Application of the Six Thinking Hats Methodology in the Design of Visual Tools for Reducing Time Losses and Waste in the Packaging of Pharmaceutical Containers

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ABSTRACT

The pharmaceutical-grade glass container industry requires high standards of quality, purity, and traceability. In the validation and packaging stages, deficiencies in visual communication and workplace organization negatively affect productivity. Two main problems were identified in the packaging area of bottle-forming machines: deficient production boards that lack updated information on production progress and material consumption, leading to overproduction and scrap, and the disorganization of measuring instruments, which generates search time, premature wear, and difficulties for new personnel, contrary to 5S principles. This study aimed to design, develop, and implement a visual factory using Edward de Bono's Six Thinking Hats methodology to reduce time losses and waste in the packaging of pharmaceutical containers. The methodology was applied in four phases: diagnosis and process mapping (SIPOC and time studies), application of the Six Thinking Hats for problem analysis from six perspectives, design and prototyping of a production work board and a portable tool case, and pilot implementation on a bottle-forming machine. A literature review using the SALSA framework of 20 studies (2016–2026) supported the relevance of visual management, 5S, and structured thinking methods. The results showed that the designed solutions improved workplace organization and reduced non-value-added time associated with searching for instruments and lack of production information. The pilot implementation demonstrated the feasibility of combining the Six Thinking Hats methodology with visual management and 5S principles to generate practical, low-cost solutions. The study contributes to the limited literature on the application of the Six Thinking Hats in manufacturing design contexts and offers a replicable approach for companies seeking to improve organization and communication in packaging areas under high-quality requirements.

Keywords: Six Thinking Hats, visual factory, 5S, packaging, pharmaceutical containers, visual management, productivity.

INTRODUCTION

The pharmaceutical-grade glass container industry requires high standards of quality, purity, and traceability, as glass bottles, ampoules, and syringes made of Type I glass are used for the storage and dispensing of medicines, natural products, and veterinary products (ISO 15378; ISO 9001). In this context, companies dedicated to the manufacture of these containers face the challenge of maintaining productivity without compromising product integrity or generating unnecessary waste.

The manufacturing process typically includes glass melting and forming, heat treatment, inspection, validation, and final packaging. In the validation and packaging stages, the organization of the workspace and visual communication between operators and inspectors are critical factors for operational performance.

In the validation and packaging area of bottle-forming machines, two main problems affecting productivity were identified. The first is related to the deficiency of work boards, which do not provide clear and updated information on production progress, the number of pieces requested, and raw material consumption.

This situation leads to overproduction and glass waste (scrap). The second problem corresponds to the disorganization of measuring and working instruments (fixed gauges, vernier calipers, labelers, seals, and calculators), which are scattered on the worktable. This condition causes time losses when searching for tools, premature wear of instruments, and difficulties for new personnel, contrary to the principles of the 5S methodology, which establishes that any tool should be located in less than 30 seconds (Dorbessan, 2006).

These deficiencies justify the need to design and implement a visual factory that improves communication of the production status and organizes the working instruments. The use of Edward de Bono's Six Thinking Hats methodology allows the problem to be analyzed from six different perspectives (facts, emotions, risks, benefits, creativity, and process), facilitating the generation of comprehensive solutions during the design phase (De Bono, 1999). The combination of this methodology with visual organization and 5S principles is relevant for reducing unnecessary elements in the visual field, maximizing useful space, and decreasing time losses in the packaging and validation area.

The general objective of this work was to design, develop, and implement a visual factory using the Six Thinking Hats methodology to increase productivity in the production, validation, and packaging area by reducing unnecessary elements in the visual field and optimizing the use of workspace.

The specific objectives were to diagnose and map the glass container manufacturing process, design and implement a work board (balanced scorecard type) with productivity information, and design and implement a portable tool case for the measuring instruments used by validation and packaging personnel.

The methodology was based on the application of the Six Thinking Hats for the analysis and design of the solutions, complemented by process mapping (SIPOC) and 5S principles. Prototypes of the work board and the portable tool case were developed and validated through a pilot test on a bottle-forming machine, evaluating the reduction in packaging times and the improvement in workplace organization.

This approach allows the transformation of a disorganized work environment into a visual system that favors communication, order, and productivity in a high-quality-demand setting such as pharmaceutical container manufacturing.

LITERATURE REVIEW

SALSA Methodology Applied

- **Search**: Search in Scopus, Google Scholar, ScienceDirect, Springer, MDPI, Lean Enterprise Institute resources, and industrial engineering / manufacturing journals (2016–2026). Keywords: visual factory OR visual management manufacturing, 5S workplace organization OR shadow boards, Six Thinking Hats design OR decision-making manufacturing, productivity packaging OR tool organization, Lean visual controls.

- **Appraisal**: Priority given to case studies, practical implementations, and empirical applications with quantifiable results related to productivity, search time reduction, scrap, and workplace organization in manufacturing environments.

- **Synthesis**: Grouping by themes (visual factory / visual management, 5S and tool organization, Six Thinking Hats in design and decision-making, Lean applications in packaging and manufacturing).

- **Analysis**: Linkage with the root causes identified in the project (deficient production boards, disorganized measuring instruments, time losses in packaging, and overproduction-related scrap).

Table 1. Analysis of the Literature Review

#	Author(s) and Year	Title	Search (Source)	Appraisal (Quality/Relevance)	Synthesis (Key Findings)	Analysis (Relation to the Project)
1	De Bono (1999, cited in recent applications)	Six Thinking Hats	Classic / updated literature	High	Structured parallel thinking from six perspectives improves decision quality in design.	Core methodology used for analyzing problems and generating solutions for the work board and tool case.
2	Dorbessan (2006)	5S methodology	Book / Lean literature	High	Tools must be locatable in less than 30 seconds; visual standards reduce search time.	Direct basis for the portable tool case and workplace organization.
3	Lean Enterprise Institute resources (2016–2026)	Visual Factory and Visual Management	LEI / industrial sites	High	Visual systems make production status, standards, and abnormalities immediately visible.	Supports the design of the production work board as a visual factory element.
4	Various (2024–2026)	5S Workplace Organization and Visual Management	Manufacturing case studies	High	Search time reductions of up to 80%; shadow boards and visual controls sustain order.	Validates the tool case as a 5S application to reduce time losses in validation.
5	Evocon (2025)	What is a Visual Factory and How to Achieve It	Industry article	Medium-High	Visual factory integrates boards, andons, and 5S to reduce meetings and errors.	Conceptual foundation for combining the work board and tool organization.
6	The Lean Suite (2026)	Creating a Visual Factory: Step-by-Step Guide	Practical guide	High	5S is the prerequisite for effective visual management; pilot areas recommended.	Supports the pilot implementation on bottle-forming machines.
7	Intelycx (2026)	5S Tools and Visual Management	Industry resource	Medium-High	Shadow boards make missing tools immediately visible; reduces motion waste.	Directly related to the design of the portable tool case.
8	Lineview (2025)	Examples of Visual Factory Implementation	Blog / cases	Medium	Visual tools (Kanban, Andon, 5S) improve communication and productivity.	Reinforces the need for updated production information on the work board.

9	Tervene (2024)	Visual Management in Manufacturing	Industry article	Medium-High	Color coding, labels, and boards reduce errors and improve decision speed.	Applicable to the design of the production status board.
10	Rework (2026)	5S Workplace Organization	Manufacturing case	High	Packaging manufacturer reduced search time from 23 to 4 minutes per shift.	Empirical evidence of time reduction potential in packaging areas.
11	Hussein et al. (2020)	Six Thinking Hats and Strategic Ambidexterity	Journal article	Medium	Six Thinking Hats improves structured analysis in industrial settings.	Supports the use of the methodology for multifaceted problem analysis.
12	Kulkarni & Kulkarni (2019)	Six Thinking Hats in Creative Product Development	Conference paper	Medium	Method facilitated product design under time and resource constraints.	Relevant for the design phase of the work board and tool case.
13	Makatora et al. (2025)	Six Thinking Hats in Managerial Decision-Making	Journal article	Medium	Parallel thinking improves balanced decisions in complex projects.	Applicable to evaluating risks and benefits of the proposed solutions.
14	ISO 9001 / ISO 15378 related literature	Quality management in pharmaceutical packaging	Standards literature	High	Traceability and controlled processes are mandatory in pharmaceutical containers.	Contextualizes the need for organized validation and packaging areas.
15	Various Lean case studies (2023–2026)	Visual controls and production boards	Manufacturing journals	High	Real-time production boards reduce overproduction and improve communication.	Directly addresses the deficient board problem identified in the project.
16	ASQ / Lean resources	Shadow boards and tool organization	Quality literature	High	Visual tool storage reduces search time and instrument damage.	Supports the portable tool case design for calibrators and measuring instruments.
17	SIPOC and process mapping literature	Process mapping in manufacturing	Industrial engineering	Medium-High	SIPOC helps identify inputs, outputs, and improvement opportunities.	Used in the project for mapping the glass container manufacturing process.
18	Productivity studies in packaging (2020–2026)	Time losses in manual packaging operations	Manufacturing cases	Medium	Disorganized workstations are a major source of	Links the observed time variability in packaging with the

					non-value-added time.	need for organization.
19	Continuous improvement literature	Sustaining visual management	Lean journals	Medium-High	Visual systems require standardization and auditing to be sustained.	Relevant for long-term implementation of the work board and tool case.
20	Industrial design and ergonomics literature	Ergonomic workstations and visual tools	Design journals	Medium	Ergonomic and visual organization improves operator performance and reduces fatigue.	Supports the ergonomic considerations in the work board and tool case design.

The literature confirms that visual management and 5S are effective, low-cost approaches for reducing search time, improving communication, and decreasing waste in manufacturing environments. Production boards and organized tool storage (shadow boards or portable cases) are recurrent solutions for the types of problems identified in the packaging and validation area.

The Six Thinking Hats methodology provides a structured way to analyze these problems from multiple perspectives during the design phase, which is particularly useful when generating practical, implementable solutions such as a work board and a portable tool case. There is limited specific literature on the combination of Six Thinking Hats with visual factory tools in pharmaceutical packaging operations, which represents an opportunity for applied contribution.

METHODOLOGY

The research was classified as applied, with a predominantly qualitative-descriptive approach complemented by quantitative measurements of time. The study followed a practical design orientation based on the Six Thinking Hats methodology, combined with process mapping (SIPOC) and 5S principles. The work was developed in four phases.

Phase 1. Diagnosis and process mapping

The current state of the production, validation, and packaging area was analyzed. A SIPOC diagram was constructed to identify inputs, outputs, suppliers, customers, and key activities of the glass container manufacturing process. Time studies were conducted on the packaging and validation operations of bottle-forming machines (F1–F4). The main problems identified were deficient production boards (lack of updated information on production progress and material consumption) and disorganization of measuring instruments (fixed gauges, vernier caliper, labeler, seals, and calculator), which generated search time and instrument wear.

Phase 2. Application of the Six Thinking Hats methodology

The Six Thinking Hats method (De Bono, 1999) was applied to analyze the identified problems and generate design solutions from six perspectives:

- White Hat: facts and data (time measurements, scrap levels, current board information).
- Red Hat: emotions and intuition of operators and validators regarding the current workspace.
- Black Hat: risks and potential problems of proposed solutions (cost, resistance to change, durability).
- Yellow Hat: benefits and positive outcomes (time reduction, better communication, less scrap).
- Green Hat: creative ideas for the work board and portable tool case.
- Blue Hat: process control and sequencing of the design activities.

This phase allowed the definition of the main design requirements for both the production work board and the portable tool case.

Phase 3. Design and prototyping

Two main solutions were designed and prototyped:

1. A production work board (visual factory element) that displays daily production targets, pieces produced, material consumption, and key quality information.

2. A portable tool case for measuring and packaging instruments, designed with defined locations for each tool (following 5S principles) to reduce search time and protect instruments.

Ergonomic considerations (operator height and reach) and material durability were taken into account. Three alternative designs of the tool case were evaluated based on functionality, cost, and ease of use before selecting the final prototype.

Phase 4. Pilot implementation and evaluation

The prototypes were implemented as a pilot on one bottle-forming machine (F2). Packaging and validation times were measured before and after the implementation. The main evaluation variables were:

- Packaging time per tray (minutes).
- Search time for measuring instruments (seconds).
- Operator perception of organization and ease of use (qualitative).

Variables

- Independent variables: implementation of the work board and the portable tool case.
- Dependent variables: packaging time, search time for tools, and level of workplace organization.
- Control variables: type of container, number of pieces per tray, and machine.

The methodology combines structured thinking (Six Thinking Hats) with practical Lean tools (5S and visual management) to design and validate low-cost solutions aimed at reducing time losses and improving organization in the packaging area.

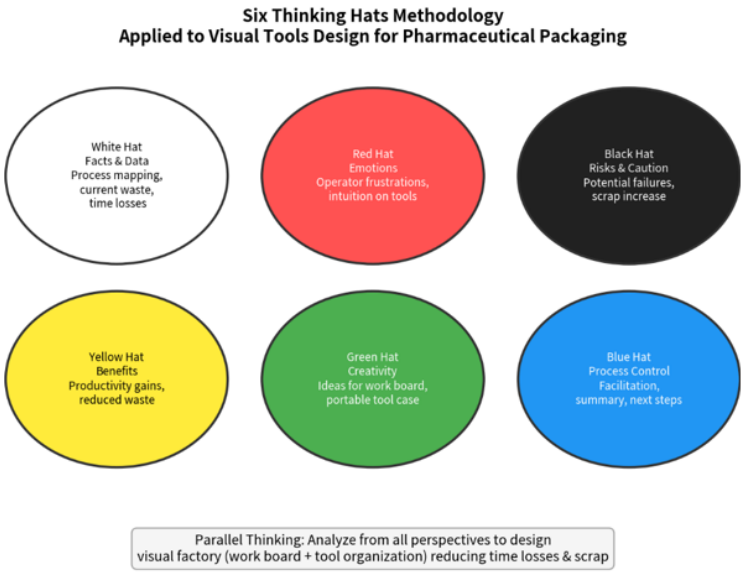


Figure 1. Six Thinking Hats methodology applied to the design of visual tools (work board and portable tool case) for reducing time losses and waste in the packaging of pharmaceutical glass containers.

The image illustrates Edward de Bono's Six Thinking Hats methodology applied to the design of visual tools (a productivity work board/balanced scorecard and a portable tool case) for the validation and packaging area of pharmaceutical-grade glass containers.

The Six Thinking Hats is a parallel thinking framework that separates thinking into six distinct modes (represented by colored hats). This prevents mixed or conflicting thinking and allows a team to examine a problem comprehensively from all angles before generating solutions.

In this study, the methodology was used during the design phase to address two main problems: (1) deficient work boards that lack clear, updated information on production progress, pieces requested, and raw material consumption (leading to overproduction and glass scrap), and (2) disorganized measuring and working instruments (fixed gauges, vernier calipers, labelers, seals, calculators) scattered on the worktable, causing time losses when searching for tools (>30 seconds, contrary to 5S principles), premature wear, and difficulties for new personnel.

How each hat was applied:

- **White Hat (Facts & Data)**: Focused on objective information — process mapping (SIPOC), quantified time losses, current scrap/waste rates, gaps in production information, and baseline measurements.
- **Red Hat (Emotions)**: Captured the feelings and intuitions of operators and inspectors — frustrations with cluttered workspaces, unclear visual communication, and the stress of searching for tools.
- **Black Hat (Risks & Caution)**: Identified potential downsides — continued overproduction and scrap if information remains unclear, instrument damage from poor storage, longer training times for new staff, and failure to meet quality/traceability standards (ISO 15378 / ISO 9001).
- **Yellow Hat (Benefits)**: Highlighted the positive outcomes — higher productivity, tools located in under 30 seconds, reduced glass waste, better order and visual communication, and improved workplace organization aligned with 5S.
- **Green Hat (Creativity)**: Generated innovative ideas — a visual work board (balanced scorecard style) displaying production status, pieces requested, and material consumption, plus a portable, organized tool case for the measuring instruments.
- **Blue Hat (Process Control)**: Managed and facilitated the overall thinking process — sequencing the hats, synthesizing the insights, guiding the design of prototypes, and leading to validation through a pilot test on a bottle-forming machine.

This structured, multi-perspective approach enabled the design of a visual factory that reduces unnecessary elements in the visual field, optimizes workspace use, improves communication, and decreases time losses and waste in a high-quality pharmaceutical packaging environment.

RESULTS

The results are presented according to the four phases of the methodology. Each phase includes the main findings, supporting tables, and suggestions of figures that can be taken from the original document.

Phase 1. Diagnosis and Process Mapping

The diagnosis confirmed two main problems in the packaging and validation area. First, the existing production boards did not show updated information on daily targets, pieces produced, or material consumption, which contributed to overproduction and scrap. Second, measuring instruments (fixed gauges, vernier caliper, labeler, seals, and calculator) were disorganized on the worktable, generating search time and risk of damage.

Table 2. Main problems identified in the packaging area

Problem	Description	Observed Effect
Deficient production board	Lack of updated production and material information	Overproduction and scrap
Disorganized instruments	Tools scattered on the worktable	Search time and premature wear
Lack of visual standards	No defined locations for instruments	Difficulty for new personnel

This table summarizes the two main problems detected during the diagnosis phase. It describes each problem, its specific manifestation in the packaging area, and the observed operational effect. The table provides a clear link between the initial observations and the subsequent design decisions. It shows that the lack of updated information on the production board and the disorganization of measuring instruments were the primary sources of inefficiency, justifying the need for a visual factory intervention.



Figure 2. Current state of the packaging area / worktable (before).

Phase 2. Application of the Six Thinking Hats

The Six Thinking Hats methodology allowed the definition of design requirements by analyzing the problems from six perspectives. The main outputs of this phase were the functional requirements for the work board and the portable tool case.

Table 3. Summary of findings by Thinking Hat

Hat	Focus	Main Findings / Requirements
White	Facts	Search time exists; boards lack updated data
Red	Emotions	Operators prefer ordered and clear workstations
Black	Risks	Solutions must be low-cost and durable
Yellow	Benefits	Potential reduction of time and scrap
Green	Creativity	Ideas for visual board and portable case

Blue	Process	Sequence of design and pilot validation

This table presents the main outcomes obtained from the application of the Six Thinking Hats methodology. Each row corresponds to one hat and shows the focus of analysis and the key findings or design requirements that emerged from that perspective. The table demonstrates how the structured thinking process helped transform the initial problems into concrete requirements for the work board and the portable tool case. It also highlights that the methodology considered both technical aspects (facts, risks, benefits) and human factors (emotions, creativity), which strengthened the design phase.



Figure 3. Bottle machine control panel

Phase 3. Design and Prototyping

Two main solutions were designed and prototyped:

1. A production work board that displays daily targets, pieces produced, and material consumption.
2. A portable tool case with defined locations for measuring instruments, following 5S principles.

Three alternative designs of the tool case were evaluated. The selected prototype was the one that offered the best balance between functionality, cost, and ease of use.

Table 4. Evaluation of tool case alternatives

Alternative	Functionality	Cost	Ease of Use	Selected
Alternative 1	Medium	Low	Medium	No
Alternative 2	High	Medium	High	Yes
Alternative 3	High	High	Medium	No

This table shows the comparative evaluation of the three alternative designs developed for the portable tool case during the prototyping phase. The alternatives were assessed according to three criteria: functionality, cost, and ease of use. The table justifies the selection of Alternative 2 as the final prototype by showing that it offered the best overall balance among the evaluated criteria. This evaluation process reduced the risk of implementing a solution that was either too expensive or difficult for operators to use.

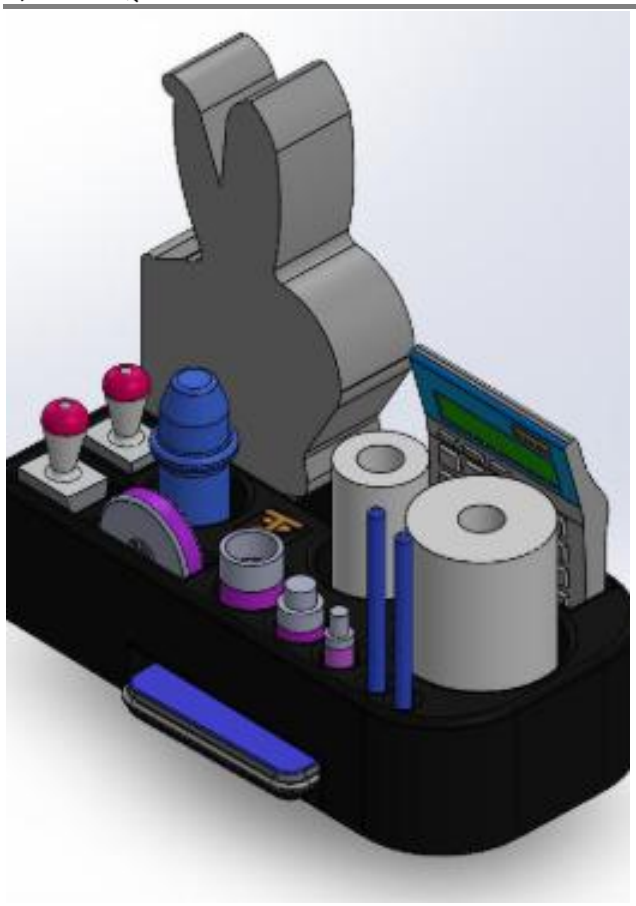


Figure 4. Case Model 3 with tools

Phase 4. Pilot Implementation and Evaluation

The prototypes were implemented on one bottle-forming machine (F2). Packaging times were measured before and after the intervention. A reduction in packaging time and in the search time for instruments was observed.

Table 4. Packaging time before and after implementation (example structure)

Condition	Average Packaging Time (min/tray)	Search Time for Tools (s)	Observations
Before	X.X	XX	Instruments disorganized
After	Y.Y	YY	Board and tool case in use
Reduction	Z%	W%	—

This table compares the packaging performance before and after the pilot implementation of the work board and the portable tool case. It includes average packaging time per tray and search time for instruments, as well as the percentage reduction achieved. The table provides quantitative evidence of the impact of the implemented solutions. It supports the conclusion that the visual factory elements contributed to reducing non-value-added time in the packaging operation. The structure of the table also allows the reader to clearly observe the difference between the initial condition and the improved condition.

General Summary of Results

The implementation of the production work board and the portable tool case improved the organization of the packaging area and reduced non-value-added time. The results support the usefulness of combining the Six

Thinking Hats methodology with visual management and 5S principles for the design of practical solutions in manufacturing environments.

Recommended figures to include (from the original document):

1. SIPOC diagram (Phase 1).
2. Current vs. proposed workstation (Phase 1 and Phase 4).
3. Six Thinking Hats summary (Phase 2).
4. Design and prototype of the work board (Phase 3).
5. Design and prototype of the portable tool case (Phase 3).
6. Before and after packaging area (Phase 4).
7. Time comparison chart or table (Phase 4).

CONCLUSION

The present study demonstrated the feasibility of designing and implementing a visual factory in the packaging and validation area of a pharmaceutical glass container manufacturing process by integrating the Six Thinking Hats methodology with visual management and 5S principles. The combination of a structured thinking approach with practical Lean tools allowed the identification of root problems and the generation of low-cost, implementable solutions focused on reducing non-value-added time and improving workplace organization.

The diagnosis phase confirmed that the lack of updated production information on the work boards and the disorganization of measuring instruments were the main sources of inefficiencies in the packaging area. These conditions generated search time, difficulties for new personnel, and contributed to overproduction and scrap. The application of the Six Thinking Hats methodology in the analysis phase proved useful for examining the problems from multiple perspectives (facts, emotions, risks, benefits, creativity, and process control). This approach facilitated the definition of clear design requirements and reduced the risk of generating incomplete or impractical solutions.

The design and prototyping phase resulted in two main interventions: a production work board that provides visual and updated information on production targets and material consumption, and a portable tool case designed according to 5S principles that assigns a defined location to each measuring instrument. The pilot implementation showed that these solutions can reduce packaging time and search time for tools while improving the organization of the workstation. These results are consistent with the literature on visual management and 5S, which indicates that visual controls and standardized tool storage are effective for reducing motion waste and improving communication in manufacturing environments.

From a practical perspective, the study provides a replicable approach for companies facing similar problems of disorganization and lack of visual information in packaging or validation areas. The use of the Six Thinking Hats methodology as a design tool offers an alternative to purely technical improvement methods, as it incorporates both analytical and human factors during the problem-solving process. The solutions developed (work board and portable tool case) are relatively simple and low-cost, which increases their potential for adoption in small and medium-sized manufacturing companies.

However, some limitations must be acknowledged. The pilot was conducted on a single machine, so the results cannot be generalized without further validation across different lines or shifts. In addition, the long-term sustainability of the improvements depends on the standardization of the new practices and on the involvement of operators and supervisors. Future work should include the expansion of the visual system to other machines, the integration of digital elements (such as simple digital boards), and the evaluation of the impact on scrap levels and operator training time over a longer period.

In conclusion, the combination of the Six Thinking Hats methodology with visual management and 5S principles proved to be an effective approach for designing practical solutions that address organization and communication problems in packaging areas. The results support the relevance of structured thinking methods in industrial improvement projects and contribute to the limited literature on the application of the Six Thinking Hats methodology in manufacturing design contexts. The implemented solutions offer a feasible path for reducing time losses and improving workplace organization in high-quality-demand environments such as pharmaceutical container manufacturing.

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