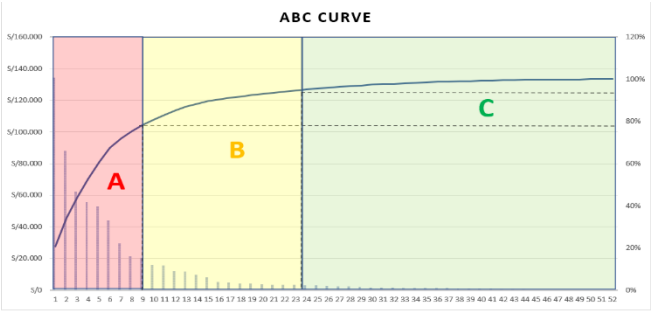


Fig. 2 ABC Curve

The ABC curve will allow to evaluate the inventoried items under the ABC classification and from the perspective of the Pareto principle mentioned above. It can be seen that a small number of items concentrate most of the value in the inventory. On the other hand, the category with the lowest value concentrates most of the inventoried items.

b) Phase 2: Implementation of the 5s

To implement the 5S methodology, it is necessary to know all the details of the warehouse. This starts by establishing instruments for the disposal of unnecessary objects; organizing the objects that are necessary, so that they are more visible; establishing cleaning guidelines; documenting methods and procedures, for the understanding of collaborators at all levels of the organization; and maintaining what has been implemented, as well as carrying out periodic audits to know the evolution of the methodology. The commitment of the organization is needed to implement the tools of the proposed model.

Seiri (Sort): The first step consists in making a 5s level audit, to see the initial status of the company based on the different phases of the 5s. This will allow us to see how the proposed model evolves and the improvements that we can obtain from it. The next figure shows the proposed 5s audit checklist used and the results obtained score after doing the first audit.

5S AUDIT

Cod.	
Version	
Date:	

Company	
Area	
Area Rep.	

Employee	
Capacity	
Auditor	

5S	Nº	Checklist item - Description	Score 4 Excellent	3 Good	2 Normal	1 Regular	0 Bad
SORT (Seiri)	1	Are all equipment and tools necessary?			X		
	2	Are there obsolete materials or unnecessary products?			X		
	3	Are there things that should belong in another area?				X	
	4	Are there unnecessary objects in the workplace?			X		
	5	Are unnecessary things found on the work table?					X
	6	¿Hay objetos afectando las áreas de circulación?			X		
		Sub total (Score points X 100/24)					38
SET IN ORDER (Seiton)	1	Are the boxes and materials in order?				X	
	2	Is it easy to identify and locate the products?			X		
	3	Are letters, numbers, pictures or colors used for indications?				X	
	4	Are the tools and technical documents in order?					X
	5	Are there unnecessary objects on top of the boxes and equipment?				X	
	6	re the product locations defined or is there some kind of sectorization					X
		Sub total (Score points X 100/24)					21
SHINE (Seiso)	1	Are the windows and walls of the warehouse dirty?		X			
	2	Are the corridors clean?			X		
	3	Are the cleaning elements in order and identified?		X			
	4	Do you have an established cleaning routine?					X
	5	Are cabinets, shelves, tools and work tables clean?				X	
	6	Are the machines and equipment clean?			X		
		Sub total (Score points X 100/24)					46
STANDARDIZE (Seiketsu)	1	Is standardization considered for each process in the area?					X
	2	Are the actions carried out formalized and communicated?				X	
	3	Is it established who should follow the improvement actions?				X	
	4	How do you consider the appearance of the workplace?			X		
	5	Are improvements made to the environment and are they documented?					X
	6	Are visual controls used as a tool?					X
		Sub total (Score points X 100/24)					17
SUSTAIN (Shitsuke)	1	Are the personnel trained in organizational methodologies?					X
	2	Are working teams formed to make improvements?				X	
	3	Are company policies and procedures being followed?				X	
	4	oes the staff keep the area tidy without the requirement of a superior				X	
	5	What is management's perception of the work area?			X		
	6	e person in charge visit the work area and provide comments for impro					X
		Sub total (Score points X 100/24)					25
		5S LEVEL (1s+2s+3s+4s+5s) / 5			29		

Fig. 3 5s level checklist and results from the first audit

The next step consists of selecting objects to identify their usefulness in the warehouse. To this end, a new procedure for the evaluation of unnecessary objects in the warehouse is established and must be implement by the collaborators.

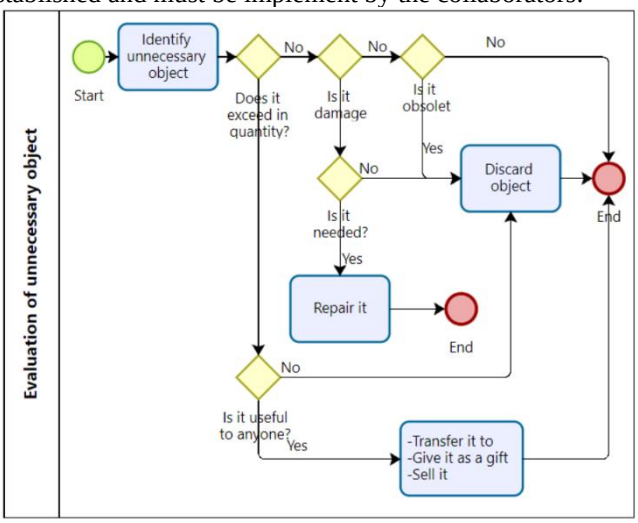


Fig. 4 Evaluation of unnecessary object

Red tag will also be used to evaluate unnecessary items and identify if any corrective action can be taken.

RED CARD			
Date			
Description:			
Category		Reason	
Accessories or tools		Contaminants	
Troughs, containers		Defective	
Office equipment		Decomposed	
Bookcase, stationery		Waste	
Machinery		Not needed	
Spare parts materials		Not needed soon	
Packaging material		Use unknown	
Other (specify)		Other (specify)	
Suggested action			
		Delete	
		Repair	
		Transfer	
		Give as a gift	
		Sell	
Responsible for the area			
Name			
Observations			

Fig. 5 Red card

Seiton (Set in Order): This phase permits the classification and distribution of items within the warehouse. It starts with the creation of codes by product family.

TABLE III
Product codes

Product family	Family Code	Type of product	Example of product code
Traffic light	SM	Vehicular	SMVH303T
		Pedestrian	SMPA302B
Optics	OP	Vehicular	OPVH3001V
		Countdown	OPCR301B

As a next step, the ABC classification is used to create a new warehouse layout.

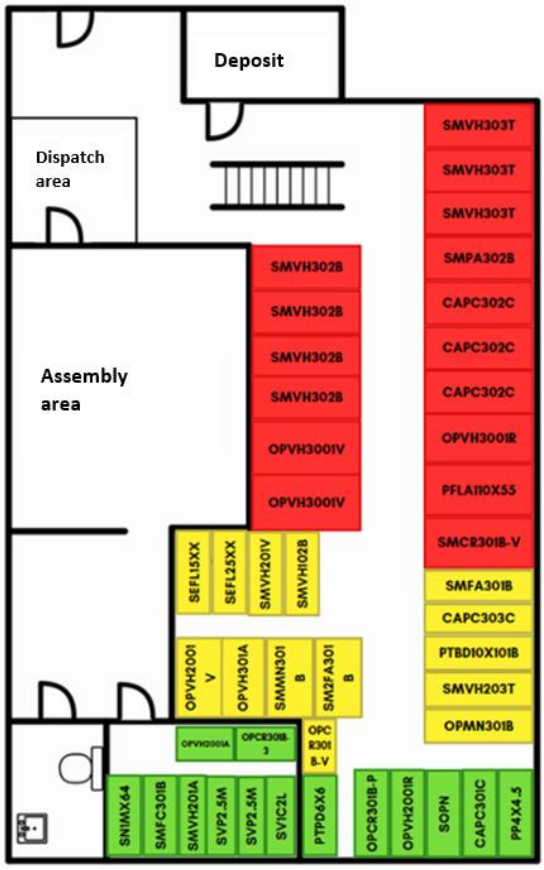


Fig. 6 Warehouse layout

The location of the items in the warehouse is based on the ABC classification and placed in the warehouse by the employees, taking into account the following considerations: Category A, which has the highest inventory value, should be located closest to the dispatch area, in order to facilitate the search process in the warehouse and avoid unnecessary effort and delays; Category C, which have low inventory value, will be located in the farthest part of the warehouse from the dispatch area. Finally, category B, which has an average inventory value, should be assigned an area between category "A" and "C".

Based on the application of this new layout based on the ABC classification, warehouse management policies are established:

Warehouse management policies:

Category “A”:

- Items should be located close to the dispatch area.
- Strict control and revision of the level of items in stock.

- Weekly monitoring.

Category "B":

- Items should be located in a middle zone with respect to the dispatch área.
- Moderate control over the level of items in stock.
- Monthly monitoring.

Category "C":

- The location of the items should be away from the dispatch area, after category "A" and "B".
- Quarterly monitoring.
  Identify items with lower inventory value and evaluate their discontinuation.

Seiso (Shining): It consists of the elimination of sources of dirt inside the warehouse through cleaning programs, regulations and controls.

Seiketsu (Standardise): The aim is to integrate the first three phases of the 5S (Seiri, Seiton and Seiso) to verify if the activities are being carried out as established.

Shitsuke (Sustain): In the last phase of the methodology, an organizational culture based on order and continuous improvement will be established. This will be monitored through audits, and a checklist will be needed for the evaluation of each phase.

D. Indicator analysis

1) Warehouse space utilization

It allows to know how much space is being occupied in relation to the total available space in the warehouse.

$$Space\ Utilization = \frac{Total\ Used\ Space}{Total\ Available\ Space} \quad (1)$$

2) Deficient warehouse space utilization

It considers the space that is not being occupied efficiently with respect to the total. To make the calculation, it is determined how much space is being occupied by waste such as: empty boxes, obsolete items, unnecessary furniture and materials to be disposed of.

$$\begin{matrix} Deficient \\ space\ utilization \end{matrix} = \frac{Space\ occupied\ by\ waste}{Total\ Available\ Space} \quad (2)$$

3) 5s level

It results from the values obtained in the audits of the implementation of the 5s, the highest score to obtain is 100 points. Its aim is to check the evolution of the organization according to the methodology.

$$5s\ level = \frac{(1S + 2S + 3S + 4S + 5S)}{5} \quad (3)$$

4) Search time

A list of the products in the warehouse is identified and created. With the list and the help of the warehouse manager, time is taken for each item, time is recorded from the moment the item is mentioned, and the times obtained are added up to obtain the total time to find the item in the warehouse.

$$Search\ time = \sum \begin{matrix} Search\ time\ of\ all\ the \\ articles\ on\ the\ warehouse \end{matrix} \quad (4)$$

IV. VALIDATION

A. Problem identification

For this study, an initial audit was carried out within the warehouse based on the 5S level. The result of the study indicates that the level of the 5S is very low, since the initial audit obtained 29 points out of 100 possible points. This would indicate that there is a lot of waste, the areas are not clean, there is no standardization and the space inside the warehouse is not being used efficiently.

In addition, products cannot be easily identified in the warehouse, since employees spend a great amount of time searching for products. Therefore, the average time spent searching for products was analyzed, resulting in 216.75 minutes.

Lastly, warehouse utilization was analyzed, which indicates that 99.25% of the total warehouse space is being used, which is not a bad indicator value, however, it is identified that, of the total utilization, 26.93% is being used in a deficient way. Therefore, the initial diagnostic would indicate that the total available warehouse space is not being used correctly.

B. Linking problems to solutions

Previously, the appropriate tools and methodology were chosen to address the problems mentioned in point A. In this way, it follows that:

- The 5s methodology will improve product search times and warehouse clutter.
- The ABC classification tool will help to overcome the lack of item organization and improve warehouse utilization.
-

C. Tool validation

1) Validation of the ABC classification

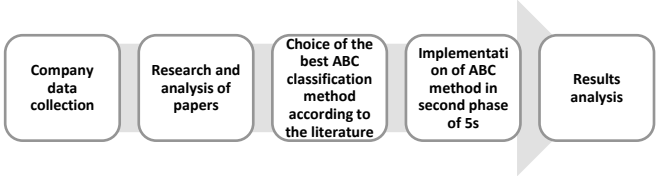


Fig. 7 ABC tool validation process

a. Company data collection

The following information provided by the company was required for the application of the model:

- List of items in inventory
- Sales per item in the established period
- Cost of items in inventory

b. ABC classification method

The ABC classification method used in the model is the annual inventory value classification, since it is the easiest and quickest method to implement [15]. Furthermore, it is possible to use this method to create a new distribution based on ABC classification [16]. Moreover, it is used to establish better inventory control and identifies that it is a method that is easily coupled with other tools. [21].

2) 5s methodology validation

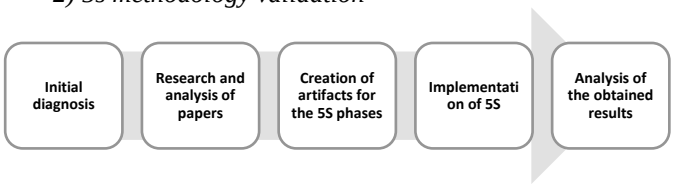


Fig. 8 5s methodology validation process

a. Artifact creation

For the implementation of the tool, the following artifacts were created to be implemented for each phase.

TABLE IV
Proposed artifacts in the model

Phases	Initial audit
1S	Red tag and tag control record
	Opportunity card control
	Product codes
2S	ABC Layout
	Signposting of warehouse areas
	Initial audit
3S	Cleaning regulations
	Cleaning program control card
4S	Checklist 3s
5S	5s audits control

D. Validation of results

The results obtained for each indicator proposed for monitoring the implementation of the model are presented. For comparison purposes, the results obtained in the initial diagnosis of the company and those obtained after implementation are presented.

TABLE V
Warehouse space utilization

Warehouse space utilization	Before	After
	Oct-22	Abr-23
% Total occupied space	99,25%	97,56%

The objective of maintaining or not presenting much variation with respect to the initial high percentage of warehouse utilization obtained is achieved. On the other hand, the maximum efficiency in the use of the warehouse is achieved, due to the fact that the deficient utilization goes from 26.93% to 0% with respect to the total space occupied.

TABLE VI
Efficiency in utilization

Efficiency in warehouse utilization	Before	After
	Oct-22	Abr-23
Efficient	73,07%	100%
Deficient	26,93%	0%

Likewise, there is an improvement in all the phases of the methodology and in the 5s level since it presents a compliance of 76% (76 points out of 100 possible points).

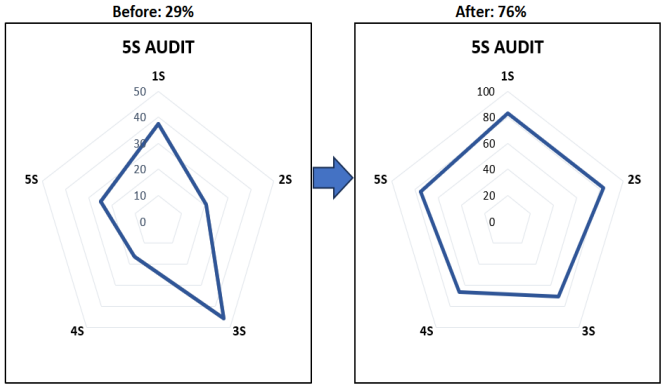


Fig. 9 Radial diagram of 5s level (before and after implementation)

Also, the percentage of the average search time indicator for a product was improved through a good distribution of the warehouse, reducing the time by 31%.

TABLE VII
Reduction in search time

Indicator	Before	After	Variation
	Oct-22	Abr-23	
% Reduction in total average product search time	216,75 min	148,75 min	31%

The following table shows an overview of the results obtained before and after the implementation of the proposed model.

TABLE VIII
Overview of results

Indicators	Obj	Before	After	Variation
Warehouse space utilization	↑	99,25%	97,56%	-1,69%

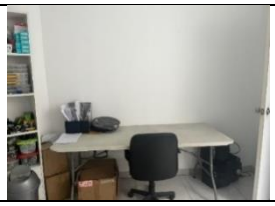
Deficient space utilization	↓	26,93%	0%	-26,93%
5s level	↑	29 pts.	76 pts.	47,00
Total search time	↓	216,75 min	148,75 min	-68,00

V. CONCLUSIONS

The study was developed to present an innovative approach to warehouse management. The proposed model presents the integration of traditional tools, such as the 5s methodology and the ABC method. On one hand, the 5s methodology allowed the establishment of an organizational culture under the principles of continuous improvement, reflected in the warehouse operations. On the other hand, the ABC method allows the identification of the highest priority items and served as a complement during the second phase of the methodology. Both tools, implemented together, made it possible to identify the most valuable items in the warehouse, establish new controls to evaluate unnecessary items, create warehouse management policies, redesign the warehouse, and establish cleaning and periodic auditing programs.

The results obtained showed a 47% improvement in the 5s level. As well as a reduction in product search times from 216.75 to 148.75 minutes. In addition, high levels of warehouse utilization, greater than 95% of the total available space, were maintained. Finally, efficiency in utilization was achieved, reducing the space occupied by waste from 26.93% to 0%.

TABLE IX
Overview of results

Before	After
	
	

To achieve efficient warehouse management practices is necessary the commitment of the entire organization to maintain the use of the proposed tools, with the objective of maintaining the levels of utilization obtained and continue improving the times in the warehouse. In a competitive and changing business environment, the model is presented as an accessible alternative for warehouse management in SMEs.

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