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Journal-Industrial Organization

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Support the international scientific community in its written production Science, Technology and Innovation in the Field of Social Sciences, in Subdisciplines of Market structure, Firm strategy, and Market performance: Production, Pricing, and Market structure, Size distribution of Firms, Monopoly, Monopolization strategies, Oligopoly and Other imperfect markets, Transactional relationships, Contracts and reputation, Information and Product quality, Industrial Organization and Macroeconomics, Macroeconomic industrial structure; Firm objectives, Organization, and Behavior: business objectives of the Firm, Firm organization and Market structure, Vertical Integration, Organization of Production, Firm Size and Performance; Nonprofit organizations and Public Enterprise: Nonprofit institutions, Public enterprises, Boundaries of public and private enterprise, Privatization, Contracting Out; Antitrust policy: Monopolization, Horizontal anticompetitive practices, Vertical restraints, Resale PRICE maintenance, Quantity Discounts, Legal Monopolies and Regulation or Deregulation, Antitrust policy and public enterprise, Nonprofit Institutions, and Professional Organizations; Regulation and industrial policy, Economics of regulation, Industrial policy, Sectoral planning methods; Industry studies: manufacturing, Metals and Metal products, Cement, Glass, Ceramics, Automobiles, Other transportation equipment, Microelectronics, Computers, Communications equipment, Other Machinery, Business equipment, Armaments, Chemicals, Rubber, Drugs, Biotechnology, Food, Beverages, Cosmetics, Tobacco, Other Consumer Nondurables, Appliances, Other consumer durables; Industry studies: Primary products and construction, Mining, Extraction, and Refining: Hydrocarbon fuels, Other nonrenewable resources, Forest products, Construction; Industry studies: Services, Retail and wholesale trade, Warehousing, Entertainment, Media, Sports, Gambling, Recreation, Tourism, Personal and professional services, Real estate services, Information and internet services, Computer software; Industry studies: Transportation and utilities, Transportation, Railroads and Other surface transportation, Air transportation, Electric utilities, Gas Utilities, Pipelines, Water utilities, Telecommunications, Utilities, Government policy.

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The works must be unpublished and refer to topics of Market structure, Firm strategy, and Market performance: Production, Pricing, and Market structure, Size distribution of Firms, Monopoly, Monopolization strategies, Oligopoly and Other imperfect markets, Transactional relationships, Contracts and reputation, Information and Product quality, Industrial Organization and Macroeconomics, Macroeconomic industrial structure; Firm objectives, Organization, and Behavior: business objectives of the Firm, Firm organization and Market structure, Vertical Integration, Organization of Production, Firm Size and Performance; Nonprofit organizations and Public Enterprise: Nonprofit institutions, Public enterprises, Boundaries of public and private enterprise, Privatization, Contracting Out; Antitrust policy: Monopolization, Horizontal anticompetitive practices, Vertical restraints, Resale PRICE maintenance, Quantity Discounts, Legal Monopolies and Regulation or Deregulation, Antitrust policy and public enterprise, Nonprofit Institutions, and Professional Organizations; Regulation and industrial policy, Economics of regulation, Industrial policy, Sectoral planning methods; Industry studies: manufacturing, Metals and Metal products, Cement, Glass, Ceramics, Automobiles, Other transportation equipment, Microelectronics, Computers, Communications equipment, Other Machinery, Business equipment, Armaments, Chemicals, Rubber. Drugs, Biotechnology, Food, Beverages, Cosmetics, Tobacco, Other Consumer Nondurables, Appliances, Other consumer durables; Industry studies: Primary products and construction, Mining, Extraction, and Refining: Hydrocarbon fuels, Other nonrenewable resources, Forest products, Construction; Industry studies: Services, Retail and wholesale trade, Warehousing, Entertainment, Media, Sports, Gambling, Recreation, Tourism, Personal and professional services, Real estate services, Information and internet services, Computer software; Industry studies: Transportation and utilities, Transportation, Railroads and Other surface transportation, Air transportation, Electric utilities, Gas Utilities, Pipelines, Water utilities, Telecommunications, Utilities, Government policy and other topics related to Social Sciences.

Presentation of the content

In the first article we present, *Analysis and comparison of exoskeleton prototypes to carry out activities under normal conditions in industrial companies to reduce risks* by Gaviño-Ortiz, Gabriela and Osorio-Reyna, Jhonny Jesús, with ascription in the Universidad Autónoma del Estado de México Atizapán de Zaragoza and Universidad César Vallejo Lima-Perú, as following article we present, *Logic control design for calcium chloride dosing hopper for TCO Group*, by Tun-Ordoñez, Jorge Sprewell, Manrique-Ek, Josué Abraham, Cardozo-Aguilar, Guadalupe, Gómez-Ku, Ricardo, with adscription in the Instituto Tecnológico Superior de Calkiní, as following article we present, *Strategic optimization: redesign of internal processes in international bulk companies*, by Benítez-López, Guillermo, with affiliation at the TecNM/ITS of Naranjos, as last article we present, *Enhancing productivity through comprehensive evaluation and contextual analysis: A model for continuous improvement*, by Toledo-Magaña, Rosa Lissette, De León-De Los Santos, Brissa Roxana, Guerra-Que, Zenaida & Eliseo-Dantés, Hortensia with affiliation at the Tecnológico Nacional de México/Instituto Tecnológico de Villahermosa.

Content

Article	Page
Analysis and comparison of exoskeleton prototypes to carry out activities under normal conditions in industrial companies to reduce risks Gaviño-Ortiz, Gabriela and Osorio-Reyna, Jhonny Jesús *Universidad Autónoma del Estado de México Atizapán de Zaragoza* *Universidad César Vallejo Lima-Perú,*	1-8
Logic control design for calcium chloride dosing hopper for TCO Group Tun-Ordoñez, Jorge Sprewell, Manrique-Ek, Josué Abraham, Cardozo-Aguilar, Guadalupe, Gómez-Ku, Ricardo *Instituto Tecnológico Superior de Calkiní*	9-16
Strategic optimization: redesign of internal processes in international bulk companies Benítez-López, Guillermo *TecNM/ITS of Naranjos*	17-25
Enhancing productivity through comprehensive evaluation and contextual analysis: A model for continuous improvement Toledo-Magaña, Rosa Lissette, De León-De Los Santos, Brissa Roxana, Guerra-Que, Zenaida & Eliseo-Dantés, Hortensia *Tecnológico Nacional de México/Instituto Tecnológico de Villahermosa*	26-35

Journal- Industrial Organization June 2024 Vol.8 No.14 1-8
Article

Analysis and comparison of exoskeleton prototypes to carry out activities under normal conditions in industrial companies to reduce risks

Análisis y comparación de prototipos de exoesqueletospara realizar actividades en condiciones normales en las empresas industriales para reducir riesgos

Gaviño-Ortiz, Gabriela * [a] and Osorio-Reyna, Jhonny Jesús [b]

[a] Universidad Autónoma del Estado de México Atizapán de Zaragoza • D-9721-2018 • 0000-0002-8951-7633• 516812
[a] Universidad César Vallejo Lima-Perú • 0000-0002-8364-9758

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* ✉ [ggavinoo@uaemex.mx]

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Abstract

The use of exoskeleton prototypes in industrial companies has emerged as a technology strategy that helps reduce workplace accidents and improve productivity OEE. This qualitative research focuses on explaining observations, using data collected from various academic sources between 2018 and 2022, selecting 47 relevant articles that address the use of exoskeletons in industrial environments. Three main objectives are presented using exoskeletons: 1) Reduction of accidents, 2) Analyze the most suitable exoskeleton prototype for industrial activities, and 3) Compare the effectiveness with respect to the activities. Some studies were discarded and most articles were found to support the effectiveness of exoskeletons in reducing ergonomic risks and workplace accidents. The functionality and effectiveness of several exoskeleton prototypes is compared under normal working conditions and is highlighted as a tool to improve safety and productivity in the industrial field.

Analysis and comparison of exoskeleton prototypes To carry out activities under normal conditions in industrial companies to reduce risks		
Objectives	**Methodology**	**Contribution**
1) Reduction of accidents, which influence productivity, 2) Analyze the most suitable exoskeleton prototype for different industrial activities, and 3) Compare the effectiveness of these with respect to carrying out the activities without them	This qualitative research focuses on analyzing and explaining observations, using data collected from various academic sources between 2018 and 2022, selecting 47 relevant articles that address the use of exoskeletons in industrial environments	This study highlights the potential of exoskeletons as a tool to improve safety and productivity in the industrial field

Research, Exoskeletons, Risks

Resumen

El uso de prototipos de exoesqueletos en empresas industriales ha surgido como una estrategia de tecnología, apoya a reducir accidentes laborales y mejorar la OEE de productividad. Esta investigación cualitativa se enfoca en explicar observaciones, empleando datos recopilados de diversas fuentes académicas entre 2018 y 2022, seleccionando 47 artículos relevantes que abordan el uso de exoesqueletos en entornos industriales. Se presentan tres objetivos principales utilizando los exoesqueletos: 1) Reducción de accidentes, 2) Analizar prototipo de exoesqueleto más adecuado para actividades industriales, y 3) Comparar la efectividad con respecto a las actividades. Se descartaron algunos estudios y se encontró que la mayoría de los artículos respaldaban la efectividad de los exoesqueletos en la reducción de riesgos ergonómicos y accidentes laborales. Se compara la funcionalidad y efectividad de varios prototipos de exoesqueletos en condiciones normales de trabajo y se resalta como herramienta para mejorar la seguridad y productividad en el ámbito industrial.

Análisis y comparación de prototipos de exoesqueletos Para realizar actividades en condiciones normales en las empresas industriales para reducir riesgos		
Objetivos	**Metodología**	**Contribución**
1) Reducción de accidentes, que influyen en la productividad, 2) Analizar el prototipo de exoesqueleto más adecuado para diferentes actividades industriales, y 3) Comparar la efectividad de estos con respecto a realizar las actividades sin ellos.	Esta investigación cualitativa se enfoca en analizar y explicar observaciones, empleando datos recopilados de diversas fuentes académicas entre 2018 y 2022, seleccionando 47 artículos relevantes que abordan el uso de exoesqueletos en entornos industriales.	Este estudio resalta el potencial de los exoesqueletos como herramienta para mejorar la seguridad y productividad en el ámbito industrial

Investigación, Exoesqueletos, Riesgos

Citation: Gaviño-Ortiz, Gabriela and Osorio-Reyna, Jhonny Jesus. Analysis and comparison of exoskeleton prototypes to carry out activities under normal conditions in industrial companies to reduce risks. Journal- Industrial Organization. 2024. 8-14: 1-8.

Journal- Industrial Organization June 2024 Vol.8 No.14 1-8
Article

Introduction

Within industrial organizations, occupational accidents occur with great frequency nowadays (Byun & Jung, 2021), being a vital issue that impacts the whole world and although policies aimed at improving occupational health and safety are implemented, the reality is that occupational accident and mortality rates continue to increase. According to the International Labour Organization (ILO), 2.78 million workers are reported to die from work-related accidents or diseases in 2020.

During the period from 2018 to 2022, around 12 thousand work-related accidents occurred in Peru according to data recorded by the Ministry of Labour and Employment Promotion (MTPE) and the General Office of Statistics and Information and Communication Technologies (OGETIC), Figure 1 shows in more detail the data published for that period (*Estadísticas Accidentes de Trabajo | Ministerio de Trabajo y Promoción del Empleo*, n. d.). Despite the confinement due to the covid19 pandemic, occupational accident rate data remained high.

Box 1

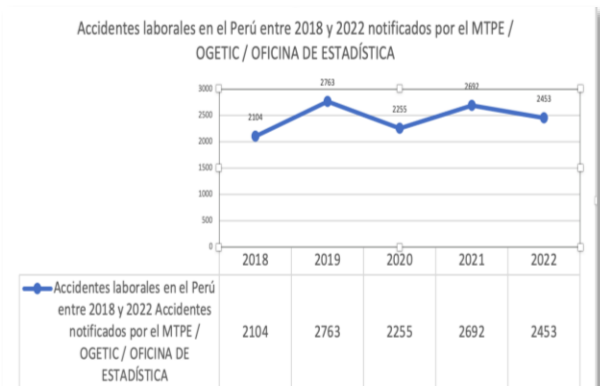

Figure 1

Accident rate data in Peru between 2018 and 2022

Own elaboration, 2024

Occupational accidents in Peru, according to the Regulations of Law No. 29783, Law on Safety and Health at Work, are defined as "those sudden events that occur due to or on the occasion of work, and which cause injury or death to the worker. These accidents may occur during the performance of the worker's normal duties, on the way to or from work, or during the performance of work-related activities.

The law establishes that it is the employer's responsibility to implement safety and prevention measures to avoid occupational accidents, as well as to provide the necessary medical care in case they occur" (Salinas, 2003). Occupational disease, according to law 29783, is defined as any disease that is the direct result of exposure to risk factors inherent to the work activity. These risk factors may include physical, chemical, biological, ergonomic or psychosocial agents present in the work environment. The law states that it is the employer's responsibility to identify and control occupational hazards that may cause illness, as well as to provide the necessary medical care in the event that a worker develops a work-related illness.

Occupational accidents are a problem of concern to all enterprises; however, despite existing safety standards and risk plans, the data provided annually by the ILO does not show a decrease in data related to occupational accidents. The fact that workers have supplementary risk work insurance (SCTR) or private insurance from the company does not guarantee that their lives can be saved or that accidents can be eliminated. Accidents at work not only leave their mark on human lives, but also lead to administrative costs, loss of time and unproductiveness in companies.

Technologies and innovation are presented as a good alternative to improve the quality of life of workers during the working day, as well as to protect their lives and reduce the accident rate and/or the lethal consequences of accidents in case they occur. From the above, it can be deduced that technologies used in the right way can contribute to minimising or reducing accident rates during the working day.

There are several mechanisms that contribute to improving the protection of industrial workers during their working day, and one that has gained special interest in recent times is the exoskeleton prototype.

Prototype exoskeletons are prostheses that function as a mechanism external to the body, which adapt to the body, helping the worker to carry out certain types of activities, with the aim of preventing the appearance of diseases in their muscles or skeleton (Miranda, 2021).

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The use of exoskeleton prototypes has seen a boom in developed countries, constituting an innovative way for companies to reduce mortality and accident rates during the working day, achieving great results in this regard and increasing the economy and profitability of companies without neglecting the life, health and safety of their employees.

Exoskeletons help the effective mobilisation of the body members and are a good option to implement in industrial companies in order to reduce accidents during the working day, as well as problems related to ergonomics, thus contributing to the reduction of mortality rates, occupational diseases and accident rates, thus providing a proposed solution to the problem described.

In this research work, the qualitative research method is applied, it is oriented to analyse problems and try to explain observations, being a reflexive, systematic, critical and verifiable procedure with real sources.

For the development of this work, we used data collected from the period 2018-2022 from various indexed scientific journals such as Scielo Peru, Redalyc, EBSCO, Proquest, Scopus, Uisek, Riecs and the repository of the Cesar Vallejo University, in order to obtain reliable data. Articles not included in indexed journals, without bibliographic information, more than 5 years old and not related to the reduction of accidents through the use of exoskeleton prototypes in industrial companies were rejected.

The study was based specifically on industrial companies that applied exoskeleton prototypes to reduce ergonomic risks and occupational accidents, obtaining a total of 57 articles of significant relevance, considering the following specific objectives:

1. To determine how the reduction of accidents influences the improvement of productivity in industrial companies.

2. To identify the most appropriate exoskeleton prototype according to the activities in industrial companies.

3. To compare the effectiveness and functionality of the exoskeleton prototype in comparison to performing activities under normal conditions in industrial enterprises.

Design

Review of studies and background information on the subject

From this search and selection of data, the articles were filtered and analysed rigorously in two stages: in the first stage, the title of the articles was taken into account in relation to the general topic, selecting a total of 57 articles and in the second stage, a group of 47 articles were selected from the total number of articles found (see appendix 1) as these had the greatest impact and relevance according to their citations and relationship with the topic. The focus of this article is quantitative and both the industrial companies and the population were determined. In the first stage, a thorough inspection of the 57 articles found in the searches was carried out, and 10 articles were discarded in these stages, mainly because their focus was oriented towards the use of exoskeletons as a means of rehabilitation and not to the reduction of occupational accidents in industrial workers.

The discarded articles are listed below:

- Exoskeleton and End-Effector Robots for Upper and Lower Limbs Rehabilitation: Narrative Review (Molteni et al., 2018).
- Exoskeletal Assisted Rehabilitation After Spinal Cord Injury (Gorgey et al., 2019)
- Exoskeletons: state of the art, design challenges and future directions (Agarwal & Deshpande, 2019)
- Current Evidence for Use of Robotic Exoskeletons in Rehabilitation (Jayaraman et al., 2020)
- Exoskeletons in Nursing and Healthcare: A Bionic Future (O'Connor, 2021)
- Lower-Limb Medical and Rehabilitation Exoskeletons: A Review of the Current Designs (Plaza et al., 2021)
- A framework for clinical utilization of robotic exoskeletons in rehabilitation (Hohl et al., 2022)

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- A systematic review of technological advancements in signal sensing, actuation, control and training methods in robotic exoskeletons for rehabilitation (Mathew et al., 2023)
- Opportunities and challenges in the development of exoskeletons for locomotor assistance (Siviy et al., 2023)
- The-state-of-the-art of soft robotics to assist mobility: a review of physiotherapist and patient identified limitations of current lower-limb exoskeletons and the potential soft-robotic solutions (Morris et al., 2023)

From the first stage, 47 articles were finally left that generate percentage data on how exoskeleton prototypes can reduce accidents in industrial companies.

Table 1 shows the number of articles used in the work for each year of the selected study period.

Box 2

Table 1

Tab Summary of publications by year

Year	Total number of items	Percentage
2018	6	13%
2019	8	17%
2020	16	34%
2021	15	32%
2022	2	4%

Own compilation,2024

The bar chart in figure 2 complements the above information. The highest percentage of articles collected was in 2020, where the following year, the highest percentage of articles were published.

In the bar chart in figure 2 we can complement the previous information, the highest percentage of articles collected was in the year 2020 where 16 articles were published, equivalent to 34%, followed by the year 2021 with 15 articles published with a percentage of 32%, occupying 66% of the total in these years alone, in contrast to the year 2022 where only 2 publications were found with a percentage of 4%.

Box 3

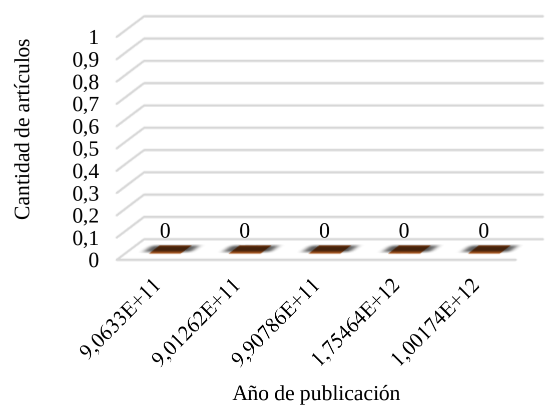

Figure 2

Number of publications per year

Own compilation, 2024

In order to analyse the number of articles according to their country of publication, table 2 can be observed and the pie chart in figure 3 shows the ratio of the percentage of publications by country of publicationSpain is the country with the highest number of published articles, with 13 publications, equivalent to 28% of the total, followed by Peru with a total of 8 published articles, equivalent to 17% of the total, and finally Venezuela, Argentina, Bolivia and Italy with only one published article each, equivalent to 2% of the total, and Venezuela, Argentina, Bolivia and Italy with only one published article, equivalent to 2% of the total article published each, equivalent to 2% of the total.

Box 4

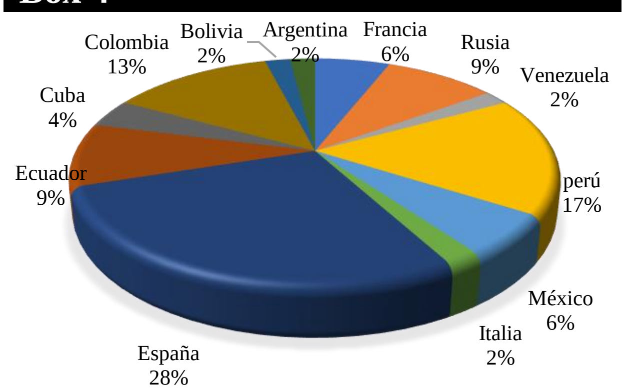

Figure 3

Percentage of published articles by country, collection, 2024

The source of information with the highest number of articles found is Dialnet with 13%, Redalyc, Science Index and the institutional repository of the UPN with 10%, for more information see figure 4.

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Box 5

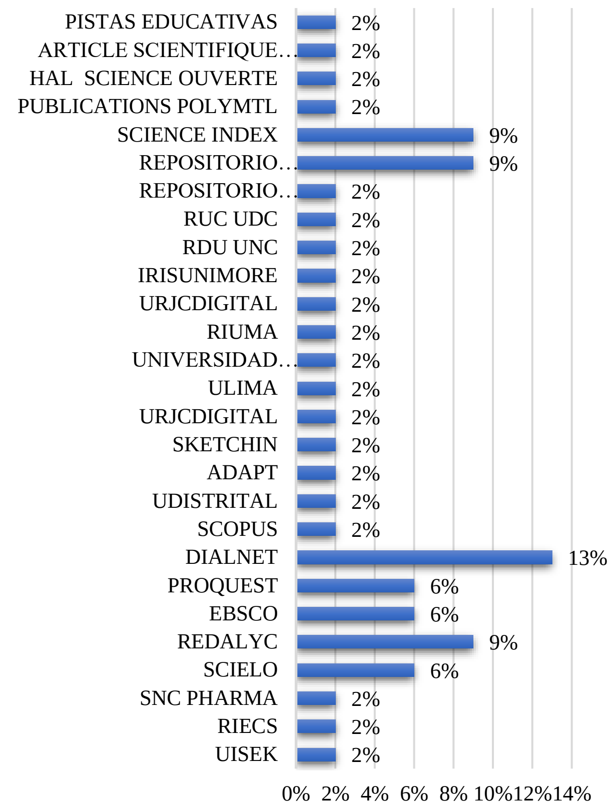

Figure 5

Percentage of articles according to their source of information

Prepared by authors, 2024

The in-depth analysis of the 47 articles made it possible to identify how many of them met the objectives set out in this research.

Rationale

Based on the evidence we have collected, we did not find a sufficiently verifiable basis for demonstrating the advantage of using more appropriate exoskeleton prototypes in terms of risk reduction activities in industrial enterprises.

General Objective

To present prototypes of exoskeletons more appropriate to the activities in industrial enterprises.

Specific objectives

1. To analyse the most appropriate exoskeleton prototypes according to the activities to reduce risks and improve the productivity of industrial companies.

2. To identify the most appropriate exoskeleton prototypes according to the activities to reduce risks and improve the productivity of industrial companies.

3. To compare the effectiveness and functionality of the exoskeleton prototype in performing activities under normal conditions in industrial companies to reduce accidents within industrial companies.

In Table (1) different prototypes are analysed, comparing the effectiveness and functionality to perform activities in normal conditions in industrial companies to reduce accidents within industrial companies.

Methodology

From the point of view of its application it is qualitative research, since by means of the collection and analysis of relevant data a thorough inspection of the 57 articles found in the searches was carried out, being discarded in these stages 10 articles, sufficiently verifiable base that demonstrates the advantage of using prototypes of exoskeleton more appropriate in function to the activities in the industrial companies to reduce risks.

Box 6

Figure 6

Collection and Analysis Methodology

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Journal- Industrial Organization June 2024 Vol.8 No.14 1-8
Article

Box 7

Table 2

Summary of the analysis of the use of exoskeletons as a function of the activities in industrial companies

N°	AUTOR(ES)	TITLE,Year of publication,COUNTRY	Ventajas	Disadvantages
1	Doris Amanda Puebla Farias	BENEFITS AND LIMITATIONS OF THE USE OF OCCUPATIONAL EXOSKELET FOR THE PREVENTION OF MUSCULO-SKELETAL DISORDERS: A SYSTEMATIC EXPLORATORY REVIEW,2020,Ecuad	• Reduction of physical demands during specific tasks - Reduction of muscle fatigue - Increase in work performance - Reduction of physical loads on the lumbar spine - Reduction of pain in the lumbar region - Reduction of the risk of disc injuries - Significant reduction in the physical load on the lower limbs - Prevention of musculoskeletal disorders.	• Possible adverse effects such as hyperextension of the knees - Increased metabolic costs during certain activities - Increased activity of antagonist musculature - Need for further research to assess short and long term consequences in real work settings - Limitations in current studies that may not fully reflect effects over full working days - Increased antagonist muscle activity associated with increased metabolic costs.
2	Laura Gema Fernández Álvarez , Susana Núñez Nagy and Roberto Cano de la Cuerda	Portable exoskeletons in people with spinal cord injury. Systematic review,2020,Spain	The advantages of wearable exoskeletons for people with spinal cord injury include their ability to facilitate standing and walking, as well as their use in rehabilitation. In addition, most of these devices have been found to focus on the hip and knee joints, making them useful for improving mobility in these areas.	On the other hand, some limitations of portable exoskeletons are the need for a complementary support product, which may imply an additional cost for users. Furthermore, although 20 portable exoskeletons have been identified in the study, it is important to consider that each device has its own specific features and benefits, so choosing the most suitable one for each person with spinal cord injury may require an individualised assessment.
3	Héctor Mardomingo Medialdea, Pilar Fernández González, Francisco Molina Rueda	Usability and acceptability of wearable exoskeletons for gait training in spinal cord injured subjects: systematic review,2018,Spain.	The advantages of using wearable exoskeletons for gait training in spinal cord injured subjects include: - They allow users to walk without the need to be continuously connected to a power source; - They generate acceptance and satisfaction among spinal cord injured patients; - No major adverse effects were described in the studies reviewed; - Participants reported an improved perception of their quality of life; - Improvements in gait parameters such as speed and endurance were observed.	The disadvantages or limitations identified in the studies included in the systematic review are: - The studies have methodological limitations, such as lack of control groups and blinding of the evaluators; - There are few studies available in the literature, which makes the data obtained less robust. - Adverse effects reported were mild, such as skin discomfort and pressure sensation in the contact areas of the wearable exoskeletons - Further research with long-term follow-up is needed to assess possible long-term adverse effects and the safety of continued use of the exoskeletons - Usability in non-laboratory environments still requires improvement.
4	Yeyson Alejandro Becerra Mora	A review of robotic platforms for the construction sector,2020,Colombia	The advantages of using robots in the construction and mining industry include: - Improved efficiency and productivity: Robots can perform repetitive tasks faster and more accurately than human workers, which can increase efficiency and productivity at construction and mining sites - Improved safety: By using robots for hazardous tasks or in hostile environments, the risk of injury or workplace accidents for workers is reduced. - Accuracy and quality: Robots can perform tasks with millimetre accuracy, which can result in higher quality in the execution of construction and mining projects - Long-term cost reduction: Despite the initial investment in robotic technology, in the long term it can result in significant savings due to improved efficiency and productivity - Ability to work in harsh environments: Robots can operate in extreme conditions or hazardous environments where humans might have difficulty working - Ability to work in harsh environments: Robots can operate in extreme conditions or hazardous environments where humans might have difficulty working.	On the other hand, some potential disadvantages of using robots in the construction and mining industry could include: - High initial cost: Robot technology can be expensive to acquire and implement, which may be a barrier for some companies - Need for specialised training: Trained personnel are required to operate and maintain robots, which may involve additional costs and training time - Potential loss of jobs: The automation of certain tasks may result in a reduction in jobs for human workers, which may have social and economic implications - Limitations in versatility: Although robots are efficient at specific tasks, they may be more costly to operate and maintain. - Potential job losses: The automation of certain tasks may result in the reduction of jobs for human workers, which may have social and economic implications - Limitations in versatility: Although robots are efficient at specific tasks, they may have limitations in terms of adaptability to changes in the environment or in the tasks to be performed.
5	Mauricio Plaza Torres , Fredy Bernal Castillo	System for the measurement and prediction of movement intention,2019,Cuba	The advantages identified in the paper on the use of bioelectrical signals to predict the movement intention of people are the following: - They allow predicting the user's movement intention before the movement is initiated, which considerably reduces the delay in starting and stopping the movement; - They facilitate the identification of movement-related patterns through signal processing and the use of artificial intelligence; - They enable the implementation of control systems for exoskeletons and orthoses to assist people with disabilities or muscle weakness; - The use of multi-layer artificial neural networks for the identification of patterns in the electro-skeleton and orthoses to assist people with disabilities or muscle weakness. - They enable the implementation of control systems for exoskeletons and orthoses to assist people with disabilities or muscle weakness - The use of multi-layer artificial neural networks for pattern identification in electrophysiological signals has proven to be effective and fast once the corresponding training has been performed.	On the other hand, the main disadvantage identified in the paper is the need for manual or reaction control of currently used devices and exoskeletons. This limitation means that the devices do not assist the initiation of movement, which makes them less practical to operate.
6	Leonardo Broche Vázquez, Mauricio Torres Quezada, Daily Milanés Hermosilla	Robotic exoskeleton for the rehabilitation of the upper limb of the hemiplegic patient,2020,Cuba	The advantages of the exoskeleton for the rehabilitation of the upper limb in hemiplegic patients are the following: - It allows controlled and precise movements thanks to the built-in actuators and sensors; - It offers the possibility of capturing the patient's electrical muscle activity or the intentionality of the movement through electromyographic signals or electroencephalography. - Can be used in a wide range of applications, from patient rehabilitation to the replacement of vital functions - Provides a customisable and adjustable design for each patient, considering their anthropometric and kinetic characteristics - Allows specific therapeutic movements with a controlled rotational speed.	The disadvantages of the exoskeleton for upper limb rehabilitation in hemiplegic patients are as follows: - It requires a complex mechanical and structural design which can be costly; - The implementation of actuators and sensors can increase the complexity of the system and its maintenance; - Although it is mentioned that the resistance applied to the patient's movement is controlled, there is a risk of injury if not applied correctly; - The need for an electronic control system and specialised software may require additional learning by physiotherapists. - Although it is mentioned that the resistance applied to the patient's movement is controlled, there is a risk of injury if not applied correctly - The need for an electronic control system and specialised software may require additional learning by physiotherapists - There may be limitations in the patient's mobility and freedom of movement during exoskeleton therapy - There may be limitations in the patient's mobility and freedom of movement during exoskeleton therapy.
7	Woge Oscar Gonzalez Ortiz Gabriela Gavino,	STRESS ANALYSIS AND DEVELOPMENT OF A MATLAB GUIDE APPLIED TO AN EXOSKELET STRUCTURE THROUGH THE VON MISES CRITERION,2022,Mexico	Advantages of exoskeletons according to the paper: - Exoskeletons can benefit people with spinal injuries and other mobility problems by providing lightweight, rigid and safe equipment - The use of carbon fibre as a material to build the structural components of exoskeletons provides the necessary rigidity and lightness to withstand the demands required in orthopaedic equipment - Finite Element simulation allows to evaluate possible flaws in the design of exoskeletons and to make adjustments to improve their structural performance - The application developed with MATLAB simplifies the process of simulation and analysis of the exoskeletons. - The Finite Element simulation allows to evaluate possible flaws in the design of the exoskeletons and make adjustments to improve their structural performance - The application developed with MATLAB simplifies the process of simulation and analysis of the exoskeletons, allowing to identify critical areas that require reinforcement.	Disadvantages of exoskeletons according to the document: - No specific disadvantages of exoskeletons are mentioned in the document provided - Evaluation of exoskeletons through simulations may depend on the accuracy of input data and component modelling - Implementation of exoskeletons may require a detailed design and analysis process to ensure their effectiveness and safety - No specific limitations in terms of disadvantages related to exoskeletons are mentioned in the document read - No specific limitations in terms of disadvantages related to exoskeletons are mentioned in the document read - No specific limitations in terms of disadvantages related to exoskeletons are mentioned in the document read.
8	López Méndez Santiago; Martínez Tejada Hader Vladimir; Valencia García Marco Fidel.	Development of an armored upper limb exoskeleton,2020,Colombia	Advantages: - Exoskeletons can enhance the physical capabilities of users and help them bear loads they could not handle on their own - Exoskeletons can restore proper limb function, assist basic movements and simplify effort-intensive tasks. - Exoskeletons can provide ballistic protection for personal safety purposes, through the use of advanced materials such as aluminium and carbon nanotubes - Exoskeletons can be controlled by electronic systems that can adjust the force and position of the system, and integrate different adaptive control strategies and impedance.	Disadvantages: - Exoskeletons can be heavy, complex and expensive, limiting their portability and accessibility - Exoskeletons may have a limited or different range of motion (ROM) than human limbs, which may cause discomfort or interference between parts. - Exoskeletons may require a large amount of electrical power to operate, involving the use of batteries or external power supplies - Exoskeletons may present safety risks or harm to the user or the environment, if an adequate control system is not in place or if a system failure occurs.
9	Joga Dharma Setiawan; Ariyanto Mochammad; Nugroho Sri; Ismail Rifky; Purbayanto, Tedi	Fuzzy Logic Control for a Soft Exoskeleton Glove Using a Motor-Tendon Actuator,2021,Colombia	Advantages: - Assistance to people with disabilities: Exoskeletons can provide assistance to people with hand disabilities, allowing them to perform everyday activities with greater ease and autonomy - Flexibility and comfort: Exoskeletons made of soft materials, such as the one developed in the study, offer greater flexibility and comfort compared to rigid exoskeletons. This makes them more comfortable to wear for extended periods - Cost-effectiveness: The use of low-cost materials, such as RTV silicone rubber, can make exoskeletons more accessible to a wider range of people, especially in resource-limited environments - Precise control: The implementation of fuzzy logic control allows for more precise control of exoskeleton movements, which can improve their functionality and utility for the user - Potential for rehabilitation: Exoskeletons can not only assist in daily activities, but also have the potential to be used in rehabilitation programmes to improve hand strength and function.	Disadvantages: - Design and manufacturing complexity: The design and manufacture of exoskeletons, especially those incorporating advanced control systems such as fuzzy logic, can be complex and require specialised expertise - Performance limitations: While exoskeletons can provide assistance, they may have limitations in terms of the amount of force they can apply and the movements they can perform, which can affect their usefulness in certain scenarios - Power requirements: Powered exoskeletons often require a power source, such as batteries, which can limit their autonomy and require frequent recharging. - Individualised adaptation: For best results, exoskeletons generally need to be adapted to the individual needs and characteristics of each user, which may require additional time and resources - Potential ergonomic issues: Although exoskeletons are designed to provide assistance, they may cause fatigue or discomfort if they are not properly fitted or if they do not adequately adapt to the user's anatomy.
10	Jorge Daniel Rodríguez Jayakumar Ashwin; García Javier Bermejo; Sánchez Francisco Romero; Sánchez Francisco Javier Alonso.	DESIGN OF AN INVERSE DYNAMICS MODEL OF A LOWER-LIMB ASSISTANCE EXOSUIT,2021,España	Advantages: - High wearability: Exoskeletons based on cable-driven actuators with anchor points on the segments to be actuated stand out for their high wearability. This means that they are more comfortable to wear and have less impact on the user's mobility compared to traditional exoskeletons - Low weight and reduced cost: These exoskeletons are lighter and less expensive compared to other assistive walking technologies, making them more accessible to a larger number of people who could benefit from them. - Increased user comfort: By using cables to transmit force from the actuators to the anchor points, these exoskeletons offer increased user comfort by dispensing with the rigid structures present in traditional exoskeletons - Design optimisation: The inverse dynamics model proposed in the paper allows for optimisation of various aspects of exoskeleton design, such as the location of anchor points, the exact number of actuators and the arrangement of cables. This helps to design exoskeletons that are better suited to the needs and characteristics of the users.	Disadvantages: - Limitations in performance: Although exoskeletons can provide assistance during walking, they may have limitations in terms of the amount of force they can provide and the movements they can facilitate. This may limit their usefulness in certain scenarios and for certain users. - Design and manufacturing complexity: The design and manufacture of cable-driven actuator-based exoskeletons can be complex and require specialised expertise. This can increase costs and development times for these devices. - Need for individualised adaptation: For best results, exoskeletons generally need to be adapted to the individual needs and characteristics of each user. This may require additional time and resources for customised assessments and adjustments.
11	DHL Supply Chain Iberia	DHL incorporates exoskeletons at the Mercedes-Benz factory in Vitoria,2020,Spain	Benefits: - Injury prevention: Exoskeletons help reduce pressure on bones, muscles and joints, which can reduce the risk of injuries related to repetitive physical activities or heavy lifting - Physical strain relief: Workers can experience a significant reduction in physical workload due to the support provided by exoskeletons, which can improve their comfort and well-being during work tasks. - Improved productivity: By reducing fatigue and the risk of injury, exoskeletons can help maintain workers' health and performance over time, potentially contributing to increased productivity in the workplace. Innovation and safety: The adoption of exoskeletons reflects an innovative approach to addressing ergonomic challenges in industrial settings, demonstrating companies' commitment to the health and safety of their employees through the implementation of advanced technologies.	Disadvantages: - Cost: Procurement and implementation of exoskeletons can be costly, which can be a challenge for some companies, especially those with limited budgets. - Training and adaptation: Additional training may be required for workers to adjust to and use exoskeletons correctly. In addition, it may take time to adapt to new technology and optimise its use in the work environment. - Limitations of use: Exoskeletons may not be suitable for all tasks or work environments, and may have limitations in terms of mobility or freedom of movement, which could affect the effectiveness of their use in certain situations. - Ongoing evaluation: As exoskeletons are implemented, it is important to conduct ongoing evaluation of their effectiveness and their impact on worker productivity and health to ensure that the desired results are being achieved.
12	Mauro Callejas Cuervo;Manuel A. Vélez Guerrero;Wilson Javier Pérez Holguín	BIOPARAMETER MEASUREMENT SYSTEM ARCHITECTURE INTEGRATING INERTIAL-MAGNETIC AND ELECTROMYOGRAPHIC SIGNALS,2018,Colombia	- Injury prevention: Exoskeletons help to reduce pressure on bones, muscles and joints, which makes them especially useful in preventing potential injuries, such as those caused by muscular overexertion or repetitive movements. - Relief of physical strain: They allow manual load handling tasks involving significant and repeated physical strain to be performed with less effort on the part of workers. In the automotive industry, it has been shown that they can provide individual relief of up to 20% in operators handling heavy tools. - Improved ergonomics: They contribute to improve ergonomics in more physically demanding workplaces, which can increase the comfort and health of workers. - Applicability in various industries: Exoskeletons can be applied in different industrial sectors where there are physically demanding tasks, such as manufacturing, construction, logistics, among others.	- Cost: Procurement of exoskeletons can be costly, which may limit their implementation in some companies, especially those with limited financial resources. - Need for fitting and adjustment: Exoskeletons require fitting and adjustment testing to ensure their effectiveness and comfort for workers, which can take additional time and resources - Technical complexity: The design and implementation of exoskeletons can be technically complex and require expertise in areas such as biomechanics and engineering, which can make their development and maintenance difficult - Interference with mobility: In some cases, exoskeletons can interfere with the natural mobility of workers, which could negatively affect their job performance and safety.
45	КУЛАГИНА А.Н., ПОНОМАРЕВ А.С.	EXOSKELETON,2018,RUSIA	- Improved quality of life: The article suggests that the use of exoskeletons can improve the quality of life of people with disabilities by enabling them to perform daily activities more independently and comfortably - Applications in military and social areas: It highlights the versatility of exoskeletons, which have proven to be useful in both military applications and everyday life - Rehabilitation potential: It mentions that exoskeletons can help in the rehabilitation process by enabling people with disabilities to regain lost motor functions.	- Cost: Not specifically mentioned in the summary, but one of the common drawbacks of exoskeletons is their high cost, which may limit their accessibility for some people or institutions - Technical limitations: Depending on the design and technology used, exoskeletons may have limitations in terms of mobility, comfort or ability to adapt to different users and scenarios - Potential adaptation problems: Some people may experience difficulties in adapting to the use of exoskeletons, either physically or psychologically - Potential adaptation problems: Some people may experience difficulties in adapting to the use of exoskeletons, either physically or psychologically - Potential adaptation problems: Some people may experience difficulties in adapting to the use of exoskeletons, either physically or psychologically.
46	БОРИСОВ А.В., ВОЛКОВА Ю.Е., КОНЧИНА Л.В., МАСЛОВА К.С.	PASSIVE-ACTIVE EXOSKELETON WITH LINKS OF VARIABLE LENGTH AND SPRING ELEMENTS OF TWO TYPES,2020,RUSIA	Advantages: - Reduced load on the joints: The proposed exoskeleton aims to reduce the load on the joints by providing support and absorbing some of the user's weight - Improved strength and endurance: By incorporating spring elements, the exoskeleton can help increase the user's strength and endurance by providing assistance during movement. - Energy recovery: The design includes springs that allow energy recovery during movement, which could increase user efficiency and extend the time of use of the exoskeleton - Adaptability and comfort: The ability to adjust the length of the links and the presence of springs could increase the adaptability of the exoskeleton to different users and activities, thus improving comfort and user experience.	Disadvantages: - Complexity and manufacturing costs: Implementing an exoskeleton with passive-active features and spring elements can be technically challenging and costly, which could limit its availability and accessibility - Potential need for customised adjustments: Due to the variable nature of the links and spring configuration, customised adjustments may be necessary to adapt the exoskeleton to the specific needs and characteristics of each user. - Maintenance requirements: Mechanical components, such as springs, may require periodic maintenance to ensure optimal functioning, which could result in additional costs and downtime for the user.

Continuation of table 2…

Gaviño-Ortiz, Gabriela and Osorio-Reyna, Jhonny Jesus. Analysis and comparison of exoskeleton prototypes to carry out activities under normal conditions in industrial companies to reduce risks. Journal-Industrial Organization. 2024. 8-14: 1-8.
https://doi.org/10.35429/JIO.2024.14.8.1.8

N°	Functionality	Effectiveness according to company conditions and how it impacts on reducing occupational risks.	SOURCE OF INFORMATION	Link
1	According to the article, the proposed exoskeletons have functionalities such as reducing physical demands in work tasks such as lifting, carrying and bending. .	The effectiveness of exoskeletons in reducing occupational hazards varies depending on the conditions of the company and the exoskeleton model used. Benefits such as reduced muscle fatigue and physical demands have been observed in work environments, but more research is needed to assess the short- and long-term impacts in real work environments.	UISEK	https://repositorio.uisek.edu.ec/bitstream/123456789/3978/2/ARTICULO%20EXOESQUELETOS%20INDUSTRIALES%20AMANDA%20PUEBLA.pdf
2	According to the article, the proposed wearable exoskeletons are mainly used for rehabilitation purposes in people with spinal cord injury, focusing on the hip and knee joints.	Regarding effectiveness in reducing occupational risks, the article does not specifically address this issue.	RIECS	https://dialnet.unirioja.es/servlet/articulo?codigo=7468522
3	According to the article, the proposed wearable exoskeletons for gait training in people with spinal cord injury have proven to be tolerable and acceptable, with mild and infrequent adverse effects, such as skin discomfort or pressure on the contact areas.	In terms of effectiveness in reducing occupational risks, it is mentioned that these devices generate hardly any significant adverse effects and have been well received by patients, which could have a positive impact on rehabilitation and improved functionality of the lower limb in spinal cord injured subjects.	SNC PHARMA	https://sncpharma.com/wp-content/uploads/2018/03/Usabilidad-y-aceptabilidad-de-los-exoesqueletos-portables-para-el-entrenamiento-de-la-marcha-en-
4	the exoskeletons proposed in the article offer specific functionalities designed to improve working conditions in the construction sector. Here is a summary of each: - HAL (Hybrid Assistive Limb) from Cyberdyne: Ø Functionality: Helps increase the user's strength and reduces the stress applied to the back from heavy lifting Ø Effectiveness: This exoskeleton can significantly reduce muscle fatigue and the risk of injury associated with handling heavy loads in construction. Its effectiveness will depend on proper fitting and training in its use by workers - Lockheed Martin's Fortis: Ø Functionality: Relieves user loading and reduces muscle fatigue through biomechanics, increasing user strength and endurance Ø Effectiveness: Like HAL, Fortis can reduce fatigue and the risk of musculoskeletal injuries in workers performing physically demanding tasks in construction. Its effectiveness will also depend on proper implementation and training.	Both exoskeletons have the potential to positively impact on occupational risk reduction by reducing the physical burden on workers, which may result in a lower incidence of musculoskeletal injuries and chronic fatigue. In addition, by improving the ergonomics and physical capacity of workers, these exoskeletons can contribute to a safer and more productive work environment in the construction industry. However, their effectiveness may vary depending on factors such as the specific application, the design of the exoskeleton, staff training and proper integration into the company's work processes.	SCIELO	http://www.scielo.org.co/scielo.php?script=sci_arttext&pid=S0123-921X2020000100115
5	The main functionality of the proposed exoskeletons is to help solve ergonomic problems in tasks such as repetitive work and rehabilitation. These devices are designed to maintain or improve the user's quality of life by enabling new movements or reducing fatigue at the end of a working day.	In terms of effectiveness, the study shows that the design and implementation of the system to obtain, process and identify electrophysiological signals has been able to predict the movement intention of the lower limbs with success rates of over 86.66%. This suggests that the proposed exoskeletons could be highly effective in assisting workers to perform specific movements, which can have a significant impact on reducing occupational risks associated with fatigue and repetitive strain.	SCIELO	http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S0864-03002019000200277&lang=pt
6	Functionality of the proposed robotic exoskeleton: Ø The developed robotic exoskeleton is designed for the rehabilitation of the upper limb in hemiplegic patients, providing a support system and controlled movement to facilitate the recovery of mobility and muscle strength in affected patients. Here are some features of its functionality: Ø Selection of actuators and rotation mechanisms: The exoskeleton incorporates force actuators and mechanisms for arm rotation and forearm pronation and supination, designed to provide controlled and precise movements that mimic the physiological movements of the upper limb. Ø Mechanical armature and ergonomic design: The structure of the exoskeleton is designed to adapt to the dimensions and anthropometric characteristics of the patients, ensuring balanced weight distribution and ergonomics suitable for use during rehabilitation sessions. Ø Control and safety system: The exoskeleton is equipped with simple and safe control systems, allowing interaction and supervision by the physiotherapist. In addition, it has integrated safety measures, such as travel limiters and emergency buttons, to ensure patient safety during rehabilitation sessions.	Ø Improvement of mobility and muscle strength: The exoskeleton provides controlled and precise movements that help hemiplegic patients to regain mobility and muscle strength in the affected upper limb, which contributes to improve the patient's functionality and autonomy in daily life activities. This contributes to improving the patient's functionality and autonomy in activities of daily living. Ø Facilitation of physiotherapeutic therapy: The exoskeleton facilitates the application of physiotherapeutic therapies by providing controlled movements and adjustable resistance during rehabilitation sessions. This helps to optimise the physiotherapist's time and resources, as well as ensuring accurate and safe delivery of therapies. Ø Progression monitoring and evaluation: The exoskeleton is designed to enable monitoring and evaluation of patient progression during rehabilitation sessions. This provides valuable information on the effectiveness of the therapy and allows the treatment to be adjusted according to the individual needs of each patient.	REDALYC	https://www.redalyc.org/journal/2251/225165187003/
7	Based on the information provided in the article, the proposed exoskeletons appear to have several potential functionalities and benefits: Physical support and assistance: exoskeletons can provide additional support to users, especially those with spinal injuries or other mobility problems. This can help them perform physical tasks that might otherwise be difficult or painful. Improved safety: By improving ergonomics and providing additional support during the performance of physical tasks, exoskeletons could help reduce the risk of musculoskeletal injuries and other occupational hazards associated with repetitive movements or heavy lifting.	In terms of the effectiveness of the proposed exoskeletons in company conditions and their impact on reducing occupational hazards, here are some points to consider: Ergonomic assessment: It would be important to conduct a detailed ergonomic assessment of the specific work tasks and activities in the company to determine how exoskeletons could be effectively integrated to improve safety and reduce the risk of injury. Assessment of costs and benefits: In addition, the costs associated with the implementation of exoskeletons in terms of procurement, maintenance and training should be considered, as well as the expected benefits in terms of reduced occupational injuries and increased productivity.	EBSCOHOST	https://eds.p.ebscohost.com/eds/detail/detail?vid=0&sid=88e6d35e-a057-409c-8c40-35314d49f066%40redis&bdata=Jmxhbmc9ZXMmc2l0ZT1lZHMtbGl2ZQ%3d%3d#db=edsgao&AN=edsgcl.699258373
8	Functionality of the proposed exoskeletons: Ø Physical support: Exoskeletons are designed to provide additional support to workers during the performance of tasks involving repetitive movements or heavy lifting. This helps to reduce muscle fatigue and the risk of work-related injuries. Ø Personal protection: In addition to providing physical support, exoskeletons are equipped with armour that protects the user from possible impact or injury while performing work tasks. This helps to ensure the safety and well-being of the worker in the workplace.	Ø Reduced musculoskeletal injuries: By providing physical support and protection, exoskeletons help reduce the workload on the body's muscles and joints, which can reduce the risk of musculoskeletal injuries such as strains, sprains and sprains. Ø Improved safety: The combination of physical support and personal protection offered by exoskeletons helps to increase workplace safety by reducing the likelihood of accidents and injuries. This contributes to a safer and more secure working environment for workers. Ø Increased productivity: By reducing fatigue and the risk of injury, exoskeletons can contribute to improved productivity in the workplace by enabling workers to perform their tasks more efficiently and safely. This can result in decreased downtime due to injury and increased efficiency in performing work tasks.	PROQUEST	https://www.proquest.com/docview/2338410285/FD36C650A21F4020PQ/1?accountid=37408
9	The exoskeletons proposed in the article have as their main functionality to provide mechanical assistance to the hands, specifically for people with hand disabilities or hand impairment. These exoskeletons are designed to assist in the flexion and extension movement of the fingers, which facilitates the performance of daily activities that require the use of the hands.	In terms of effectiveness, these exoskeletons could have a significant impact on reducing occupational risks in environments where repetitive and strenuous use of the hands is required, such as in manufacturing, construction or agriculture. By providing mechanical support to the hands, these exoskeletons can help prevent musculoskeletal injuries such as muscle fatigue, carpal tunnel syndrome and other work-related conditions. In a company, the implementation of these exoskeletons could improve worker health and safety, reduce absenteeism due to injury, and improve productivity by allowing workers to perform tasks more efficiently and comfortably. In addition, by reducing the risk of workplace injury, the company could also experience significant cost savings associated with medical treatment and workers' compensation. In summary, the proposed exoskeletons can not only improve workers' quality of life, but also have a positive impact on the company's profitability and sustainability.	PROQUEST	https://www.proquest.com/docview/2593129795/FD36C650A21F4020PQ/2?accountid=37408
10	The main functionality of the exoskeletons proposed in the article is gait assistance, especially designed for people with disabilities or mobility difficulties. These exoskeletons use an inverse dynamic model to calculate the traction forces on the cables and the torque demanded from the actuators, thus providing support and improving mobility during walking.	In terms of their effectiveness in business conditions and their impact on reducing occupational risks, we can consider the following: Ø Effectiveness in business conditions: Wearable exoskeletons can be effective in work environments where workers perform tasks that require repetitive movements or heavy lifting. By providing gait assistance and reducing the load on joints, these devices can improve worker comfort and health, which can lead to increased productivity and job satisfaction. Ø Impact on reducing occupational risks: Exoskeletons can help reduce occupational risks associated with musculoskeletal injuries and physical activity-related fatigue. By providing support and assistance during walking, these devices can help prevent joint and muscle injuries, especially in workers performing physically demanding tasks. This can result in a decrease in workplace accidents, sick leave and costs associated with medical care and workers' compensation.	PROQUEST	https://www.proquest.com/docvie/2605660386/FD3C650A21F4020PQ/3?accountid=374
11	The main functionality of the proposed exoskeletons is to improve ergonomics in the most physically demanding workplaces at the Mercedes-Benz factory in Vitoria. These devices are designed to provide support during manual load handling tasks, such as sequence preparation or activities in the empty container folding area, which involve significant and repeated physical effort for workers. Exoskeletons reduce stress on bones, muscles and joints, which helps prevent potential musculoskeletal injuries and repetitive motion fatigue.	In terms of effectiveness, exoskeletons are expected to be highly effective in company conditions, especially in reducing occupational risks associated with overexertion and musculoskeletal injuries. Tests in the automotive industry have shown individual relief levels of up to 20% in operators handling heavy tools. By providing support and reducing the physical strain required by workers during physically demanding tasks, exoskeletons are expected to contribute to improving working conditions and reducing the number of accidents and medical leaves related to musculoskeletal injuries and repetitive motion fatigue.	DIALNET	https://dialnet.urioja.es/servlet/ticulo?codigo=751454
12	Based on the article, the main functionality of the proposed exoskeletons is to assist in the rehabilitation of people with physical limitations, especially those affected by cerebrovascular accidents (CVA) or injuries that affect mobility. These exoskeletons are designed to provide support and assistance in body movements, especially in the upper and lower extremities, with the aim of improving motor function and facilitating patients' recovery.	In terms of effectiveness, as described in the article, exoskeletons have proven to be a useful tool in the rehabilitation process. By integrating motion capture technologies, such as motion processing units (MPUs) and electromyography (EMG), along with digital processing algorithms, these devices can provide accurate information on patient performance during rehabilitation. This allows healthcare professionals to monitor patient progress, adjust treatments as needed and provide real-time feedback. From a business perspective, the implementation of exoskeletons in work environments can have a significant impact on reducing occupational risks. By providing physical support and reducing the burden on the human body during physically demanding tasks, exoskeletons can help prevent work-related injuries such as musculoskeletal injuries and chronic fatigue. In addition, by improving workers' ability to perform physical tasks, exoskeletons can increase productivity and efficiency in the workplace.	REDALYC	https://www.redalyc.org/journal/678/607866319010
45	The functionality of exoskeletons includes: Ø Rehabilitation support: Exoskeletons provide physical support for people with disabilities, helping them to perform movements and tasks that would otherwise be difficult or impossible to perform. Ø Improved mobility: They enable people to regain or improve their ability to walk, stand, sit and perform other daily activities. Ø Stabilisation and postural correction: Exoskeletons can correct posture and provide joint stability, which is especially useful for people with balance problems or muscle weakness. Ø Reduction of physical load: In work environments, exoskeletons can help reduce the physical load on workers by providing support for heavy lifting or repetitive tasks.	In terms of the effectiveness of exoskeletons in business conditions and their impact on reducing occupational risks, the following points can be highlighted: Ø Increased safety: By reducing the physical burden on workers, exoskeletons can help prevent musculoskeletal injuries and fatigue, contributing to a safer work environment. Ø Improved productivity: By facilitating physically demanding tasks, exoskeletons can increase worker efficiency and productivity by reducing downtime due to injury or fatigue. Ø Reduced costs: By preventing workplace injuries and reducing the need for sick leave, exoskeletons can help companies save on medical costs and workers' compensation. Ø Adaptability and customisation: Exoskeletons can be designed to adapt to different work environments and specific worker needs, making them effective in a variety of industries and working conditions.	SCIENCE INDEX	https://www.eliary.ru/item.asp?=35121986
46	Functionality of the proposed exoskeletons: Ø Variable length links: These allow better adaptation to the user's anatomy and movements, providing a more precise fit and greater capacity for movement. Ø Two types of spring elements: Tension-compression and torsion springs help maintain link length and recover energy during movement, reducing muscle fatigue and load on the joints. Ø Energy recovery: The ability of the springs to recover energy during the user's movement increases the efficiency of the exoskeleton and reduces fatigue, allowing prolonged use and improving the user's endurance.	Effectiveness under company conditions and reduction of occupational risks: Ø Improves work ergonomics: By providing additional support and improving the user's biomechanics, the exoskeleton helps reduce the load on the joints during work tasks that require repetitive movements or lifting. Ø Increases safety and prevents injuries: By reducing the load on joints, the exoskeleton can help prevent work-related musculoskeletal injuries, such as back, shoulder or knee injuries. Ø Improves productivity and efficiency: By reducing muscle fatigue and increasing user endurance, the exoskeleton can help improve productivity by allowing workers to perform physical tasks more efficiently and for longer periods of time. Ø Facilitates rehabilitation: In environments where rehabilitation or recovery from work-related injuries is required, the use of the exoskeleton can aid in the recovery process by providing support and relief from the load on affected joints.	SCIENCE INDEX	https://www.eliary.ru/item.asp?=43912827

Tr s a comprehensive examination of the information gathered and studies reviewed in this paper, table (2) presents a summary of the articles on occupational exoskeletons, which present a wide range of benefits as well as limitations that need to be considered. These devices are noted for their ability to reduce physical demands in work tasks such as lifting, carrying and bending, resulting in reduced occupational hazards, muscle fatigue and physical demands in work environments. In addition, exoskeletons are a valuable support tool for people with spinal cord injuries, facilitating standing, walking and actively participating in rehabilitation processes. However, it is important to note that their implementation entails additional considerations, such as additional cost for users and the need for individualised assessment to determine the most appropriate option. Personalised fitting and adjustment are essential to ensure the effectiveness and comfort of these devices, which can require considerable time and resources.

Gaviño-Ortiz, Gabriela and Osorio-Reyna, Jhonny Jesus. Analysis and comparison of exoskeleton prototypes to carry out activities under normal conditions in industrial companies to reduce risks. Journal-Industrial Organization. 2024. 8-14: 1-8.
https://doi.org/10.35429/JIO.2024.14.8.1.8

On the other hand, the technical complexity involved in the design and maintenance of exoskeletons can pose challenges, especially in terms of interference with workers' natural mobility and the need for expertise in areas such as biomechanics and engineering. Despite these considerations, exoskeletons show great potential in a variety of areas, from patient rehabilitation to improving ergonomics and occupational safety in industrial settings. Their ability to provide physical support, reduce body burden and prevent work-related injuries offers significant benefits for both workers and companies, which can translate into significant improvements in quality of life, productivity and long-term profitability. In summary, exoskeletons represent a promising innovation with the potential to positively transform both the workplace and the health and rehabilitation field.

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Journal- Industrial Organization June 2024 Vol.8 No.14 9-16
Article

Logic control design for calcium chloride dosing hopper for TCO Group

Diseño de control lógico para tolva dosificadora de cloruro de calcio para TCO Group

Tun-Ordoñez, Jorge Sprewell [a], Manrique-Ek, Josué Abraham *[b], Cardozo-Aguilar, Guadalupe [c], Gómez-Ku, Ricardo [d]

[a] ROR Instituto Tecnológico Superior de Calkiní • KDN-6279-2024 • 0009-0008-5551-5147 • 2014659
[b] ROR Instituto Tecnológico Superior de Calkiní • 1-5873- 2018 • 0000-0002-1369-3526 • 94919
[c] ROR Instituto Tecnológico Superior de Calkiní • 1-5874- 2018 • 0000-0001-8033-2280 • 435868
[d] ROR Instituto Tecnológico Superior de Calkiní • KOC-1907-2024 • 0009-0004-1540-1007 • 24791

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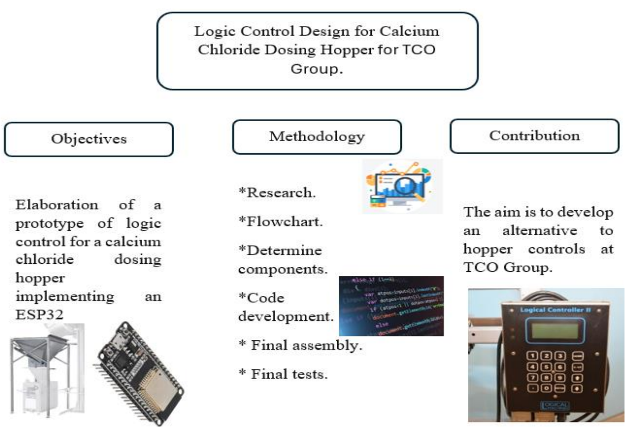
* ✉ [jmanrique@itescam.edu.mx]

Abstract

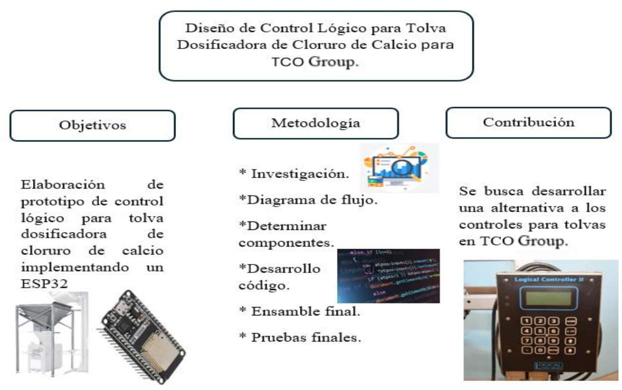
This paper highlights the implementation of the project "Logic Control for Calcium Chloride Dosing Hopper" in order to demonstrate the process to be followed for the development of this project that has been very useful for the company TCO Group, looking for a more economical alternative to the existing logic controls. The diagrams used, connections, programming, among other elements, are explained.



ESP32, Prototype, Dosing hopper

Resumen

En el presente escrito se pone en evidencia la realización del proyecto "Control Lógico para Tolva Dosificadora de Cloruro de Calcio" con la finalidad de demostrar el proceso a seguir para la elaboración de este proyecto que ha sido de gran utilidad para la empresa TCO Group, buscando una alternativa más económica a los controles lógicos ya existentes. Se explican los diagramas utilizados, conexiones, programación, entre otros elementos.



ESP32, Prototipo, Tolva dosificadora

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Journal- Industrial Organization June 2024 Vol.8 No.14 9-16
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Introduction

In the field of industrial automation, the design and implementation of control systems play a key role in improving the efficiency, accuracy and reliability of processes.

In this context, this paper presents a project for the design of a logic control for the operation of a dosing hopper.

Dosing hoppers are essential devices in many industrial processes, as they allow the precise metering and delivery of materials along a production line. However, the effectiveness of these operations is highly dependent on the quality of the control system used.

One of the problems encountered at TCO Group is the high cost of the logic controls used for the hoppers, as the conditions in which the company operates (humidity factor and calcium chloride chemical) make exposing these controls risky for the company.

In conjunction with this, there are no electrical diagrams or operations manual, which can cause problems when carrying out any type of repair or for learning how the control works.

Proposal

The idea accepted by the company is to create their own logic control, which allows them to carry out the basic functions of the controls they currently have, but at a much lower cost (it is estimated at no more than 2,000 pesos per control).

This offers the possibility of not only reducing costs, but also of having a more user-friendly control system for the maintenance personnel, as well as the generation of the electrical diagrams needed for future occasions.

Methodology

As a start, a flow chart was developed to define the process to be followed in this project, showing step by step the development for the adequate design during the prototype elaboration. (Gómez & Molina, 2022)

Box 1

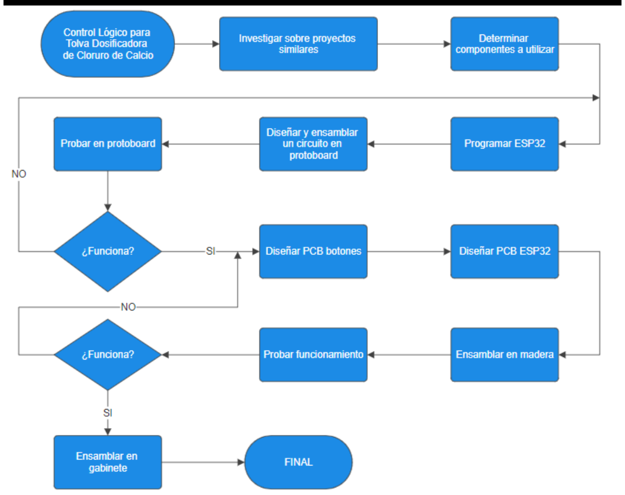

Figure 1
Flow chart

Research design

For the development of the project it is necessary to combine knowledge of analogue electronics and embedded systems, specifically the microcontroller (ESP32) linked to the IDE Arduino software, in order to obtain the dosing functions required by the company, among which is the calibration of the scale and the correct reading of the weight.

The ESP32 is chosen because it has a dual-core processor and a processing speed that allows it to execute the actions we need for the tasks to be executed in acceptable time. It also takes into account the Wi-Fi and Bluetooth capabilities that are already built in, allowing you to add connectivity capabilities to the project in the future. Similarly, it is relatively inexpensive compared to other microcontroller options with similar capabilities, and simple to program, as it is compatible with the Arduino development environment.

Programming

The language used in the code provided is C/C++, which is commonly used in the development of firmware and embedded software for microcontrollers such as the ESP32. A code was created with the purpose of obtaining the functions requested by the company TCO, which consist of the calibration of the load cell, the control of the vibration that is in charge of making the material fall, and the correct reading of the weight. A link is left where you can access the programming files for the Arduino IDE.

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How it works

The process starts by turning on the microcontroller to display a welcome message with the name TCO Group (name of the company), to subsequently display the weight reading provided by the load cell and the HX711 module. However, random values will be displayed because it is necessary to perform a calibration.

To do this we enter with button 3 (calib) and a menu will be displayed where by pressing button 2 (tare) we can scroll between three different weights to calibrate (500g, 1000g and 2000g). Once we get to the desired weight, we press button 1 (mode) which is configured to function as a "select" to select the weight. At this point we must have an object whose weight we are sure of and which is equal to the values we have in the programme for a correct reading and calibration. Knowing this, a message will appear asking us to place the object on the load cell for a few seconds. After this time, a message will appear asking us to remove the object and wait a few more seconds. At the end it will take us to the first screen where the weight must be at 0 to be able to measure any weight that we place on it.

It is at this moment that dimmer number 2 with high vibrations is activated through the relay module, as in the program it is declared that it is activated from -300g to 280g. Once this weight is achieved, dimmer 2 is deactivated and dimmer number 1 with low vibrations switches on from 281g to 450g, which is the weight requested by the company for its product in the 500g presentation.

If we look at the code, we notice that the dimmers seem to be operated in reverse according to this description, because in theory if we want to operate any component it is necessary to declare it as "HIGH" and to turn it off as "LOW", however, in the process we realised that the relay module works with an "inverse logic or is normally closed", so it is necessary to invert the code statements, since when we set HIGH the current that energizes the relays makes the pins separate and therefore does not allow energy to pass, contrary to when we set LOW, since not receiving energy the pins are kept together and the current can pass without any problem.

Having clarified this, we end this description by explaining that when the 450g is reached, both dimmers are deactivated until the material is unloaded from the scale and the process starts again.

Design and testing

Once the code shown in the previous section was finished, the next step was to perform the first tests on our breadboard. To do this, a circuit was made for the 3 buttons that includes the control and the LCD screen, using the online program ***Wokwi.***

Box 2

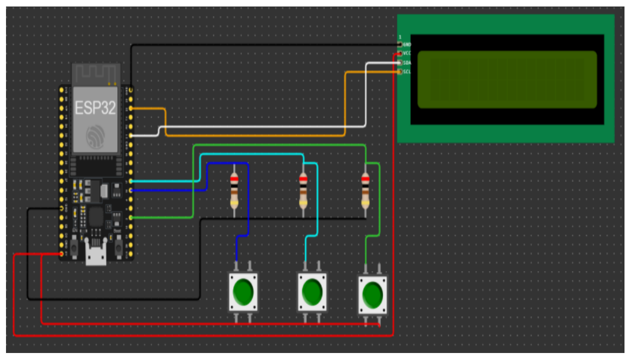

Figure 2
Diagram of buttons and LCD

With this, we transfer the circuit to a breadboard.

We test the correct functioning of the display.

Box 3

Figure 3
LCD test

Then we make the connections for the load cell, which will be in charge of reading the weight values with the help of the HX711 module.

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Journal- Industrial Organization June 2024 Vol.8 No.14 9-16
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Box 4

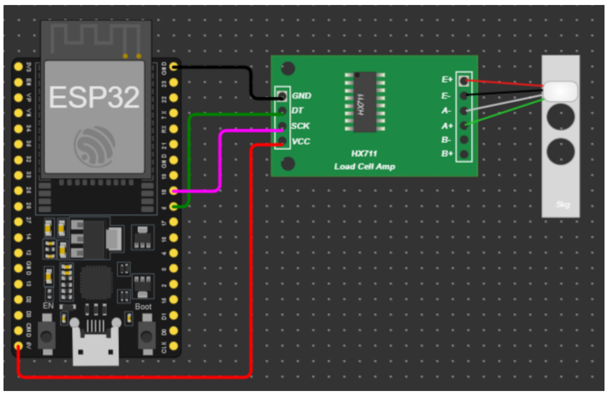

Figure 4
Load cell connection

We confirm that it starts to show the weight on the display.

Box 5

Figure 5
Weight reading test

Next, we check that the readings of the cell are correct, thanks to the calibration and measurement with a 5Kg weight that was within our reach.

At the end of all these tests, we have a diagram that includes the connections of all the electronic components.

Box 6

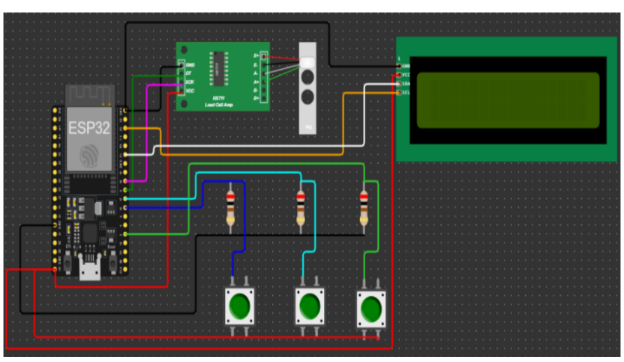

Figure 6
Electronic diagram

We then went on to create a diagram that includes the rest of the components to be used, such as the vibrator, the two analogue dimmers together with the electronic diagram previously created. To do this, a **link** is attached where you can find the different diagrams and diagrams that were drawn up, as well as the code in text format. Now we will test that the change between the dimmers is carried out correctly according to the weight that we declared in the programming, for it, images are attached where we observe the change in the relay module, where we confirm that everything works as it should.

Plates

The design for the buttons board we used the program SolidWorks to draw the tracks that we needed, taking into account that here it is necessary to include a feeding line, a negative line and to consider the resistances that go between the connections of the pins of the ESP32 and the buttons.

Box 7

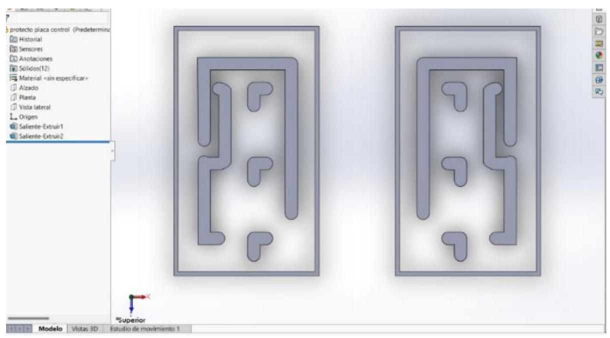

Figure 7
Button board design

Now that we have the design, we can move on to the process of making the circuit on the phenolic board. To do this, we follow the steps listed below:

- Print the design on transfer paper.
- Attach the print to the phenolic board with some adhesive tape.
- Wrap the plate with notebook paper.
- With a clothes iron, heat the area where we have the design for about 7 minutes, making a firm and constant pressure so that the ink adheres to the plate.

- Carefully remove the tape and paper.

- In the areas where the ink did not stick completely, we fix it with a black permanent marker to complete the ink areas.

- Pour ¾ parts of ferric acid to ¼ of water into a plastic container.

- Put the plate with the design already stuck to the acid and shake gently for about 10 minutes.

- Carefully remove the plate from the acid with gloves and clean it properly.

Once these steps were completed, the result of our plate was as shown in figure 14.

Box 8

Figure 8
Button plate

For aesthetic purposes, the copper that remained around the plate was removed with the help of a Dremel and sandpaper.

With the same Dremel we proceed to drill the holes with a 1 mm drill bit where the components will go. Afterwards, we placed and soldered the components.

For the second board, using everything we had available, I made the decision to do it on a breadboard due to lack of resources. The idea is to have a board where the pins can be soldered in a safe and secure way, without damaging the ESP32. That's why we use male and female pinheads to insert the microcontroller.

With all this in mind, the circuit on the board looked like this, with the addition of terminal blocks to connect power cables from the ESP32 later on.

Box 9

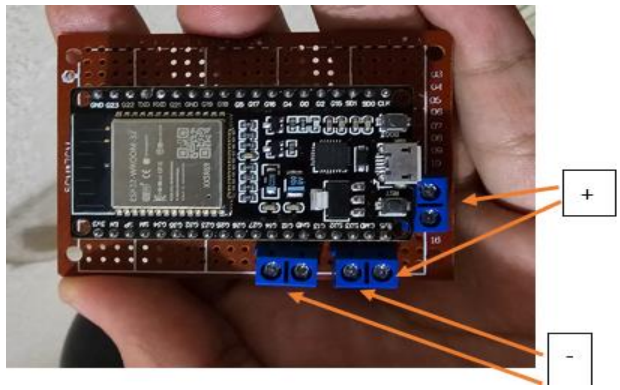

Figure 9
Button plate welding 2

Now we can solder the components we need on each pin, based on the diagrams described above.

The next step was to fix all the components to be used in wood, cutting it to size and painting it blue for better presentation (see annex 1).

With the help of screws and pins to fix the components, we obtained the result shown in figure 10.

Box 10

Figure 10
Wooden assembly

This same wood had to be inserted into a cabinet, so it had to be cut to the measurements needed to achieve this. With the help of screws and an acrylic base, the wood was fixed to the cabinet (see annex 2).

At the bottom, the necessary holes were drilled for the power plug and the cables for the load cell.

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Results

One of the aims of the project was to provide the necessary diagrams to be able to replicate the control we produced at any time, or to find faults if required. I consider this objective to have been achieved, since, as we saw earlier, different electrical diagrams and schematics were produced and used in this control.

We were also asked to develop the program for this project in a microcontroller that would give better results than the Arduino Nano that was originally used. This point was undoubtedly a success, as we were able to run the program on an ESP32, giving us faster read and response times than the Arduino Nano, based on the previous experience of the maintenance staff, as the tests documented on this same project at an earlier stage were lost at some point. However, we are told that the system is faster and more efficient than what was initially available.

One of the most important challenges was the development of the PCB boards, as this time we used SolidWorks software for the buttons, something that was new to us up to that point and which we overcame successfully. For the ESP32, there are not many softwares where this component is included for PCB, and due to the lack of time, I opted to use an already drilled board, adding terminals to supply the necessary components with the 5V that this microcontroller offers, as well as GND if required.

We obtained a logic control capable of performing the actions that are necessary for the TCO printer in its process of dosing calcium chloride, which we verified by seeing that everything worked properly: the screen gave us the corresponding messages and menus, the buttons performed their actions properly, the weight readings were correct, so this point is to highlight within the results of the project.

With more detailed tests, we were able to observe that the hoppers that had the controls that were previously used, managed to get around 200 bags per hour, while with our control they were around 185-190 bags per hour, considering that the level of production is very good if we take into account that our prototype only costs 9% of what the other controls cost.

Conclusions

Based on the main objective of the project "Elaboration of a prototype of a logic control for a calcium chloride dosing hopper implementing an ESP32 in a period of 4 months for TCO Group, Mérida, Yuc.", I can conclude that I have fulfilled it successfully, since we have respected the deadline that was intended from the beginning, doing each of the tasks that were required in the control. A first functional prototype control for dosing hoppers was obtained at the TCO Group company, with the aim of having an alternative with similar efficiency to the controls already in use there, with much lower costs and with the benefit that it can now be manufactured by the same maintenance personnel, with the different diagrams that were drawn up in the process, the list of materials required and the programming carried out exclusively for this project.

Technology nowadays gives us many possibilities to carry out projects, and although I was limited in certain things by the availability and time at some points in the process, the project could be done without so many complications. However, I consider it necessary to mention a series of recommendations that could make this project a lot better.

- The idea was to set a deadline of 4 months to create this control, because for the professional residency it takes about 500 hours divided into 4 months, which did not allow me to finish perfecting or testing the device in hoppers one hundred percent, despite having verified that the basic actions work properly. So, clearly, with a little more time, it is certainly possible to obtain an even more efficient control with the certainty that there are few failures that could occur, with a better design, and even adding more functions to the programming.
- Much of the material used for this project was reused, as they were components that the company had had at its disposal for some time. Many of them had some wear and tear due to the humidity of the place. All this leads me to think that with brand new components, we could avoid certain problems, such as the noise in the LCD that I originally intended to use, or facilitate the soldering process in some components that were already affected by rust.

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- I was able to get a program that manages to perform the basic actions of the controls already in place in the company. That is why I think that with more time and more tests, we can include more functions, such as the cutting speed, fully automated opening of the solenoid valves and that they are not in a separate system, and even control the vibrator without analogue dimmers, giving way to a more automated hopper depending only on the control.
- I got the PCB boards for the buttons and microcontroller to work correctly. But obviously we can achieve a more professional result that even to the eye looks better. For this, you can choose to make the boards in more specialised software, and using CNC machines have boards with the measurements, holes and tracks that we need with a higher precision and with a more attractive design.

Declarations

Conflict of Interest

The authors explicitly declare that they have no conflict of interest related to the research presented in this article. There are no competing financial interests or known personal relationships that could have influenced the objectivity, integrity or interpretation of the results and conclusions presented in this paper. This statement confirms the authors' transparency and impartiality in communicating the research findings.

Authors' contribution

Tun-Ordoñez, Jorge Sprewell: Definition of Objectives: Definition of the intended objectives at the start and scope of the calcium chloride dosing system project for the company TCO Group. Project Management: Coordinating the different activities, processes, work assignment and monitoring the correct development of the project as established (time and form). Circuit Design and Coding: Responsible for the development of all electrical and electronic circuits, as well as the programming of the microcontroller.

Manrique-Ek, Josué Abraham: Drafting and Documentation: Responsible for all documents necessary to support the project through evidence and development proposals. Coordination of documentation and project development: Responsible for the revision of all the bibliographic material used, as well as the supervision of the documents requested and the progress of the project.

Cardozo-Aguilar, Guadalupe: Project supervision: In charge of verifying the correct functioning of the project, complying with the specifications requested. Review of electrical diagrams: Gives the go-ahead to the different diagrams and diagrams where the connections of the device are shown, validating them for their implementation and exposure in the documentation.

Gomez-Ku, Ricardo: Validation of results: Checks and determines satisfactory results of the project, complying with the established objectives. Drafting of conclusions and recommendations: In charge of analysing the results for the generation of conclusions, highlighting possible fields of improvement in the project.

Availability of Data and Materials

Data generated during this research will be [available upon request / deposited in a public repository / shared with interested parties]. Access to data will be granted in accordance with ethical considerations, privacy regulations and any relevant institutional or legal restrictions.

Funding

The realisation of the project was possible thanks to the financial support of the company TCO Group through the maintenance manager Ing. Noe Avila Balverde, in addition to leaving at our disposal the components and materials already held in the company. Documentation and other expenses were paid for by the research team itself.

Acknowledgements

The project was made possible thanks to the financing of the engineer Noe Avila Balverde, with the support of the company TCO Group S de Rl.

Annexes

Annex 1. Wood used

Annex 2. Cabinet

Abbreviations

1. ESP32: is the name of a family of low-cost, low-power SoC (System on a chip / 32-bit System on a Chip) chips with WiFi and Bluetooth technology.

2. LCD: stands for Liquid Crystal Display.

3. PCB: stands for Printed Circuit Board.

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Article

Strategic optimization: redesign of internal processes in international bulk companies

Optimización estratégica: rediseño de procesos internos en empresas graneleras internacionales

Benítez-López, Guillermo *[a]

[a] TecNM/ITS of Naranjos • AFL-0219-2022 • 0000-0003-2006-9876 • 468967

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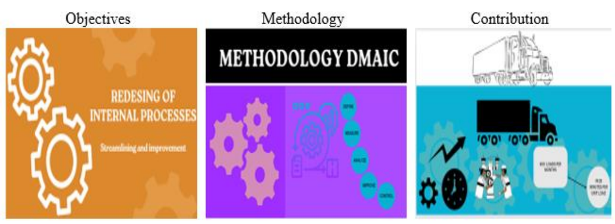
* [guillermo.benitez@itsna.edu.mx]

Abstract

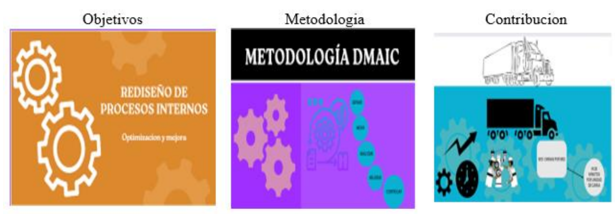
This research aims to redesign the surveillance and scale processes of an international bulk company, with the aim of streamlining and improving them. The DMAIC Methodology was systematically applied at each stage from a structured approach that improved and optimized existing internal processes, clearly establishing the problem and objectives of the redesign to subsequently collect and analyze necessary information, establishing key measurement metrics that evaluated the success of the redesign. Once the causes and areas for improvement were identified, solutions were developed and changes were implemented in the structure of the processes. The results obtained were the redesign of the company's internal surveillance and scale processes with optimized times of 44 and 77 minutes respectively, obtaining a difference of 25 to 33 minutes, allowing the company to carry out a total of 900 loads per month in 28 minutes. per unit load.



Process Redesign, DMAIC Methodology, Optimization

Abstract

Esta investigación tiene como objetivo rediseñar los procesos de vigilancia y báscula de una empresa granelera internacional, con la finalidad de agilizarlos y mejorarlos. La Metodología DMAIC se aplicó sistemáticamente en cada etapa desde un enfoque estructurado que mejoró y optimizó los procesos internos existentes, estableciendo claramente el problema y los objetivos del rediseño para posteriormente recopilar y analizar información necesaria, estableciendo métricas clave de medición que evaluaran el éxito del rediseño, Una vez identificadas las causas y áreas de mejora se procedió al desarrollo de soluciones e implementación de cambios en la estructura de los procesos. Los resultados obtenidos fueron el rediseño de los procesos internos de vigilancia y báscula de la empresa con tiempos optimizados de 44 y 77 minutos respectivamente, obteniendo una diferencia de 25 a 33 minutos permitiéndole a la empresa realizar un total de 900 cargas por mes en 28 minutos por unidad de carga.



Rediseño de Procesos, Metodología DMAIC, Optimización

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Introduction

Process redesign is important for companies as it allows them to better adapt to changes in the business environment, improving operational efficiency, reducing costs, improving product or service quality, increasing customer satisfaction and remaining competitive in the market. It also facilitates the identification of bottlenecks, the automation of repetitive tasks and the implementation of best practices, which leads to more agile and efficient functioning in the organization.

According to Ramos Aulla, C. G. (2023). That the redesign of processes to achieve better control and internal management within a company focuses on the fact that every organization must have a mission, vision and organizational chart, to be able to establish its processes accordingly. The implemented processes have a characterization, a flow diagram that allows visual understanding, development of processes and indicators that allow their control so that they can be improved in the future. The Process Map and the General Organization Model. With the use of these techniques and tools, the critical issue of the business in the company is identified, the insufficient integrated management of the processes, weakens the possibilities of the entity to take advantage of the opportunities that the environment offers, jeopardizing the fulfillment of its mission. This is indicated in their research work; Alfonso-Robaina, D., Et. to the. (2011).

According to León-Duarte, J. A., & Viramontes-García, C. G. (2014). By establishing the correct processes that are carried out in each department or specific area of a company, they allow them to be streamlined. The redesign of processes in a warehouse management system seeks to stabilize the annual inventory levels of a marketing company, as well as establish the correct processes improvement consists of five phases: process selection, understanding the selected process, proceeding with process measurement, executing process improvement, and reviewing the improved process. Obtaining improvement results; the improvement in delivery times to customers, the improvement of the work environment, the development of sales and quality policies, as well as the improvement in communication between areas, as stated by Cordova Gomez, S. A. (2021).

Campozano Moyano, N. A. et. al. (2022). They maintain that; The use of technologies with the purpose of reaching new business sectors to cover the technological demand of the market, increases their sales and their client portfolio, organizations have managed to quickly adapt to the needs of the market and innovate their internal processes to improve development of its products and services offered, conducting technical training for its staff, as well as introducing quality standards. ought the use of an appropriate Methodology.

Within global logistics; Supply chain management and competition in a globalized market justify the reasons for developing this research since it includes improving the productive efficiency of bulk carriers by evaluating and redesigning their internal processes, adapting to changes in the business environment such as new regulations, technologies. emerging or market demands, seeking a competitive advantage by optimizing its processes to offer products or services quickly, economically or with higher quality than competitors, reducing operating costs, waste and downtime, ensuring that internal processes comply with national and international standards and regulations in this sector, improving the customer experience in the delivery of products or services, promoting innovation within the company through the search for new ways to address human errors, failures in the supply chain supply or technological interruptions.

The Methodology used for this research was DMAIC used in Six Sigma to improve and optimize existing processes, performing an effective process redesign focusing on continuous improvement and maximization of value for the customer.

Six Sigma (6σ) is a business strategy aimed at improving competitiveness. It has two components: one aimed at management, which involves new ways of thinking, and another technical, based on statistics and 6σ metrics. It is based on six principles: customer orientation, process management, management based on data and facts, proactive management, collaboration without borders, and the search for perfection and tolerance of errors.

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It is a business philosophy that seeks continuous improvement and customer satisfaction through reducing the variability of processes, increasing their The methodology for carrying out improvement projects used in 6σ is known as DMAIC (Define, Analyze, Improve, Control), in Spanish: define, measure, analyses, improve and control as stated by Jaya Escobar, A. I. , et. al. (2018). After carrying out the detailed analysis of the internal processes of the international bulk carrier, it has provided a solid basis for the identification of areas of improvement and formulation of specific recommendations. By implementing the proposed solutions, the organization will be able to improve operational efficiency, reduce costs and increase customer satisfaction, thus strengthening its competitive position in the global market capabilities and drastically reducing the number of defects.

Development of headings and subheadings of the article with subsequent numbers

In this research, to address the problems found that allowed the redesign of the company's internal surveillance and scale processes, the DMAIC methodology was used, due to the nature and characteristics that make it up, considered to obtain the necessary data. Treatment and analysis of the same and thus make the improvement proposal for the bulk company. First, a collection of company data was carried out to be able to make a sketch, a general sketch of the company to locate the areas of the surveillance and scale processes, a general organizational chart of the company to locate those responsible for the processes and the Ishikawa diagram to identify the general problem of the company, showing inefficiency in internal processes.

Box 1

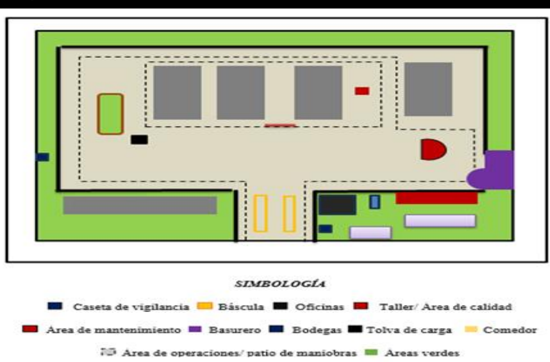

Figure 1

Sketch Granelera Internacional de Tuxpan S.A de C.V

Box 2

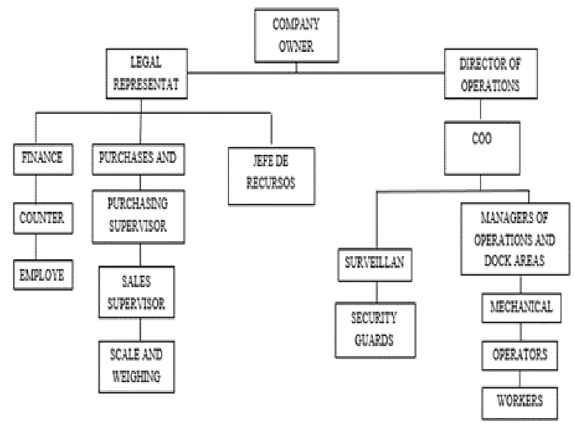

Figure 2

Organizational Structure of the company Granelera Internacional de Tuxpan S.A. of C.V

Box 3

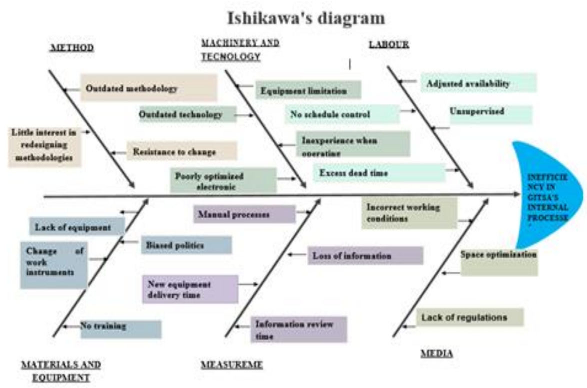

Figure 3

Ishikawa diagram to determine the problems of the company Granelera Internacional de Tuxpan S.A. of C.V.

Subsequently, the stages of the DMAIC Methodology were applied to obtain more data, perform an analysis of these and be able to redesign and improve the already established processes, focusing on continuous improvement and maximizing customer value.

Methodology

Below you can see the application of the stages of the DAMAIC Methodology and the results of the data obtained for analysis and to be able to generate the necessary improvements and optimizations to the existing internal processes in the company with the purpose of redesigning them focused on continuous improvement and maximizing value for the customer.

1st. Define Stage

As the first stage of this DMAIC methodology, the aim is to define the current situation of GITSA. Therefore, it is stated that the Tuxpan International Grannelera S.A. of C.V Company currently operates as a for-profit organization, whose business is focused on the sale of grain by the ton.

Likewise, it is announced that one of the most notable areas that the institution has is the private dock located on the edge of the river, from which unloading operations for input imports are carried out. Likewise, a conveyor belt is provided whose function lies in the movement of grains from the landing stage to the four warehouses; this set of tools, in addition to providing operational benefits, positively influences the company's value chain. As part of the methodology, the respective areas that make up the internal processes of the Tuxpan International Bulk Company are defined:

Surveillance process

This phase represents the starting point in the structure of GITSA's internal processes. This stage consists of a strategic place in front of the main entrance. The personnel in charge of carrying out activities such as: recording all information on carriers and loading units, generation and approval of departure order documentation is called a security guard.

Likewise, surveillance personnel carry out anti-theft inspection activities by carefully inspecting each transport unit before and after shipping inputs. The interior of the trailer is examined in order to prevent the entry of trucks with objects that could alter its weight, or devices that affect the operation of the pit scale. It is important to mention that the waiting yard is related to the responsibilities of the surveillance area, since these elements are responsible for directing and announcing the order of entrances***.(see annex 1)***

Scale process

This activity is carried out on a pit or truck scale, which subsequently sends the tonnage of each unit to a computer and/or database for the generation of the corresponding control documentation.

Additionally, it is important to note that this process is carried out twice. The first time when the base tonnage of the truck is weighed and the ticket is given to the carrier to send it to the waiting yard, so that it can then load your order in the order indicated. And the second time when the gross tonnage of the truck is weighed, so that with this information the final details of the purchase and the subsequent release of the unit can be finalized***. (see Annex 2).***

Loading process

This process is carried out either inside or outside the four large warehouses that are part of the company's infrastructure. Likewise, this stage has a certain amount of hauling machinery called "travelers" that have the purpose of moving the grain on elevated conveyor belts, colloquially called by employees as "bazookas", whose functionality It is placing the inputs into the trailers and containers in order to complete the loading stage of the transport units***.(see Anex 3)***

Quality process

In this area, activities related to checking the quality of the grain that is loaded into the trailers of the transport units are carried out. To be more precise, specific tasks are carried out such as: fumigation, dusting and certification of the quality of the input. In turn, this stage is carried out out on an elevated structure close to five meters high, which allows the person in charge or “fumigator” on duty to carry out each of the aforementioned activities. This milestone represents the last process within the maneuvering area, subsequently said unit must move to the truck scale to exit to its destination***.(See Annex 4)***

Problem description

According to the data collected and organizational movements observed and recorded, the internal processes of the company Tuxpan International Grannelera S.A. of C.V. present a considerable index of downtime that is generated both internally and externally, and therefore, due to the analysis of the nature and characteristics of the information, it was decided to direct attention to the stage of monitoring truck entries and exits.

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Other causes found during the course of investigation:

The truck scale has the inability to display the exact tonnage that was loaded onto each truck. Furthermore, if there is a unit that is overloaded and the customer does not want to pay the difference, then it must be unloaded and reloaded until the requested weight is obtained. This situation eventually generates delays in the process.

Little availability of signs within the maneuvering area, as well as poor use of regulations and no safety culture practice, which is why, occasionally, accidents occur that cause delays in the process as a result of these deficiencies.

And in that same current, politics and customs of resistance to change are introduced into the equation, since due to the reticent posture of certain subjects within the organizational structure of the company, the development of proposals and/or requests for improvements they take a long time to obtain a follow-up or the action is dismissed.

2nd. Measure stage

This second part of the methodology has the main objective of germinating an approach that is useful, to establish the bases that carry out the development and measurement of transition times, in which all internal processes are carried out within the International Bulk Carrier. from Tuxpan.

Therefore, representing one of the first activities carried out within the present study, a documentary investigation was carried out that was later transferred into tables, whose objective was to show the different variations in entry and exit times of each unit load between the three shifts in proportion to the first month of the exploration period.

Likewise, the internal processes that were subject to study were identified to collect significant data as explained in the previous section, that is, the four stages of surveillance, scale, loading and quality control will be measured.

3rd. Analyse stage

As a result of the previous research activities developed in the measure stage, much more supported knowledge has been obtained about the deficiencies suffered by the process subject to improvement.

Consequently, a descriptive analysis was carried out with the problem statement as reference points, in addition to all statistical and empirical information during the study period.

The following two tools were used as means for the development of this analysis:

Box 4

Table 1

Comparison matrix of current internal processes

Activity	Expected (Minutes)	Actual (Minutes)
Monitoring time (input)	2	3
Scale review time (entry timer)	2	1
Scale time (empty unit weight)	2	6
Charging times with bazooka per box	15	20
Hopper loading time per box	8	12
Quality review time	10	15
Scale time (unit weight with load)	6	10
Scale check time (exi timer)	2	1
Monitoring time (exit)	2	1
Total, Time of the units within the company (normal and full)	40 y 50 minutes	77 minutes = 01:28 hrs

Source: *Self Made*

Results

Taking into account the data obtained and the previous analysis of the data, a redesign of the internal processes was carried out as an improvement alternative for the company, implementing the use of a technological device to make it more efficient and streamline it as shown below:

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Box 5

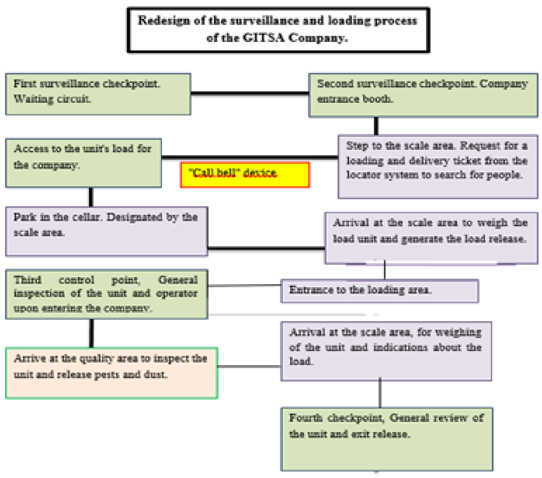

Figure 4

Redesign of the Surveillance Process with implementation of technological improvement

As we can see in the previous process, a suggestion was implemented to use a technological device, Call Bell* that notifies the operator without the need to physically go look for him at the unit and he is aware of the corresponding shift for his mobilization within the company maneuvering yard.

Call bell* Corresponds to the warning signal through a technological device (beepers or pager system), which the transporter of each unit will receive to let them know that their entry or exit turn is authorized.

The following diagram shows the redesign of the scale process and the use of the "call bell" device that will speed up the truck entry process times by announcing the access of the units in advance.

Box 6

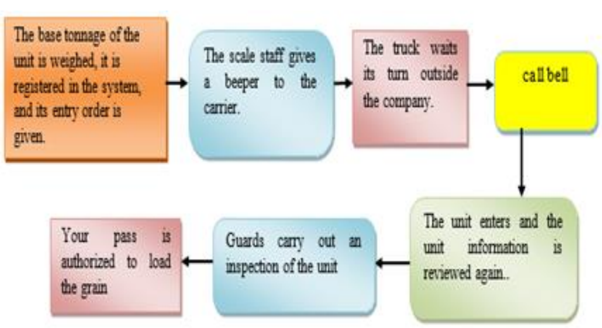

Figure 5

Redesign of the scale process with technological implementation

The implementation of the Call Bell* technological system represented a simple and appropriate alternative due to its characteristics, as well as its low implementation cost. One of the advantages of this device is that it does not require rigorous installation or training Intensive to the personnel who will use it.

The following Table shows a comparison of the times carried out in each of the areas and internal processes of the company, showing the difference in each one and the total time necessary that each unit must carry out within the maneuvering yard. the company obtaining an optimization of it per unit within the maneuvering yard.

Box 7

Table 2

Comparison matrix of completion times of new internal processes.

Activity	Expected (Minutes)	Reals (Minutes)	Difference (Minutes)
Monitoring time (input)	2	3	1
Checking time on scale (checker-entrance)	1	1	No difference
Scale time (empty unit weight)	3	6	3
Charging times with bazooka per unit	15	20	5
Hopper loading time per load	8	12	4
Quality review time	8	15	7
Scale time (unit weight with load)	5	10	5
Scale check time (exit timer)	1	1	No difference
Monitoring time (exit)	1	1	No difference
Total time of a unit within the company (normal and full)	**44 and 54**	**77 minutes = 01:28 hrs**	**25 and 35**

Box 8

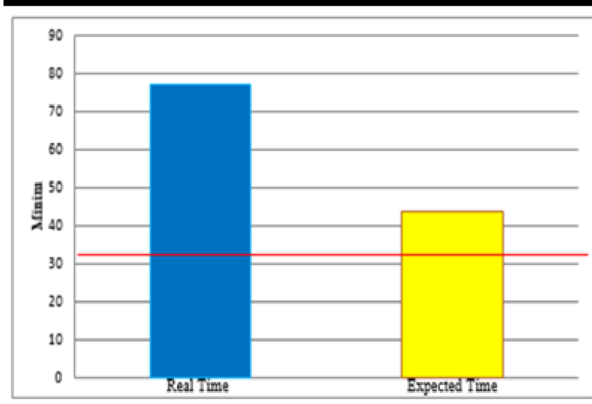

Figure 6

Expected time cycles per unit of load within the maneuvering yard

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In this graph we can see the expected cycle times per load units in real time, which as we can see is a lot of wasted time and the real expected time as shown in the following table six where we calculate the Takt Time of the company and which represents the ideal time to be carried out and meet the client's demand.

Box 9

Table 3

Development of takt time of internal processes

Specifications	Unit	U. time
Expected monthly demand	927	Loads/month
daily demand	39	Loads/day
Net available time	1906	Total minutes
Result	28	Total minutes to be performed per unit

In the previous table it is observed that; the accumulation of days minutes worked, unproductive times such as breaks; shift changes; The period of availability of the tools and the percentage of loss of the inputs, represent a set of significant elements for the search for the TAKT Time in the processes, resulting in a monthly demand of 927 units loaded with a daily demand of 39 units and A 28 -minute realization time dedicated to each unit in the total process within the company.

Conclusions

Finally, we can conclude that the redesign of internal processes of an international grain Decisions based on data, these benefits are fundamental to maintain the competitiveness and success of the company in a globalized business environment.

The use of DMAIC methodology; (Define, measure, analyze, improve and control), raised through a structured approach to improve and optimize the processes existing in any company through an effective redesign, focusing on continuous improvement and maximizing the value of customers. For future studies it would be convenient to analyze how the redesign of the processes affects the profitability of the graneras companies, the return of investment, as well as the impact of customer satisfaction at the national level and investigate how the organizational culture influences the success of the processes redesign.

Annexes

Annex 1

Surveillance Area Process

Annex 2

Scale Process

Annex 3

Loading process

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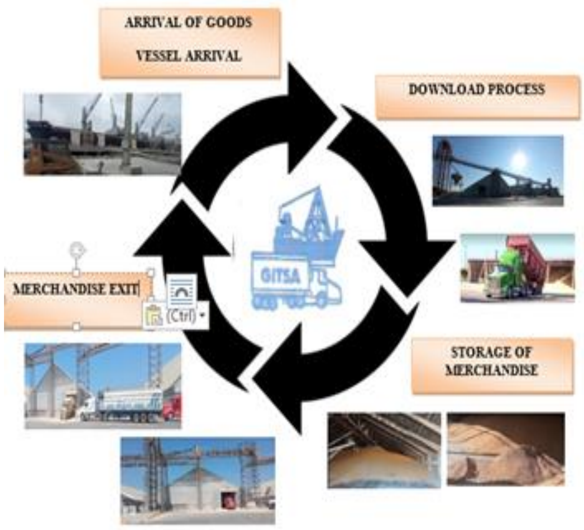
Annex 4
Operations Diagram of the International Bulk Carrier



Declarations

Conflict of interest

The author declare no interest conflict. They have no known competing financial interests or personal relationships that could have appeared to influence the article reported in this article.

Author contribution

Benitez-Lopez, Guillermo: Developed the idea of the project, method and applied research technique.

Availability of data and materials

The data used in this study come from various internal and external sources. Internal sources include operating records and performance data provided by the International Company of Tuxpan S.A. of C.V. participant of this study. External sources Industry databases and sector publications.

Entroys in obtaining specific data can contact the author to discuss the possibility of access, under adequate confidentiality agreements:

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Abbreviations

List abbreviations in alphabetical order.

DMAIC	methodology; (Define, measure, analyze, improve and control)
GITSA	Granelera International of Tuxpan S.A. of C.V.

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Article

Enhancing productivity through comprehensive evaluation and contextual analysis: A model for continuous improvement

Evaluación y mejora integral de la productividad empresarial: Un modelo basado en el análisis del contexto interno y externo

Toledo-Magaña, Rosa Lissette*[a], De León-De Los Santos, Brissa Roxana [b], Guerra-Que, Zenaida [c], Eliseo-Dantés, Hortensia [d]

[a] Tecnológico Nacional de México/Instituto Tecnológico de Villahermosa • GPW-8485-2022 • 0000-0002-4526-2333 • 1226436
[b] Tecnológico Nacional de México/Instituto Tecnológico de Villahermosa • G-3140-2018 • 0000-0002-4775-6185 • 778437
[c] Tecnológico Nacional de México/Instituto Tecnológico de Villahermosa • 0000-0001-8389-7930 • 291346
[d] Tecnológico Nacional de México/Instituto Tecnológico de Villahermosa • F-6749-2018 • 0000-0003-4006-4669 • 411079

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* ✉ [rosa.toledo.m96@gmail.com]

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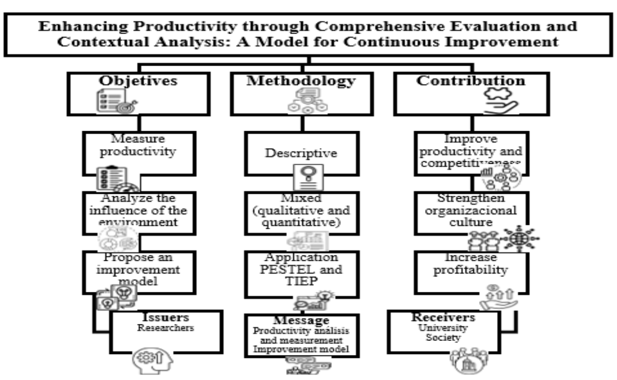
Abstract

The main objective of the case study is to measure the productivity of a laboratory dedicated to the development of dermatological products from coconut oil and other natural ingredients, as well as to analyze the influence of the external context on it in order to propose an improvement model that will allow it to improve its competitiveness in the market, strengthen its organizational structure and increase its profitability. This will be done through the application of the PESTEL analysis and the Integral Productivity Evaluation Technique in order to identify areas for improvement. It should be noted that the study is descriptive, with a mixed approach (qualitative and quantitative).



Science, Technology and Innovation

Resumen

El objetivo principal del caso de estudio es medir la productividad de un laboratorio que se dedica al desarrollo de productos dermatológicos a partir del aceite de coco y de otros ingredientes naturales, asimismo, analizar la influencia del contexto externo en la misma para proponer un modelo de mejora que permita mejorar la competitividad en el mercado, fortalecer su cultura organizacional y aumentar su rentabilidad. Lo anterior, se realizará a través de la aplicación del análisis PESTEL y de la Técnica Integral de Evaluación de la Productividad con la finalidad de identificar las áreas de mejora. Cabe señalar que el estudio es tipo descriptivo, con un enfoque mixto (cualitativo y cuantitativo).

Ciencia, Tecnología e Innovación

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Introduction

Productivity can be defined as " *the art of being able to create, generate or improve goods and services*" (Nemur, 2016). It is a key and important concept in business management, because it is an indicator that is closely related to efficiency and effectiveness, allowing to assess the company's ability to achieve its objectives, goals and the optimisation of its resources.

Productivity is systematic, i.e. it is not determined by a single factor, but by a series of elements that have a significant influence in determining the level of productivity of a company or society. There are internal factors, which are influenced by the organization. Similarly, there are external factors that do not depend on the company, but are essential in determining productivity. It is important to mention that in order to achieve business or organizational success it is necessary to measure and improve productivity continuously, because ignoring these actions can lead to a number of negative consequences, such as decreased competitiveness, stagnation of growth and, in a severe case, bankruptcy. This requires long-term commitment from the management or top management as well as from all employees in general.

In the case study, there is a need to evaluate the productivity of a laboratory located in the state of Tabasco, which is dedicated to the development of a wide range of products derived from coconut oil and other natural ingredients, focused on treating various conditions. For this, it is necessary to analyse the current situation of the external (through the PESTEL method) and internal connection with the application of an instrument called TIEP (Integral Productivity Evaluation Technique), which consists of the study of ten essential elements that every organization or company must consider.

Theoretical review

Today we live in a dynamic and competitive world. In today's organizations, measurement "*has become a determinant of success, both at the individual and societal level*" (Sabry, 2024), such that strategies alone do not have the capacity to be activated in the organizational environment without recourse to the measurement process and the users at different management levels to execute and measure it.

Therefore, the impact is significantly negative for any type of company, when there is an absence of structuring and management indicators, since this leads to a lack of control and evaluation in the organization causing damage to the internal functioning as well as its performance in the market.

According to Zabala Jarami (2005), "*measurement should be planned as a system composed of several factors for the achievement of results, such as: personnel, procedures, facilities and equipment, information, objectives and goals, all according to the needs of each organization*". Acevedo Gamboa, D. (2022) explains that "today managers, specialists and academia seem to affirm that a balanced approach is the best way to measure". Although most organizations have these components in place, the failure to integrate them into a coherent and planned organization-wide system is common. In addition, there is a common lack of formal documentation defining the responsibilities and roles of staff involved in this system.

It should be noted that identification, commitment and involvement are concepts that "*influence worker behaviour and, in turn, have a significant impact on the productivity of their daily activities, either positively or negatively*" (Aguilar et al. 2024). Therefore, it is necessary to consider them when measuring productivity.
Similarly, it should be taken into consideration that "*job performance and productivity have a close relationship in employees, which shows that they perform their tasks efficiently and effectively and contribute to the achievement of goals and use the means efficiently, which implies productivity and organizational success*" (Torres & Córdova 2022, Limaylla 2022, Serpa 2019, Barcia et al. 2019, as cited in Mahoma, 2024).

It is important to know the context of the environment in which the companies are located in order to carry out an adequate measurement; this can be done through the application of the PESTEL Analysis, because it refers to the study of Political, Economic, Social, Technological, Ecological and Legal factors (Murcia Cabra, 2023).

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To identify problems specifically, in order to provide the location of areas of opportunity to improve productivity in a comprehensive manner, it is necessary to measure through the measurement instrument called "*Integral Technique of Evaluation of Productivity*" (TIEP), because it allows "to*integrate the knowledge and development of the organization, these elements are essential for the integral knowledge of the company and integrate a series of general and specific aspects that denote the productive scope of the company*" (López et al., 2021).

According to Eliseo Dántes (2023), the TIEP is based on ten priority elements that cover the essence of organizational functioning in a comprehensive manner:

1. Conceptual approach to the company: This refers to the vision that the members of the organization have, i.e. whether it is partial or systemic.

2. Process knowledge: This element assesses the in-depth understanding of internal processes. It allows to identify areas for improvement and to optimise the use of resources; therefore, if members do not know the processes, it will have a negative impact, because a series of errors and consequences arise.

3. Social sphere of the organization: It is the product of the interaction that exists between its components, where synergy or dysfunction can be identified, which influences productivity.

4. Planning management: The evaluation takes into account the effectiveness of strategic planning management, including objectives, goals, strategies, tactics, policies, values, philosophy, programmes and projects, which is crucial for success.

5. Management involvement: Achieving positive results requires the active involvement of top management in the overall development of the organization, both tangible and intangible, therefore, the involvement of top management in the organization is assessed.

6. Creativity and organizational innovation: During the evaluation, a fundamental value of the company is considered; this is the ability to generate new ideas and apply them to improve processes, products and services, since it is a fundamental driver of productivity and competitiveness.

7. Knowledge of the customer(s): This evaluates the in-depth understanding of the needs, expectations and behaviour of customers, both internal and external. It is essential to guide the organization's actions.

8. Technological development: As mentioned by Jawad & Balázs (2024) "*in the dynamic and changing field of technology and business operations, keeping abreast of recent trends is paramount*". It is therefore important to adopt and adapt appropriate technologies to the needs of the organization, as this is a key factor in optimising processes, increasing efficiency and improving productivity.

9. Macroeconomic knowledge: Understanding economic and political changes at the macro level allows the organization to anticipate trends, make strategic decisions and prepare for challenges and opportunities.

10. Comprehensive human resource development: "*Learning and training refers to the acquisition of knowledge, skills, attitudes and abilities that are used to perform tasks in the workplace*" (Aguilar et al. 2024). Investing in the integral development of human capital, including attitudes, skills and abilities, leads to personal and professional growth, boosting productivity and organizational success.

According to Pérez et al. (2021), the TIEP "*is a tool that gives us the security of being able to evaluate...*"the entire company "*with this we generate a measurement through a qualitative and quantitative analysis*".

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By applying the TIEP, it is possible to have a comprehensive view of productivity, because it allows to evaluate from a holistic perspective, considering tangible and intangible aspects, facilitating the identification of specific areas where actions can be implemented to improve productivity and increase competitiveness. It should be noted that the understanding of external factors is fundamental for the TIEP.

Methodology

Box 1

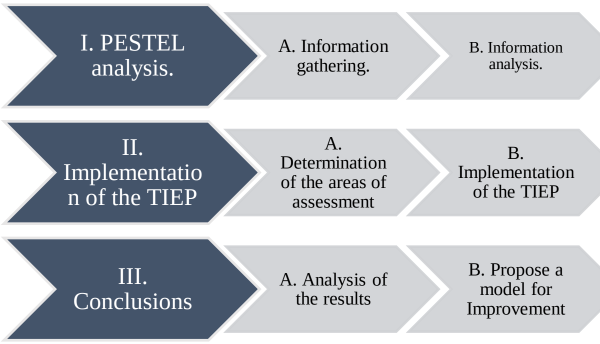


Figure 1
Productivity measurement methodology

Figure 1 shows the methodology used to carry out the productivity study of the laboratory, which is a descriptive study with a mixed approach (qualitative and quantitative). It consists of three stages: PESTEL analysis, application of the Integrated Productivity Evaluation Technique.

I. PESTEL analysis

A. Information gathering

- Political factors: Review of the political panorama of the state of Tabasco and identification of possible changes in government policies.
- Economic factors: Analysis of the economic situation in the state of Tabasco, consideration of the impact of global economic conditions and assessment of economic trends in the sector.
- Socio-cultural factors: Examination of demographic and social trends in the state of Tabasco, identification of cultural values and consumer preferences, and consideration of the impact of social trends on the workforce.
- Technological factors: Assessment of the level of technological development in the state of Tabasco, identification of new technologies relevant to the laboratory and consideration of the impact of technological changes.
- Ecological factors: Analysis of existing environmental regulations, assessment of the impact of environmental concerns and consideration of opportunities for sustainable practices.
- Legal factors: Review of laws and regulations affecting the laboratory, identification of possible legal changes, and seeking opportunities to take advantage of existing laws.

B. Information analysis

- Careful analysis of information to identify the most relevant factors.

II. Application of the Integrated Productivity Evaluation Technique (IPET)

A. Determination of the areas of evaluation.

- Division of the laboratory into three areas:

Area 1: R&D and Production.
Area 2: Accounting, Purchasing and Warehouse.
Area 3: Quality and Administration.

Reasons for the division into areas:
- Greater specialisation and depth of analysis.
- Integral and systemic vision of productivity.
- More efficient and complete evaluation.
- Simplification of implementation and monitoring.
- Greater employee participation and commitment.
- Encouragement of communication and collaboration.

B. Application of the TIEP.

- Understanding of contextual variables.
- Involvement of representatives from all three areas.
- Regular 60-90 minute meetings.
- Interviews to gather information.
- Application of the TIEP for each area.
- Assignment of assessments and weights to elements.

ISSN: 2524-2105
RENIECYT-CONAHCYT: 1702902

- Calculation of simple average per item.
- Calculation of the composite average.
- Application of the formulas to each element.
- Calculation of the simple average and composite average by variable.
- Elaboration of graphs to analyse the impact.

III. Conclusions

- Analysis of the results obtained.
- Identification of areas of opportunity to improve productivity.
- Propose a model for improvement.

Results

According to the PESTEL analysis, opportunities and threats that impact the laboratory were identified (Table 1. Summary of the PESTEL analysis).

Box 2

Table 1

Summary of the PESTEL analysis

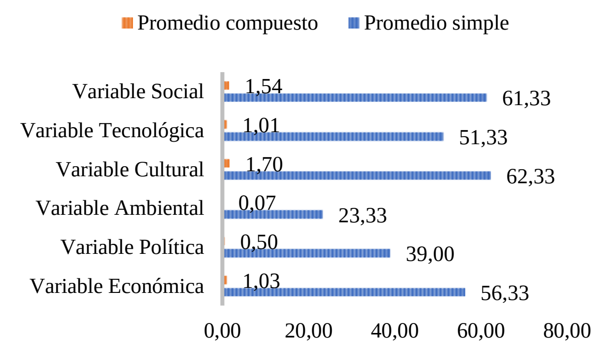
Factor	Opportunities	Amenazas
Politics	Access to finance, tax incentives, intellectual property protection.	Policy changes, expropriations, political instability, unfair competition.
Economic	New markets, generic products, cost reduction, access to finance.	Competition, low prices, economic recession, currency devaluation.
Sociocultural	New market segments, customized products, customer loyalty.	Changes in preferences, cultural competition, loss of customers.
Technological	New products, efficient processes, cost reduction, access to new markets.	Technological obsolescence, technological competition, lack of access to technology.
Ecological	Sustainable products, reduced environmental footprint, access to green markets.	Environmental costs, stricter regulations, loss of markets, damage to public image.
Legal	Intellectual property protection, access to new markets, legal compliance.	Changes in laws, strict labour laws, environmental regulations, lawsuits.

Given the above, the following is recommended:

- Political: Monitor the political environment, diversify markets, build relationships with government.
- Economic: Diversify products, optimise costs, seek alternative financing, protect against inflation.
- Sociocultural: Adapt products, strengthen brand, offer customised products, build community relationships.
- Technological: Invest in R&D, adopt new technologies, protect intellectual property, form strategic alliances.
- Ecological: Implement sustainable practices, comply with regulations, develop sustainable products, communicate environmental initiatives.
- Legal: Monitor legal changes, comply with laws, seek legal advice, establish compliance programmes.

On the other hand, Graph 1 represents the result of the application of the TIEP, which shows the impact of each of the variables:

Box 3



Graph 1

Impact of variables on laboratory productivity Source: Author's perspective, 2024

- The economic variable has a simple average of 56.33 and a composite average of 1.03. This indicates that the laboratory has an average performance in economic terms.
- The political variable has a simple average of 39.00 and a composite average of 0.50. This indicates that the laboratory has a poor average in political terms.
- The environmental variable has a simple average of 23.33 and a compound average of 0.07. This indicates that the laboratory performs efficiently in environmental terms, as it implements actions of optimal use of resources and waste minimisation.

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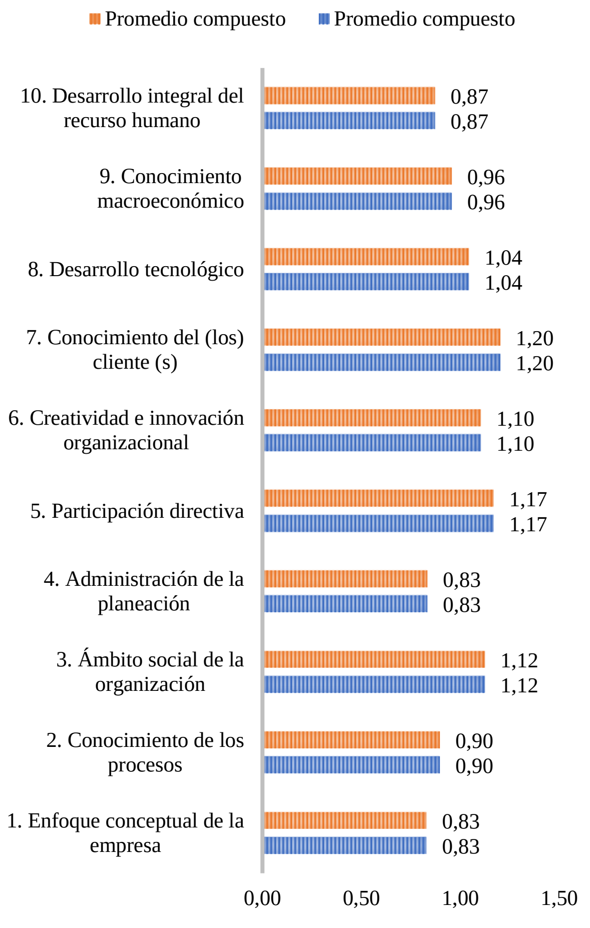
- The cultural variable has a simple average of 62.33 and a compound average of 1.70. This indicates a fair performance, and opens up areas for improvement.
- The technology variable has a simple average of 51.33 and a composite average of 1.01. This indicates fair performance.
- The social variable has a simple average of 61.33 and a composite average of 1.54. This indicates good performance.

Box 4



Graphic 2
Results of the impact of variables on the elements

- There is a low level of knowledge of the conceptual approach to business. This means that they do not have a systemic and integral approach. The laboratory has a medium level of knowledge of the processes. However, there is no formalisation of process management.
- In terms of the social scope of the organization, there is a basic understanding of social responsibilities.
- In planning management, there is no basic system in place to establish objectives, strategies, among other elements.
- There is a high level of managerial participation.
- There is a medium level of creativity and organizational innovation, due to the operations that the laboratory executes, it is encouraged, however, the ideas that the collaborators propose are not managed.
- The level of knowledge of the client(s) is high. This means that employees have a clear understanding of customer needs and expectations.
- In technological development, the laboratory is at a medium level, because this area concentrates most of the technology, leaving aside the other areas.
- There is a medium level in the macroeconomic knowledge element. This means that there is a basic and superficial understanding of the economic factors affecting the business level.
- There is a low level of comprehensive human resource development, as there is no investment in training and development.

According to the results obtained in the application of the PESTEL method and the Integrated Productivity Evaluation Technique, an improvement model is proposed, which is mainly based on four pillars:

1. Homeostasis theory: Homeostasis is a regulatory process in organisms to maintain their equilibrium. This principle applies to organizations, which must be able to adapt to new market conditions in order to maintain their success.

2. Continuous improvement: Continuous improvement seeks to permanently improve processes by employing strict discipline in quality, productivity, customer satisfaction, cycle times and costs. It is based on a feedback loop to identify problems, implement solutions and monitor the results.

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3. Context variables: It is necessary to monitor the external context in which the company operates in order to know the situation of the variables that impact the internal environment, thus being able to take action in the face of changes in the external environment.
4. The 10 elements of the TIEP provide us with a framework to assess our current productivity and identify areas of opportunity for improvement.

The objective of the model is to help you improve your productivity in a comprehensive way, addressing all aspects of the organization that affect productivity, from internal processes to the external context, and to achieve sustainable improvement through the implementation of a continuous improvement approach that allows the company to adapt to changes in the environment and maintain its productivity in the long term.

Box 5

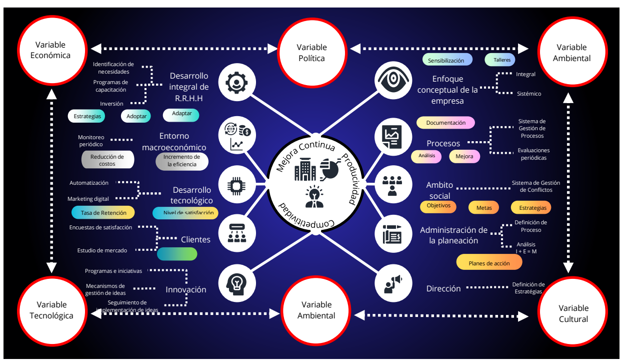

Figure 2
Productivity measurement methodology Source: Author's perspective, 2024

External Context: Interpretation of each variable.

a. Economic Factors: Economic market conditions, such as inflation, interest rates and the exchange rate, can affect production costs, product demand and the profitability of the company.
b. Political Factors: Government policies, regulations and the political stability of the country can influence the firm's operating environment, affecting aspects such as hiring of personnel, access to financing and ease of doing business.
c. Social and Cultural Factors: The values, customs and expectations of the society in which the enterprise operates can influence the availability of labour, work ethic and the acceptability of the enterprise's products or services.
d. Environmental Factors: Environmental regulations, the availability of natural resources and the environmental impact of the company's operations can affect production costs, public image and long-term sustainability.
e. Technological Factors: Technological advances in related industries may generate new market opportunities, create challenges for existing products or services, and require constant upgrading of the company's technological capabilities.

Internal Context: Interpretation of each element.

1. Conceptual approach of the company:

- Strategy: Foster a systemic and holistic view of the organization among all members, through awareness raising, workshops, trainings and effective communication.
- Indicators: Measure the alignment of individual actions with the overall vision of the company through surveys and interviews.

2. Processes:

- Strategy: Implement a process management system that documents, analyses and continuously improves internal processes. Periodically evaluate process knowledge.
- Indicators: Reduce cycle time, eliminate waste and improve the quality of the processes.

3. Social:

- Strategy: Foster a culture of collaboration, teamwork and open communication through integration activities, recognition of teamwork and conflict resolution. Establish a conflict management system.
- Indicators: Measure the level of job satisfaction, team cohesion and participation in collaborative activities.

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4. Planning management:

- Strategy: Implement a robust strategic planning process that defines clear objectives, measurable goals, achievable strategies and concrete action plans. Periodically analyse the internal and external context in order to improve. - Indicators: Achieve set objectives, meet targets and deadlines, and evaluate the effectiveness of implemented strategies.

5. Leadership:

- Strategy: Actively involve senior management in strategy setting, decision making and performance monitoring.
- Indicators: Frequency of senior management communication with employees, participation in organizational activities and support for improvement initiatives.

6. Innovation:

- Strategy: Create an environment that fosters creativity and innovation, through idea competitions, training programmes in creative thinking, idea management mechanisms, spaces for experimentation and follow-up on the implementation of ideas.
- Indicators: Number of new ideas proposed, implementation of new ideas and innovative products or services.

7. Clients:

- Strategy: Conduct market research, satisfaction surveys and data analysis to understand customer needs, expectations and behaviours.
- Indicators: Level of customer satisfaction, customer loyalty and customer retention rate.
-

8. Technology development:

- Strategy: Implement technologies appropriate to the needs of the organization (automation, digital marketing), continuously evaluate new technologies and train staff in their use.
- Indicators: Cost reduction, increased efficiency, improved quality and development of new products or services.

9. Macroeconomic environment:

- Strategy: Monitor macro-level economic and political changes, analyse their impact on the organization and develop strategies to adapt to changes.
- Indicators: Ability to anticipate trends, make timely strategic decisions and address challenges and opportunities in the macroeconomic environment.

10. Integral development of human resources:

- Strategy: Invest in staff training, education and skills development, both technical and soft.
- Indicators: Level of staff training, individual and team performance, and job satisfaction.

Influence of External Variables on Internal Elements

External variables can influence the internal elements of the productivity improvement model in several ways. For example:

a. Economic factors: A period of economic recession may reduce demand for the laboratory's products, which may force it to reduce production and lay off employees, negatively affecting training, motivation and organizational culture.
b. Political factors: New government regulations on product safety or environmental protection may require investment in technology and processes to comply with such regulations, which may affect production costs and efficiency.
c. Social and cultural factors: Changes in consumer preferences towards healthier or more environmentally friendly products may require you to modify your product or service offering, which may involve changes in staff training, technology used and company infrastructure.

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d. Environmental factors: New technologies for renewable energy production or waste reduction may represent an opportunity to improve environmental efficiency and reduce costs, which may improve the company's public image and increase employee satisfaction.

e. Technological factors: The emergence of new production or distribution technologies may require upgrading your systems and processes to remain competitive, which may involve investments in training, technology and infrastructure.

Conclusions

Productivity is a complex phenomenon that is influenced by a variety of factors. It is important to understand how the different variables interact with each other in order to develop effective strategies to improve productivity in a specific organization.

The Productivity Improvement Model is a valuable tool to help a company achieve its productivity goals. The model is based on sound principles.

Successful implementation of the productivity improvement model for Quiper® Laboratories will require a joint effort from top management, employees and all stakeholders. With strong commitment and dedication, the model has the potential to help the company achieve its productivity goals and improve its overall performance.

Declarations

Conflict of interest

The authors declare no conflict of interest. They have no known competing financial interests or personal relationships that could have appeared to influence the article reported in this article.

Author contribution

Toledo-Magaña, Rosa Lissette: The main contribution was the search for information, fieldwork and the design of the proposal.

De León- De los Santos, Brissa Roxana: Analysis of the external environment and suggested recommendations.

Guerra-Que, Zenaida: Analysis of the external environment from an ecological approach and suggested recommendations.

Eliseo-Dantés, Hortensia: Provided information on the Integrated Productivity Assessment Technique,

Availability of data and materials

Data were obtained by applying instruments directly to the study subjects.

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Abbreviations

PESTEL Political, Economic, Socio-Cultural, Technological, Ecological and Legal
TIEP Comprehensive Productivity Evaluation Technique

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Introduction

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General explanation of the subject and explain why it is important.

What is your added value with respect to other techniques?

Clearly focus each of its features.

Clearly explain the problem to be solved and the central hypothesis.

Explanation of sections Article.

Development of headings and subheadings of the article with subsequent numbers

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Products in development No.12 TNRoman, single spaced.

Including figures and tables-Editable

In the article content any table and figure should be editable formats that can change size, type and number of letter, for the purposes of edition, these must be high quality, not pixelated and should be noticeable even reducing image scale.

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Box

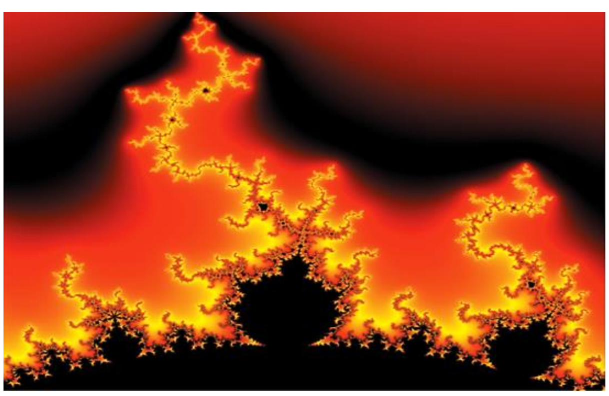

Figure 1
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Table 1
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<u>The maximum number of Boxes is 10 items</u>

For the use of equations, noted as follows:

$$Y_{ij} = \alpha + \sum_{h=1}^{r} \beta_h X_{hij} + u_j + e_{ij} \quad [1]$$

Must be editable and number aligned on the right side.

Methodology

Develop give the meaning of the variables in linear writing and important is the comparison of the used criteria.

Results

The results shall be by section of the article.

Conclusions

Clearly explain the results and possibilities of improvement.

Annexes

Tables and adequate sources.

<u>The international standard is 7 pages minimum and 14 pages maximum.</u>

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The authors declare no interest conflict. They have no known competing financial interests or personal relationships that could have appeared to influence the article reported in this article.

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Author contribution

Specify the contribution of each researcher in each of the points developed in this research.

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Benoit-Pauleter, Gerard: Contributed to the project idea, research method and technique.

Availability of data and materials

Indicate the availability of the data obtained in this research.

Funding

Indicate if the research received some financing.

Acknowledgements

Indicate if they were financed by any institution, University or company.

Abbreviations

List abbreviations in alphabetical order.

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ANN	Artificial Neural Network

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Article	Page
Analysis and comparison of exoskeleton prototypes to carry out activities under normal conditions in industrial companies to reduce risks Gaviño-Ortiz, Gabriela and Osorio-Reyna, Jhonny Jesús *Universidad Autónoma del Estado de México Atizapán de Zaragoza* *Universidad César Vallejo Lima-Perú,*	1-8
Logic control design for calcium chloride dosing hopper for TCO Group Tun-Ordoñez, Jorge Sprewell, Manrique-Ek, Josué Abraham, Cardozo-Aguilar, Guadalupe, Gómez-Ku, Ricardo *Instituto Tecnológico Superior de Calkiní*	9-16
Strategic optimization: redesign of internal processes in international bulk companies Benítez-López, Guillermo *TecNM/ITS of Naranjos*	17-25
Enhancing productivity through comprehensive evaluation and contextual analysis: A model for continuous improvement Toledo-Magaña, Rosa Lissette, De León-De Los Santos, Brissa Roxana, Guerra-Que, Zenaida & Eliseo-Dantés, Hortensia *Tecnológico Nacional de México/Instituto Tecnológico de Villahermosa*	26-35

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