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Manufacturing in the fourth industrial revolution: A positive prospect in Sustainable Manufacturing

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Abstract

Industrialization throughout history has been one of the main contributors to pollution, disregard for environmental issues, resulting in an unsustainable production model. A change from this context, the imminent new industry model called the Fourth Industrial Revolution or Industry 4.0, aims for a manufacturing system that is both viable and sustainable. This paper seeks to describe the main forms of collaboration of Industry 4.0 in relation to sustainability. Scientific works point out the advantages provided by the new industry model such as improved product life cycles, manufacturing works in an integrated way with the use of cyber-physical systems allied to the principles of this industry, such as decentralization, virtualization, interoperability, among others which lead to more adaptability to natural resources availability and environmental costs. Smaller batches can lead to a more accurate response to the demand curves and consequently lessen the waste for production.

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Keywords: Industry 4.0; Cyber-Physical Systems; Sustainable Manufacturing.

1. Introduction

The process of industrialization went through three phases that were described as industrial revolutions. Each one presented its specificities, and along with them, its characteristics of how to preserve the environment and avoid the accumulation of waste. With the attainment of revolutions this environmental preservation has become more complex, large-scale production, the demand for primary raw materials and the generation of waste have increased significantly.

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The intensification of global industrialization along with the accelerated population increase, the development of new products, high levels of production and excessive consumption contributed to economic development, but resulted in environmental degradation of ecosystems. Within this context, the development of corporate environmentalism, as a strategic part of the business, is one of the most significant changes are occurring in the markets at the beginning of the 21st century [1].

Since the First Industrial Revolution, subsequent revolutions have brought radical changes in manufacturing, from steam engines to automated electrical and digital production. Manufacturing processes have become more complicated, automatic and sustainable, meaning that people can operate machines simply, efficiently, and persistently [2]. Today, modern manufacturing plays a key role, especially in European countries. About 17% of GDP is represented by industry, which also creates some 32 million jobs with several complementary occupations in the European Union [3].

Aiming at the imminent industrial revolution it is observed that it covers technological concepts and solutions to generate a combination of economy of scale and economy of scope. This fourth industrial revolution or Industry 4.0 is characterized by a high level of complexity and use of a full network integration of products and production processes. [4] Using the definition formulated by the World Commission on Environment and Development [5], sustainability consists of: "meeting the needs of the present without compromising the ability of future generations to meet their own needs", so industries must pay attention special not only to the development of products and their life cycles, but also to the processes that involve their elaboration.

Based on this explanatory context, this paper aims to present the main characteristics of the imminent industry 4.0 that have already been perceived and described in scientific works, and in what ways these characteristics cooperate for the environmental preservation resulting in the permanence of an industry model that includes sustainable methods, processes, techniques and strategies.

2. Fourth Industrial Revolution

2.1. First aspects of Industry 4.0

By the mid-eighteenth century, the initial movement in terms of industry began in England. Following the US and European countries such as Germany began a shift from agricultural society to industrial society [6].

The phenomenon of Industry 4.0 was mentioned in the German language for the first time in 2011 in Germany, during the "Hannover Fair" event as a proposal for the development of a new concept of German economic policy based on high technology strategies, symbolizing the beginning of Fourth Industrial Revolution [7, 8].

Passive machines and robots have replaced the workforce, which means that they are controlled by a human being without consciousness. Already in 2012, the number of industrial robots was about 273 per 1000 workers in Germany [9].

The imminent Industry 4.0 implies a complete communication network that will exist between various companies, factories, suppliers, logistics, resources, customers, etc. Each organizational area optimizes its configuration in real time depending on the demands and status of the associated sections in the network. In addition, costs and pollution, raw materials and CO_2 emissions, for example, will be reduced. In other words, the future business network is influenced by each cooperating section, which can achieve a self-organized status and transmit the responses in real time, in the financial sphere generates the maximum profit for all the cooperatives involved with the limited resources of sharing [10].

2.2. General understandings of the Industry 4.0 structure

Industry 4.0, has been perceived as a collective term for technologies and concepts of value chain organization. Within modular intelligent manufacturing factories 4.0, Cyber-Physical Systems (CPS) monitor physical processes, create a virtual copy of the physical world, and make decentralized decisions. Internet of Things (IoT) and CPS communicate and cooperate with each other and with humans in real time. Through Internet of Services (IoS), both internal services and interorganizational services are offered and used by participants in the value chain [11, 12, 13].

This smart factory model that already begins to appear employs a new approach to production. Smart products are uniquely identifiable, can be located at all times and know their own history, current status and alternative routes to reach their target state. Embedded manufacturing systems are vertically networked with business processes within factories and enterprises and are connected horizontally to dispersed value networks that can be managed in real time - from the moment an order is placed to the logistics of output. In addition, both enable and require end-to-end engineering throughout the value chain [14].

The Figure 1 shows the general composition of Industry 4.0 or the fourth industrial revolution. Involving connection and collaboration, as well as data and analysis as key capabilities, the industry 4.0 can be distributed in three basic components: 1 - Digitization and integration of vertical and horizontal value chains; 2 - Digitization of product and service offerings; 3 - Innovative digital business models [15].

The first component refers to the "horizontal integration" that occurs between enterprises through the value chain and the information network to achieve an integration of resources, so that enterprises can achieve continuous cooperation and provide real-time products and services. The "vertical integration" is based on the future intelligent factory in the network of manufacturing system, from the demands to the mode of manufacturing services, to achieve custom production, instead of the traditional fixed production process (for example, a line of production). During this vertical integration process, there are some services to support it, such as integrated digital product lifecycle management, product design, digital evaluation and virtual manufacturing [16]. The second component refers to the extension of the existing product range with complete descriptions of digital products as well as ("embedded systems"/"Internet of Things"). These include online connection for regular matching of performance and wear data or custom product development [15]. Finally, the third component consists, in general, of offering Internet services based on a service-oriented reference architecture [17].

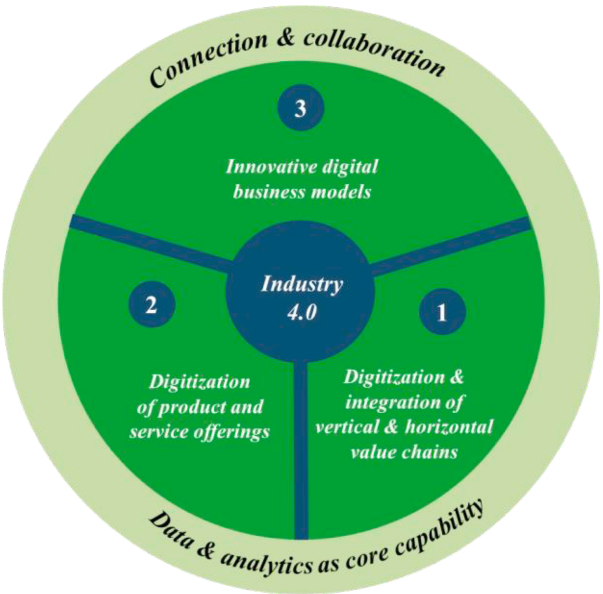

Fig. 1. Basic components of Industry 4.0. Adapted from [15].

3. Main principles of Industry 4.0

3.1. Interoperability

Interoperability is to exchange machines and equipment that perform the same function, even from different manufacturers. This gives rise to multiple networks in a trusted environment, for equipment to intercommunicate, enabling an awareness that is required for the development of I. 4.0 intelligent functions [18].

3.2. Decentralization

Decentralization as understood in I 4.0. is the increased ability of local companies, operations personal, as well as machines to make decisions. Instead of using central computers or pass down decision hierarchically, capacitating and allowing local operators to respond to changes and readapt themselves grants more flexibility and facilitates the use of specialized knowledge. This fits with a decomposition of the classical hierarchy of production and a shift towards decentralized self-organization [19]. The growing demand for individual products makes it increasingly difficult to centrally control systems. Embedded computers allow the CPS to make necessary decisions on their own. Only in cases of failure tasks are delegated to a higher level [20].

3.3. Virtualization

Virtualization means that through the usage of monitoring and machine-to-machine communication a virtual twin can be abstracted. The sensor data are linked to virtual plant models and simulation models. In this way, a virtual copy of the physical world is created. In case of failure a human being can be notified. In addition, all necessary information, such as the next work steps or safety provisions, are provided [21]. Cyber-Physical Systems offer to close the gap between information sharing and production of sense by promoting decentralized communication, while two features of Industry 4.0 are fundamental: At first, the activeness of the sensors will make it possible to obtain information about a new level of granularity with the least possible delay. Second, real-time data-based simulation will allow the anticipation of the effect of local optimization in the general context, allowing a better sense-making and using decentralized control circuits [22].

3.4. Real-Time Capability

To perform the organizational tasks, it is necessary that the data is collected and analyzed in real time but I 4.0. notion of real-time capability goes a step further. It includes plants that can react to the failure of one machine and forward products to another machine [23] as well as a throughout linkage between the end consumer, via social network or direct selling points, that allows for a faster response to changes in demand. This use of real-time information and robotic systems is set to disrupt the modes of production and the way manufacturing is currently organized. This is something that will affect all types of functions, from engineers to maintenance operators, and will also can change the physical locations of the plants [24].

3.5. Modularity

This principle involves modular systems that can adapt flexibly to changing requirements by replacing or expanding individual modules which makes adding or removing production modules in a much easier way. These modular systems can therefore easily be adjusted in the event of seasonal fluctuations or changes in product's production needs, such as in the case of incorporating new technologies [23]. In addition, many manufacturing processes, such as product design, production planning, production and production engineering and services, will be simulated as modular and then will be closely connected end-to-end and interchangeably [18, 25].

3.6. Service Orientation

Within this principle, business, human and CPS services are available through the internet of services and can be used by other participants, facilitating the creation of product-service systems. They can be offered internally and across company boundaries. [23] Service orientation and transformation enable organizations to be agile and flexible and respond to market changes much more quickly than they used to. Enterprise IT is becoming more flexible to partner with the IT networks of its value chain partners to co-create value for consumers (for example, federated service-oriented technology framework). Organizations can collect and process unprecedented amounts of data with large unstructured data solutions [26].

4. Sustainable Manufacturing

4.1. Strategies for sustainable business models

The selection criteria of the examples assembled and used to develop sustainable business model archetypes include innovations that generate environmental and/or social benefits in business operations that change the value proposition for the environment and society. This can be achieved by creating new value, or significantly reducing negative impacts on the environment and society. When defining the main objectives of the categorization of sustainable business model archetypes, these basically consist of:

1. Provide a means of categorizing and explaining business model innovations for sustainability;

2. Define generic mechanisms to actively collaborate with the innovation process of the business model for sustainability;

3. Define a clearer research agenda for business models;

4. Provide examples that report and communicate innovations of business models to organizations (through education and workshops, for example) [29].

Table 1 presents two main types of entrepreneurs linked to the sustainability of their businesses [33]. It is observed that the behavior of both is in parts similar. In setting the priorities of its business model, the "Ecopreneurship" presents concerns related to the economic area. "Sustainable entrepreneurship" encompasses more strongly linked visions of sustainable development.

Table 1. Characterization of different kinds of sustainability oriented entrepreneurship.

Aspects	Ecopreneurship	Sustainable entrepreneurship
Core motivation	Contribute to solving environmental problem and create economic value	Contribute to solving societal and environmental problems through the realization of a successful business
Main goal	Earn money by solving environmental problems	Creating sustainable development through entrepreneurial corporate activities
Role of economic goals	Ends	Means and ends
Role of non-market goals	Environmental issues as integrated core element	Core element of integrated end to contribute to sustainable development
Organizational development challenge	From focus on environmental issues to integrating economic issues	From small contribution to large contribution to sustainable development

Source: Adapted from [33].

4.2. Sustainable Industry 4.0 contributions

The industry 4.0 paradigm will be a step towards more sustainable industrial value creation. In the current literature, this step is characterized mainly as contribution to the environmental dimension of sustainability. Resource allocation, i.e., water, energy, materials and products, can be more efficiently performed based on intelligent cross-platform value creation [27]. In addition to these possible environmental contributions, industry 4.0 holds a great opportunity to realize the creation of sustainable industrial value in all three dimensions of sustainability: environmental, social and economic [28].

In I 4.0, new evolving business models are highly driven using intelligent data to deliver new services. This development tends to be exploited to anchor new sustainable business models that can contribute to the solution of social or environmental problems [29] and are necessarily characterized by long-term competitiveness [30].

The interconnection of value creation networks in industry 4.0 offers new opportunities for the realization of product life cycles in closed circuit and industrial symbiosis. It enables efficient coordination of product, material, energy and water flows throughout product life cycles as well as between different plants. Closed loop product life cycles help keep products in multipurpose phase life cycles with remanufacturing or reuse between them. Industrial symbiosis describes the cooperation between organizations of different factories to achieve a competitive advantage through the exchange of water, energy, materials and products, [30] as well as intelligent data at the local level [28].

As for manufacturing equipment in industries, it is often a capital asset with a long usage phase of up to 20 years or more. Modernization allows an easy and economical way of modernizing existing manufacturing equipment with sensor and actuator systems, as well as their control logic, to overcome the heterogeneity of equipment in factories [32]. Modernization can thus be used as an approach for performing a CPS in a value creation module, such as a factory, with existing manufacturing equipment. It extends the use phase or facilitates the application in a new phase of use of the equipment, and can thus contribute essentially to the environmental and economic dimensions of sustainability. It is particularly suitable for small and medium-sized enterprises, being a low-cost alternative to the new acquisition of manufacturing equipment [28].

In relation to human workers, they will still be the organizers of value creation in industry 4.0 [34]. There are three sustainable approaches that can be used to address the social challenge in Industry 4.0. The first is to increase the efficiency of employee training by combining new technologies such as learnstruments. The second is to increase intrinsic motivation and foster people's creativity by establishing new approaches to work organization and design by implementing the concepts of flow theory [35] or by using new technologies to implement concepts of gamification, so to support decentralized decision-making. And finally, the third seeks to increase extrinsic motivation by implementing individual incentive systems for the worker considering the intelligent data within the product life cycle to provide individual feedback mechanisms.

The approach to sustainable product design in industry 4.0 focuses on the realization of closed-loop life cycles for products, enabling the reuse and remanufacturing of the specific product or applying cradle principles to cradle. Different approaches also focus on designing for the well-being of the consumer. These concepts can be supported by the application of identification systems, to recover the cores for the remanufacturing or applying new additional services to the product to reach a greater level of well-being for the client [36]. In this context, Cleaner Production (CP) methods offer a very viable alternative for organizations through their implementation in production processes, as it allows waste minimization, wastewater generation and atmospheric emissions, contributing with efficient use of raw materials and energy, rationalization of water consumption, providing environmental and economic benefits to companies [37].

5. Design Principles and Sustainability

The design principles of industry 4.0, as discussed above leads to many improvements in regarding sustainable manufacturing. Table 2 relates the six design principles with their most significant contributions to the environment.

Table 2. Design Principles and Sustainability Contributions.

Design Principle	Significant contribution to Sustainability
Interoperability	Longer machine life cycle, decrease in industrial waste, faster adaptation towards more efficient processes.
Decentralization	Improved usage of local resources, better use of available assets.
Virtualization	Decrease in industrial waste, easier promotion of state-of-the-art environmental practices, increased recycling opportunities.
Real Time Capabilities	Better adaptation to demand curves, better use of resources, faster response to energy supply changes.
Modularity	Better usage of industrial resources, longer machine life cycle
Service Orientation	Improved usage of final products, increased recycling and reuse opportunities.

5.1. Interoperability

The capacity to use machines from different manufacturers and in different contexts interchangeably can lead to longer machine life cycles and decrease the volume of discarded machines through internal or industry to industry commerce while allowing state of the art companies to use the most efficient machines without having to redesign their production processes.

5.2. Decentralization

With greater opportunity for decentralized decision making, organizational time is decreased and use available resources better without the need to communicate local realities to foreign decision makers. This creates industry that can adapt faster and seize local opportunities, both regarding environmental resources (such as deciding to buy only from alternative sources or adopting self production of energy) and market opportunities.

5.3. Virtualization

Virtualization creates an easier way to follow-up production practices, leading to decrease in industrial waste because of its advantages to evaluate results and to implement better practices. This ease in implementing best practices can also be used for environmental practices. It can also be used, in a partnership with the final user, to increase recycling opportunities since the virtual self of the product could communicate its status, thus allowing the company to offer a replacement (and dealing with the old product) or tell the consumer where to discard.

5.4. Real-Time Capability

Better adaptation to demand curves, better use of resources, faster response to energy supply changes are all results of a faster response to changes. If costumer behavior changes, this can help avoid overproduction.

5.5. Modularity

Being able to add and remove processes in a modular way allows for a more flexible and thus longer use of machines due to the increased ability of reuse. This goes together with the advantages of Interoperability.

5.6. Service Orientation

Improved usage of final products, increased recycling and reuse opportunities are already seen as a result of Product-Service-Systems and I 4.0. orientation towards service goes in the same direction. By increase the usage percentage of highly environmentally demanding assets, such as car and manufacturing equipment, a decrease in waste, resources and energy consumption is immediate.

6. Final considerations

As can be seen, industry 4.0 has a considerable area of significant aspects for sustainable industrial development. As mentioned, through its principles contains various concepts in technology, industry 4.0 intends to deliver significant improvements: a networked manufacturing system, virtually interconnected, which is modular, responding in real time to the internal and external demands, and the main one, with the sustainability inserted in each technique and strategy that involves the productive processes.

Characteristics such as waste minimization, the sensible use of natural resources, the efficient use of raw materials, high energy efficiency and the dynamization of factory time are part of the set of values that are intrinsic to the sustainable operation of the industry. It is noteworthy that some of these characteristics come in part from productive techniques already used by industries, in a historical context, that have been improved and are used to date. But the capacity of industry 4.0 to really bring them to fruition and make them everyday practices in manufacturing is largely due to the high level of virtualization, digitization and integration expressed by the technologies that exist today, and potentiate not only production, but also environmental awareness.

Regarding its interconnection to Ecotreneurship, this new revolution has an unparalleled potential for fast and significant change. While some sustainability improvement can be inferred from the increased efficiency and adaptation to demand curves, a deepen impact on sustainability can only be achieved by incorporating environmental and social issues into the very concept of manufacturing companies' success.

Industry 4.0 is not devoid of defects or flaws. It can adjust quickly but the parameters to which it adjusts and the goals of this adjustments is defined by humans. To achieve its environmental potential, this technological development must be tied to sustainable awareness. In this way, the present work covers the main initiatives of industry 4.0, expressed in its principles, for the construction of an industrial model with high capacity to create, maintain and fully use effectively sustainable methods, processes, techniques and strategies.

References

[1] E. A. Severo, J. C. F. de Guimarães, E. C. H. Dorion, Cleaner production and environmental management as sustainable product innovation antecedents: A survey in Brazilian industries, J. Clean. Prod., vol. 142, pp. 87–97, 2017.
[2] W. Wahlster, From Industry 1.0 to Industry 4.0: Towards the 4th Industria Revolution, Forum Business meets Research, 2012.
[3] E. Commission, The Factories of the Future. (2015).
[4] H. Kagermann; W. Wahlster; J. Helbig, Secure the future of Germany as a production location, implementation recommendations for the future project industry 4.0. Original citation: Deutschlands Zukunft als Produktionsstandort sichern, Umsetzungsempfehlungen für das Zukunftsprojekt Industrie 4.0. Forschungsunion, Berlin, 2012.
[5] G.H. Brundtland, The United Nations World Commission on Environment and Development: Our Common Future, Oxford, UK, 1987.
[6] U. Dombrowski, T. Wagner, Mental strain as field of action in the 4th industrial revolution, Procedia CIRP, vol. 17, pp. 100–105, 2014.
[7] F. Mosconi, The new European industrial policy: Global competitiveness and the manufacturing renaissance. London, England: Routledge, 2015.
[8] J. Lee, Industry 4.0 in Big Data Environment. German Harting Magazine (2013) 8–10.
[9] R. Berger, Industry 4.0: The new industrial revolution–How Europe will succeed, Roland Berger strategy consultants, maart, 2014.
[10] H. Kagermann, J. Helbig, A. Hellinger, W. Wahlster, Recommendations for Implementing the Strategic Initiative Industrie 4.0: Securing the Future of German Manufacturing Industry; Final Report of the Industrie 4.0 Working Group, Forschungsunion, 2013.
[11] T. Hermann, M. Pentek, Desingn principles for industrie 4.0 scenarios: a literature review, no. 1, p. 15, 2015.
[12] R. Drath, A. Horch, Industrie 4.0: Hit or Hype? IEEE Ind. Electron. Mag. 8 (2014) 56–58.
[13] S. Hoppe, Forerunner to Industry 4.0 and the Internet of Things. Control Engineering 61 (2014) 48-50.
[14] H. Kagermann, W. Wahlster, J. Helbig, eds.: Recommendations for implementing the strategic initiative Industrie 4.0: Final report of the Industrie 4.0 Working Group, 2013.
[15] V. Koch, S. Kuge, R. Geissbauer, S. Schrauf, Strateg. Former. Booz Company, PwC 13 (2014) 1–51.
[16] K-S. Wang, M-Y. Lee, Big Data Analysis Method, Social Science Electronic Publishing, 2015.
[17] B. Vogel-Heuser, D. Hess, IEEE Trans. Autom. Sci. Eng. 13 (2016) 411–413.
[18] J. Qin, Y. Liu, R. Grosvenor, Procedia CIRP 52 (2016) 173–178.
[19] V. Roblek, M. Meško, A. Krapež, SAGE Open 6 (2016) 1–11.
[20] T. M. Hompel, B. Otto, Technik für die wandlungsfähige Logistik. Industrie 4.0. 23. Deutscher Materialfluss-Kongress, 2014.
[21] D. Gorecky, M. Schmitt, M. Loskyll, Mensch-MaschineInteraktion im Industrie 4.0-Zeitalter. In: Bauernhansl, Industrie 4.0 in Produktion, Automatisierung und Logistik: Anwendung, Technologie, Migration, 2014.
[22] G. Schuh, V. Stich, T. Brosze, S. Fuchs, C. Pulz, J. Quick, M. Schürmeyer, F. Bauhoff, High resolution supply chain management: Optimized processes based on self-optimizing control loops and real time data, Prod. Eng., vol. 5, no. 4, pp. 433–442, 2011.
[23] J. Schlick, P. Stephan, M. Loskyll, D. Lappe, Industrie 4.0 in der praktischen Anwendung. In: Bauernhansl, Industrie 4.0 in Produktion, Automatisierung und Logistik. Anwendung, Technologien und Migration, 57–84, 2014.
[24] P. Verrière, C. Quenedey, Can the Fourth Industrial Revolution Save French Industry?, Wavestone, pp. 0–3, 2012.
[25] D. Lucke, C. Constantinescu, E. Westkämper, Smart Factory - A Step towards the Next Generation of Manufacturing, in: M. Mitsuishi, K. Ueda, F. Kimura (Eds.), Manufacturing Systems and Technologies for the New Frontier, Springer London, 2008, pp. 115-118.
[26] H. Demirkan, J. C. Spohrer, Emerging service orientations and transformations (SOT), Inf. Syst. Front., vol. 18, no. 3, pp. 407–411, 2016.
[27] H. Kagermann, W. Lukas, W. Wahlster, Abschotten ist keine Alternative. In: VDI Nachrichten, Issue 16, (2015).
[28] T. Stock, G. Seliger, Opportunities of Sustainable Manufacturing in Industry 4.0, Procedia CIRP, vol. 40, no. Icc, pp. 536–541, 2016.
[29] N. M. P. Bocken, S. W. Short, P. Rana, S. Evans, A literature and practice review to develop sustainable business model archetypes, J. Clean. Prod., vol. 65, pp. 42–56, 2014.
[30] S. Schaltegger, M. Wagner, Sustainable entrepreneurship and sustainability innovation: Categories and interactions, Bus. Strateg. Environ., vol. 20, no. 4, pp. 222–237, 2011.
[31] M. R. Chertow, Industrial Symbiosis, Encicl. energy, vol. 3, no. 1, pp. 407–415, 2004.
[32] D. Spath, O. Ganschar, S. Gerlach, M. Hämmerle, T. Krause, S. Schlund, Produktionsarbeit der Zukunft-Industrie 4.0, Fraunhofer- Inst. für Arbeitswirtschaft und Organ. IAO, p. 155, 2013.
[33] S. Schaltegger, M. Wagner, Sustainable Entrepreneurship and Sustainability Innovation: Categories and Interactions, vol. 237, no. July 2010, pp. 1–21, 2002.
[34] D.-I. P. Adolphs, P. D. U. Epple, Statusreport: Referenzarchitekturmodell Industrie 4.0 (RAMI4.0), Verband der Elektrotechnik, vol. 0, no. April, 2015.
[35] S. Engeser, Tätigkeitsanreize und Flow-Erleben, pp. 1–19, 2005.
[36] T. Larsson, A. Larsson, L. Leifer, H. Kobayashi, Design for Wellbeing, 2015.
[37] J.C.F. Guimarães, E.A. Severo, E.C.H. Dorion, Cleaner production and environmental sustainability: multiple case from Serra Gaúcha Brazil. Espac. (Caracas) 35, 1 e 8, 2014.