

Machine Learning and Human Resources Management in the private sector: A bibliometric mapping perspective

Mario Cueva-Mayo, Kamila Chiroque-Valencia

Facultad de Ingeniería y Arquitectura, Universidad de Lima, Lima, Perú
20160427@aloe.ulima.edu.pe, 20162975@aloe.ulima.edu.pe,

Martin Collao-Diaz, Juan Carlos Quiroz-Flores and Alberto Flores-Perez

Facultad de Ingeniería y Arquitectura, Universidad de Lima, Lima, Perú
Research Professors

mcollao@ulima.edu.pe, jcquiroz@ulima.edu.pe and alflores@ulima.edu.pe

Abstract

The objective of the research was to collect information on the research variables: Machine Learning and Human Resource, through the literature review to generate a contribution to the scientific community and to future research. As part of this research, the Prism Method was more didactic and orderly for the search for information. Through the selected criteria, it was possible to obtain 214 articles related to the research topic that sought to answer the questions posed in the introduction of this work. The problem was duplication of information in the two databases. In this sense, the Excel program was used to solve this problem. The paper is based on the collection of information through a systematic review, which includes a bibliometric software such as VOSviewer.

Keywords

human resource management, machine learning, bibliometric analysis, artificial intelligence.

1. Introduction.

The notion of “Human Resources” has given way to other terms such as “Human Management”, to separate the “subject” from the notion of “resource”, which it shared with technology, raw materials, and financial capital. Likewise, to vindicate the complex nature of human beings, as a unit of the social systems that make up companies (Dorado et al., 2019). The area of Human Resources in a company is well known because it is responsible for selecting, hiring, training, motivating, and managing personnel to meet the objectives of the organization; Its functions include promoting innovative, proactive, and risk-oriented behavior, which will lead to greater innovation results and a greater competitive advantage for the company (Canet et al., 2020). Human resource management has evolved from the division of labor based on technical skills. A knowledge of technology and procedure contributes to the exchange and development of cognitive, affective, and communicative skills of individuals (Zavala-Villalón & Frías, 2018). It is pertinent to point out that the GTH is seen as a system in which the employees within the company are seen as a resource that must be constantly improved from an innovative and dynamic vision (Blanco-Ariza & Vega, 2019). The processes through which knowledge is created and managed, and therefore human talent, constitute the source of dynamic capabilities and sustainable competitive advantage (Barrios et al., 2020). Likewise, the management of human talent makes it possible to dynamize the work environment in companies to meet the demands of the labor market with personal care (Acurio et al., 2020). In addition, it collectively predicts and manages change, to create lasting strategies that ensure the direction of the development of the organization and its future (Ramirez et al., 2019). In the era of data science and big data analytics, people analytics is an alternative to reduce attrition for organizations and HR managers by attracting and retaining talent (Yahia et al., 2021).

From the human resources management model, it is necessary to understand the processes of incorporation (recruitment and selection), the processes of development (training and careers) and compensation, and the remuneration system of the organization (assessment and compensation) (López et al., 2018). Human resources processes are evolving very quickly, and it is advisable to involve other points of view to identify areas of opportunity for their application, such as identifying the preferences and expectations that employees have regarding benefits and

analyzing this information according to a different age or generation groups, marital status, and academic level (Madero, 2016).

The Machine Learning tool is also called automatic learning, as it allows machines to “learn from data to identify patterns and support better decision-making through predictions. Lasse Rouhiainen (2018) points out: “The ability of computers to do activities that normally require human intelligence”. In that sense, for this tool to work properly, programmers must refine algorithms that specify a set of variables to be as accurate as possible. The Big data tool and machine learning are important for data management that helps organizations in the different process management (Oswald et al., 2019). Artificial Intelligence covers a wide range of technologies, these help human talent to better understand the environment in which it is developed to optimize its strategic advantages (Wamba-Taguimdje et al., 2020), moreover, this technique is increasingly reshaping the service by performing various tasks, which is an important source of innovation (Huang et al., 2018). Furthermore, it can be used to identify effective strategies for autonomous management behaviors, driven by objectives (Liu et al., 2018).

When cloud computing is applied to recruitment, the right candidates are selected (Wang, 2021). Advances in machine learning and big data should be leveraged to automate the classification of CVs/skills and improve productivity in the analysis of skills-based labor market dynamics and mechanics (Sitek et al., 2020). The most complex task for directors and/or heads of Human Resources is to evaluate the resumes of the people who apply for a job and thus select the ideal candidate. The Machine Learning tool is extremely useful for these cases, as it allows to discard those people who do not meet the requirements. (As cited in Tiwari et al., 2021). The Big Data tool could capture large volumes of information, managing it with algorithms, analytics, and computing. In organizations, processed data can match qualified candidates with job opportunities and tailor their skills development to the needs of the economy. (Bernal, 2020)

Researchers and practitioners in industrial-organizational psychology (IOP) and human resource management (HRM) can add significant value to big data and artificial intelligence (Oswald et al., 2019). “Big data, algorithms and artificial intelligence now allow employers to process information about their employees and potential employees much more efficiently and at much lower cost” (Todoli, 2019). Achievement of strategic objectives in all sectors of a company is based primarily on the company’s employees (Moro et al., 2020). Well, "companies tend to adopt innovative processes in the search for transformation, which implies changes in management practices and with the organizational level" (Madero-Gómez; 2020). Likewise, a new corporate culture is emerging that breaks traditional practices and highlights the commitment to participatory management of human resources (Rodríguez-Sánchez, 2020). "For several decades, human talent management has focused on operational functions without advancing in the strategic design of the areas and their contributions to achieving long-term objectives" (Anzola, 2018). In this sense, the old logic is being left behind in which they did not consider that improving people's well-being is a guarantee of greater profitability (Gisnera et al., 2020). Recent studies show how leadership skills, and the form of communication organizations use meet the objective of improving the skills and competencies of their employees (Meirinhos & Barreto, 2020). It is also important to mention that, in developing countries, there is still much to manage, starting with the personal development opportunities available to workers within the institution itself (Jara et al., 2018).

A guideline established by the Prisma method is followed to achieve greater clarity and transparency in published systematic reviews. This method seeks to answer the following questions.

RQ1. What is known about Machine Learning and Human Resource Management in the private sector?

RQ2. What are the difficulties in artificial intelligence technology about the issue of performance assessment?

RQ3. What have Machine Learning techniques been used to improve the Human Resources area?

RQ4. What are the main advantages and improvements offered by the Machine Learning tool that can benefit the compensation process?

2. Literature Review

A systematic review (SR) is an article exploring the quantitative and qualitative aspects of initial research to synthesize information about a specific topic (Manterola et al., 2013). In addition, this methodology minimizes the biases of the individual studies and provides more reliable results from which conclusions can be oriented (as cited in Valero, 2018). Researchers typically use this method to evaluate relationships between the most influential publications by

analyzing direct and examining direct and cross-citations and assylose them into related sets to determine established and emerging topics or subtopics of inquiry (Kouropalatis et al., 2019).

To ensure the proper development of the research in which the recommended information is collected through its list of guidelines, the PRISMA methodology (Preferred Reporting Items for Systematic reviews and Meta-Analyses) is used. This methodology was published in 2009 and designed to help the authors of systematic reviews transparently document the reason for the study, what the authors did and what they found (Yepes-Nuñez et al., 2021). Likewise, it allows good development and planning to reduce bias, as well as eliminate irrelevant or low-quality studies (Linares-Espinós et al., 2018). To complement this study and carry out a more exhaustive analysis regarding the bibliometric analysis of the literature, the software tools VOSviewer and CitNetExplorer were used to create a system for evaluating, measuring, rating, and comparing search results.

Within the study selection process, inclusion and exclusion criteria have been established to determine the relevance of these. First, documents such as books, reports, theses, schematics, etc., will be discarded. Therefore, for this research, we are considering those scientific articles whose publication date is within the range of years from 2018 to 2020 since, when the review of the 2021 publications was carried out, they were still under development. Second, articles whose original language is English (international) or Spanish (Ibero-American) are considered. Thirdly, the information was collected through two search options for internationally produced scientific data:

- Scopus de Elsevier.
- Web of Science (WoS) de Clarivate Analytics.

Finally, the information has been selected through the search fields such as article title, abstract, and keywords.

2.1 Search Equation

The process for developing the search equation consisted of combining keywords and operators in the Scopus and Web of Science databases, introducing Boolean operators, AND and OR to extend or refine the search.

The search equations were established with the keywords specific to the research topic, in Table 1 the terms used are specified, such as Machine Learning, Artificial Intelligence, Human Resources Management, Human Talent, Compensations, Training and Private Sector. (Table 1)

Table 1. Search equation

Data base	Equation
Scopus	Article title, abstract, keywords (machine learning) or article title, abstract, keywords (artificial intelligence) and article title, abstract, keywords (human resources management) or article title, abstract, keywords (human talent) or article title, abstract, keywords (compensations) and article title, abstract, keywords (training) or article title, abstract, keywords (private sector)
WOS	TS= (Machine Learning) OR TS= (Artificial Intelligence) AND TS= (Human Resources Management) OR TS= (Human Talent) OR TS=(Compensations) AND TS=(Training) OR TS= (Private Sector)

2.2 PRISMA Method

As part of this research work, the most didactic and orderly PRISMA method in the search for information was considered. In Figure 1, in the first section, the question that seeks to be answered was raised by applying selection criteria (inclusion and exclusion) to delimit the range of the investigation. For the extraction of information, the Scopus and Web of Science databases were used, as well as the Excel, VOSviewer and CitNetExplorer software.

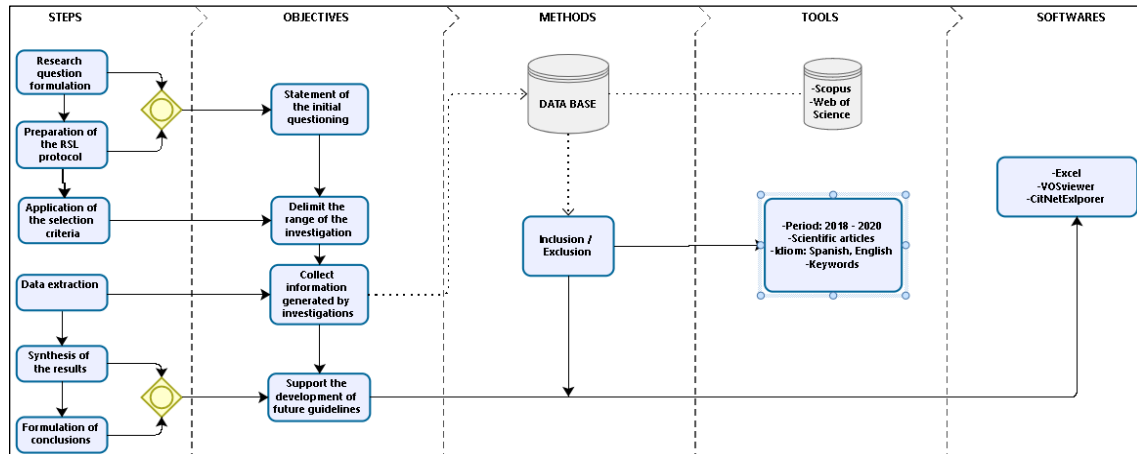


Figure 1. Prisma method

3. Findings

The search was performed in the Web of Science and Scopus databases. It is visualized in Table 2 that the time period from 2018 to 2020, the type of document was filtered to scientific article, whose topics are engineering, business and management, neuroscience and machine learning. Likewise, the selected language was English and Spanish. With this, the documents that were obtained under the inclusion and exclusion criteria were 214 scientific articles.

Table 2. The selection process for items based on inclusion criteria

Inclusion and exclusion criteria		Web of Science	Scopus
Result from a search equation		35146	821
Time Window	2018-2020	13145	341
Document Type	Scientific Article	1082	171
Theme	Engineering, Business and Management, Neuroscience, Machine Learning	3891	91
Language	English and Spanish	137	77
Articles that answer the research question		137	77
Total, Articles		137	77

In the attached Figure 2 it can be seen that the largest collection of selected scientific journals were obtained from the Web of Science database, which were 137 equivalent to 64.02% of the total, while in the Scopus database 77 equivalent articles were selected. to 35.98% of the total.

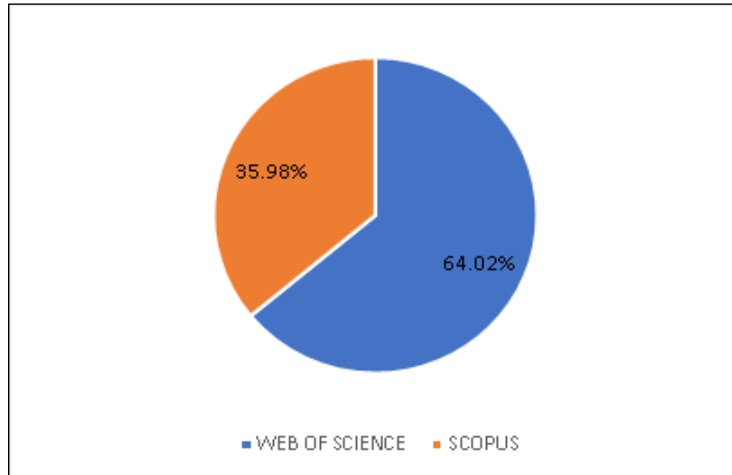


Figure 2. Publications by database

In accordance with the principle of incorporation and discard, when filtering the scientific journals by the range of years of publication, it is visualized in Figure 3 that the largest number of articles were obtained in the year 2020, while in the year 2018 it was the highest. minor, representing 57.48% and 14.02% respectively of the 214 selected articles. Likewise, it is evident that the interest in research topics has been increasing over the years.

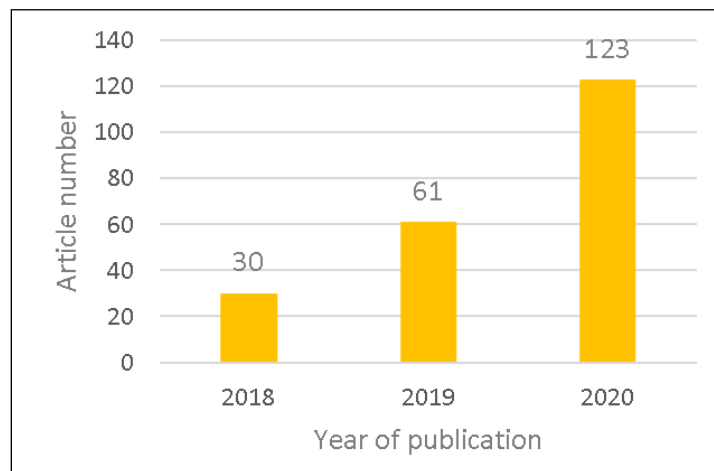


Figure 3. Publications by year

Publications by country of origin were also analyzed. Figure 4 shows that the country with the highest number of investigations is China with 44 journals equivalent to 20.56%, followed by the United States with 14.49% and England with 10.76%. Likewise, the countries with the least research are Australia with 4.67% and Brazil with 4.21%.

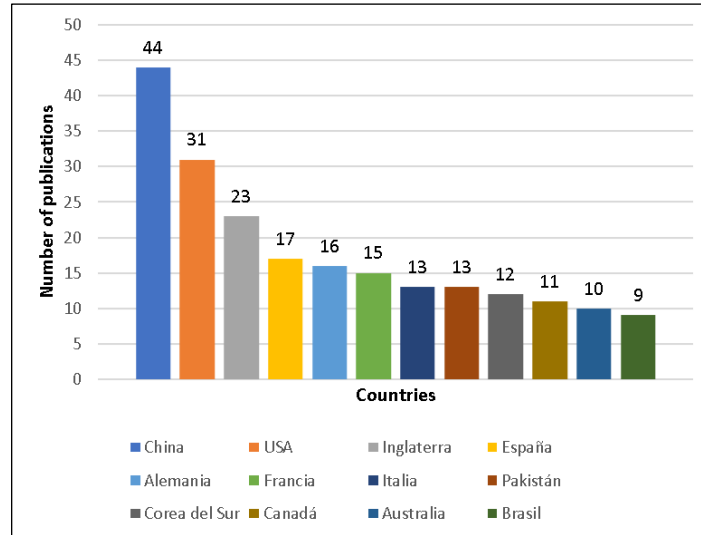


Figure 4. Publications by country

Figure 5 shows the heat map in which a scale of cold and warm colors is used that helps to understand which focuses generate interest among users and which go unnoticed. It can be seen that in the research the topics of Machine Learning and Human Resources Management predominate.

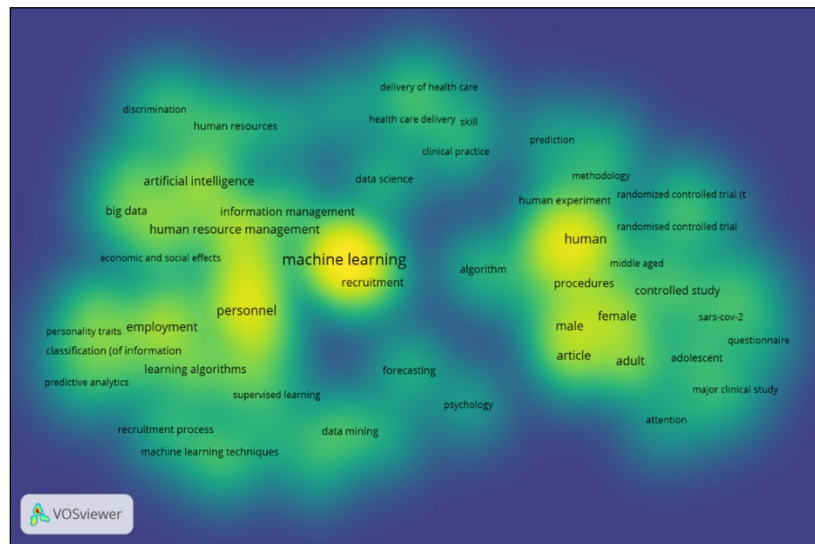


Figure 5. Heat map

The VOSViewer tool has been used to visualize and analyze bibliometric networks. The bibliometric analysis of Figure 6 allows us to observe how the research areas and topics are related to the years of publication, for which nodes have been built that represent keywords obtained from abstracts and bodies of research articles.

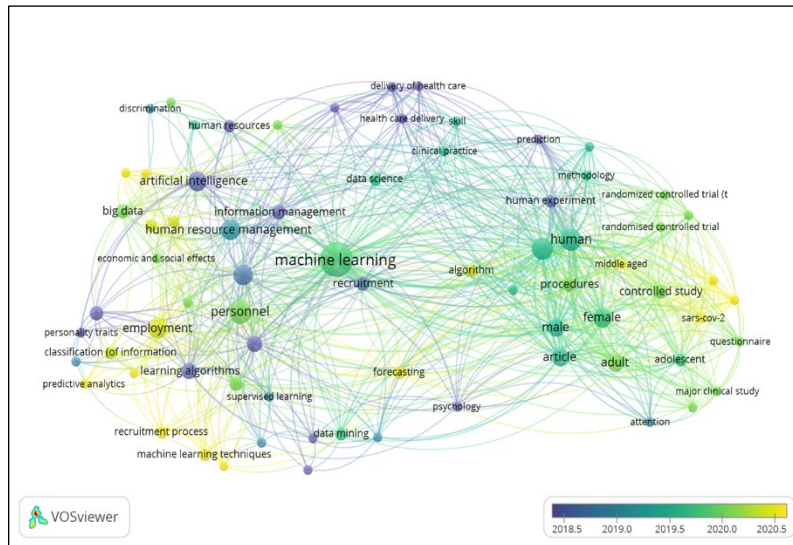


Figure 6. Bibliometric network

4. Discussion

From the systematic mapping carried out in this research study, some impacts are established regarding the advantages and shortcomings of the different selected works.

Most of the works consulted provide a great contribution from the Machine Learning tool, the emergence of innovative approaches has posed significant challenges to human resources management. The constant development of data and the development has required an update of skills that include Information Technology skills, communication, and business knowledge. This creates a challenge for organizations in their quest to improve the talent of their workers. (De Mauro et al., 2018).

However, these studies have some flaws that make it possible to establish several gaps in relation to the research theme. In this sense, the main openings of these are addressed below to establish a point of suggestion in this study for the generation of new knowledge around this tool, Machine Learning and Human Resources Management. For example, although humans design the algorithms for machine learning, the decisions made by the machine will be different from those made by humans because of the precision it has (Nishant et al., 2020). AI is not limited to imitating human tasks but is capable of surpassing the expert in the field of decision-making, as it has lower error rates when identifying patterns that are imperceptible to the human eye, which makes it a tool with a focused approach. Different from the traditional one (Dorado-Díaz, 2019).

Machine learning is a powerful and innovative tool for data extraction, but there is little evidence in stand-alone networks. Some limitations for this tool to work are data limitation, cost of computer resources and storage (Ayoubi et al., 2018). The field of ML is linked with other areas, such as simulation, modeling, system optimization, and statistics. The mathematical techniques require specific training (Nuñez et al., 2019).

5. Conclusions

A wide range of master data based on the analysis of selected journals and citations using bibliometric mapping, has been used to conclude the research work. Therefore, it is intended to answer the questions raised at the beginning of this paper.

¿What is known about Machine Learning and Human Resource Management in the private sector?

Thanks to the continuous development of technology and the Internet, large amounts of data have been developed, and these are often characterized by being of large volume, which poses challenges for their analysis (Cai et al., 2019). Machine learning techniques can effectively support this analysis to discover complex patterns that allow the data to be identified and categorized (Caggiano et al., 2019). ML is more accurate than human classifiers in a variety of test and training data sets and across all assessment panels (Goh et al., 2020).

In this sense, researchers use the Machine Learning tool because it can learn the relationship between the input and output variables of a data set; these relationships can be summarized in generalizations to make informed decisions under new conditions (Cipullo et al., 2019). On the other hand, human resource management is an essential factor for organizations seeking a competitive advantage (as reported in Mauro & Borges-Andrade, 2020). Innovation is sought, and this is based on a network of joint actions to enhance the competitiveness of the company (Alves et al., 2018). To complete this process, operations must be expanded beyond the shareholders' economic goals (Macke & Genari, 2019). Therefore, continuing education is essential to enhance professional skills since it allows professionals to maintain quality and knowledge standards in their work practice (Mejía et al., 2020).

¿What are the difficulties in artificial intelligence technology regarding the issue of performance assessment?

Staff appraisal is of great importance from both the employee and the organization perspective, to establish efficient evaluation methods that are closely linked to the achievement of organizational goals (Rahimli, 2020); however, it faces a number of serious challenges, such as the lack of critical evaluation data, the demand for the Big Data process, the demand for simple expression of trust and the expectation of automation (Wang et al., 2020), for example, emotion detection is a challenging problem in text analysis, most existing work on emotion detection uses less efficient machine learning classifiers with limited data sets, leading to performance degradation (Asghar et al., 2020). Also, Enron's email corpus, which is a test case, to demonstrate how fingerprints can predict such phenomena (Gelbard et al., 2018). Also, another of the biggest challenges in data storage today is the speed of transactions. There are different types of databases that can be used; relational (SQL), nonrelational (NoSQL), and NewSQL (Lasluisa et al., 2020).

¿What Machine Learning techniques have been used to improve the Human Resources area?

Artificial intelligence techniques help automate enterprise master data for generating reports and predictions (Dutta et al., 2020). One of the techniques used is random forest classification, which facilitates the classification of employees according to their monthly income and the informal way of performing data analysis (Kakulapati et al., 2020). Another technique used is "the latent factor (LFM) and the deep forest algorithm to optimize and integrate key recruitment links into the human resource system" (Xie, 2020), There is also another technique such as the Generalized Linear Model (GLM), in which linear regression and binomial distribution are used to predict employee participation, so that employers can make relevant decisions about their employees (Choi et al., 2020). Also, the classification and regression tree (CART) to predict the intention of staff rotation (Kang et al., 2020) and the data-based and the multi-attribute decision-making method that fuses artificial intelligence so that HR managers can select staff more objectively (Chaung et al., 2020).

The Variable Order Bayesian Network (VOBN) model can be applied for recruitment data. Specifically, an exceptionally large dataset containing history of employees who were hired over a period (Pessach et al., 2020). The Intelligent Information System Resource combines the Intelligent Decision Support System tool and the Knowledge Discovery in Database (KDD) to optimize HR decision-making process (Masum et al., 2018). Another important factor is the wear and tear of employees that can have an impact on low performance in their work and even on the abandonment of work (Jain et al., 2020). ML can be applied to obtain data from the job application form and thus develop interpretable measures of the relevance of work experience, the history of permanence and the history of rotation to hire good employees (Sajjadiani et al., 2019).

¿What are the main advantages and improvements offered by the Machine Learning tool that can benefit the compensation process?

The world's most valuable resource is no longer oil: it is data (as cited in Bravo et al., 2020). This is how the Machine Learning tool promotes strategies for the management of human capital based on data consumption. This data can be used to constantly review and modify strategies. Predicting results is fundamental in many areas of organizational research and practice (Putka et al., 2018), the algorithm allows to identify which of the previously defined patterns (learned by the algorithm) the new data best fit and whether the ML algorithm is really achieving an efficient classification of the existing patterns among the data. For this purpose, they use a series of indicators such as precision, sensitivity, or specificity, among others (Vázquez-Marrufo, 2021). Also, there are investigations where the increase in equity in hiring and hiring is evidenced, identifying and attracting talent. Well, AI reduces the risk of bias in hiring by introducing merit by algorithm (Szechter et al., 2020, 75). In addition, it is feasible to build an Artificial Neural Network (ANN) by integrating a Discrete Hopfield Neural Network (DHNN) and a Clonal Selection Algorithm (CSA) with 3-Satisfaction logic (3-SAT) to initiate a model that optimizes tasks. (Zamri et al., 2020).

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Biographies

Mario Francisco Cueva Mayo is a bachelor's degree in Industrial Engineering from the University of Lima with knowledge in the area of Human Resources and is interested in the strategic management of talent.

Kamila Alejandra Chiroque Valencia graduated from the University of Lima with experience in Information Security in the financial sector.

Martín Fidel Collao-Díaz at ESAN University and Industrial Engineer from the University of Lima specialized in supply chain management and operations. A leader with more than 25 years of local and international experience in national and multinational companies in the industrial, hydrocarbon, and mass consumption sectors. Broad experience in supply chain management (purchasing, inventory, suppliers and supply sources management, logistics: transport, distribution, and warehouse management), operations (planning and control of production and maintenance), and integrated system management (ISO 9001, ISO 14001, and OHSAS 18001). Business alignment based on sales and operations planning (S&OP). Besides, continuous search for improvements in profitability based on process optimization and saving projects using tools such as Six Sigma methodology, among others, focused on being a High-performance Organization (HPO). Development of a high-performance team. Member of IEEE and CIP (College of Engineers of Peru).

Juan Carlos Quiroz-Flores is an MBA from Universidad ESAN. Industrial Engineer from Universidad de Lima. Ph.D. in Industrial Engineering at Universidad Nacional Mayor de San Marcos, Black Belt in Lean Six Sigma. Current is Undergraduate teaching at Universidad de Lima. Expert in Lean Supply Chain and Operations with over 20 years of professional experience in the direction and management of operations, process improvement, and productivity; specialist in implementing Continuing Improvement Projects, PDCA, TOC, and Lean Six Sigma. Leader of transformational projects, productivity, and change generator. Capable of forming high-performance teams aligned to company strategies and programs for "Continuous Improvement". "He has published journal and conference papers. His research interests include supply chain management and logistics, lean manufacturing, lean six sigma, business process management, agribusiness, design work, facility layout design, systematic layout planning, quality management, and Lean TPM. He is a member of IEOM, IISE, ASQ, IEEE, and CIP (College of Engineers of Peru).

Alberto Flores-Pérez holds a doctorate degree in Education from Universidad de San Martín de Porres. Master's degree in Supply Chain Management from Universidad ESAN. Engineer in Food Industries from Universidad Nacional Agraria La Molina. Currently working as an undergraduate professor at Universidad de Lima and postgraduate professor at Universidad Nacional Agraria. Professional, consultant, businessman and professor with more than 27 years of experience in project implementation, quality management and safety and agro-industrial plants' management. Expert in Supply Chain (supplier management, storage systems, transport modeling and distribution systems), Supply Chain and Operations. Specialization in integrated management system audit and Shortsea Logistics at the Escola Europea Short Sea Shipping. Leader of transformational projects, productivity, and change generator.