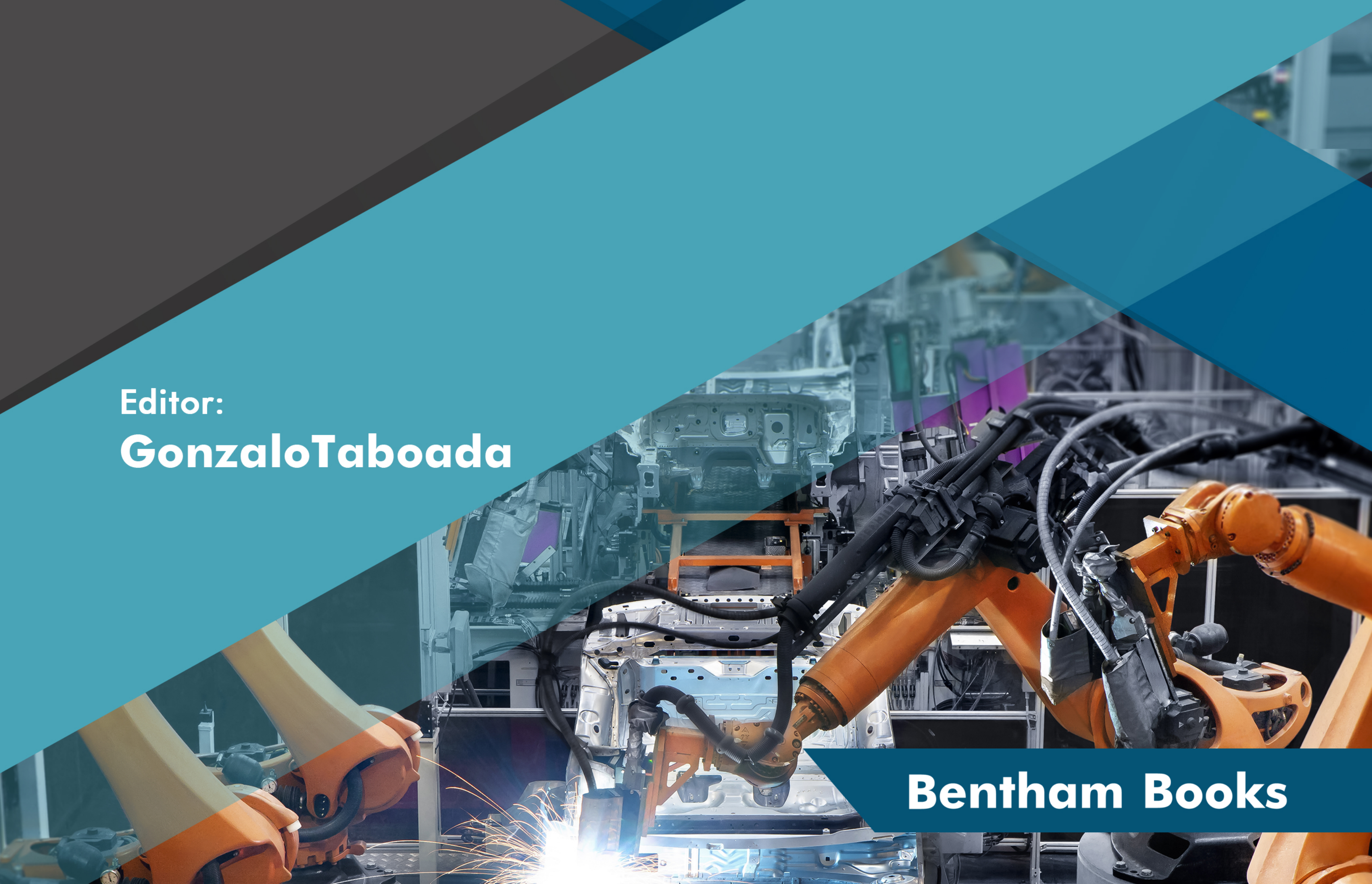
LEAN MANAGEMENT SOLUTIONS FOR CONTEMPORARY MANUFACTURING OPERATIONS "APPLICATIONS IN THE AUTOMOTIVE INDUSTRY"

Editor:
GonzaloTaboada



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Lean Management Solutions for Contemporary Manufacturing Operations

“Applications in the Automotive Industry”

Edited by

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Lean Management Solutions for Contemporary Manufacturing Operations

“Applications in the Automotive Industry”

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FOREWORD

People are impacted by Science every day. This simple fact is advantageous when it represents an improvement in the quality of life. Many times, when people refer to their quality of life, they associate it with free time. However, this book sheds light on improving the quality of life from the work perspective. Since we probably spend a third of our time working, it is especially important to embrace Science and Technology to produce meaningful changes that benefit us.

These changes, however small they may seem, can have major impacts on the society in which they are generated. Incorporating Science and Technology in everyday work-life can help increase opportunities, improve mental well-being, and enhance productivity which are central to a better quality of life. These changes could substantially contribute towards the incorporation of people with special abilities into today's industry.

Dr. Juan Pablo Zanin
Rutgers University, New Jersey, EEUU
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PREFACE

Lean Management Solutions for Contemporary Manufacturing Operations opens an illustration of some of the smart functionalities that can be implemented. The book also introduces technologies, soft and hard skills, suitable for the general integration. Following this, the authors provide a comprehensive review of the recent advances in technologies and methods, in different areas, including synergies with human capital.

The following chapters establishes a standard for application of mathematical concepts in workplaces, agile methods for projects, applicated design, low cost solutions. It also includes people development, planning, motivation and especially deals with persons with disabilities in workplace context.

The goal of the work is to open the eyes to the new industry revolution.

Various setups are thoroughly examined by the authors, considering the contribution of each case.

Chapter 1: This article tries to use Euler's concept to solve the problem of the 7 Königsberg bridges, applied in the workplace organization.

This new application of Graph Theory is intended to help improve different jobs, either from the design of new workstations, as well as opportunities for improvement for those workstations current.

Chapter 2: This chapter explores the concept of non-value-added operations in the manufacturing industry and how it impacts part design. The idea is to describe what are currently considered operations that do not add value to manufacturing and show examples of applied design, giving an idea of how the designer or engineer should think when making a new product, they should not only focus in functionality, also in the process and always contextualizing the different technologies available, current laws and the market to which it is trying to introduce.

Chapter 3: In times where the fourth industrial revolution is looming on the near horizon, technological advances and new employment configurations invite us to question access to quality jobs for vulnerable groups such as people with disabilities. This requires investigating the management of resources, physical, technical and procedural factors involved in the design of jobs and reviewing some alternatives such as the Supported Employment methodology.

Chapter 4: The influence of strategic planning can be a link or obstacle to the good performance of the company and can be a factor of distinction and influence in the commitment of those who are part of it. Strategic planning must be understood as a participatory process, which will not solve all uncertainties, but which must draw a line of those affected to act accordingly.

Chapter 5: In this article we are going to review different solutions for material handling problems to increase productivity.

In this process we are learning some tools used to analyze time and methods and improve them.

The aim is to demonstrate that automation is not always expensive, if we use our brain we can find out mechanism cheaper than a robot.

Chapter 6: This article consists of analyzing the feasibility of using agile methodologies tools in industrial manufacturing projects.

Since its inception, agile management tools have been used for software development projects and technology innovation. Currently, manufacturing projects use only traditional project management methodologies; the challenge is to apply agile tools in traditional management.

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CHAPTER 1

Application of Graph Theory in Workplace Design

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Abstract: This article tries to use Euler's concept to solve the problem of the 7 Königsberg bridges, applied in the workplace organization.

First of all, it is important to keep in mind that Euler was a mathematician who in 1736 proposed a solution to a problem posed at the time that consisted in taking a walk through the city of Kaliningrad, starting from one of its regions, crossing once all its bridges over the Pregolya River and returning to the same region from which he had started.

Keywords: Assembly, Bridges, Chart, CILR, Design, Diagram, Euler, Eulerian Cycle, Eulerian Way, Graph Theory, Movements, Regions, Route, Workplace, Workstations.

INTRODUCTION

Before entering fully into the article, we will briefly review Leonhard Euler (1707 - 1783) Swiss mathematician (Fig.**1**), main promoter of mathematical analysis in the 18th century, with more than 50 books published, on mathematical analysis, algebra, fluid mechanics, astronomy, *etc*.

Fig. (1). Leonhard Paul Euler.

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Amongst his many discoveries and developments, Euler is credited for introducing the Greek letter π to denominate the Archimedes constant (the ratio of a circle's circumference to its diameter), and for developing a new mathematical constant, the "e" (also known as Euler's Number), which is equivalent to a logarithm's natural base, and has several applications such as to calculate compound interest.

Another application that we will develop is the Graph Theory.

Graph Theory is a branch of mathematics that studies flow and/or movements through networks of points and lines by means of graphical representation.

The subject of graph theory had its beginnings in recreational mathematical problems (see numbers game), but has become an important area of mathematical research, with applications in chemistry, social sciences, and computer science [1].

PROPOSED DESIGN

Seven Königsberg Bridges

As we mentioned in the beginning, Euler tried to solve the problem posed on the crossing of the 7 bridges (Fig.**2**).

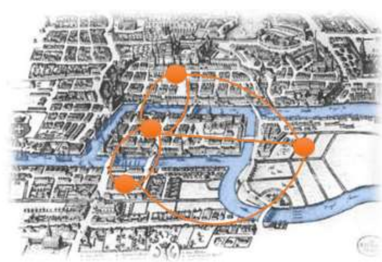

Fig. (2). Seven Königsberg Bridges.

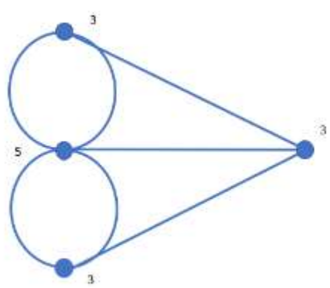

Fig. (3). Graph.

The problem posed has no solution, it is impossible to get a route that meets the condition of connecting all regions using all bridges only one time.

From this problem, Euler enunciated the Graph Theory, which we will use in this chapter to achieve greater efficiency and organization in the different workstations, that is, we will show one of the possible applications of Euler's Theory [2, 3].

Graph Theory

It is the graphical and simplified representation made by Euler to try to solve the problem of the 7 bridges (Fig.**3**), based on what was called position geometry. Euler designed a graph that represents regions as nodes or vertices and routes (in this case bridges) as edges of that representation.

For a graph to be solved, with the premise of finding a route that crosses all bridges only once, two necessary and sufficient conditions must be met [4].

1. If an even number of bridges arrive at each of the regions of the graph, then the path starts and ends at the same place. This is an Eulerian Cycle (Fig.**4**).

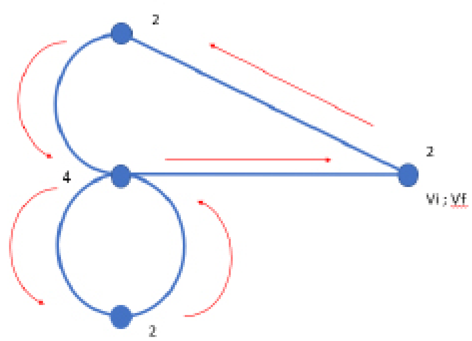

Fig. (4). Eulerian Cycle.

2. If there is a region where an odd number of bridges arrive, then there are exactly two regions with that configuration and the trajectory starts in one of them and ends in the other, where an odd number of bridges also arrive. This is called an Eulerian Way (Fig.**5**).

CHAPTER 2

Applied Design – Efficiency & Added Value

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Abstract: This chapter explores the concept of non-value-added operations in manufacturing (NVAA; non-value-added-activities) and how it affects part design. In the past, parts were designed to be functional to the mission they would serve, usually without regard to ergonomics, assembly method, and efficiency, as in the aftermarket. The idea is to describe what currently are considered operations that do not add value to manufacturing and to show examples of applied design, giving an idea of how the designer or engineer should think when manufacturing a new product. They should not only focus on functionality but also on the process, always contextualizing the different technologies available, the laws in force and the market to which it is intended to be introduced.

Keywords: Activities, Aftermarket, Applied Design, Banjo, Bolt, Efficiency, Manufacturing, NVAA, Product, Tool, Value, Washer.

INTRODUCTION

Non-value-adding activities (NVAA) for efficient manufacturing pay special attention to the efficiency of different jobs, since they try to minimize or eliminate everything that does not provide added value to the final product. To this end, we will define below the operations that do and do not add value in the manufacturing industry; in order to have a clear idea of where to focus our efforts in the different assembly lines and processes.

After the definition, we will give way to the analysis of how to perform when designing new parts, with a concept of efficiency and functionality of the finished product as well as in the assembly process and its usefulness life. The latter refers to after-sales and of course to the accessibility of the components and their standardization, since the quality of a product is defined by how it performs for the purpose for which it was designed, with the lowest cost and highest efficiency (Fig. **1**).

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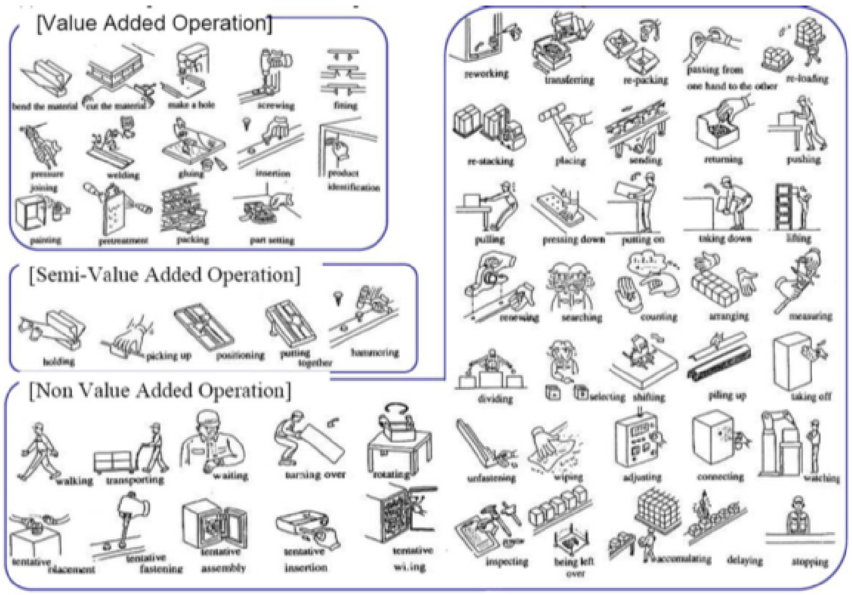

Fig. (1). Operations.

VALUE ADDED OPERATIONS

The operations considered for manufacturing with added value are all those that are assumed to modify the product or transform the product from an initial state to a new one, either a final or partial state; for example, two pieces must be joined by a screw, the adjustment of that screw generates a transformation of our product, they cease to be only two pieces, to become a finished or semi-finished assemble.

NON-VALUE-ADDED OPERATIONS

The operations that do not add value are all those that refer to the contour of the operations that modify the product, that is, operations or micro-operations must be performed so that those that add value can be completed, for example, if a screw must be adjusted, it must first be taken from the shelf and the latter, although it is a necessary operation, does not add any value to the product since it does not transform it. What need to be analyzed are the positions where the screw is to be picked up. The position is not only analyzed as distance to reduce movements with which we reduce time and as we know time translates into an economic account, but we must also analyze the position from the ergonomic point of view since an inadequate position can bring us consequences of physical fatigue or injuries, with which first we will have an injured worker and then we will have associated losses due to the fact that the most skilled operator will not be able to perform the operations. For practical reasons we will take semi-value-added operations as non-value-added operations [1, 2].

PARTS DESIGN

For lean manufacturing much has been written about "Design of Workplaces, their Environment, Tools and Equipment" but most of the time these advances are made as technological solutions for manufacturing and not for product design. This article aims to provide a vision from the applied design or as other authors have called design for manufacturing and assembly (DFMA), which is the sum of design for manufacturing (DFM) and design for assembly (DFA), this means that the design is thought of with a deep knowledge of the technologies and manufacturing means for the plants where they are installed, that is, always taking into account the environmental conditions. However, we must not lose sight of the standardizations since the standards allow us to be more efficient, in terms of manufacturing costs, assembly, storage space, *etc*. I would also like to add a concept which is design thinking about aftermarket (DFAf), since the conservation of components and their replacements must be taken care of from the design conception. Therefore, we will call "applied design" as "design for manufacturing, assembly and aftermarket" (DFMAAf).

Engineering judgment is therefore an important factor in the design and manufacture of reliable components. A typical design project will require detailed information, a good level of understanding and clear decision making on the following aspects.

- Material behavior.
- Product behavior.
- Material and product performance.
- Details of the service loads, working environment.
- Potential failures modes.
- Cost basis of raw materials, manufacturing processes and assembly.
- Design life, maintenance possibilities and consequences of failures.

The following is a series of examples to clarify the concepts explained above, following the methodology of the aspects mentioned above [3].

Hold and Drive

It is an efficient nut tightening system, designed to reduce assembly times in the automotive industry (Figs **2-9**).

CHAPTER 3

Disability and the 4th Industrial Revolution

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Abstract: In times where the fourth industrial revolution is looming on the near horizon, technological advances and new employment configurations invite us to question access to quality jobs for vulnerable groups such as people with disabilities.

It is observed that barriers persist in the accessibility and use of services, products and transportation and an ineffective professional training that supports the old paradigm of considering this group as a handicap in the processes of growth and industrial development. This requires investigating the management of resources, physical, technical and procedural factors involved in the design of jobs and reviewing some alternatives such as the Supported Employment methodology.

Keywords: Disability, Employment, Handicap, Industry 4.0, Individualized, Jobs, Opportunities, Skills, Supported, Work, Workplace.

INTRODUCTION

The entry into the labor market of people with disabilities entails a series of difficulties in the searching and adapting the job, mobility, maintenance of employment, and remuneration aspects.

Tackling these issues requires recognizing the differential quality of educational and vocational training programs, bonus and/or social pension systems that promote inactivity, barriers inherited from social and cultural clichés, and business barriers in hiring them.

Although different conceptions of industrialization and growth may coexist worldwide, given the level of development of each region, to speak of industries is to refer to quality of life, wealth, and development. The problem is the relationship between the accessibility chain at work and its implication in the advancement of new economic-social models and situations, opening a research

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field of multidisciplinary participation to provide answers in different fields of action.

As the Economic and Social Council of United Nations points out in its program "Incorporating the perspective of disability in the development program," that between 80% and 90% of disabled people of working age are unemployed in developing countries, while in industrialized countries, this figure ranges from 50% to 70%.

It shows that the greater the handicap, the greater the reluctance to employ people with disabilities, because it is believed that the tasks and duties will not be fulfilled.

In order to have a comprehensive and social perspective that takes into account the rights of people with disabilities, it is necessary to promote access to education and training, inclusive and non-discriminatory human resources policies, adequate facilities in the workplace and anti-discrimination laws [1].

Therefore, it is important to recognize that disability issues cut across disciplines and are not limited to the health and welfare professions and that participation in the industrialization process depends on factors related to rehabilitation in health as well as factors external to the organization related to people management, organizational culture and semantic issues associated with the scope of disability and its transformation [2].

CURRENT DEFINITION OF DISABILITY

The concept of disability has undergone transformations over time, giving rise to two predominant schemes that seek to define it: the individual model and the social model.

The first focuses on the individual disability and attributes any activity restriction or social disadvantage faced by the individual in his or her daily life as an unavoidable consequence of that disability.

On the other hand, the social model postulates that it is society that creates barriers for any person with a disability. These barriers include, among others, negative attitudes and inaccessible environments, systems, and structures. Disability arises when a person with a disability is excluded due to social barriers [3].

In order to unify criteria and to capture the integration of these two perspectives, the World Health Organization (WHO) established the International Classification of Impairments, Disabilities and Handicaps (ICIDH), adopted in Geneva in 1980 (updated in May 2001 as the International Classification of Functioning, Disability and Health ICIDH-2), which defines a person's functioning and disability as a dynamic interaction between health conditions (diseases, disorders, injuries, traumas, *etc*.) and contextual factors [4].

The social model has also been widely adopted and endorsed by the United Nations Convention on the Rights of Persons with Disabilities (UNCRPD) drafted in 2006 and put into force in 2008. This instrument guarantees equal participation and representation of persons with disabilities in their communities, where disability is established as an evolving concept "recognizing that disability is an evolving concept resulting from the interaction between persons with disabilities and attitudinal and environmental barriers that hinders their full and effective participation in society on an equal basis with others."

Recognizing the value of the contributions that persons with disabilities make and can make to the overall well-being and diversity of their communities, and that the promotion of the full enjoyment of human rights and fundamental freedoms by persons with disabilities and their full participation will result in a greater sense of belonging for persons with disabilities and significant progress in the economic, social and human development of society and in the eradication of poverty.

Following this definition; it is understood that the environment will become an enabler or a disabler depending on how it manages to operate in interaction with the individual.

EMPLOYMENT CHALLENGES IN THE WORKPLACE

In recent years, concepts supported by universal equal opportunity regulations have also emerged that refer to design criteria so that environments, products and services can be used by all types of users, including people with functional diversity.

An example of this are the notions of Design for All, which is the process of creating products, services and systems that are used by the greatest number of people possible, covering the greatest number of situations, and Universal Accessibility, which is understood as the condition that environments, processes, products and services, instruments, tools and devices must meet in order to be understandable, practicable and usable by all people in conditions of safety and comfort, in the most autonomous and natural way possible.

Different experiences show that if workstations are designed with general Universal Design criteria, accessibility and use would be improved in a more

CHAPTER 4

People Development, Motivation & Results

Gustavo R. Mena[1,*]

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Abstract: The influence of strategic planning can be a link or obstacle to the good performance of the company and can be a factor of distinction in the commitment of those who are part of it.

Strategic planning allows diagnosing, analyzing, reflecting, and making collective decisions regarding current tasks and the path that organizations must explore in the future to adapt to the changes and requests imposed by the environment to achieve their viability.

Strategic planning must be understood as a participatory process, which will not solve all uncertainties, but must draw a line of those affected to act accordingly.

Keywords: Behavior, Commitment, Goals, Motivation, Planning, Roles, Satisfaction, Skills, Strategic, SWOT, Work.

INTRODUCTION

Strategic planning facilitates the possibility of thinking about the future, visualizing new opportunities and threats, focusing on the organization's mission, and effectively guiding its course, facilitating direction and leadership. It also allows facing problems such as the allocation of human and financial resources. In relation to classic forms of management, strategic planning introduces a modern methodology.

This modern form of management requires deep knowledge of the organization, greater participation, improving communication and coordination between different levels, and improving management skills, among others.

For the reasons mentioned above, the investigation raises the following question.

How does strategic planning influence employees' job performance?

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Nowadays, due to the changes and the new technologies that appear in the market that determine the development of more abilities, skills, and knowledge, organizations find themselves with the need to implement changes in their labor strategy when facing the challenges presented to them.

It is necessary for companies to develop new techniques for production, market, distribution, service, and customer service, for which human capital is needed, and thus assume the organizational challenges.

Within this context, the productivity and management of human capital in organizations will become key elements of survival; therefore, coordination, direction, motivation, and staff satisfaction are increasingly important aspects of the administrative process [1,2].

PLANNING

Planning is the process by which the company's executive bodies continually design the desirable future and select how to make it feasible; It is based on advanced decision-making that, in a systematic and complex way, is oriented to ensure the highest probability of achieving previously designed desired futures.

The planning process works as a global system, considering that all the functions and organizational levels of the company must be planned simultaneously and interdependently, using the methodology of systemic reasoning since the global system works through the joint interaction of its components. Planning is usually classified as strategic and tactical.

Technical planning aims to optimize the allocation of resources to the maximum consequence of compatible company objectives. It is known as programming and is linked to the third stage of budgeting, which refers to the specific time frame in which the accepted programs must be executed. Within the integral perspective of the planning process, budgets are the formalized quantitative and qualitative expression of the partial or global quota of the programs that must be executed in each period.

Three classes are distinguished:

a. Optimal, which follows policies of maximization or minimization of the variables.
b. Satisfactory, which refers to the level of objectives that, by consensus, satisfy the overall organization of the company.
c. Adaptive, which emphasizes the planning process itself, highlighting its value for training and continuous learning.

The plan represents the set of explicit and coherent decisions to allocate resources to pre-established ends.

Planning represents the exercise (the concrete application) of the plan linked to the theoretical instrumentation required to transform the economy or society; for this reason, it is the concept of planning that will be taken during the investigation.

Strategic planning is nothing more than the process of relating the goals of an organization, determining the policies and programs necessary to achieve specific objectives on the way to those goals, and establishing the necessary methods to ensure that the policies and programs are executed, that is, is a formulated long-term planning process that is used to define and achieve organizational goals [3].

Its characteristics are:

a. It is conducted or executed by high hierarchical levels.
b. Establish a framework for the entire organization.
c. It faces higher levels of uncertainty with respect to other types of planning.
d. Generally, it covers long periods. The longer the period, the more irreversible the effect of a more strategic plan will be.
e. Its parameter is efficiency.

The central objective of strategic planning is to get the most out of internal resources by selecting the environment where they are to be deployed and their deployment strategy. For example, it is about finding a market niche that the company can serve better than potential competitors; therefore, the application of resources is more beneficial than in other circumstances.

It is the antithesis of improvisation and a management style that reacts instead of making decisions based on a plan. Due to its characteristics, it allows the manager to grasp the future of his organization as it commits him to follow previously defined lines of action.

The intensity of planning will depend on different factors such as the anticipation with which a decision must be made, the difficulty of coordination in decision-making, the magnitude of deviations and the consequent changes to be introduced. Available resources cannot be ruled out.

The limits are defined according to the type of organization, the behavior of resources, and the type of activity in question. The short, medium, and long terms can be distinguished.

CHAPTER 5

Low Cost Logistics Solutions

Cristian F. Stiefkens[1,*]

[1] *Industrial Compass, Córdoba, Argentina*

Abstract: In this article, we are going to review different solutions for material handling problems to increase productivity.

In this process, we learn about some tools used to analyze time and methods and improve them.

The aim is to demonstrate that automation is not always expensive; if we resort to our knowledge, we can find a mechanism cheaper than a robot.

Keywords: Automation, Chart, Design, Diagram, Karakuri, Low-cost, Manufacturing, Movement, Payback, Work, Yamazumi.

INTRODUCTION

During my professional life, I have seen many automation projects that have not been fully developed because they did not have a successful payback period. I have also seen several ideas that were discouraged before they were implemented as well as projects that did not deliver the expected results.

After studying the principles of World Class Manufacturing, I realized that the problem is not automation. When we hear this word, the first thing that comes into our mind is "robot". In fact, that is only a limited view of the concept because we can automate processes with a lot of low-cost automation mechanisms. The key element is to find out which of these automation processes is necessary and consequently, apply it accurately.

For example, in a project to automate the end of a packing line there were 6 lines where different products were packed through the same process. A filling machine inserted the products into the primary container, then two operators grouped the

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filled units and put them into a box. After that, another operator took the boxes and consolidated a pallet. Once the pallet was completed, it was wrapped and stored (Fig. **1**).

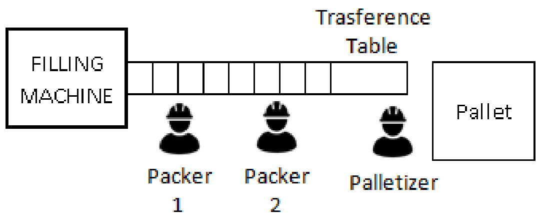

Fig. (1). Standard Work Without Automation.

The automation proposal was to buy 3 machines, one to prepare the box to receive the product, a robot to pick the product and place it into the box, and another robot to palletize the box. The investment was huge, but the process was not fully automated because a skilled operator was required to feed and operate the 3 machines. In addition, productivity had to be improved so we had to look for another solution because the project was neither feasible nor cost-effective. At that point, we started looking at low-cost automation alternatives, and we found out that the Karakuri concept was our solution.

KARAKURI

Karakuri means gimmick, mechanism, machinery, trick, contrivance, or device. The key point here is some mechanical trickery. It originated with mechanical dolls in Japan, called Karakuri ningyo. These dolls were first mentioned around 1500 years ago but were most popular around 200 years ago (Fig. **2**).

Fig. (2). Karakuri Dolls.

These dolls are the precursor of robots. One of the most well-known examples is the tea-carrying doll. The weight of a bowl of tea put on the tray made the doll move forward to a set distance while moving its feet (powered by a wound-up spring). After removing the bowl and drinking the tea, the empty bowl was placed on the tray again. This weight causes the doll to turn around and return to its original position.

When it comes to lean manufacturing, Karakuri is also known as Karakuri Kaizen. This mechanical device has the aim of improving processes and conveyance systems. The device uses only mechanical gadgetry and shuns electric, hydraulic, or pneumatic power. It is also not controlled by a computer but rather by the design of the mechanics.

Power

A Karakuri device needs the power to function, or more generally, it needs energy. Rather than using a dedicated power source like a motor, Karakuri devices take their energy from wherever they can. Often, the energy source is human muscle. Many Karakuri devices are operated by hand, like a lever or a pair of custom pliers. This can also be in an indirect form (*i.e.*, when the worker takes a power tool out of a holder or returns it, the movement of the power tool can power a mechanism). Many other Karakuri devices are operated by stepping on a lever or pedal. This provides more power as the muscles in the leg are stronger. Another energy source is taking away a bit of energy from another machine. The movement of another machine is used to power the K device. For example, a material supply cart driving by a storage rack may activate some levers within the rack.

Energy Storage

For many Karakuri devices, energy must be stored. Seesaw is a very common type of these devices. While one thing moves down (releases gravitational energy), the other thing moves up (stores gravitational energy). Later this stored gravitational energy can be used when the first thing has left the device.

Closely related is weight on strings. During a movement, this weight is pulled up. Later, this weight is released again to provide energy. Often, these weights are plastic bottles or canisters filled with water or sand, which allow easy fine-tuning of the weights. Yet another ingenious way of energy is a pendulum.

One example is the extraction of screws using a magnetic pendulum. This pendulum pulled the screws out of a storage container, oriented them and placed

CHAPTER 6

Agile Methodologies in Manufacturing Projects

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Abstract: This article analyzes the feasibility of using agile methodologies tools in industrial manufacturing projects.

Since their inception, agile management tools have been used for software development projects and technology innovation. Currently, manufacturing projects employ only traditional project management methodologies; the challenge is to apply agile tools in traditional management.

Keywords: Agile, GPD, Kanban, Lean, Management, Methodology, PDCA, Project, Scrum, Sprint, TPS, Tools, WIP.

INTRODUCTION

Before going into the development of the article, we will briefly review the origins of agile management methodologies.

It is difficult to identify a creator of agile methodologies; in fact, there is no date in history that we can mark as the birth of agile methodologies. This is because agile methodologies are an incremental philosophy of knowledge and experience that haves been in constant evolution for more than a hundred years.

However, to understand the birth of agile tools, we must travel back in time to the year 1900` and analyze different technological milestones in history. Below we will review these milestones, and briefly explain the contribution they made to the agile methodologies we know today.

TEMPORARY REVIEW

To study the beginning of agile methodologies, it is necessary to review several contributions throughout history, starting in 1891, Frederick Taylor (1856-1915),

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who first defined the concepts of the Scientific Administration of Labor. He extended his ideas on division of labor to simple and routine tasks, motivation and productivity through control and supervision of employees. (USA-1891).

In 1924, Sakichi Toyoda (1867-1930) in Japan created and implemented process automation for the first time with the help of humans, concept known as ***Jidoka***. Invent the loom machine capable of automatically detecting when the thread breaks and stopping production from avoiding waste or defects in the final fabric. Later at Toyota Motor Company, Sakichi Toyoda would apply these concepts known today as Lean Manufacturing [1] (Fig. **1**).

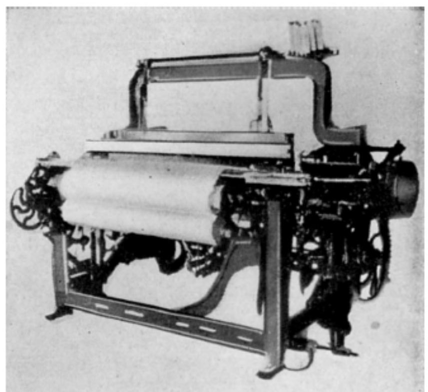

Fig. (1). First Toyoda Loom.

In 1936 Alan Turing (1912-1954 England) developed the Turing Machine, which explained years later the logical operation of a computer. It was the first machine to use symbol processing using logic (Fig. **2**).

Fig. (2). Turing machine.

Walter Shewhart (1891-1967 USA), known as "The father of quality", in 1939 published in his book Statistical Method from the Viewpoint of Quality Control the process of continuous improvement and iterative and incremental work through short cycles of " Plan, Do, Check and Act "(plan-do-study-act). "P.D.C.A."

In 1946, in the USA, the ENIAC was created, the first digital computer in history. ENIAC is the acronym for "Electronic Numerical Integrator and Computer" It was the first general-purpose computer, with the possibility of being reprogrammed to solve numerical problems. It was initially designed to calculate artillery firing charts destined for United States Army military research.

In 1948 the engineer Taiichi Ohno (1912-1990) in Japan, begins to create the Kanban methodology in Toyota, to give rise to what is known as "Toyota Production Systems" (TPS).

In 1950, in the USA, the X-15 hypersonic jet was developed. It was the first technology project developed with "Iterative and Incremental methodology" recorded in history (Fig. **3**).

Fig. (3). X-15 jet.

NASA in 1958 used an Iterative and Incremental methodology for the Mercury project. (for the first trip of a man to space). Incremental methodology begins to have more military uses and in research developments.

Between 1966 and 1969, the United States Department of Defense developed the first computer network, which was called ARPANET, considered this milestone as the birth of the Internet.

APPENDIX

Graph Theory

In mathematics, graph theory is the study of graphs, which are mathematical structures used to model pairwise relations between objects. Conceptually, a graph in this context is made up of vertices (also called nodes or points) which are connected by edges (also called links or bridges). A distinction is made between undirected graphs, where edges link two vertices symmetrically, and directed graphs, where edges link two vertices asymmetrically; see Graph (discrete mathematics) for more detailed definitions and for other variations in the types of graph that are commonly considered. Graphs are one of the prime objects of study in discrete mathematics (Fig. **1**).

The following are some of the more basic ways of defining graphs and related mathematical structures.

In one restricted but very common sense of the term, a graph is an ordered pair $G = (V, E, \phi)$ comprising:

V, a set of vertices (also called nodes or points)

$E \subseteq \{\{x, y\} \mid x, y \in V \text{ and } x \neq y\}$, a set of edges (also called links or bridges), which are unordered pairs of vertices (that is, an edge is associated with two distinct vertices).

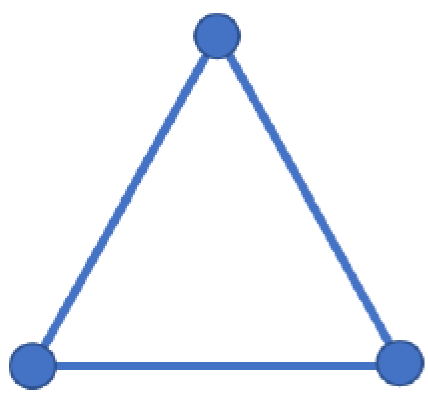

Fig. (1). Graph with three vertices and three edges.

This type of object may be called precisely an undirected simple graph.

In the edge $\{x, y\}$, the vertices x and y are called the endpoints of the edge. The edge is said to join x and y and to be incident on x and on y. A vertex may exist in a graph and not belong to an edge. Multiple edges, not allowed under the definition above, are two or more edges that join the same two vertices.

In one more general sense of the term allowing multiple edges, a graph is an ordered triple G = (V, E) comprising:

V, a set of vertices (also called nodes or points)

E, a set of edges (also called links or bridges)

ϕ: E $\subseteq$ $\{\{x, y\} \mid x, y \in V$ and $x \neq y\}$, an incidence function mapping every edge to an unordered pair of vertices (that is, an edge is associated with two distinct vertices).

This type of object may be called precisely an undirected multigraph.

A loop is an edge that joins a vertex to itself. Graphs as defined in the two definitions above cannot have loops, because a loop joining a vertex x to itself is the edge (for an undirected simple graph) or is incident on (for an undirected multigraph) $\{x, x\} = \{x\}$ which is not in $\{\{x, y\} \mid x, y \in V$ and $x \neq y\}$. So to allow loops the definitions must be expanded. For undirected simple graphs, the definition of E should be modified to E $\subseteq$ $\{\{x, y\} \mid x, y \in V\}$. For undirected multigraphs, the definition of ϕ should be modified to ϕ: E $\rightarrow$ $\{\{x, y\} \mid x, y \in V\}$.

These types of objects may be called undirected simple graph permitting loops and undirected multigraph permitting loops, respectively.

V and E are usually taken to be finite, and many of the well-known results are not true (or are rather different) for infinite graphs because many of the arguments fail in the infinite case. Moreover, V is often assumed to be non-empty, but E can be the empty set. The order of a graph is |V|, its number of vertices. The size of a graph is |E|, its number of edges. The degree or valency of a vertex is the number of edges that are incident to it, where a loop is counted twice.

In an undirected simple graph of order n, the maximum degree of each vertex is $n - 1$ and the maximum size of the graph is $n (n - 1)/2$.

The edges of an undirected simple graph permitting loops G induce a symmetric homogeneous relation ~ on the vertices of G that is called the adjacency relation of G. Specifically, for each edge (x, y), its endpoints x and y are said to be adjacent to one another, which is denoted $x \sim y$.

Glossary

Applied Design: Design that considers factors of manufacturing, methods and the behavior of the product.

CILR: Cleaning, Inspection, Lubrification and Refastening.

GPD: Global Product Development, is when a company has their product development activities globally distributed, from R&D to production.

Graph: Graphical representation for solutions of discrete mathematics.

JIT: Just in Time, is a methodology aimed primarily at reducing times within the production system as well as response times from suppliers and to customers.

Kanban: Is one method to achieve JIT. The system takes its name from the cards that track production within a factory. For many in the automotive sector, Kanban is known as the "Toyota nameplate system".

Japanese mechanical automaton devices to produce surprise in a person

Lean Manufacturing: Efficiency manufacturing process

NVAA: Non-value-added-activities for efficiency process.

PDCA: It is the Deming cycle, plan-do-check-act to solve problems.

CILR: Cleaning, Inspection, Lubrification and Refastening.

Supported Employment: Methodology based on experimental psychology and behavior modification through reinforcement, intended for pathologies with intellectual and physical disabilities.

Scrum: Concept sport, typical of rugby, related to training required for the quick recovery of the game before a minor offense.

SWOT: SWOT analysis is a type of diagram widely used in business and education used for exploring strengths, weaknesses, opportunities, and threats in a given situation.

TPS: The Toyota Production System is a lean manufacturing system which entrusts team members with well-defined responsibilities to optimize quality by constantly improving processes and eliminating unnecessary waste in natural, human and corporate resources.

WCM: World Class Manufacturing, it's the same to Lean Manufacturing.

WIP: The term "work-in-process" to mean a manufacturer's inventory that is not yet completed, as the goods that are on the factory floor of a manufacturer

WOW System System, without washers for banjo fitting.

Yamazumi: A Yamazumi chart (or Yamazumi board) is a stacked bar chart that shows the source of the cycle time in a given Process. The chart is used to graphically represent processes for optimization purposes.

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Gonzalo Taboada

Gonzalo Taboada is a mechanical engineer born and based in Argentina. During the last two decades, he has served in various professional positions in the private sector of the industry, "Resident Engineering Coordinator of IVECO Argentina S.A., Central Quality Coordinator of IVECO LATAM, Production Supervisor of CNH Industrial Argentina" among others. He has also developed activities as a Co-Pillar Leader in World Class Manufacturing, in Autonomous Activities and Quality.

He obtained his BA in 2010 through the Executive MBA Program at Universidad de San Andrés.

Gonzalo has published articles in journals and books on topics ranging from applied statistics to mathematics. His recent articles are available in "SAE International." He is also the owner of Taboada & Asoc., an engineering, consulting, and new product developing firm in Cordoba, Argentina.

Gonzalo's current mission is to develop content for the current needs of the industry and its users. The philosophy behind all his activities is the same: "everyone, regardless of their background, should be able to benefit from the preceding experiences and knowledge."