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AN OVERVIEW ON PRODUCT DEVELOPMENT PROCESS, INNOVATION, KNOWLEDGE MANAGEMENT, STARTUP AND INDUSTRY 4.0

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ABSTRACT

The growth and maintenance of companies in a competitive global market makes the search for knowledge and technological innovation something continuous today. Some topics, such as Knowledge Management, Industry 4.0, Startups, Technological Innovation, Product Development Process Management, are extremely relevant, especially when it comes to managing excellence in the production of goods or services. Therefore, this article will present a brief bibliographic review on the mentioned topics in order to provide readers with an overview of this topic.

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INTRODUCTION

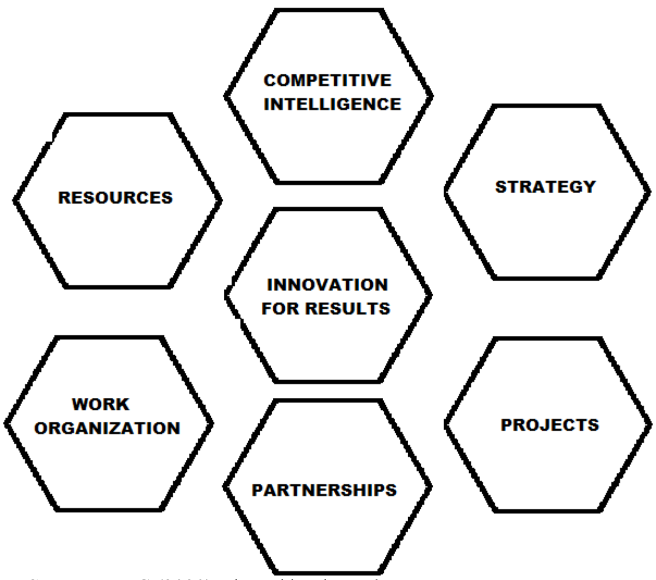
The search for knowledge and technological innovation has become vital for the development and growth of companies today. In this way, companies have invested more in research and development (R&D), launching innovative products (goods and / or services) as part of a strategy to acquire new markets (KOTLER; KELLER, 2006). In this context, a business sector known as Product Development Engineering (PDE) has strategic importance, as it is the area of R&D, responsible for the birth of new products and / or services of the company (TOLEDO, 2008). It is known that for the company to be successful it needs to have a good administration, where management by processes is applied, using continuous improvement techniques aiming at perfecting the organizational competences (TOLEDO, 2008). Specifically in the R&D sector, professionals with greater creative potential, capable of developing varied skills and competences must be recruited (TOLEDO, 2008). In this way, the potential for increasing technological and productive capacity becomes easier to be achieved, with a great possibility of market domain (TOLEDO, 2008). In Development Engineering, innovation is an essential element for the medium and long term survival of organizations, and must therefore be managed and disseminated in the organization by well-defined organizational strategies, structure, processes and culture (EPSTEIN *et al*., 2007). Innovation can be defined as an idea that shapes a product or a A great example of innovation is Industry 4.0, which introduces a big change in the global production chain and transforms labor relations (KAGERMANN *et al*., 2013). Industry 4.0 can also be considered a strategy for integrating productive manufacturing with the internet, communicating people and production systems more quickly (ANDERL, 2015). In view of the great technological progress that is taking place and knowing that many technologies are about to arrive, transformations will occur in the current corporate model, so it is necessary to have knowledge and innovate (GARCIA *et al*., 2017). In this context, this article aims to present a brief bibliographic review on the following topics related to Development Engineering:

- Product Development Process;
- Innovation management;
- Knowledge management;
- Technology-based Startup;
- Industry 4.0.

DEVELOPMENT

Product Development Process (PDP): The Product Development Process (PDP) is part of Development Engineering, and like any process, it is necessary to be well managed, executed, controlled and improved, seeking good performance and learning results (ROZENFELD *et al*., 2012). In the PDP, information about the market, competitive strategies, organizational skills, technological and productive capacity are articulated in order to achieve the project objectives and obtain good acceptance in the market (TOLEDO, 2008). The PDP is typically performed as a management project assigned to a development team (ROZENFELD *et al*., 2012). This team must be composed of people with creativity, in addition to the skills and competences necessary to develop technologies and design differentiated products and / or services in the market and extreme value (ROZENFELD *et al*., 2012). The development of innovative products and services is the result of the creativity experiment of organizations (ZIVKOVIC *et al*., 2015). Successful development with the implementation of the creative idea leads to a new product or service (ZIVKOVIC *et al*., 2015). Creativity is a fundamental element for the generation of new ideas and for a possible implementation feasibility (BAGNO, 2017). It is considered the fuel of development, being the innovation potential of organizations (BAGNO, 2017). Therefore, managing creativity in the PDP implies managing the creativity of the team (BAGNO, 2017). Zivkovic *et al*. (2015) state that the company's ability to manage team dynamics in the development sector, providing an appropriate environment for generating creative ideas provides a competitive advantage. With the continuous advancement of technology in all sectors of industry and commerce, it is extremely necessary to innovate, always seeking to meet the needs of customers and, consequently, fostering business competitiveness (ZIVKOVIC *et al*., 2015). Many companies have launched new products or services more frequently, as part of the market and portfolio management strategy, aiming to retain customers and meet possible changes in their needs or even develop new needs for them (KOTLER; KELLER, 2006).

Innovation Management: The strongest competitive position to be in is to have no competition. Companies can achieve this position by developing and executing different strategies that make competition irrelevant (ZIVKOVIC *et al*., 2015). Technological innovation is an essential strategy for companies to obtain competitive advantage and expand their market segment and / or to conquer new markets (PIRES; URBINA, 2013; CAMPOS, 2017). Innovation management is a continuous process that aims to make organizations capable of generating innovation and creating value for their products, be they goods or services (CAMPOS, 2017). This is a strategy that consists of identifying opportunities for the company to be able to reinvent itself, have something different and be able to deliver news (CAMPOS, 2017). Figure 1 shows six foundations for innovation of results.

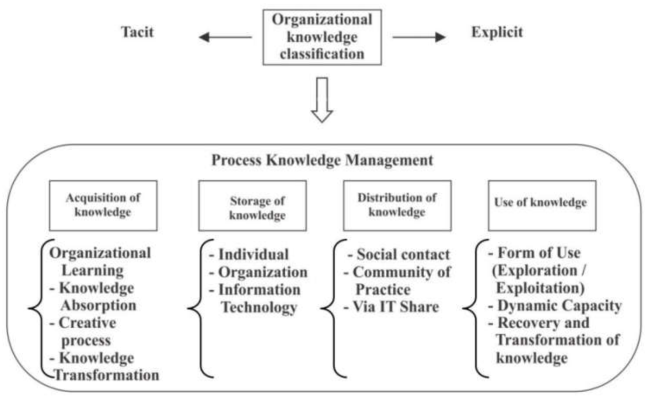


Source: IITIC (2020) adapted by the author

Figure 1. Foundations for innovation of results

Innovation can be given through small continuous improvements in a process or product. Process innovation involves significant changes in production and distribution methods (KEELEY *et al*., 2015). According to Bagno (2017), innovation consists of improvements in a certain product (good or service) already existing in the company's portfolio, better satisfying the needs of current or future customers. Innovations are manifested in the form of adaptations or improvements in product characteristics in order to bring more benefits to consumers (ZIVKOVIC *et al*., 2015). In general, innovation can occur in a product (good or service), process or organization (ZIVKOVIC *et al*., 2015).

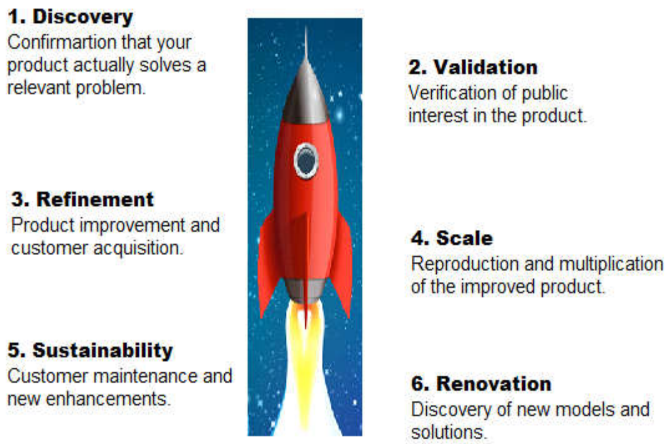
Knowledge Management: Knowledge management (KM) is the systematic, formal and deliberate action to capture, preserve, share and reuse the tacit and explicit knowledge created and used by people during routine tasks and to improve production processes, in order to generate measurable results for the organization and people (MUNIZ; NAKANO, 2009; CARTONI, 2015). In relation to its nature and application, the view that it is a practice aimed at creating mechanisms that improve the generation, diffusion and protection of knowledge in organizations, is complemented by four phases necessary for its formalization: creation, retention, transfer and application of knowledge (ALAVI; LEIDNER, 2011; CARTONI, 2015). According to Jannuzzi *et al*. (2016) the tacit (scarce and difficult to appropriate) and explicit (not scarce and easily replicable) components of knowledge are not distinct and exclusive. Thus, when created in an organizational context, knowledge is initially "stuck" to individuals due to its tacit component. As the firm is a knowledge distribution system, it will only be possible to exploit it when it becomes organizational knowledge (JANNUZZI *et al*., 2016). Therefore, one of the first roles of the KM is to be able to capture and gather it in a repository, be it a system or an individual, so that it can be shared (SEDERA; GABLE, 2010; CARTONI, 2015). After being inserted in the repository, KM needs to create formal and informal channels for its transfer and application in the solution of an organizational problem (CARTONI, 2015). Figure 2 shows the knowledge management process.



Source: Kakabadse *et al*. (2003); Gonzalez; Martins (2017) adapted by the author

Figure 2. Knowledge Management Process

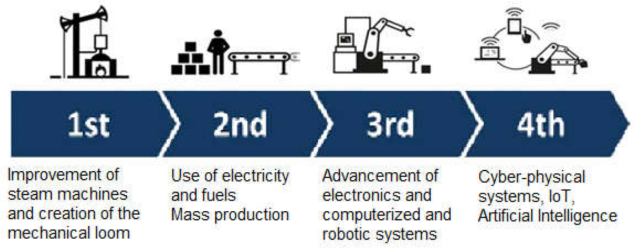
Technology-based Startup: According to Blank and Dorf (2014), startup is a temporary organization that is looking for a sustainable business model. Nascimento (2016) states that the term startup serves to name the stage of development of a company, ceasing to be so named when they manage to prosper and reach a stage of business maturity. Kidder (2012) classifies startup as a way to describe the phenomenon of new technology-based companies that emerged from venture capital investment. According to Sebrae (2017), startup is a group of people starting a company, working with a different, scalable idea and in conditions of extreme uncertainty.For Maia (2016), technology-based startups apply a high density of knowledge in their production process and are, by nature, generators and dependent on innovation. According to Guitahy (2016) technology-based startups are industrial companies that are committed to the design, development and production of innovative products or processes. They are also characterized by the systematic application of technical and scientific knowledge. These companies use: innovative technology; have a high proportion of R&D spending; employ technical-scientific and engineering personnel; and serve specific markets (GUITAHY, 2016). Figure 3 shows the cycles of a startup.



Source: NVOIP (2020) adapted by the author

Figure 3. Cycles of a startup

Industry 4.0: Industrial revolutions were marked, at different times, by great progress in disruptive technological innovation, which remodeled production processes, as examples are the introduction of the steam engine in the late 18th century (Revolution 1.0), with the production system mass movement in the early 20th century (Revolution 2.0) and with the Toyotist automation and production system in the post-World War II period until the mid-1970s and 1980s (Revolution 3.0) and now with Revolution 4.0 from the 1990s, 2000 to the topicality (FARIA *et al*., 2017; SCHWAB, 2018). Figure 4 represents the four industrial revolutions.

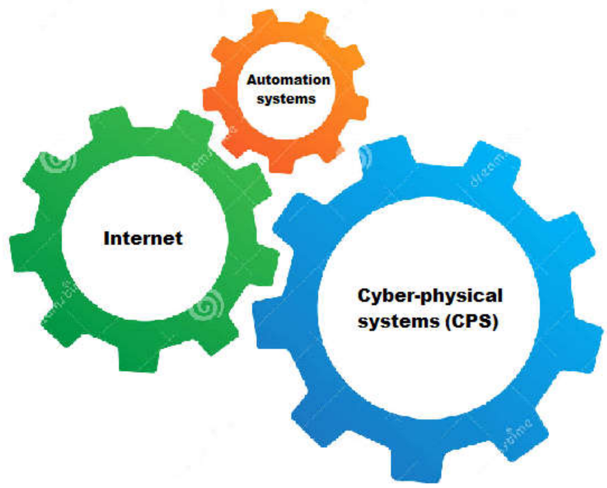


Source: Firmo (2020) adapted by the author

Figure 4. The four industrial revolutions

Industry 4.0 modifies not only production systems, but also all relations between society and companies in general. Also known as the internet revolution, this set of technologies is transforming the integration between machines, logistics and supplies (FARIA *et al*., 2017; SCHWAB, 2018). Industry 4.0 emerged to transform the interactions between society and industry, based on innovative control technologies linked by the internet. Revolution 4.0 can also be defined as an integration of advanced systems controlled via technologies using the internet, providing easy interoperability between humans, products and systems (FARIA *et al*., 2017; SCHWAB, 2018). Revolution 4.0 emerged in Germany, which sought to increase competitiveness by increasing investments in innovation, in order to then promote a technological leap (FARIA *et al*., 2017; SCHWAB, 2018).

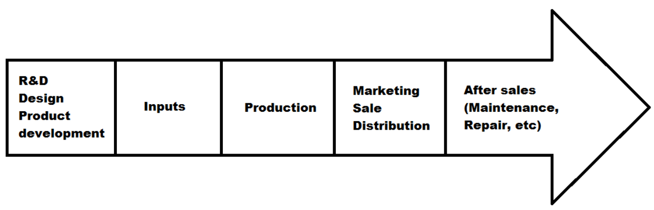
The high german expertise in R&D and consequently producing new technologies, both in the manufacturing area and in the industrial area in general, has made the german productive secondary sector extremely competitive in the world and makes Germany one of the global leaders in manufactured equipment (FARIA *et al*., 2017). With the advent of the internet and specific control technologies called cyber-physical systems, there will be a profound transformation of organizations and also of labor and productive relations, in addition to relations with customers and suppliers and society in general (SCHWAB, 2018). Since Revolution 2.0, the industry has sought to create ways to provide greater efficiency in the productive sector and as a development of automation this has become possible and real. The needs of customers have increased and become more selective, requiring personalized product development by companies and forcing corporations to adapt to new demands in order to remain competitive (SCHWAB, 2018). According to Faria *et al*. (2017), production systems will become highly flexible due to more individualized production. The supply chain must have flexible configurations, times and routes. Inventory levels and the process setup should remain low so that the processes remain agile (FARIA *et al*., 2017). According to Reinhart *et al*. (2013), cyber-physical production systems are integrated into the production area, creating so-called smart factories. The integration of these systems with production will increase productivity and customer satisfaction (FARIA *et al*., 2017). Figure 5 illustrates the integration of these technologies, which constitutes Industry 4.0 itself (SEBRAE, 2017).



Source: Sebrae (2017) adapted by the author

Figure 5. Integration in Industry 4.0

Constant technological upgrades and application of financial resources in innovation have shortened the time for launching new products or services. With faster insertion of novelty in the market, companies start to compete for better positions in the market (FARIA *et al*., 2017; SCHWAB, 2018). Figure 6 illustrates the steps in the value chain from R&D to post-sale, with the fourth revolution impacting the entire process (SEBRAE, 2017).

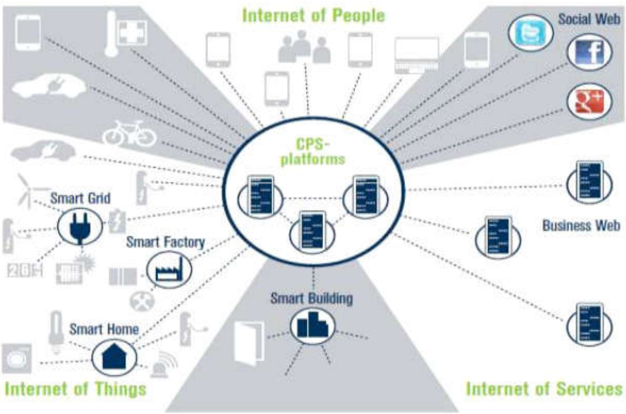


Source: Sebrae (2017) adapted by the author

Figure 6. Integration of a product's value chain

Modifying the structure of productive organizational models is also possible with the use of 4.0 technologies. The reduction of the product development cycle requires more agile management, requiring reduction of bureaucracy and modification of the hierarchical structure (LASI *et al*., 2014). Despite the need for change, most of today's industries still have a centralized architecture and are quite hierarchical (FORSTNER; DUMMLER, 2014). In the traditional industrial system, the organizational model is seen as a pyramid divided into three sectors, which are the operational (base), tactical (middle) and strategic (top) (SCHWAB, 2018). Communication between sectors takes place in such a way that it is currently seen as an outdated process (SCHWAB, 2018). With the advent of Industry 4.0 technologies, there will be an organizational rearrangement, decentralizing the management model, making direct exchange between stakeholders and the production system, exchanging information independently through the Internet of Things (FARIA *et al*., 2017; SCHWAB, 2018).

Cyber Physical Systems (CPS): Cyber-physical systems are systems based on embedded computer technology, responsible for monitoring and controlling any physical processes, which send and receive information to computers (BAGHERI *et al*., 2015; STOYANOV *et al*., 2020). Figure 7 exemplifies the integration of cyber-physical systems with the internet of things and other systems.



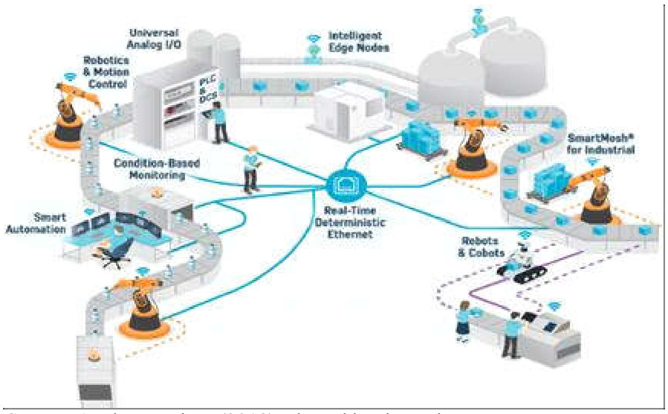
Source: Lepikson (2020); Correia (2014) adapted by the author

Figure 7. Cyber-physical systems and internet integration

The cyber-physical productive systems are composed of intelligent machines, centers of production and storage of digital information, integrating logistics, supplies, marketing, production and services in general (KAGERMANN *et al*., 2013; STOYANOV *et al*., 2020). This provides greater flexibility in production and also provides information for more efficient process management (FARIA *et al*., 2017).

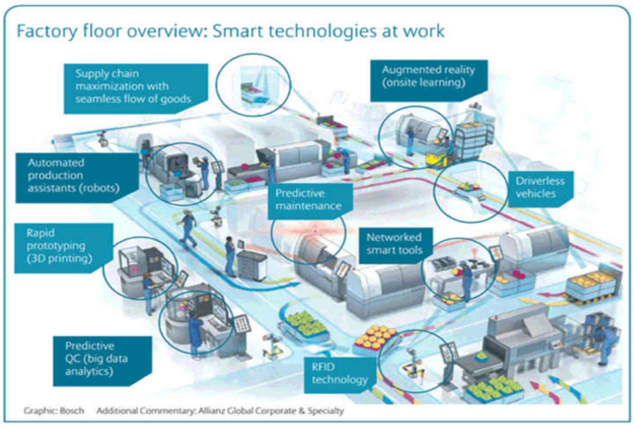
Smart Factories: According to Kagermann *et al*. (2013), intelligent factories enable the interaction between productive resources, the machine and the human being. In these factories, the products are endowed with intelligence and know in detail how they were produced and what their destinations should be, and in this way, the products control their own production in a completely autonomous way (YÁÑEZ, 2017). Manufacturing becomes extremely flexible and capable of self-configuring according to production (FARIA *et al*., 2017; YÁÑEZ, 2017). According to Anderl (2015), the smart factory is flexible and adapted to production processes. This intelligent factory uses automation, combining software, hardware or mechanisms that improve manufacturing, promoting greater production efficiency and optimization of resources (YÁÑEZ, 2017). The smart factory basically has sensors and intelligent systems that monitor and control the entire industrial process in an autonomous and efficient way (YÁÑEZ, 2017). Figures 8 and 9 illustrate smart factories.

Internet of Things – IoT: Internet of Things promotes communication between products of the production line and devices through different technologies. IoT is used both in the industrial environment and also in social life (WORTMANN; FLUECHTER, 2015). As an example of IoT technology, we can already mention entertainment establishments that use a bracelet with radio frequency identification (RFID) chips that work as a ticket and that also enable the purchase of products, connecting customers with a data center, which receives all user information (WORTMANN; FLUECHTER, 2015). In industries, products already receive tags with RFID technology, capable of informing a production management software their specifications and processes that they have already gone through or will go through (LEE; LEE, 2015; WORTMANN; FLUECHTER, 2015). According to Lee and Lee (2015), RFID technology is basically composed of radio waves, a tag and a reader. This technology then makes it possible to identify and capture data. The tags are generally used in supply chains, in object monitoring and tracking, in temperature, pressure, chemical process and other sensors (LEE; LEE, 2015). Figures 10 and 11 show RFID technology.



Source: Analog Devices (2018) adapted by the author

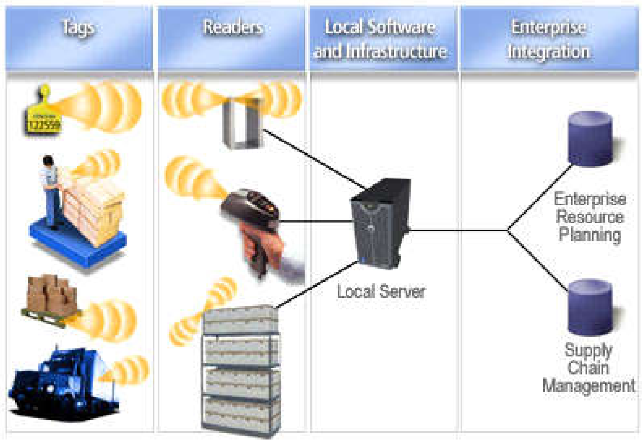
Figure 8. Smart factory with integration between CPS and IoT



Source: Insurance Gateway (2016) adapted by the author

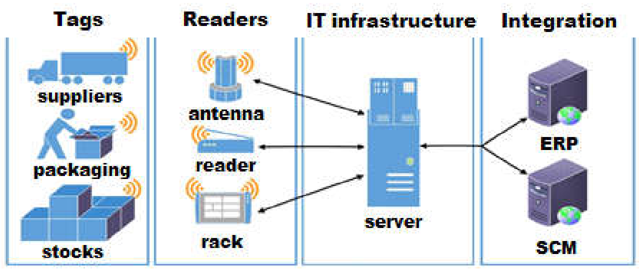
Figure 9. Smart factory and integrated technologies

Another technology used by IoT is Wireless Sensor Networks (WSN), formed by a wireless sensor network, with a large number of nodes, each node being able to detect a physical variable, such as light, temperature, pressure and heat, among other variables (FARIA *et al*., 2017). The use of WSN technology will increase the efficiency and robustness of the systems, being considered an innovative technology in capturing field information (FARIA *et al*., 2017). WSN technology is extremely advantageous as it has no wires, making it an extremely flexible solution. In addition, wireless sensor networks are simple to implement (FARIA *et al*., 2017). The wireless sensor network (WSN) has different applications and can be used to measure the temperature of perishable products that are in transport and be monitored along the logistics chain, it can also, for example, be used in goods tracking systems or vehicles and also in predictive maintenance and / or focused on reliability of machines and equipment (FARIA *et al*., 2017). Figures 12 and 13 show applications of WSN technology.



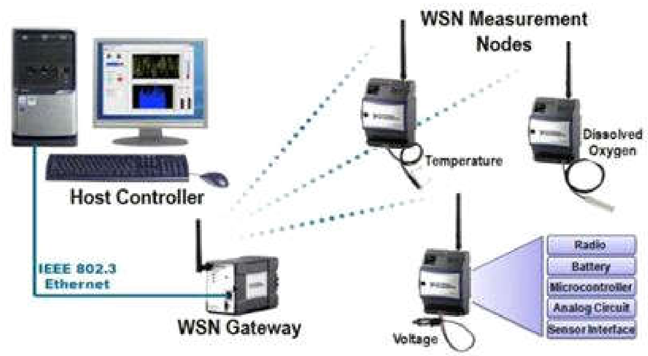
Source: Costa (2016) adapted by the author

Figure 10. RFID technology and its integration



Source: Haddad *et al*. (2016) adapted by the author

Figure 11. RFID technology in the industry

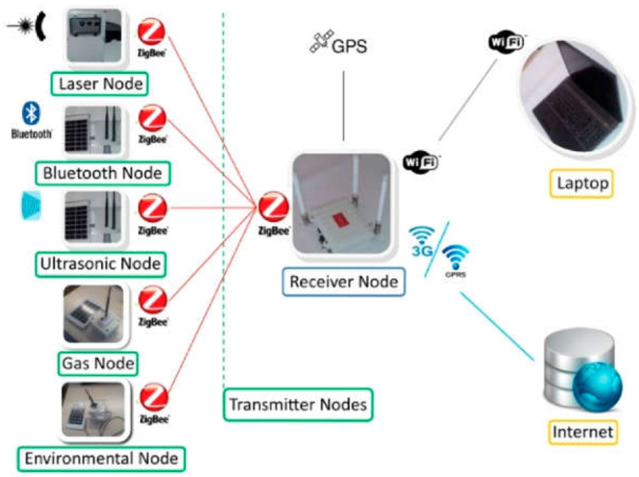


Source: National Instruments (2020) adapted by the author

Figure 12. WSN technology in the industry

Source: Zigbee (2008) adapted by the author

Figure 13. WSN technology in general



Source: Lozano *et al*. (2015) adapted by the author

Figure 14. Integrated wireless technologies

CONCLUSION

Innovation has proved to be a key element in sustaining companies' competitive advantage. In this regard, knowing how to manage the innovation process becomes a great differential when it comes to modern and high performance management (OLIVEIRA *et al*., 2017). The product development process (PDP) has become increasingly challenging, with the need for external and internal knowledge of the company, with the search and acquisition of new intellectual properties, being a vital sector, responsible for the success or failure of organizations today (DAHLANDER; GANN, 2010). Innovation management seeks ways to increase the knowledge and technology base for the organization, systematizing and integrating internal and external activities to the company, related to a kind of technological management (CARUSO, 2017). In this context, by increasing the organizational knowledge base due to innovative practices, Knowledge Management (KM) contributes to the management of these new resources and technologies (PEREZ *et al*., 2016). As defined by Guitahy (2016), technology-based startups are companies that design, develop or produce innovative products or processes. Therefore, startup is a practical example of innovation. According to Schwab (2018), Industry 4.0 is also an example of innovation, resulting from the increase in investments in R&D in companies and universities. In general, it can be said that many concepts and technologies addressed in this literature review will be part of changes by different organizations, through the implementation of new processes or products, which will guarantee competitiveness to companies and their survival in the market.

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