

THE IMPACTS OF THE FOURTH INDUSTRIAL REVOLUTION IN PEOPLE AND ORGANIZATION ENVIRONMENT.

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Abstract.

One of the biggest challenges of the 21st century for organizations is to follow the changes brought by new technologies and their trends, impacts and interrelationships, which occur at an exponential speed hindering the perception, understanding and requiring a permanent updating of the people involved in this process of transformation. Thus, people tend to maintain their current state of security, for fear of the new and unknown for which they do not yet have full dominion; seeing technological innovations as a threat to their beliefs, habits, knowledge and social position, which can slow down, limit or distort the process of evolution and growth associated with change. In this scenario there is motivation to address the "Fourth Industrial Revolution" from a perspective that allows exploring and simultaneously analyzing the system formed by the dimensions Information - People - Organizations, presenting in this work under the acronym - IPO. The information obtained daily from the data generated, collected, analyzed and processed, so that they become useful and relevant to people, should consider their personalities, exclusive and complex, which are confronted with the constant process of organizational change. The proposal of this work is to evaluate the human role in organizations as central entities in decision-making processes, very linked to greater informational densification and the knowledge required by the "Fourth Industrial Revolution" called "Industry 4.0". It is intended to present a new perspective that enable it to help people understand better and prepare for the future that new digital technologies offer to organizations.

Keywords: The Fourth Industrial Revolution, Industry 4.0, People Management, Organizational Change, Data Preparation, Framework.

1 Introduction

A great transformation of any nature, which occurs suddenly progressively, continuously and sharply, causing great changes and impacts is what we define and known as "Revolution". Throughout history, revolutions have driven human evolution, causing profound and significant changes with immediate impacts not imagined, perceived and understood; but that have brought us to the present, and certainly they will continue to fulfill their role of leading us to the future ^[2]^[17].

The changes are constantly present in our lives, however, we often do not perceive them, we do not understand them, sometimes even ignore them, for various reasons, from the fear of the new and unknown, of trying to maintain our “status quo”, and the inability to treat them appropriately ^[32]. In this 21st century - the age of knowledge - we are again challenged to change, through the information that floods our everyday lives, forcing us to make decisions immediately, either individually, or collectively in public or private organizations ^{[14] [19]}.

This new challenge is named as "Fourth Industrial Revolution", which is the movement of tendency to integrate all available digital technologies, as well as those still to be developed, to improve processes in various sectors, not only the productive of industry, but also in agriculture, trade, construction, health, transport, governments and even in homes ^{[22] [26]}. It is therefore a movement of great amplitude, coverage and impact, that needs our special attention, because it will define and shape our future.

Faced with this challenging new situation, we must ask ourselves: Are people and organizations really ready for the Fourth Industrial Revolution? In order to be able to answer this question, we must look at important perspectives:

- 1) The information available, and that grows vertiginously every day.
- 2) Our personality, individual and collective.
- 3) Organizations, these complex systems composed of persons and information.

This study is an initiative whose objective is to investigate and analyze these three perspectives IPO, considering their interactions, their different levels of maturity and try to answer the question raised, to assist professionals from various sectors in the concepts Fourth Industrial Revolution: the Challenges, Benefits, Opportunities, Impacts and Expected Results.

2 Theoretical Basis

2.1 The fourth industrial revolution and Industry 4.0

The name "Fourth Industrial Revolution" is comprehensive, being defined in several ways by authors in the literature, still without a consensus of a standard description, but which basically synthesizes and refers to the integration and convergence of current digital technologies in the field of manufacture ^[20]. A "revolution" alludes to an abrupt and radical change, which in history began with agriculture and domestication of animals, moved into the production, transport, urbanization and industrialization ^[32]. In order to improve production, from the mid-eighteenth century, man experienced three Industrial Revolutions: 1) mechanization at the end of the 18th century, 2) Electrification in the early twentieth century and 3) Computing in the early 1970s ^{[24] [37]}.

The current movement of the Fourth Industrial Revolution is very recent, presented in 2011 Hannover – Germany, and has been termed in different ways in each country, relating to its innovation programs and technological integration of manufacturing, but the term that gained the greatest prominence and popularity worldwide was even the originally adopted in Germany in 2011: "Industrie 4.0" or Industry 4.0 ^{[4] [12]}. We understand that the great differential between the four revolutions, is that the first three originally occurred within the factories, and then set out to be adopted by the whole

society, industrial machines for trains, both steam-powered, electrified production lines, for the daily life of homes and commerce, from large central computers Mainframes and industrial automation controllers, for personal computers ^{[27][33]}.

However, in this fourth revolution digital technologies are simultaneously present, both in the various personal devices such as smartphones, tablets, smart products; as in industrial control and automation equipment. Due to its scale, scope and complexity, this fourth industrial revolution is already different from everything humanity has experienced so far ^[32]. This new reality requires people to have greater perception, understanding and preparation to be able to deal with the digital technologies that appear every day and that generate other new technologies ^[18].

2.2 The digital enabling technologies

Industry 4.0 is the composition of Cyber-Physical Systems (CPS), which unite the real and virtual worlds, through the various digital technologies present in our daily lives: 3D Printing, Virtual and Augmented Reality, Big Data, Artificial Intelligence, Machine Learning, Cloud Computing, Digital Twin, Digital Shadow, Internet of Things, Collaborative Robots, Smart Factory, Products and Cities, among others ^{[13][18]}.

The principles that guide Industry 4.0 are interoperability, real-time decision making, decentralization, virtualization, modularity and service guidance; and the expected benefits and results are the improvements of production processes, greater human-machine-machine interaction, ubiquity of information, increased safety and reliability, resource optimization, cost and waste reduction, large-scale customization and technological innovation ^{[4][11]}. However, technologies should not be seen as external forces that control and dominate us, but seen as an opportunity, and an invitation, to reflect on our role in the world, to shape and direct our future. So, technology and humans must coexist ^[32].

2.3 The data and information

The basis of these technologies is data, which are generated daily, and in large volume, by various devices in industrial, commercial and residential environments. Because data is a valuable raw material still in “raw” form, through mining algorithms and methodology KDD - Knowledge Discovery in Databases, they are processed to improve their quality, usability, accessibility and portability ^[7].

Once transformed, data can provide useful and relevant information so that people can make agile decisions, an important feature that denotes the ability to analyze and implement real-time changes required by the Fourth Industrial Revolution ^{[11][16]}. For this, it is important that the visualization and representation of the data facilitate their understanding and analysis, expanding the cognitive capacity of the human being in his learning process, organizing the information, recognizing patterns, facilitating the deduction and completion, detecting the expected and discovering the unexpected ^[34].

Organizations seek, from the knowledge discovered, to identify patterns that serve as the basis for establishing actions in their operations, and that are adherent to their business models, and to this end, they use process mining methodologies that subsidize managers in understanding the operation of the organization, and make decisions

aligned with strategic planning ^{[3][35]}. Because of its importance, the data is evaluated according to parameters of Integrity, Consistency, Credibility, Accuracy and Clarity, and questions of "How can we use this data productively?" and "What can we do with this data?", are pertinent so that any analysis algorithm can discover models and patterns, relevant characteristics or hidden trends in organizational historical records, the so-called "Event Log" ^[15].

2.4 People

Because personality is unique and exclusively to each one, their combinations when grouped, generate sets of information and build organizations also exclusive and unique, which makes the entire system very complex and dynamic. Therefore, people are the central point of this system, and should be considered primarily in research studies. In this sense, since the emergence of the concept of Industry 4.0 in 2011, human skills, abilities and qualifications have been addressed in order to better prepare people to enter the context of Industry 4.0.

These attributes are technical-social in information technology, knowledge of new technologies, information analysis, organizational and business understanding, ability to work and interact with modern interfaces and media, integration of different processes, management and transfer of knowledge, networking, communication and linguistic skills, teamwork and self-management ^{[10][37]}.

Studies on the subject, for the most part, still address more the technical aspects of technologies relevant to Industry 4.0, than the management issues and organizational culture. The effort is to balance skills simultaneously in the fields of technical, social, personal and methodological knowledge, conflict resolution, decision-making, aggregating values, norms, beliefs, attitudes, how activities are performed, the way people behave, their flexibility, tolerance for change, leadership, motivation to learn, commitment and cooperation, ability to work under pressure, thinking about sustainability and ethics ^{[10][23]}.

Human Resources Development (HRD) will be important in this context, both to define the technical-social role of people within the new processes, through a systematic approach evaluating their maturity levels with appropriate tools and supporting them in order to reduce the level of inhibition and support the process of change, by a transparent and open communication culture ^[27]. Professional Management includes studies with proposals of HR-oriented life cycles, which consider planning, attraction, recruitment, support, skills areas, retention and leaving of the system employee, when then a new cycle begins with a new hiring planning ^[28].

The process should be holistic due to the need for a higher level of preparation for the professional, where the challenge is to work simultaneously to acquire new skills that will become important, and the improvement of current fundamentals that will remain at the heart of qualified work education. In addition, studies recommend that the process consider the transformation from early childhood education, the school transition process to work, and continuing vocational training ^{[10][37]}.

It seems that the fourth industrial revolution is only at a very early stage, not yet fully understood, what its effects may be on society, companies and individuals, and

organizations will have to deal with a paradox of being open and adaptable to external effects; and be stable internally to maintain knowledge and intellectual property [28].

2.5 Organizations

Traditional hierarchical models of shop floor, office and peripheral departments of logistics, inventory and support; do not fit in the new concept of the fourth industrial revolution^[24] that presents an autonomous intelligent manufacturing model, where physical and cyber systems interact instantly, where artificial intelligence allows better human-machine-machine communication, in collaborative and interactive work, with control and monitoring of the entire process, with a self-organization capacity without human intervention, supported by a infrastructure of the Technology Information and Communication, digital modeling, data collection, storage and processing system^[37].

What is required here is a long-term transformation of our global perception of industrial production through the perfect connection of the digital and real worlds, where the principles of this new factory design are modularity, decentralization, virtualization, service orientation, real-time capacity and interoperability^[13]. This new manufacturing configuration is a four-dimensional physical-cybernetic system: factory and smart products composing the real physical world; and data-driven operations and services, these in turn, composing the virtual world^{[18][21]}.

Interoperability functions as a catalyst, as it allows continuous communication between machines and systems, in open standards with flexible interfaces, providing a layer where everything works in an integrated way - information, services and processes - and some authors include perspectives of organizational, economic aspects, technological and social changes^{[5][11]}.

2.6 The requirements, challenges and barriers to Industry 4.0

The challenges and barriers to be transposed into the implementation of Industry 4.0 are multifaceted and related to: cultural factors of people and organizations, technology and innovation, infrastructure, qualification of labor, communication, economy, jurisdiction, politics, environmental, social, accelerated pace of new technologies, difficulty in understanding and absorbing the theme since it is still very incipient^{[31][33]}.

The main feature of the Fourth Industrial Revolution is real-time decision making and response, and following in this sense, companies should be agile to develop in an environment still uncertain and turbulent. They should understand changes in a competitive environment, with immediate demands from integrated platforms and data-based business models^[22].

Factories will also innovate with new requirements for their physical-digital infrastructures that consider the product lifecycle at all stages of integrated production, sensors and humans integrated, the digital shadow that creates a virtual model of all things, cloud computing-based platforms, data such as the raw material (Big Data/Analytics), Internet of communication, all things people and services^[18].

The Implementation of the innovative project of Industry 4.0 is a challenging process that requires a long-term plan, so-called Roadmap, which evaluate internal (vertical) and external (horizontal) scenarios of organizations, from a strategic perspective,

considering existing technologies and experiences, combined with the research of new solutions and markets^[11]. Roadmap models developed by researchers consider different perspectives structured in phases or steps that address in general the creation of an initial common understanding, identifies and evaluates the different scenarios relevant to the organization, prioritizes and prepares the implementation plan^[12].

At a greater depth of detail, the following phases are considered: 1) perception / visualization are considered, 2) activation / understanding 3) promulgation / implementation. In (1) perception / visualization, the organization is conducted the familiarization of the concept in general lines, develops its own understanding, its objectives to be achieved in its strategic vision. In (2) activation / understanding your business model is defined, and the main strategies are outlined, considering the market to be reached, the product processes and the value network, relative to the timeline. Finally, with the (3) promulgation / implementation, the projects are evaluated prioritized and integrated, the existing ones and the ones to be created, according to the allocation of the resources available by the organization^[6].

In more elaborate long-term plans, the vertical and horizontal perspectives of integration in the value chain, the product and project lifecycle, personnel infrastructure and the development of new associated technologies are considered^[4].

In this regard, a recent study^[30] proposes the introduction of a methodology using multi-criteria decision making and analysis (MCDM/A), which allows the evaluation between systems for the implementation of projects related to Industry 4.0, consisting of six steps: 1) Process evaluation, 2) Project definition, 3) Local systems assessment, 4) Legacy systems assessment, 5) Choose better solution and 6) Decision-Making.

Throughout the Industry 4.0 process, the main focus is people, for whom the entire production system exists, with actions focused on human requirements, desires and capabilities, that will be at the heart of the future world of goods. People will have collaborative robots (Cobots) on their side that will support them in non-ergonomic activities, heavy cargo handling tasks or dangerous that requires high levels of accuracy and speed, or that are cognitively stressful^[18].

3 Framework

Due to the need for a better understanding and organization of the different perspectives related to the trinomial IPO – Information – People - Organizations, this work proposes the framework as shown in figure 1, which will be detailed in this section.

The purpose is to present a new perspective that enable and to help people understand better and prepare for the future that new digital technologies offer to them and to organizations.

In the course of the qualitative review of the selected literature, it is noted that scientific papers raise the themes pertaining to the trinomial Information - People - Organizations, with approaches to knowledge management^[1], communication in organizations^[9], Roadmap for the implementation of Industry 4.0^{[8] [25]}, digital maturity in organizations^[29], and the management of intellectual capital^[36].

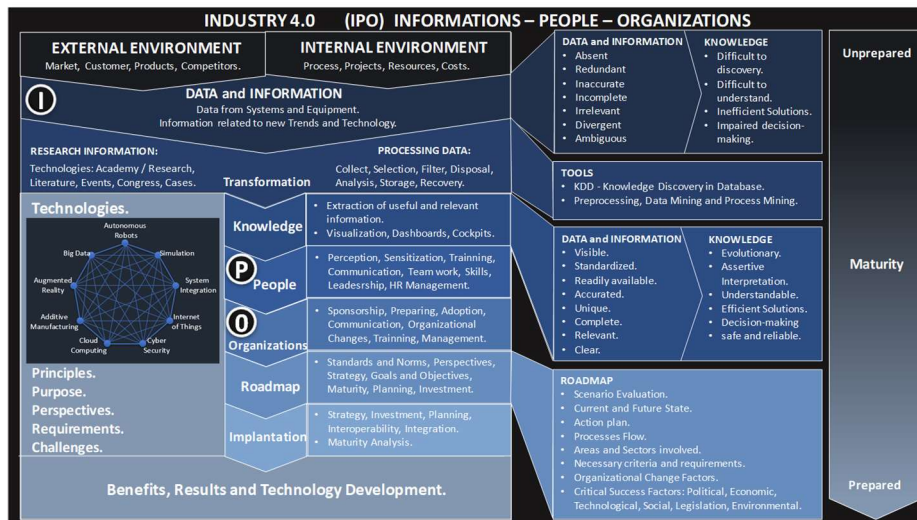


Fig 1. IPO - Information - People - Organizations. (Source: Prepared by the authors).

However, it is observed that these works focus more on the implementation of Industry 4.0 from the perspective of organizations, on technologies, presenting Frameworks addressing processes, business models, organizational structures and culture, competencies, knowledge and market management [8] [25]. It is perceived that there is a lack of approach regarding the training and improvement of people, professionals who will implement Industry 4.0, regarding the challenges and barriers to be overcome, and especially a guidance for people to situate themselves, understand and assimilate this new concept and the disruptive technologies [1] [8] [36].

The studies consulted point out that the challenge is to develop organizational and people's capacities, and that there are attempts by leaders to promote digital transformation and the training of professionals, but there is a lack of clear definition of strategies to implement Industry 4.0 [9] [25]. Also point out a lack of understanding of technologies addressing the basic and front-end, seeking to discover what are the current patterns of adoption of such technologies [8].

The process of structuring this work considered the election of topics of interest, which are data and their processing, people and organizations within the context of the fourth industrial revolution. A selection of the most recent scientific articles was then made, expanding the scope with methodologies, frameworks, maturity evaluation, contextualization of concepts, challenges and opportunities related to Industry 4.0.

Once the articles of interest were selected, a qualitative review of the literature was made to create a structured framework that will serve to guide the concepts and that can be evaluated subsequently for an investigation of their applicability as to feasibility, usability and usefulness. Based on it, to build up the Framework was considered:

- 1) Strategic analysis for internal and external environments [6] [17] [19] [21],
- 2) The nature of the data and information [3] [5] [7] [34],
- 3) The mining and processing process [15] [16] [35],
- 4) The acquired knowledge obtained [4] [6] [12] [14] [20] [24] [32] [33],
- 5) To the people and their skills and abilities [10] [23] [26] [37],

- 6) The organizations, their culture and structure ^{[11] [14] [17] [18] [21] [22] [23] [28] [31]},
- 7) The Roadmap s guidance roadmaps for Industry 4.0 ^{[4] [19] [27] [30]},
- 8) As strategies for deployment, its concepts and enabling technologies ^{[2] [4] [5] [13]},
- 9) Benefits and results expected with technological and digital transformation ^{[19] [33]}.

As a practical result, we hope that this framework will contribute to the main points of the organizational process of analyzing the internal and market environment, data processing and knowledge discovery. Also support the awareness and empowerment of people to adopt Industry 4.0. Finally, assess the maturity to plan the implementation of digital transformation and the technological development of organizations.

The work on the subject, and used as a reference in this study, covers under different prisms, the elements of the IPO trinomial - Information – Persons – Organizations, from an overview on Industry 4.0 ^[17], analysis of the maturity of companies ^{[2][13]}, interoperability ^[5], data mining and processes ^[35], data preprocessing ^[15], the prospects of the future ^{[20][24]}, requirements ^[21], challenges ^[31], success and change factors ^{[22] [33]}.

They also bring the issues of people management^[28] and leadership^[26], organizational changes^[23], and finally, the Roadmap for the implementation of Industry 4.0, from the perspective of organization and technologies ^{[4][6][12]}, standardization ^[19], and the necessary skills of human resources ^[10]. These approaches focus on one of the IPO trinomial items, typically discuss the issues of more technical aspects with less approach to social, managerial and organizational issues ^[23], allowing new studies to explore the connection of data and information, with people and organizations.

From a strategic point of view, organizations consider the analysis of the external environment, with the demands of the market and customers, the products and services of interest and their position facing their competitors; and also assess their internal environment, where they consider their processes, projects, resources and cost structure, in order to be prepared internally to take advantages of market opportunities.

The theme of the data is treated with a focus on the technical field, considering its nature and processing, but that could be treated on a more underlying basis for people and organizations. The data are generated by systems and equipment, processed and transformed to be consumed as information by people, and that due to its increasing quantity, requires a preparation, effort, careful and attention, which once neglected, results, inefficient solutions and impaired decision-making.

The visualization of information should be a point of attention, where the human being must be able to access, identify, analyze, understand easily, immediately, simple and that does not require great efforts, all content provided by the equipment and systems, so that they can make their decisions. All this is achieved through interactive dashboard and cockpit scans that explore the easy and intuitive visual operation present in much of today's digital media.

The relevant information related to the new technologies need to be addressed in order to show their state of the art, and thus support people to identify existing skills, and the needs of new developments with media and information security issues, the understanding of the processes and methods necessary for the awareness, comprehension and implementation of Industry 4.0 ^[37].

Such information needs to consider influencing and limiting factors of knowledge that provide correct interpretation, contribute to the gain of new knowledge that is

necessary to develop human skills and capabilities of self-management of time, teamwork, communication, adaptability to changes, understanding organizations and processes, analytical capacity, considering continued learning.

It is of great importance in the management cycle of people a balance between technical and social factors, with the development of attributes related to conflict resolution issues, decision-making and tolerance to pressures and changes, systematically allied to technical training issues in order to support people's maturity over Industry 4.0 [28]. Studies indicate that the social factor is fourth among six success factors in the implementation of Industry 4.0 in organizations, behind technology, legislation and politics, and ahead only of economic and environmental aspects [33].

Studies also recommend a massive investment in data to ensure its quality standard to leverage industry potential 4.0 [14]. The big challenge lies in preparing professionals specialized with knowledge in Information and Communication Technology (ICT), social and media skills, especially for small and medium-sized companies, which still fail to evaluate and understand the potential of Industry 4.0 [11]. Considering that this fourth industrial revolution is in its early days, and not yet fully understood by people, careful and adequate preparation of data and information is necessary so that they can be properly visualized and consumed by people assertively.

Organizations develop their business plans considering strategic perspectives, management, culture and people, using the data generated by their most diverse systems and equipment, seeking to discover patterns and knowledge so that decision-making in their operations is aligned with their business models and strategic plans [22].

Studies on Industry 4.0 take a large approach from the perspective of enabling digital organizations and technologies, their areas of knowledge, the guiding principles of this industrial revolution, strategies, investments, infrastructure and physical-digital systems, maturity analysis and implementation of roadmaps with analysis of benefits, capacities and filling of knowledge gaps, always from a technical perspective [4][6][12].

These scripts are presented as guides or tools that show macro process flows, defining phases and steps to follow, indicating the areas and sectors involved, highlighting the critical success factors, patterns to follow and the necessary requirements, emphasizing the technical aspects and relegating human/social factors and data/information to "supporting" elements.

However, the perception or visualization of the new industrial revolution configures precisely as starting point factors for the entire process of these scripts, and therefore require special attention in the Information & People interrelationship. Data transformed into information are basic elements that are directed at correct decision-making, and it is essential to consider the nature of its parameters regarding integrity, consistency, credibility, accuracy and clarity.

The roadmap for the implementation of Industry 4.0 is challenging and requires a simultaneous analysis of the information available, of the people involved, the requirements and criteria to be followed between both, integrating the company internally between its departments, as externally in their chain of suppliers and customers, and improving existing knowledge with new ones. Thus, strategic objectives can be evaluated, prioritized and achieved.

With people already sensitized and prepared for the process of adoption of Industry 4.0, one should seek the discovery of knowledge from the data, considering its content and nature, the way they are collected, their standardization and semantics, the mode of preparation and processing, which allow an accurate analysis, interpretation, visibility, understanding, and which, finally, enable the discovery of patterns and knowledge that lead to efficient solutions by the decision-making persons.

The process of knowledge discovery in databases (KDD) includes the selection, processing, mining, and evaluation steps, each of which can go back a previous phase. Among all of them, preprocessing is the phase that requires attention and demand a large amount of time and is determinant in the results of subsequent phases regarding the processing time and quality of the final product that is knowledge.

Preprocessing is often abbreviated and even neglected, compromising the knowledge obtained, when the original data collected are not properly analyzed in advance as to its absence characteristics, inaccuracy, redundancy, ambiguity, irrelevance, lack of pattern, manual collection, texts with personal language, erroneous transcriptions and subject to different interpretations.

Thus, its analysis is limited, restricted interpretation, difficult to understand, demanding excessive time for processing, which in the end hinders the extraction of knowledge and lead to inefficient solutions and compromised decision making.

With people already sensitized, data transformed into useful and relevant information and organizations with its planned deployment roadmap, this trinomial IPO can be integrated, forming a system that provides the perception and understanding of the concept of Industry 4.0, facilitating and preparing the development of human skills and abilities, for the adoption and implementation of new digital technologies, taking advantage of their opportunities and benefits and overcoming challenges and barriers.

4 Conclusions

The challenges and barriers to be overcome may be related to technological, cultural, political, social, environmental and financial factors, and also incomplete, inaccurate, distorted, divergent, absent, redundant or ambiguous information, which can directly affect people's understanding and implementation of Industry 4.0, and may even drive their rejection and abandonment altogether.

We therefore believe that the data and information arising therefrom are the underlying basis for people to have full mastery of this new concept, understanding the true potential of technological innovations and their benefits, from their comprehension until its effective implementation, leading to discoveries of efficient solutions and decision-making and the correct implementation of Industry 4.0 in its organizations.

Analyzing studies in the development of this work, the authors' perception is that all those consulted mostly address and emphasize one of the items of the Trinomial IPO, not exploring the potential of integration between them within the current movement of change digital technology. The management and information technology systems are increasingly required, leading organizations to face new and challenging borders, where people are required to improve their skills and knowledge to monitor

the growing wave of these new technologies and where data is not always transformed into adequate information.

The great challenge is to realize the interrelationships of the trinomial IPO so that the process of awareness, sensitizing and implementation of the concept of Industry 4.0 is a success, and thus provide competitive advantage for organizations to achieve their strategic business objectives.

Based on the findings of the articles researched in this present work, the question initially proposed: "Are people and organizations really ready for the Fourth Industrial Revolution?" is an open issue; is still a challenge. Therefore, future studies will need to deepen the theme, considering that the approaches should include the three elements of the trinomial IPO - Information - People – Organizations, so that the concept of Industry 4.0 is adopted and implemented more assertively in organizations.

5 References

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