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Characteristics and Skills of Leadership in the Context of Industry 4.0

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Abstract

Leadership is essential in organizations to successfully promote a culture of innovation. Consequently, leaders assume a crucial role in the paradigm shift towards Industry 4.0. This paper aims to present key leadership characteristics and skills in the context of Industry 4.0. It was based mainly on a literature review about leadership and Industry 4.0. This work results in 10 leadership characteristics found for industry 4.0 and their relationship with 4 leadership skills groups: cognitive skills, interpersonal skills, business skills, and strategic skills. The organizations might consider these skills as requirements for the leaders in the transition process towards Industry 4.0.

1. Introduction

Industry 4.0 (I4.0) is the term to describe the current movement toward a highly connected and automated manufacturing system, or Smart Factory [1]. In a smart factory, human, machines, and resources involved in manufacturing communicate with each other as naturally as in a social network [2]. The smart-manufacturing application depends on real-time data acquisition obtained from sensors and the inclusion of connectivity in discrete industrial components [3]. In addition, the investments related to I4.0 implantation, digital technologies, like sensors, connectivity devices, software and applications as manufacturing execution system (MES) [4] play a particularly important role.

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I4.0 can be considered as the movement toward a digital revolution in manufacturing [1]. In this context, the digital environment embraces the fusion of the virtual and real world and the digitalization of processes [5]. The digital industrial revolution promises to improve the flexibility in the manufacturing systems, the mass customization, the increase in the velocity and the upgrading of quality and productivity [6]. Meanwhile, to reach these benefits, the companies will need to invest in equipment, information and communication technologies, data analyses, as well as in the integration of all data through the value chain [6]. Not only are these investments can be expensive, but the changes and interventions in processes at all levels of value creation involve the risk that stable process chains may get out of balance or get significantly disturbed.

For organizations, leadership plays an important role in I4.0, as the change mode of production calls for far-reaching strategic decisions at all levels of the organization. [1]. In this context, future leaders will need to be more responsive to perceive the patterns and signals shown by network data [7]. They should estimate a collaborated direction from multiple agents in a constant field of growth, change, and opportunity [7]. These leaders will need to cultivate connected organizations and networks to understand the science of connectivity and organizational network learning [7].

R. Kelly [7] shows phases to characterize leadership for each Industrial Revolution (IR). For the first IR, *charismatic leadership* [7] is related to how leader act and mobilize an organization through actions and personal characteristics [8]. The second IR was strongly shaped by scientific management, in which leaders assume a top-down style, while they could be characterized as a *directive leadership* [7]. For the third IR, leadership is characterized by *relational leadership*, considering the theories of transformational leadership [7] to stimulate the autonomy of followers for new ideas, collaboration among them [9]. The third IR is also characterized by *transactional leadership* more conducted and recognized by the achievements of followers' goals [10]. The fourth IR requires both existing characteristics and new required characteristics from leadership, that will be approached through this study.

Further, I4.0 needs more than a *transformational leadership*. It needs also a more specific focus on learning and innovation [11]. A. Haddud and D. McAllen [12] emphasize the importance to know and to understand more about characteristics and skills of leaders in managing effectively digital environments and the alignment of leadership styles with the requirements set by the digital environments. [12]. Thereby, considering that a characteristic of someone is "a prominent attribute or aspect of something" [13], the identification of leadership characteristics in I4.0 context becomes an important issue. It can help leaders to deal with the disruptive changes that arise with smart production systems and support the transition process of I4.0, making them understand better how they should act in such an environment.

The term *skill* is the ability to do something well, embraces the physical, and mental proficiency, that is related to understanding or knowledge of something [14]. Own a skill means a relevant knowledge [15] acquired by training [16], practice and experience [17]. In a digital environment, leaders need to adapt or enhance their skills to act, to anticipate markets and trends, to make an experienced business decision, and to change the plan, if technology and market environment emerge in unexpected ways [18]. However, the leaders need to prepare themselves, updating knowledge, skills and understanding more about which characteristics could contribute to their work in a digital and responsive environment, as expected by the I4.0.

Thus, this paper has as objective to present the main characteristics for leadership in the I4.0 context and the respective skills, which could contribute to develop these characteristics based on a subjective theoretical analysis. For that, exploratory research is noted in this paper. This is because the subject is still ongoing and the knowledge is not consolidated in the area yet. We also believe that a theoretical analysis in the area will contribute to put the paper objective into practice in forward research initiatives. The exploratory review used different bibliographies databases from Web of Science (WoS) and Scopus. Thereby, the structure of this paper is composed of five sections. This first section is for introduction. The second section presents a literature review on I4.0, the characteristics of leadership in I4.0 context and the recommended skills of leaders. The third section shows the methodology of this research, based on a theoretical contribution, and the fourth section presents the results and the discussion of the analysis. Finally, the fifth section refers to the conclusion and potential future research.

2. Literature Review

2.1 Industry 4.0

I4.0 is known as the fourth industrial revolution [4]. Although simple digitalization characterized already the third industrial revolution, the fourth industrial revolution has an inexorable change of this simple digitalization, in which a boost of innovation results from many combinations of technologies in new forms [19]. There are three reasons that can distinguish the fourth industrial revolution from the other ones: first, the *velocity*, about the world's interconnection in an exponential rhythm and the emergence of new technologies, that generate further innovation. The second reason, *breadth, and depth*, considering the third industrial revolution as a referential, combined with various technologies. And the third, the *systemic impact*, refers to the transformation of the entire systems, inside the countries, companies, value creation networks or in the society at all [19].

I4.0 is a collective term for technologies and concepts of organizations in smart connected value creation chains. In the modular structure of smart companies, the Cyber-Physical System (CPS) monitor the physical process to create a virtual copy of the physical world and making decentralized decisions [20]. The Internet of thing (IoT) is considered as the main bridge between physical and digital applications, connecting uniquely identifiable physical objects (things) with a virtual representation in an Internet-like structure. It is no longer just human participants, but things [19]. Hence, through IoT, the CPS communicates and cooperates with the people in real time. In addition, the Internet of Services (IoS) contribute to the internal and cross-organizational services offered for the use of value chain participants [20].

The set of changes on manufacture process, design, product, operation and systems related to the production, is increasing the complexity of products lifecycle and value creation chains [21]. For example, sensors, transmitter or radio frequency identification systems (RFID) at many points along the value creation chain are constantly sending information through the IoT that allows organizations to monitor their processes. [19]. This can be the tracking of transports, material, or equipment but also process parameters or key performance indicators (KPIs).

In the context of the digital era and the cyber-physical systems, customer requirements and the expectation of constant innovation lead to shorter product life cycles and, therefore, present a special challenge for many companies [22]. The technology integration, organizational transformation, data security [22], the incentive of experimentation of new ideas in workplace, acquisition, and implantation of right technologies, and decision-making distribution are examples of challenges in I4.0 environment [23]. To promote cooperation between people, leaders must guide with confidence and agility, focus on communication, and people's capacity to transcribe a vision into something tangible and inspiring [24]. This leadership has to act in and support an agile environment, which is the basis to drive innovations, and to create higher customer satisfaction [25]. Innovative approaches need to create values from digitalization, connected smart devices, and establish new ways of communication and collaboration. These challenges require guided decisions and leadership.

2.2 The Leadership in Industry 4.0 context

Besides the administration of ongoing processes, leadership has to deal with change. It means leading groups or organization to constructive transformation by setting a direction and by aligning people with the strategies needed to achieve a vision [26]. Thereafter, leadership assumes an important role to support this transition towards I4.0. That is the reason why this section presents the approach of leadership in I4.0 context. The term leadership will be known as leadership 4.0, as some authors [7, 25, 28, 39] have been already nominating it.

The implementation of *leadership 4.0* requires investment and *openness* to cultural change. Leadership role assumes a crucial point, since the digitalization is not just through the application of new technologies, but also their correct use [25]. So leadership styles for I4.0 need to be open guiding to a *learning and innovation*-oriented culture, focusing on improving the knowledge and the out-of-box thinking [27]. Also, the fourth IR will be characterized by a *responsive leadership* that is able to respond to situations in an adaptive way [7].

A *leader 4.0* is different from a technological leader, who has the ability to estimate just how new technologies can be used to deliver value, leaving aside focus on people. Alternatively, from a social leader who has the ability to create a friendly environment, putting aside the technologies and innovation approach [28]. According to B. Oberer

and A. Erkollar [28], an ideal style of 4.0 leadership based on their "4.0 Leadership Matrix" is the digital leader, who knows about the importance of people, technologies and innovations. This leader focuses on innovation and technologies, understanding also how technologies impact people and about the alignment of the organizational model with human nature [28].

The leadership 4.0 (or digital leadership) is fast, cross-hierarchical, team-oriented, and with a cooperative approach, with a strong innovation focus [28]. Personal skills, open mindsets or the ability to apply new instruments are essential in an I4.0 scenario [28]. The *digital leadership* refers to make the right thing into the strategic success of digitalization of the company and in its business ecosystem [29]. Digital leadership means thinking differently about business strategy (combining digital and business strategy), business model (considering digital business strategy and collaborative ecosystem platforms), the IT function (rethinking role of corporate function of IT), enterprise platforms (as adaptive and responsive platforms), mindset and skill set (referring to experiment and innovate with appropriate skills and digital know-how), and workplace (considering a "humanized" environment, flexibility of work) [29].

As the world operates into a digital state highly connected, with emerging digital trends like Big Data, mobile technologies, artificial intelligence or network learning [7], so the leadership of the future has to be more *connected, responsive*, *collaborative* and *network-experienced* to deal with such external influences [7]. Also, some highlighted requirements of leadership in the digital age are providing vision and objective, creating conditions to experiment, empowering people to think in different ways and getting the people to collaborate beyond the limits [23]. In this way, it is critical that leadership, even more, encourages learning and innovation [11].

In digital 4.0 environments, so-called swarming could be increasingly required. Swarm is defined as "a moving crowd" [30]. A *swarm leadership* is required to navigate in complex adaptive systems, where a decision, innovation, and direction come up from the own system [7]. Swarm leadership is responsive, because leaders act in an agile environment, operating at a systemic level and following the uncertainty and the volatility of the I4.0 [7]. This leadership is part of a network system, characterized as adaptive, collaborative, complex and self-organized [7]. In addition, leaders could also consider the swarm intelligence term to practice in I4.0 environments. The term resulted from the collective behavior that emerges from a social insect group [31]. The advantages to "practice" swarm intelligence could encourage individuals for the flexibility, robustness and self-organization in companies [31].

Additionally, T. Petry [32] mentions main characteristics of the digital leadership (or leadership styles) that need to be considered in the VUCA environment [33] (volatility, uncertainty, complexity, and ambiguity), which are: *agile leadership* (it describes the leader who thinks in different scenarios, considering different options, experiencing distinct ideas); *participative leadership* (that should consider more the decentralization and sharing), *network leadership* (that gives support to internal and external connections), *open leadership* (being able to communicate, giving and receiving feedback) and, as a complement of these characteristics, the *trust-based leadership* (that considers leaders support showing confidence within the employees) [32].

Based on the theoretical approach of leadership in the I4.0 context sourced in databases such as WoS and Scopus, we chose and analyzed key terms that could represent the "characteristics" of leadership 4.0. For this, we considered the associated relevance and possible definitions of referenced authors regarding leadership 4.0 or leadership in the I4.0 context, since a consolidated definition of this subject is still ongoing. Thus, the synthesis of these characteristics include: 1) *responsive leadership*, 2) *swarm leadership*, 3) *learning and innovation leadership*, 4) *open leadership*, 5) *agile leadership*, 6) *participative leadership*, 7) *network leadership*, 8) *trust leadership*, 9) *digital leadership*, and 10) *collaborative leadership*. The leadership 4.0 characteristics identified will be used in the methodology section. The next section approaches the importance of leadership skills in organizations.

2.3 Skills of leadership

Understanding which leadership skills are necessary to relate them as the drivers for the main characteristics required by the leadership 4.0 presented in the previous section is paramount to define how to development leaders for I4.0. The acquisition and improvement of leadership skills are influenced by individual differences in cognitive capacities, personalities, temperaments, abilities to control emotions, identities and values resulting from both, cultural context and personal experience [34].

The authors T. Mumford, M. Campion, and F. Morgeson [35] developed a model in order to organize leadership skills. They classified these skills in four groups: 1) *the cognitive skills*, which are needed by executive leaders to understand the required complex behavior of patterns, involving creative thinking, decision making and strategic problem solving [36]; 2) *the interpersonal skills*, which are defined as "goal-directed behaviors used in face to face interactions, in order to bring about a desired state of affairs" [37]; 3) *the business skills* include organization, negotiation and management of personal, financial, and material resources [38]; 4) and *the strategic skills* are associated with the conceptualization of mission and vision of organization [39]. These four leadership skill groups are composed of other respective skills [35], as presented in Table 1.

Table 1- Four Groups of Leadership Skills

Cognitive Skill (CS)	Business Skill (BS)	Interpersonal Skill (IS)	Strategic Skill (SS)
CS1: speaking	BS1: operations analysis	IS1: social perceptiveness	SS1: visioning
CS2: active listening	BS2: management of personnel resources	IS2: coordination	SS2: systems perception
CS3: writing		IS3: negotiation	SS3: system evaluation
CS4: reading comprehension	BS3: management of financial resources	IS4: persuasion	SS4: identification of downstream consequences
CS5: active learning	BS4: management of material resources		SS5: identification of key causes
CS6: critical thinking			SS6: problem identification
			SS7: solution appraisal

Source: adapted from [35]

R. Ashkenas and B. Manville [17] identified six leadership skills, based on interviews of successful leaders of large corporations, startups, and non-profits companies to get to know their view about what it takes to become a leader. Based on their research, these skills are: 1) shaping a vision for focusing and challenging the team; 2) translating the vision into clear strategy about what action to take and what not; 3) recruiting, developing and rewarding a team of great people; 4) focusing on measurable results; 5) promoting innovation and learning to sustain the team or organization and 6) leading yourself. According to the authors the main points to develop proficiency of these leader skills are based on continual practice and real experience, rather than just reading books or attending courses or seminars [17].

M. J. Sousa et al.[40] identified two skills set profiles of 4.0 leadership for the hospitality sector: one was more related to the relationship among people, and the other one more related to knowledge about the use of technologies. The main leadership skills are customer attendance service, listening ability, teamwork, relationship with customers, relationship with subordinates, proper personal image, use of digital tools in their function, management of customer complaints, and ability to deal with change [40]. The identification of two 4.0 leadership skills profiles, as well as the respective skill itself, will incentive hospitality organizations to design new leadership training to contribute to the business success [40].

A survey carried out by the MIT Sloan in partnership with the Deloitte about jobs in the digital era reported that more than 90% of the interviewed people, including managers, analysts, and executives emphasized the need of upgrading skills at least once in a year, to be able to work in a digital world [23]. In this context, training and preparation is essential to adopt skills that contribute to the fourth industrial revolution environment. Therefore, new skills can lead to a new organizational culture in the work environment [40].

3. Methodology

As presented in first section, the objective of this research is to identify key leadership characteristics and skills in I4.0; for that we develop the next steps 1) a theoretical approach of leadership in I4.0 context based on key terms to represent the leadership characteristics in I4.0 described in section 2.2; 2) leadership skills were searched to support leadership characteristics in I4.0 considering the use of leadership skill proposed by [35]; 3) therefore, a subjective interpretation analysis was carried out to develop a relationship between leadership skills groups and leaders 4.0 characteristics. The relation and construct of each step is explained below.

This study defined the expected characteristics for leadership 4.0 based on a literature review in the following publications' databases: WoS and Scopus. As drivers for acquiring these characteristics, skills demanded by leaders to interact in I4.0 environments were also identified. As mentioned by [23] and [40], the leadership skills in I4.0
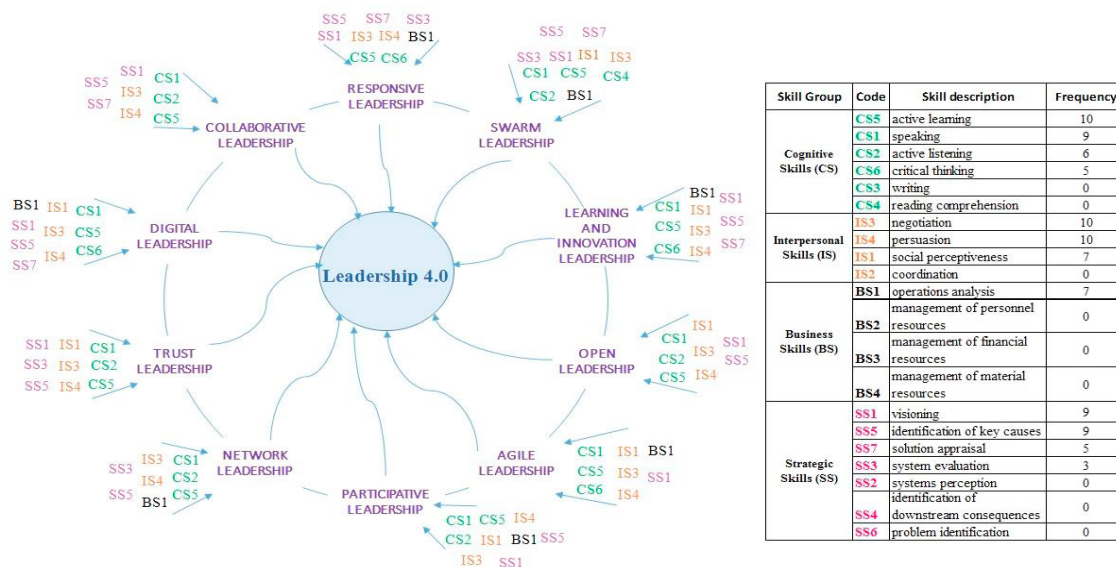
context are essential to support the role of leaders, so the hypothesis here is that leadership skills could drive the development of the identified leadership 4.0 characteristics. Therefore, it is important to identify which skills should be pursued to promote each leadership characteristic related to I4.0. The relationship of those leadership skills with the leadership characteristics was established considering the model of T. Mumford, M. Campion, and F. Morgeson [35]. The authors named the construction of the leadership skills in all organizational levels as "Straplex": the term derived from "stratify" related to the number of levels in an organized system, and "plex" resulted from "complex" word that means divided in specified numbers of parts [35].

The required leadership skills were codified (as already shown in Table 1) for each group [35]. For example, *negotiation* from the interpersonal skills group was codified as IS3, and then it was associated with the leadership 4.0 characteristic. For this present study, we analyzed the leadership skills from Table 1 considering a subjective interpretation based on the role description of each skill referenced by [35] and linked them to those characteristics related to leadership 4.0 based on their context and description. Thus, the skills chosen for each characteristic allow the understanding of the skills role when putting into practice. The selection of skills is based on the number of times that each skill was linked with the characteristics of leaders in I4.0. The criteria to explain this link was based on skills with higher connections rates (linked to five or more frequency of the ten leadership 4.0 characteristics). The relationship between leadership 4.0 characteristics and leadership skills is illustrated in the next section explaining the main results.

4. Results and Discussion

Figure 1 shows the relationship of the ten leadership characteristics (that represent the Leadership 4.0 or leader's characteristics in an I4.0 environment summarized in section 2.2), with the required skills (Table 1) that are aggregated and codified in four groups: cognitive skills, interpersonal skills, business skills, and strategic skills [35].

Figure 1- The network of characteristics and skill requirements for Leadership 4.0

Skill Group	Code	Skill description	Frequency
Cognitive Skills (CS)	CS5	active learning	10
	CS1	speaking	9
	CS2	active listening	6
	CS6	critical thinking	5
	CS3	writing	0
	CS4	reading comprehension	0
Interpersonal Skills (IS)	IS3	negotiation	10
	IS4	persuasion	10
	IS1	social perceptiveness	7
	IS2	coordination	0
Business Skills (BS)	BS1	operations analysis	7
	BS2	management of personnel resources	0
	BS3	management of financial resources	0
	BS4	management of material resources	0
Strategic Skills (SS)	SS1	visioning	9
	SS5	identification of key causes	9
	SS7	solution appraisal	5
	SS3	system evaluation	3
	SS2	systems perception	0
	SS4	identification of downstream consequences	0
	SS6	problem identification	0

Source: created by the author

For the **cognitive group (CS)**, the important skills are: *speaking (CS1)*: it is needed for leaders to communicate and to disseminate the information in a digital and agile environment for a better connection among all involved people, promoting learning and innovation, constructing a network environment and stimulating higher participation. *Active listening (CS2)*: encouraging the collaboration, constructing feedbacks culture and the openness given to people for suggestions of ideas. *Active learning (CS5)*: to prepare and act in new digital scenarios and to incentive the experimentation for learning and innovating with the use of different technologies, driven by a digital

mindset. And *critical thinking (CS6)*: required by leaders in order to evaluate the digital environment and the challenges to apply the new favorable technologies in their companies.

In the group of **interpersonal leadership (IS)**, the more distinguished skills are: *negotiation (IS3)*: it becomes important for leaders to establish agreements for common benefits to everybody in their companies, creating a more collaborative and participative environment, stimulating workers to experiment and contributing with new ideas. *Persuasion (IS4)*: it is important to build a learning and innovation environment that encourages the decision-making of collaborators and, therefore, persuading people to adopt a more open and digital mindset. And finally, the *social perception (IS1)*: it is important for leaders to understand how to prepare and develop the people to act in digital environments, and to assure participation, trust and collaboration, promoting a more participative culture.

For a group of **strategic leadership (SS)**, the more highlighted skills are: *visioning (SS1)*: that becomes relevant for a leader in formulating a vision and a direction for the construction of an innovative and learning culture that is also more collaborative, participated and decentralized. The *identification of key causes (SS5)*: verifying the requirements that could contribute with the incentive of experimentation, dissemination of a more collaborative, participative and networked culture, as well as, the use of main technologies related to I4.0. Moreover, the *system evaluation (SS3)* and *solution appraisal (SS7)* were also distinguished skills for leaders allowing them to analyze the acquired technologies by companies, besides evaluation for the use of internal and external network communication platforms, and, therefore, identifying gaps and challenges that require immediate solutions.

In contrast, the estimated relationship between the **business leadership skills group (BS)** and the leadership 4.0 characteristic was lower. One explanation could be that these skills support the *management of personnel resources (BS2)*, the *management of financial resources (BS3)* and the *management of material resources (BS4)* are less demanded. If the leadership styles characterized for I4.0 are more collaborative, participative and decentralized, people feel more stimulated to make decision and experiment to create an agile and responsive network culture. However, the operations *analysis skill (BS1)* was more related to the characteristics of leadership 4.0, because it benefits in evaluating the digital, responsive and agile scenarios demanded by the I4.0 environments. To relate the leadership skills with leadership 4.0 characteristics, the contribution of *technical skills* was not mentioned, because the analysis concentrated on the four leadership skills groups [35]. However, technical skills could also be considered in the next studies, since leaders have to deal and use technologies demanded by I4.0.

Although much effort has been put in connecting specific leadership skills with characteristics of the leadership 4.0, this paper main contribution may be considered as the systematization of the ten leadership characteristics for I4.0 based with literature, as previously shown in Figure 1. Each leadership 4.0 characteristic may be better understood by means of the relationship of each of them with the leadership skills proposed by [35]. Therefore, we believe that the development of these characteristics and skills when put into practice will enable leaders to execute a better transition toward I4.0.

5. Conclusion and Future Research

The objective of this research was to present a relationship between the characteristics of leadership 4.0 and specific leadership skills, considering a theoretical approach. Based on this association, the main skills that could best contribute I4.0 context are based on the following groups of skills: *cognitive skills*, *interpersonal skills*, and *strategic skills*. The result of this research can contribute with the development of leaders in digital environment, in order to better understand and to enable the development of these skills, putting them into practice, therefore, sustaining and building the ten characteristics of leaders 4.0 summarized in this study. In addition, this paper could contribute with understandable content to people of different areas and not only experts. Also, an academic contribution of this paper refers to the investigated literature, since it approaches leadership and skills in I4.0 context, which, in turn, are important subjects to be considered for the implantation of new technologies, and also are subjects on development, without yet a consolidated knowledge in the area. The present paper can be considered as a theoretical contribution. Theoretical contribution contemplates the factors description to be analyzed (what), the relationship between these factors (how) and explanation importance of these relationship factors (why) [41]. For this reason, we presented in the literature review the leadership 4.0 characteristics and leadership skills (i.e., the factors to be analyzed). After that, we illustrated the relationship and the relevance between these factors.

A limitation of this paper is not to consider other factors such as the challenges of I4.0 and leadership 4.0. The use of leadership model proposed by [35] was another limitation because other leadership skills could be considered, as the technical skill set, for example. Finally, a subjective analysis carried out only by the authors and the absence of industry experts' validation were also a limitation of this paper. For future research, we plan to expand the literature review and to carry out a field research with industrial and academic experts, and compare the data to consequently improve and show the relevance and applicability of the leadership 4.0 characteristics and their respective skills.

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