Accomplish the 4Ps model using Visual Management tools: a case study approach

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Abstract: The spread of Lean methodologies in the Western production reality over the last few years, along the lines outlined by the so-called 'Toyota Production System" (TPS) has not proven to be always effective. Implementing such a methodology is, indeed, not just a technical matter, but it also affects cultural and methodological aspects, according to the principles described by the 4P Liker's model, namely philosophy, process, people and problem solving. A crucial factor which results to be highly important whenever undergoing an optimisation path of this kind is represented by the adoption of Visual Management, which has proven to be a back-up tool highly effective in the achievement of results in the long term. An insight regarding how these tools and techniques affect the different fields described by Liker is, though, still unknown in literature. Based on six real case studies, success stories of correct Visual Management logics implementation, this paper aims to describe the impact of Visual Management in a lean organisation, taking as reference the four distinctive dimensions described in Liker's 4P model, by building a relationship map that links visual systems with the different functionalities they absolve and the benefits they bring. The results of the analysis show how effective Lean visual systems are globally on all the considered fields, but with a different ratio among the single different tools, for which it may be necessary to take a more 'quantitative' approach to better define in which measure each instrument impact on the different management aspects.

Keywords: Visual Management, Lean Manufacturing, Mieruka, Lean Management

I. INTRODUCTION

The use of visual images has always been the most effective and incisive way to achieve the maximum communicative effect in a short time [1], thanks to the strong power of recall, immediate comprehensibility and ease of images memorisation.

This reason has led many companies to adopt Visual Management (VM) to create a responsive, flexible and resilient production system. In particular, VM has emerged as crucial for the successful implementation of lean manufacturing principles [2]. Indeed, by "*connecting and aligning organisational information with the process environment and stakeholders*" [3], VM tools enable instant monitoring of production activities [4], while supporting staff involvement and training. This special form of communication not only facilitates interpretation of the data collected, but also makes the information accessible to everyone, from operators, who need specific instructions to perform their tasks effectively, to managers who can use this information to plan factory activities, coordinate production resources and improve operational processes. Indeed, whenever entering a lean factory that actively adopts the precepts of VM, it can immediately be understood the state of production, whether it is running properly, as well as the configuration of the different working areas, how to reach them and what to pay particular attention to [5].

Although in literature visual management has been recognised as essential to achieve operational excellence in contexts where lean management principles are implemented, it is still unclear how and to what extent the distinctive features of VM tools can influence this outcome. Not all VM tools may in fact work in any context, as each tool can impact in a different manner on performance operations. In this regard, the 4P model, created by Liker and Convis [6] which describes the distinguishing characteristics of an effective lean management system (the True North), can be an effective reference point to identify the functionalities of the VM tools that can fulfil the pursuit of an effective lean system.

To address this question, six case studies concerning manufacturing companies who have undergone a successful lean optimisation program in the last few years, adopting VM tools that fulfil different functionalities. The main results of the case analysis are then adopted to provide a relationship map built upon three main domains, namely Liker's 4Ps, VM functionalities and related tools, to highlight how VM may contribute to the accomplishment of dimensions characterising a lean organisation by performing specific task.

The paper is structured as follows: following this introduction, a brief introduction of 4P model and its distinctive dimensions is provided in Section II. Then, the

research methodology is explained in Section III, while the description of some success stories of VM tool implementation is reported in the fourth section. Section V provides a detailed discussion on the benefits that can be derived from the correct application of VM tools and what functionalities they fulfil or manage to improve. The section ends with the proposal of a relationship map that precedes the final conclusions and the presentation of the limitations and future developments, reported in the last section.

II. 4P Model

Although it is unanimously recognised that there is no universal organisational culture that guarantees success, it has been shown that distinctive cultural characteristics can be associated with positive benefits [7]. For example, many managerial studies have proven that the adoption of lean manufacturing can contribute to the success companies, adopting a different approach to tackling problems. However, the secret of lean success is not so much based on proper application of methods and techniques for process optimisation, but rather on overcoming the rigidity typical of industrial organisations, exploiting human and technical resources through their interaction and involvement [8]. Such approach can be summarized in the so-called Toyota way, a special way of seeing, thinking and acting based on the centrality of people on one hand, and the continuous improvement on the other [9] and developed around four main principles described by the 4P model [10]:

- Philosophy - A long term perspective is required to achieve an organisational philosophy change that foresees the desire to excel above markets, by constantly challenging themselves, working tenaciously and learning from mistakes or from competitors [11];
- Process - Lean is a managerial approach that aims to maximise value creation through the reduction (and, if possible, elimination) of process wastes through kaizen [12], according to which perfection should be pursued through continuous improvement;
- People - Lean implementation necessarily involves teamwork and respect towards other, inspiring growth of people working together [13]. Making people fully responsible for their actions and day-to-day work is an authentic form of respect and trust, which elicits the desire to contribute to a company's success, by delivering better products and services [14].
- Problem Solving - Empowering workers to directly address problems, by going to the source and verifying the facts personally (Genchi Genbutsu), to eliminate misunderstandings and facilitate teamwork.

III. Methodology

Consistent with the main goal of this research, this paper was developed around an inductive study based on the interpretation of six practical case studies. Outcomes from the case studies denoting the important feedback from the application of VM in different manufacturing contexts were adopted to create a relationship map linking VM tools, the dimensions characterising a lean manufacturing system (philosophy, processes, people and problem solving) through their functionalities.

The analysis was carried out by two researchers belonging to the academic environment with both a theoretical and practical experience concerning distinctive traits of VM and its application in real production contexts.

Further meetings following some Gemba sessions taken in factories were helpful to avoid any bias in the evaluation process and to balance the assessment provided by any researcher, thus ending with the realisation of a shared relationship map.

Outcomes from the analysis, with particular reference to the built map, were then validated by the managers of the companies involved to further confirm the relations between the different elements assumed by the researchers.

IV. Case Studies

In this section six success stories, representative of the direct experience of the researchers on the implementation of VM in production, are presented. All cases concern companies with production activities in Italy that have been implementing lean manufacturing principles for at least two years.

TABLE I
Overview of Visual Management tools and related benefits for the considered study cases

Case	Visual Management tools	Benefits
Alpha	Obeya Room, A3 sheets, PDCA and Kanban boards, Ishikawa diagram	More participative climate and cooperative workforce
Beta	Visual signals, Horizontal and vertical signalling	Higher awareness about accident risks
Gamma	OPL, Checklists, QCDS boards	Higher autonomy in the execution of daily tasks, Lower processes variability
Delta	VSM	Shared network of information, Blueprint for improvement
Epsilon	Heijunka Board, Kanban	Higher productivity and flexibility (Pull + JIT)
Zeta	Andon, Production dashboards	Adjustment of the production rate in real time

A. Alpha

Alpha, a leading manufacturer of moulding systems, has been committed to the lean philosophy for around five years. Strongly convinced of the strategic role of collaboration and teamwork in achieving high production standards, Alpha management has for some years now set up a dedicated room (Obeya) in the shopfloor. Here, the optimisation team and the workers can meet together to discuss everyday problems and share their ideas and opinions on how to solve them. The room has been equipped with A3 sheets, PDCA-scanned work programmes and kanban boards to help people plan and manage their improvement actions. Process maps, different types of diagrams for problem classification and cause and effect analysis, such as Ishikawa and mind map diagrams, can also be found. A special area has been set aside for the observation and analysis of defects. Everything is at hand and within sight, to make the analysis of the causes and finding solutions easy and effective. As a result, in a very short space of time, Alpha has experienced a greater participation of people in decision-making processes, an increase in the number of improvement proposals, with an almost doubled implementation rate and significantly reduced application times. The end result is more flexible and efficient processes, a more participative climate and a much more cooperative workforce.

B. Beta

Beta is a small industrial foundry, operating mainly for the nautical sector. Recently, the company has launched a programme to optimise its factory processes by introducing the lean manufacturing principles. Alongside the implementation of 5S trainings, a number of visual management tools have been implemented to improve safety in the factory. To this end, the company has introduced many visual signals in the shopfloor to increase people awareness about risks, to instruct operators on how the protective equipment must be worn and to inform about critical machinery. Supported by an in-depth safety training programme, the adopted visual aids, including appropriate horizontal and vertical signalling systems to regulate the routes of vehicles and people and to mark critical areas where dangerous semi-finished products are stored or suspended loads are moving, have led to a clear reduction in the annual accident rate.

C. Gamma

Gamma is a leading manufacturer of machinery for the textile-clothing industry. Since the introduction of lean management principles in production about ten years ago, the company has focused on VM to improve the attentiveness of factory operators to activities that require special care. To this end, a series of tools have been made available to clearly inform people about how to act in case of extra quality controls required by the quality department or directly by customers. Gamma has also introduced simple and detailed visual instructions to guide the workers through their assembly operations. This measure has eliminated any possibility of error by speeding up the operators in the execution of each production phase. In addition, One Point Lesson (OPL) boards and checklists have been installed near machinery and factory warehouses to instruct workers through visual schemes and images, on what to do in case of short breaks, productive maintenance, and loading/unloading operations. QCDS (Quality, Cost, Delivery, Safety) boards have also been set up to collect feedback information on the difficulties that arise on a daily basis in terms of quality, safety, materials management and lead times. Operators' tasks are now faster, more controllable and easier to understand. The risk error has been almost completely eliminated and the variability inherent in the processes has been drastically reduced. At the same time, the productivity of workers, who have rapidly developed new technical and organisational skills, has significantly improved.

D. Delta

Delta operates in the construction sector, handling the entire production chain for the construction of infrastructures and industrial and commercial facilities, including the production of aggregates, concrete and asphalt, that is carried out directly at its quarries and processing plants. As part of an optimisation plan undertaken since the beginning of 2020, particular importance has been given to the implementation of VM tools, with specific interest on process mapping using VSM techniques. This activity, carried out involving both operators and employees, as well as the operations management, has represented an opportunity to create a shared network of information in which all the participating figures could, on the one hand, become aware of the criticalities affecting the company, and on the other, learn to plan a roadmap for optimising the production process. Indeed, the use of VSM has revolutionised the way of communicating within the company: while previously employees in non-production areas were often not fully aware of the problems affecting production, and conceived their department as completely separate from production, now, thanks to visual maps and posters accessible to all, a greater awareness has developed within the company, permeating its departments and orienting them towards a common objective.

E. Epsilon

Epsilon is a small-sized company active in the production of beer and soft drinks equipment. About ten years ago, the company began a lean transformation of its operations. Among others, the lean manufacturing project concerning the optimisation of production processes according to the pull logic, has succeeded thanks to the introduction of several VM tools. Specifically, detailed horizontal and vertical signals has resulted in a more fluid and uninterrupted flow of people and goods. An Heijunka board located in the centre of the shopfloor and many panels indicating the progress of production allows each operator to know at a glance whether they are working in accordance with the production pace or whether they need to speed up or slow

down their activities to adjust to the takt time. In addition, pre-assembly workstations have been equipped with instruction panels and electronic kanbans where a three-colour signalling system indicates to the operator the priority level (high in red, intermediate in yellow and low in green) to be assigned to the different items by facilitating the activities of workers, the adopted planning system has increased the productivity and flexibility of the whole production area, encouraging the factory operators to maximise their time and resources by working according to a Just In Time (JIT) logic.

F. Zeta

Zeta is an industrial company operating in the automotive sector that has adopted the principles of lean management for over twenty years. The visual management system is extremely sophisticated and covers the planning, execution and control phases, involving aspects of safety in the workplace, production and material management and maintenance. Of particular interest is the visual performance analysis and control system adopted by Zeta. Here, the Andon system, consisting of a set of traffic lights placed on board the machine, combined with audible signalling systems, has been integrated with panel screens placed in the working area and clearly visible to operators and managers. This allows the operators to adjust the production rate in real time, speeding it up or slowing it down, and to intervene promptly if necessary. The monitoring systems have been integrated into the production dashboard, which can be accessed from several points in the factory shopfloor where touchscreens have been positioned, or directly on a tablet, used by the production manager to monitor plant performance, directly accessing each control line system. Moreover, the system offers the access to graphs and diagrams of different colours through which managers can identify the position and the operating conditions of transport units for material handling, highlight any deviations in the delivery and production plan and thus reschedule production and material handling activities more quickly and effectively.

V. DISCUSSION

The case studies provide some interesting insights into the role of VM in production. First of all, each story highlights the existence of several and distinctive features characterising VM tools. While in the Alpha case it is clear that the most important advantage deriving from the adoption of VM is a more efficient organisation of production activities, in the Beta case it is instead the improvement of workplace safety that represents the strong point of the adoption of VM tools. Moreover, as underlined by the Epsilon and Zeta cases, VM emerges as particularly important for the improvement of factory activities planning and control. Nevertheless, VM not only plays a key role in the planning, execution and control of processes but, as the Gamma and Delta cases suggest, can also bring significant benefits in relation to organisational culture, people participation and commitment. While the Gamma case shows that VM has been central to improving skills and feedback improvement, the Delta case highlights that its adoption fostered the development of cooperation and awareness.

In conclusion, from the observation of the six case studies, it can be stated that there is a direct relationship between the dimensions of lean management, referred to Liker's 4P model, and VM systems. Consistent with this and in line with what is summarised in Table 1, the next sections provide a discussion of how and to what extent this relationship exists, highlighting the VM tools that most support each of these relationships.

A. Visual management and philosophy

Liker's model emphasises the importance for lean manufacturing firms of having an organisation focused on operational excellence, which is pursued through the creation of a culture aimed at promoting continuous improvement. From this point of view, VM tools, such as OPL systems and operating instructions, promote the development of an operational and behavioural discipline through the building a habit of maintaining correct procedures. Furthermore, the increased transparency of information, achieved through the use of visual planning tools such as kanban boards and A3 sheets, contributes to the creation of a positive competitive climate, based on challenge, while maintaining a high level of respect for others.

B. Visual management and process

Case studies suggest a direct relationship between the adoption of VM tools and the process dimension characterizing the organisation of lean enterprises. Indeed, all cases underline how the use of VM helps production operators to speed up their activities, reducing production waste. Thanks to the use of horizontal and vertical signalling systems, movements and transports can be reduced. In addition, the introduction of panels with work instructions (such as the OPL instructions) encourages faster learning of right production methods, thus reducing the risk of unnecessary operations (over-processing) and improving the quality of output, that is a source of unnecessary waste of time and resources, due to scraps and reworks. The use of VM also improves safety in the workplace, resulting in increased availability of technical and human production resources. Finally, it helps to develop a more transparent and responsive planning system, as in the case of the introduction of the Heijunka board and kanban boards, while a simpler intuitive control, facilitated by the use of dashboards and information panels, is provided. The use of VM not only enhances the development of more efficient processes per se, but also creates the conditions for facilitating their improvement. Indeed, the introduction of tools for collecting information from the field on the one hand (e.g. QCDS boards) and for evaluating critical processes and identifying possible mitigation solutions on the other

(e.g. VSM), create the ideal conditions for introducing more frequent and effective improvement plans.

C. Visual management and people

The cases analysed highlight a strong and direct link between VM and the human dimension, the third distinctive feature of Liker's model. In particular, it emerges that visual tools create the ideal conditions for capturing an organisation's tacit knowledge more quickly and effectively, accelerating the process of employee learning and the development of a creative approach. Furthermore, the adoption of visual tools, such as company dashboards, encourages a sense of belonging and sharing of results, while the use of top-down and bottom-up communication tools, such as information and QCDS boards, promotes openness to dialogue and the sharing of information and ideas, thus stimulating staff to actively participate in decision-making processes.

D. Visual management and problem solving

As all the study cases suggest, there are numerous VM tools that support the development of problem solving. In particular, its use encourages management by facts, meaning management based on data and statistics rather than guesswork and intuition, helping, through the use of a rigorous methodology, managers and team leaders to guide and improve the quality of tasks and projects. In addition, VM tools support optimisation teams to design and manage process improvement through robust and structured criteria, as in the case of the adoption of VSM for process analysis and optimisation or A3 sheets, used to design improvement plans according to PDCA principles.

TABLE II
RELATIONSHIP TABLE BETWEEN LIKER'S 4PS, VM FUNCTIONALITIES AND RELATED TOOLS

4Ps	Visual Management functionalities	Visual Management tools
Philosophy	Inspiration	OPL; Kanban board; A3 sheets
Process	Identification; Information; Improvement; Indication	Red tag for 5S; Horizontal and vertical signal; Kanban; VSM; Visualisation Boards; Andon; QCDS dashboards; Kanban board; Heijunka board; X-Matrix
People	Information; Instruction; Involvement	Visualisation Boards; Andon; QCDS dashboards; VSM; Horizontal and vertical signal; Kanban Board; OPL; Visualisation Instruction
Problem Solving	Instruction; Inspiration	Kanban Board; OPL; Horizontal and vertical signal; Visualisation Instruction; A3 sheets

VI. CONCLUSIONS, LIMITATIONS AND FURTHER DEVELOPMENTS

This study highlights how the adoption of VM tools facilitate the purpose of lean management principles summarised in the so called 4P's model. As highlighted by six practical case studies, whether made available in traditional or in digital format, VM provides operators with complete, accurate, timely and clear information, leading to the generation of high operational performance. Operators with VM systems are thus able to make immediate and correct decisions and independently recover from any emergency. Moreover, the use of VM has a positive influence on staff behaviour, improving productivity and quality through greater involvement and participation.

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