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Digitalización de procesos en la industria 4.0

Digitization of Industrial 4.0 Processes

Digitalização de processos na indústria 4.0

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Resumen

El Internet ha demostrado ser una herramienta de gran utilidad tanto en el ámbito familiar como laboral para cumplir numerosos procesos que de otro modo podrían resultar tediosos. Estos abarcan desde las tareas domésticas hasta las responsabilidades en el entorno laboral, los cuales permiten mejorar la productividad y ahorrar tiempo en la resolución de problemas que requieren soluciones específicas. En efecto, gracias a Internet, hemos incorporado notables mejoras en los espacios de trabajo, lo cual incluye la automatización de procesos, el almacenamiento de bases de datos en la nube y la implementación de nuevas tecnologías que van desde el uso de Internet hasta la aplicación de tecnologías basadas en la inteligencia artificial para automatizar tareas que, para la persona promedio, suelen ser complejas. Este avance nos ha llevado a una nueva era tecnológica. Por ende, el objetivo de esta investigación es explorar los beneficios que aporta la industria 4.0, así como su impacto en el empleo. Además, busca evaluar el nivel de familiaridad de las personas con el internet de las cosas (IoT) y cómo este se integra en nuestro entorno.

Palabras clave: internet, optimización, automatización, tecnología, empleo.

Abstract

The Internet has proven to be a very useful tool both in the family and at work, allowing the optimization of numerous processes that could otherwise be tedious. These processes range from household tasks to responsibilities in the work environment, with the purpose of improving productivity and saving time in solving problems that require specific solutions.

Thanks to the Internet, we have significantly advanced technology in recent years, incorporating notable improvements in work spaces. This includes the automation of processes, the storage of databases in the cloud and the implementation of new technologies ranging from the use of the Internet to the application of technologies based on artificial intelligence to automate tasks that, for the average person, are usually be complex. This has brought us to a new era of technology in the digital age.

The objective of this research covers several aspects, including the exploration of the benefits provided by Industry 4.0 and its impact on employment. In addition, it seeks to evaluate people's level of familiarity with the Internet of Things (IoT) and how it is integrated into our environment.

Keywords: Internet, optimization, automation, technology, employment.

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Resumo

A Internet provou ser uma ferramenta muito útil tanto na família como no trabalho para realizar numerosos processos que de outra forma poderiam ser enfadonhos. Vão desde tarefas domésticas até responsabilidades no ambiente de trabalho, que permitem melhorar a produtividade e economizar tempo na resolução de problemas que exigem soluções específicas. Com efeito, graças à Internet, incorporamos melhorias notáveis nos espaços de trabalho, que incluem a automatização de processos, o armazenamento de bases de dados na nuvem e a implementação de novas tecnologias que vão desde a utilização da Internet até à aplicação de tecnologias baseadas na inteligência artificial para automatizar tarefas que, para uma pessoa comum, são muitas vezes complexas. Esse avanço nos levou a uma nova era tecnológica. Portanto, o objetivo desta pesquisa é explorar os benefícios proporcionados pela Indústria 4.0, bem como o seu impacto no emprego. Além disso, busca avaliar o nível de familiaridade das pessoas com a Internet das Coisas (IoT) e como ela está integrada ao nosso ambiente.

Palavras-chave: internet, otimização, automação, tecnologia, emprego.

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Introduction

A digitized and automated world would be an environment in which technology and automation would play a central role in almost all aspects of daily life, economy and society. The advantages offered by such a world include the following:

1. Internet of Things (IoT): Would allow common items (furniture, cars, medical equipment, and more) to connect to the Internet and communicate with each other to gather information and make decisions
2. Automation in industry: Robots and sophisticated control systems would automate most of the dangerous and repetitive tasks in manufacturing.
3. Smart cities (ur-botics): Cities would be equipped with sensors and management systems that would monitor and optimize traffic, energy use, water availability, waste disposal, and other public services.
4. Artificial intelligence (AI): This is already present in many aspects of life, from chatbots and virtual assistants that offer customer service to personalized recommendation systems in e-commerce and entertainment.

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5. E-commerce and digital payments: Will become commonplace, with the potential to change the way security and transaction processing is handled thanks to *blockchain technology* .
6. Renewable energies and energy efficiency: The dissemination of renewable energy sources and intelligent management systems will make energy production and consumption more sustainable and efficient.
7. Cybersecurity: In a highly digitalized world, cybersecurity will be crucial to preserve the privacy and integrity of data, with the creation of more sophisticated security systems (Camacho *et al* ., 2017).

As can be seen, the Internet plays a very important role when carrying out our daily tasks, since it offers a great advantage by allowing us to find information on our topics of interest, perform tasks, store data in the cloud and study topics related to our career. In fact, the next step in this evolution is the optimization of speed with 5G technology.

Development

Industry 4.0

Industry 4.0 concept represents a notable technological innovation that has emerged in recent times driven by the introduction of intelligent machinery capable of monitoring its environment and adapting to various applications. According to Ynzunza *et al.* (2017), this idea involves the integration of digital technologies in the manufacturing environment, such as mobile devices, cloud computing, *big data analysis* , wireless sensor networks, embedded systems and others.

However, although the implementation of this technology has shown significant results, the majority has been carried out in isolation, which is due to uncertainty regarding the possible future impacts of the digitalization of industrial processes, particularly in what regards cybersecurity. In other words, a lack of knowledge about Industry 4.0 and smart manufacturing has contributed to this caution. Therefore, although constant growth is recognized in this area in recent years, uncertainties still persist about its full potential and the factors that could influence its mass adoption.

Indeed, industry 4.0 promises to radically transform the way manufacturing processes are carried out, so its constant growth suggests continued development in the short term (Ynzunza *et al.* , 2017). Some of the advantages of industry 4.0 are the following:

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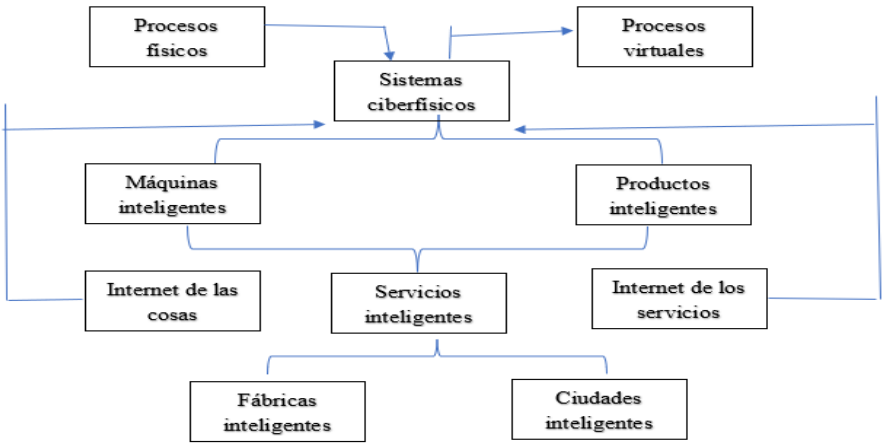
1. Process optimization: Industry 4.0 allows companies to improve the management of their operations, which reduces the use of resources and maximizes efficiency.
2. Increased productivity: Thanks to technologies such as advanced automation and data analysis, companies can produce more in less time and with fewer resources.
3. Efficient customization: Agile adaptation to customer preferences and large-scale customized production are key advantages of Industry 4.0, allowing you to better meet changing market demands.
4. Cost control: Automation and process optimization can lead to a reduction in labor, energy and material expenses, which improves profitability.
5. Quality improvement: Automation and advanced process control guarantee greater quality and uniformity in products, thereby minimizing errors and variations.
6. Market agility: Digitizing the supply chain and production speeds time to market, allowing for faster response to market demands.
7. Operational Flexibility: The ability to quickly reconfigure production lines and adapt to changes in demand is essential in a dynamic business environment.
8. Improved workplace safety: Automation and robotics can take over hazardous tasks, reducing the risk of accidents in the workplace.
9. Advanced data analytics: Real-time data collection and analysis allows businesses to make more informed decisions and foresee problems before they happen.

In short, it can be predicted that industry 4.0 and its technologies will replace traditional ones.

Figure 1. Components of industry 4.0



Source: Ynzunza *et al* . (2017)

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Artificial intelligence

Artificial intelligence is described as a field of computing that allows the development of systems, programs and tasks that normally require human intervention due to their knowledge and intelligence. This concept is based on the idea that machines can simulate human behavior through algorithms that recognize patterns and devise plans consistent with the requests received. To achieve this, AI researchers employ a variety of techniques and methods, such as machine learning, natural language processing (NLP), artificial neural networks, and computer vision.

Today, artificial intelligence is used in a wide range of applications, from virtual assistants like Siri and Alexa to recommendation systems on streaming platforms , computerized medical diagnostics, autonomous vehicles and many other fields. Thus, artificial intelligence continues to develop and plays an increasingly important role in modern society.

Navas (2021) raises the idea of a world that could be completely automated, where human intervention in daily tasks would be minimal, especially in manufacturing processes due to the speed of the machinery implemented. In this context, industry 4.0 together with artificial intelligence seems closer to robotization and the implementation of intelligent systems in conjunction with home automation, building automation and urbotics tasks .

It has even been shown that artificial intelligence, thanks to its advanced algorithms, can be implemented to recognize the tasks that must be carried out. That is, AI is responsible for identifying patterns that allow us to find solutions to problems, in a similar way to how a human being would do it. However, the difference is that the machine can execute the task in an optimized and efficient manner. Therefore, the idea of using AI seems very promising for the future.

The Internet of Things (IoT)

The Internet of Things (IoT) is a concept that refers to the interconnection of physical objects using the Internet infrastructure. This technology allows everyday devices, as well as equipment and sensors, to communicate and share data with each other autonomously, without direct human intervention. Some of its properties are the following:

1. IoT devices : They span a wide range of natures and functions, from smart systems to environmental sensors, security cameras and connected vehicles, as well as advanced industrial equipment.

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2. Connectivity: Camacho *et al.* (2017) explains that these devices are equipped with sensors to collect information from the environment, actuators to perform certain actions, and internet connections for data transmission. Connectivity, therefore, is a crucial aspect of IoT , as it allows devices to communicate in various ways, such as through wireless networks such as Wi-Fi and *Bluetooth* , cellular networks or special low-power technologies (LPWAN).
3. Data Collection: Data collected by the sensors of IoT devices is transferred to a central platform where it is processed and analyzed. These platforms use algorithms and data analysis techniques to extract valuable insights from raw data that can be used to make informed decisions and automate operations.
4. IoT Platforms : One of the key benefits of IoT is its ability to automate tasks and processes based on real-time data. For example, a smart thermostat can automatically adjust the temperature of a room based on user preferences and detected environmental conditions.
5. Cybersecurity: Camacho (2017) refers to security in the Internet of Things as a critical issue because the interconnection of devices can create potential vulnerabilities. Therefore, strong security measures such as authentication, encryption, and regular *software updates must be implemented* to protect the device and transmitted data.
6. Applications: IoT has applications in various industries, including healthcare, agriculture, logistics, building management, transportation, and more. Examples of applications include patient health monitoring, supply chain optimization, and energy management in smart buildings.

On the other hand, Camacho (2017) considers that the internet of things encompasses a series of concepts that are beneficial for humans, including artificial intelligence, automation in the context of industry 4.0 and a critical aspect: cybersecurity. In other words, constant protection is essential for highly advanced devices, since, being digital devices, they are exposed to possible hacks that could divert their original functioning towards other undesirable purposes.

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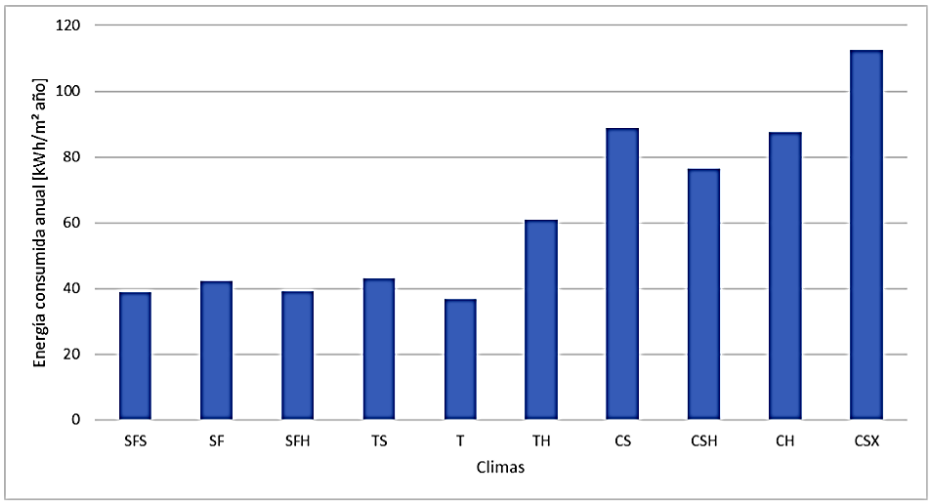
Energy efficiency

Energy efficiency in the field of the Internet of Things (IoT) is a crucial aspect, given the growing adoption of network-connected devices. IoT involves the interconnection of physical objects over the Internet, enabling real-time data collection and sharing to improve automation, decision-making, and convenience in various applications, such as smart cities, connected homes, and industrial systems . .

IoT are explained below :

1) Optimization of energy consumption: Energy efficiency is essential in IoT devices , especially those that operate with batteries, so it is essential to optimize their consumption to prolong their life. This involves careful design of both *hardware* and *software* to ensure that devices consume as little power as possible when idle or in standby mode (Calixto and Huelsz, 2018).

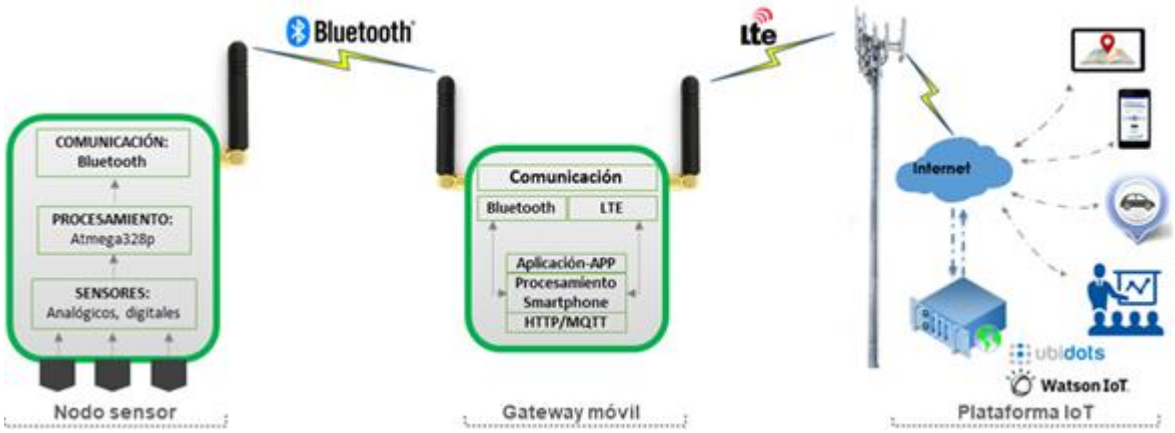
Figure 2 . Average energy consumption per unit area in buildings by climate



Source: Calixto and Huelsz (2018)

2) Efficient communication protocols: Wireless communications between IoT devices can represent a significant source of energy consumption. Therefore, it is crucial to use efficient communication protocols, such as MQTT or CoAP . Additionally, transmitting only necessary information, rather than redundant or unnecessary data, can significantly reduce power consumption.

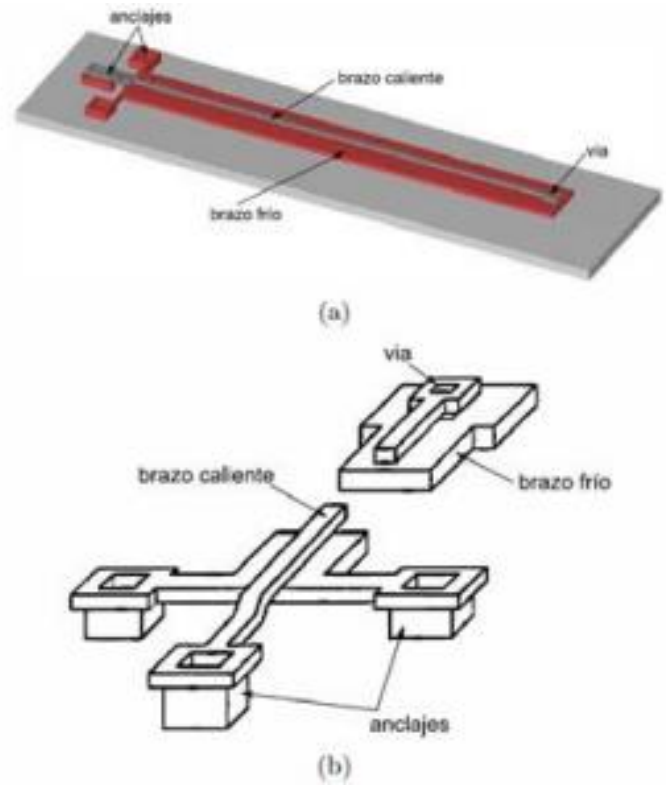
Figure 3 . System architecture to be used in MQTT protocols



Source: Quiñones *et al.* (2020)

3) Low consumption sensors: Selecting low consumption sensors is essential to guarantee the energy efficiency of IoT devices . An example of this can be shown in figure 4. Advances in this technology have made it possible to create devices capable of operating for long periods with small batteries.

Figure 4. Three-dimensional model of a low-consumption thermal actuator



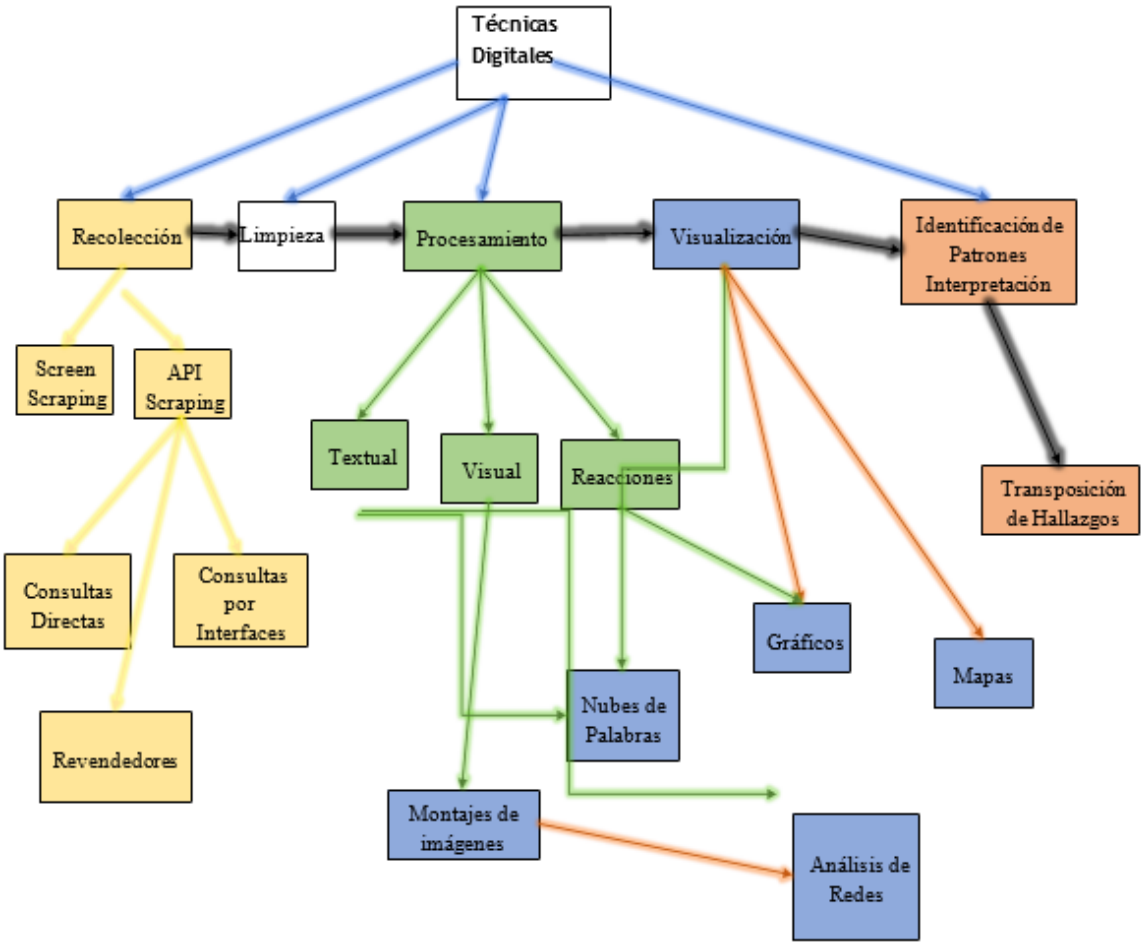
Source: Quiñones *et al.* (2020)

4) Energy Management: Implementing smart energy management strategies is essential in IoT devices . This involves the use of algorithms that adjust the sampling rate of sensors as needed and the ability to put devices into sleep mode or turn off devices when not in use.

5) Efficient network architecture: Choosing an appropriate network infrastructure is crucial to ensure energy efficiency. The use of low-power networks, such as LoRaWAN or NB- IoT , allows for greater energy efficiency by reducing the power needed to transmit data over long distances.

6) Smart data collection and analysis: Real-time data collection and analysis can help identify usage patterns and behaviors that enable more efficient energy consumption decisions.

Figure 5. Classification of digital techniques



Source: Sued (2020)

Firmware and security updates : Keeping the *firmware of* IoT devices updated is crucial not only for security reasons but also to ensure energy efficiency. Upgrades may include

improvements to power management and *hardware optimization* , contributing to more efficient and sustainable operation.

Industrial robotics

Industrial robotics is a branch of engineering and automation that focuses on the design, development, and application of robots in industrial manufacturing and production environments. These industrial robots are intended to carry out specific tasks autonomously or semi-autonomously in production lines, factories, and other industrial environments. Below is important information about industrial robotics:

1. Types of industrial robots: Industrial robots can come in a wide variety of shapes and sizes, depending on the task they must perform. Some common examples include robotic arms, mobile robots, Cartesian robots, and SCARA robots. Each type has its own capabilities and limitations, and they are chosen based on the specific application.
2. Applications in industry: Industrial robots are used in a wide range of applications, such as welding, painting, assembly, material handling, palletizing, quality inspection, cutting and food handling, among many others. Their versatility makes them essential elements to improve efficiency and quality in industrial production.
3. Automation of repetitive and dangerous tasks: Industrial robotics offers the ability to automate repetitive and dangerous tasks that previously required human labor. This automation not only improves product quality, but also reduces the risk of workplace injuries.
4. Programming and control: According to López and Andrade (2013), industrial robots are programmed to perform specific tasks using control *software.* Programming can be carried out by robotics engineers or using more accessible interfaces that allow operators to teach movements and tasks to robots.
5. Human-robot collaboration: Human-robot collaboration (HRC), as López and Andrade (2013) point out, is a growing trend in industrial robotics. Collaborative robots, or “co-bots” are designed to work alongside human workers safely and efficiently, harnessing human experience and intuition while harnessing the precision and strength of robots.
6. Sensors and computer vision: Many industrial robots are equipped with sensors and computer vision systems that allow them to detect and adapt to their environment,

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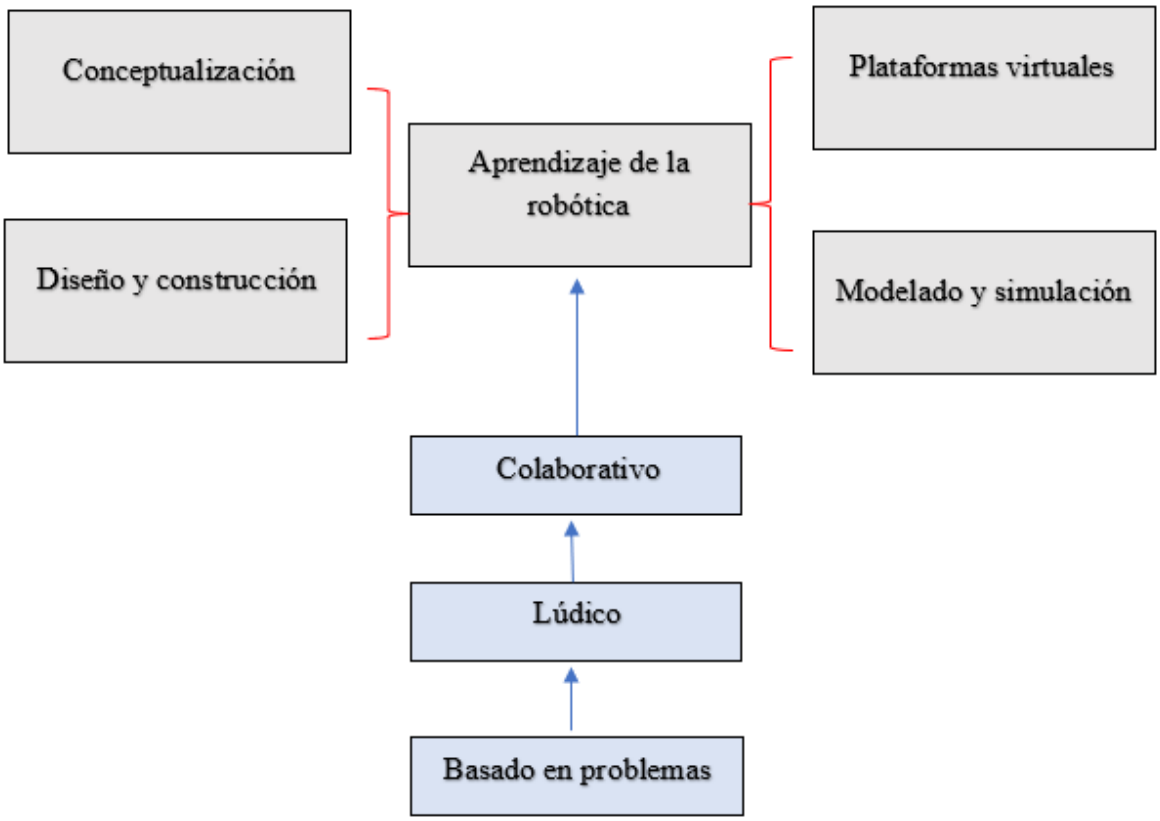
which is essential for tasks such as quality inspection and manipulation of variable objects.

7. Efficiency and cost savings: The introduction of industrial robots in production can significantly improve efficiency, reduce production costs and speed up production cycles. However, the initial investment in robotics is often considerable and requires careful analysis of the return on investment (ROI).
8. Challenges and considerations: Despite the benefits, the implementation of industrial robotics also presents challenges, such as personnel training, safety, system interoperability, and adaptability to changes in production.

Figure 6. Learning robotics



Source: López and Andrade (2013)

Impact on employment

Automation has a significant impact on employment and can affect the workforce in several ways, both positive and negative. Below are some of the main effects of automation on employment, as proposed by Minian (2018).

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Positive effects

- Increased productivity: Automating repetitive and routine tasks can increase productivity, as machines and automated systems can perform these tasks faster and more accurately than humans.
- Higher quality and consistency: Automated systems tend to make fewer errors and produce products or services of higher quality and consistency, which benefits businesses and consumers.
- Freeing up workers: Automating routine tasks can free up workers to focus on more creative, strategic, and high-value-added tasks that require human skills, such as decision making, problem solving, and creativity.
- Creating technology jobs: As companies invest in technology and automation, they are also creating technology-related jobs, such as *software engineers*, robot maintenance technicians, and cybersecurity specialists.

Table 1. Occupations with the highest number of employees at high risk of automation

No.	SINCO code	Description	Employment at risk of some automation	Stake	Cumulative participation
1	7513	Workers in the production of bread, tortillas, pastries, and other cereal and flour products	517,392	10.9	10.9
2	8212	Assemblers and assemblers of electrical and electronic parts	434,937	9.2	20.1
3	7341	Tailors and dressmakers, seamstresses and clothing makers	298,838	6.3	26.3
4	8133	Machine operators for the production and assembly of plastic and rubber products	266,601	5.6	32.0
5	8153	Operators of sewing, embroidery and cutting machines for the manufacture of textile and clothing products	262,076	5.5	37.5
6	7311	Carpenters, cabinetmakers and planers in the production of wood products	256,586	5.4	42.9
7	8123	Cutting, drilling, bending and metal parts machine operators	252,040	5.3	48.2
8	4211	Sales employees, dispatchers and shop assistants	219,263	4.6	52.8
9	8211	Assemblers and assemblers of tools, machinery, equipment and metal products	203,105	4.3	57.1
10	8341	Drivers of vans, trucks and cargo cars	145,730	3.1	60.2
eleven	8161	Machine operators in the production of foods, oils, fats, salt and spices	116,987	2.5	62.6
12	8352	Drivers of mobile machinery for the movement of goods in factories, ports, shops, etc.	113,035	2.4	65.0
13	2634	Mechanics in maintenance and repair of industrial machinery and instruments	95,588	2.0	67.0
14	7332	fiber weavers	93,357	2.0	69.0
fifteen	4214	Sales drivers	92,578	1.9	70.9

Source: Minian and Martínez (2018)

Table 2. Total employment according to its level of risk of being automated

Risk level	Employment (people)	Percent share
High	30 342 792	63.4
Half	8 413 405	17.6
Low	9 098 438	19.0
Total	47 854 635	100.0

Source: Minian and Martínez (2018)

General objective

Recognize productive processes that implement digital devices that facilitate tasks automatically, as well as their impact on long-term employment. To do this, the following question is posed: how familiar is society with the issue of the Internet of Things?

Specific goal

Make a significant focus on how the Internet of Things can be used to our benefit to increase energy efficiency in a particular environment, for example, in an office building significantly reduce energy consumption, system monitoring and control IoT , which can include sensors that modify lighting and climate based on occupancy and environmental factors.

Methodology

Electronic journals and websites registered on the Redalyc page were consulted to extract the main ideas related to the chosen topics. Additionally, a survey was conducted among people within our scope to validate the findings obtained during the research. Finally, an exhaustive analysis was carried out in the discussion section of the results, where it was evaluated whether the main research question is supported by the information collected.

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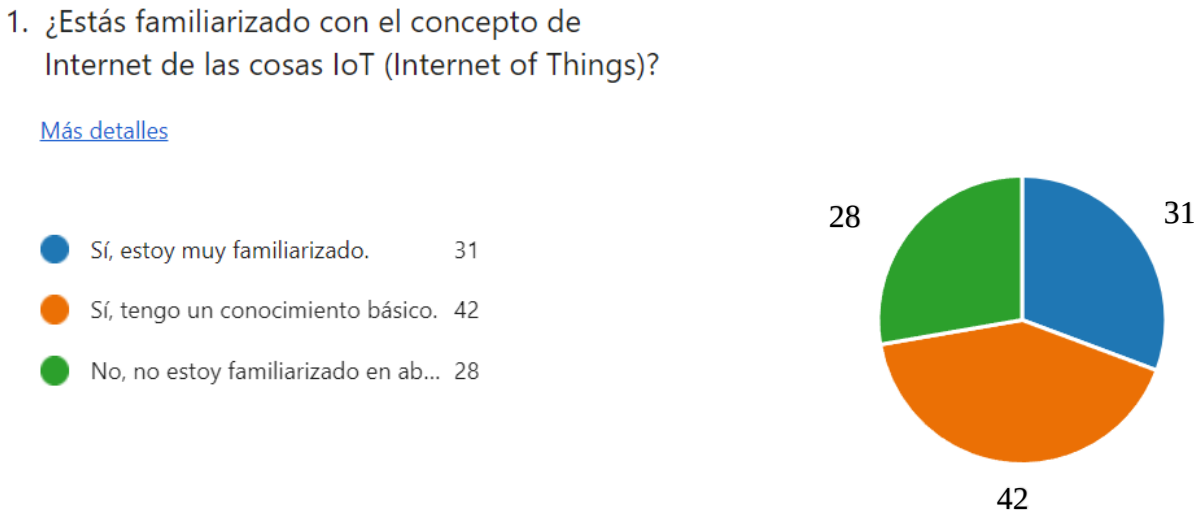
Method

A survey was used to collect data on people's knowledge about the Internet of Things (IoT), which provided valuable information for making informed decisions in product development, education, security, *marketing* and research, as well as to help understand people's needs, perceptions and concerns in relation to this constantly evolving technology.

Results

Figure 7. Familiarization with the IoT



Source: self made

Figure 8. Device management

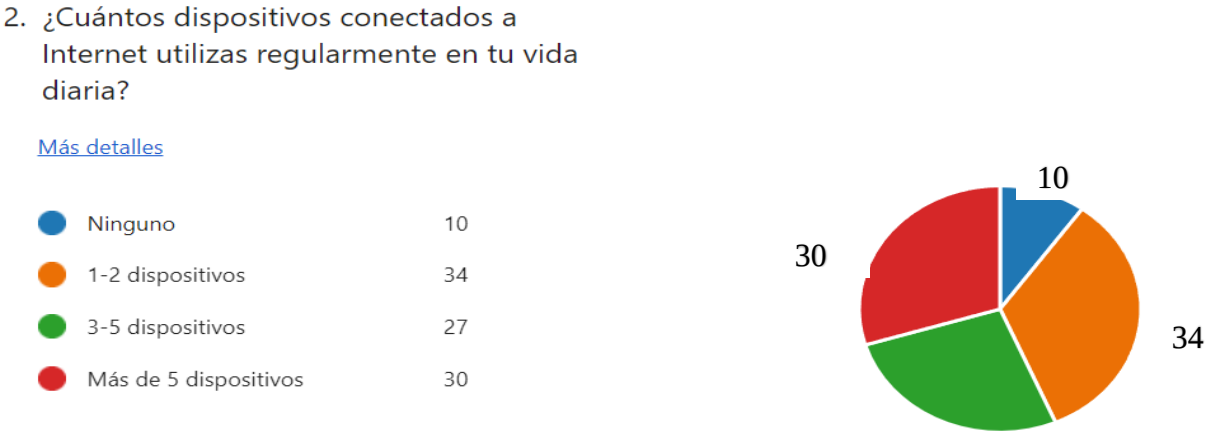


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Figure 9. Main advantage

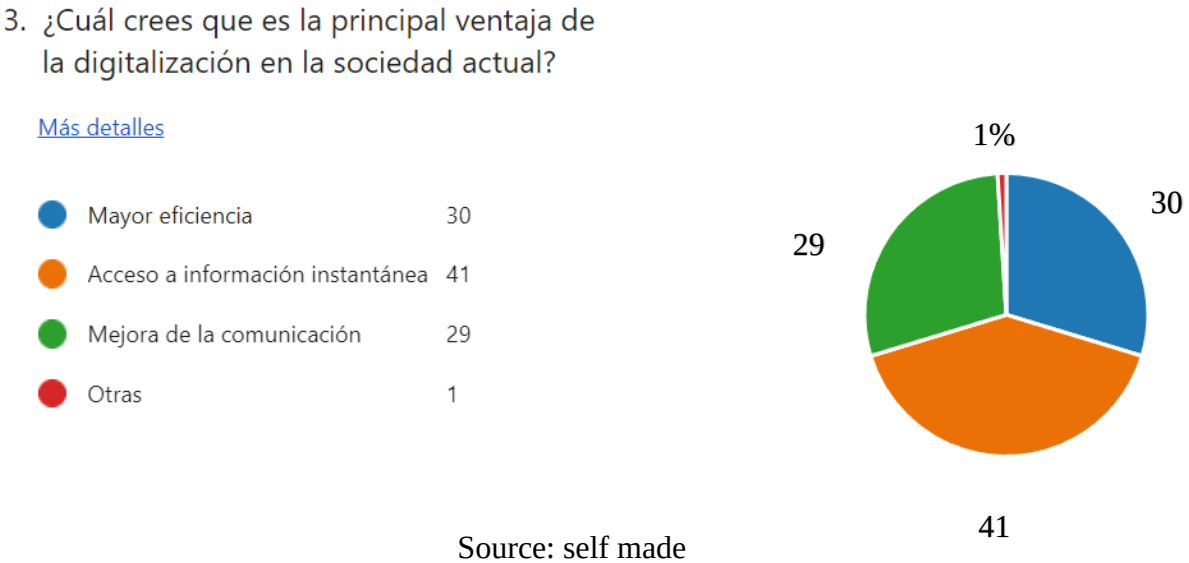

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Figure 10. Device security

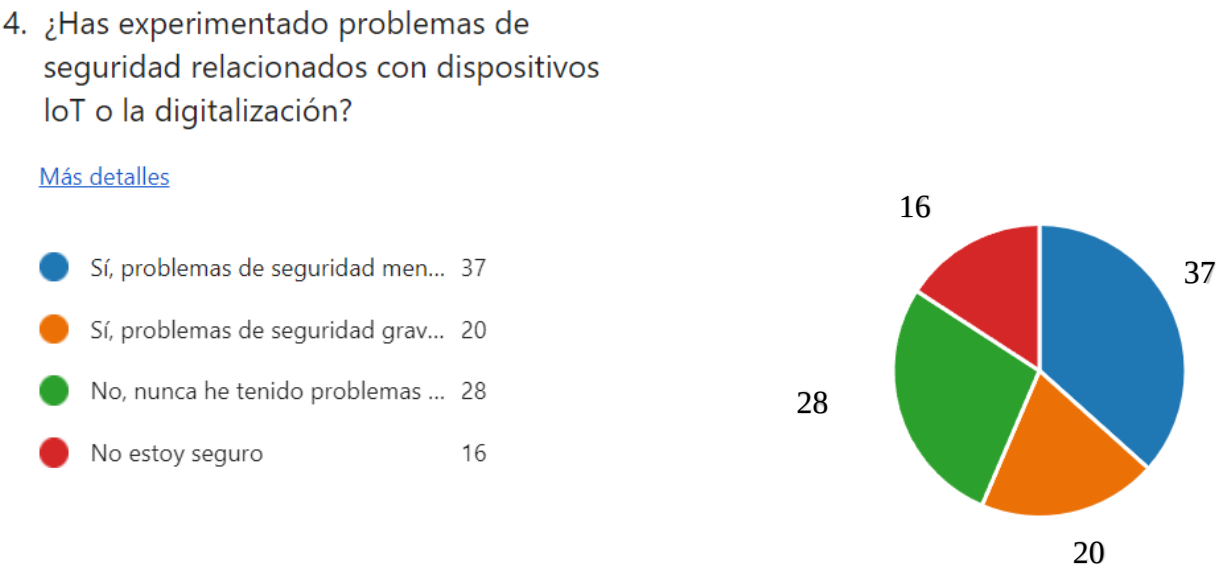

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Figure 11. Impact on work

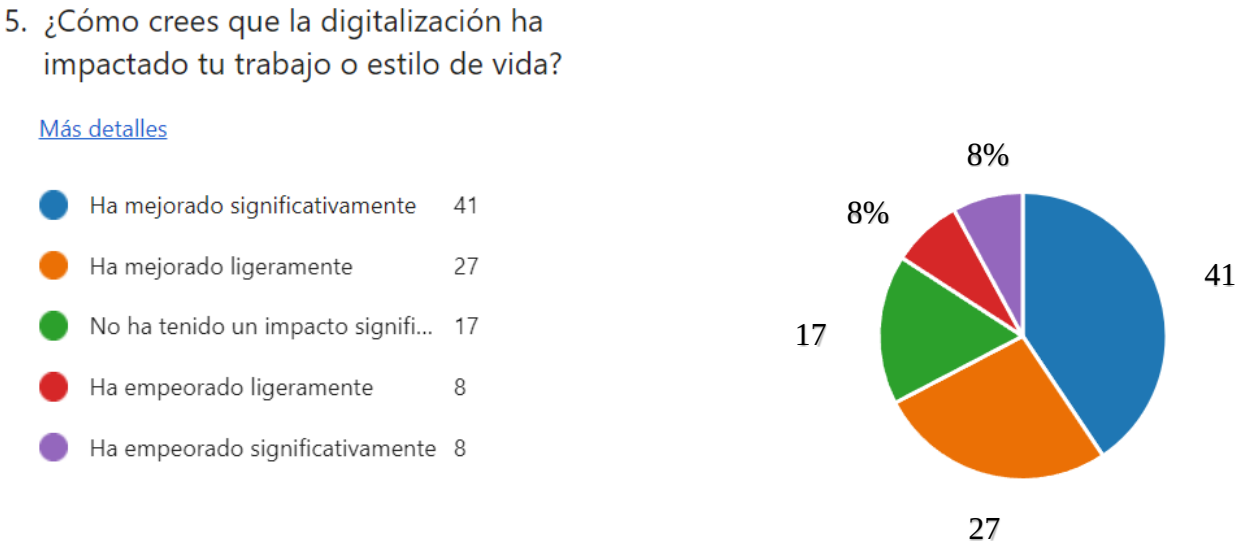

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Figure 12. Future vision

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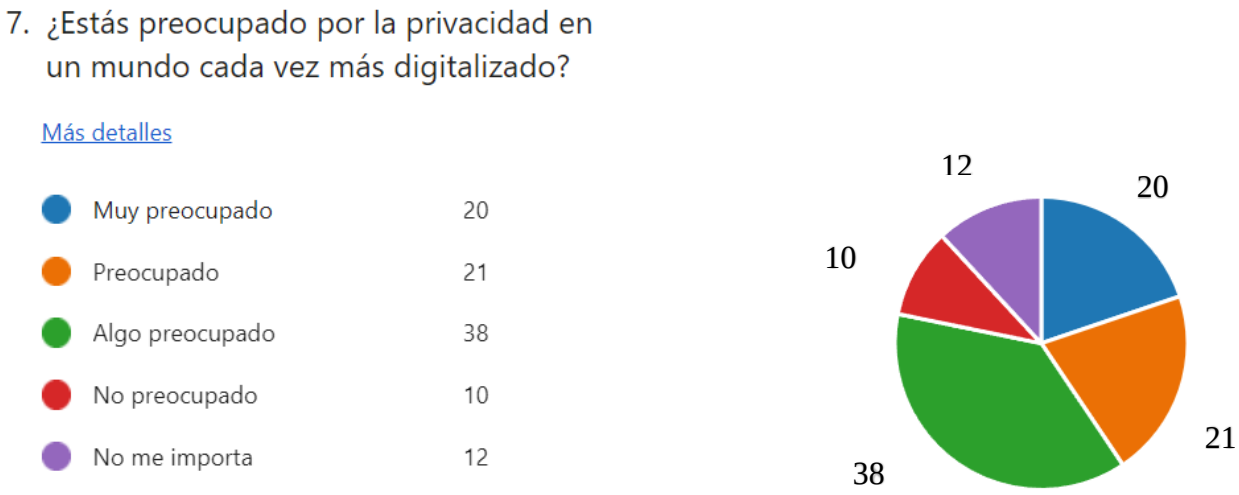
Figure 13. Privacy



Source: self made

Figure 14. Sectors benefiting from IoT

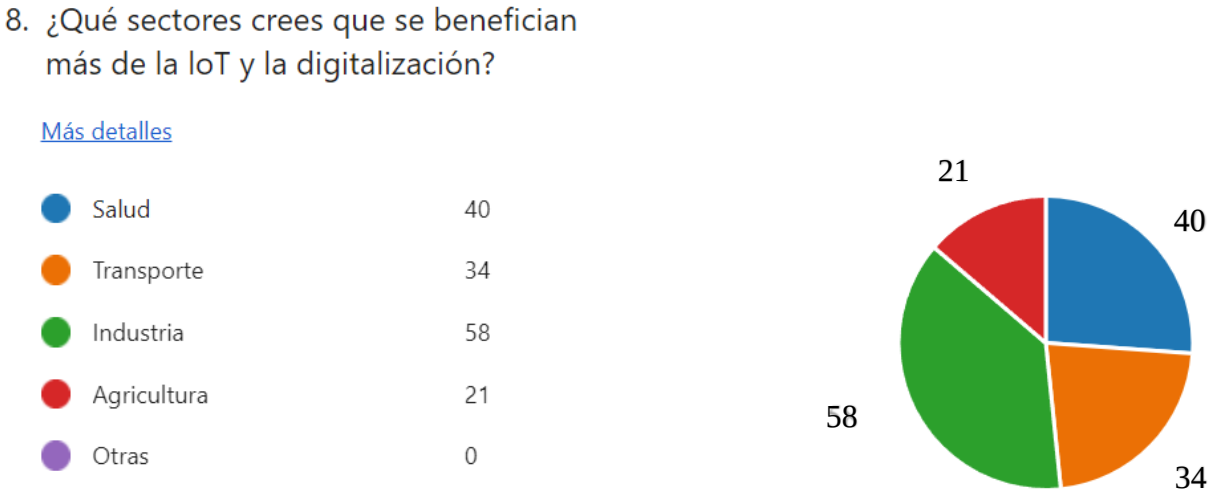


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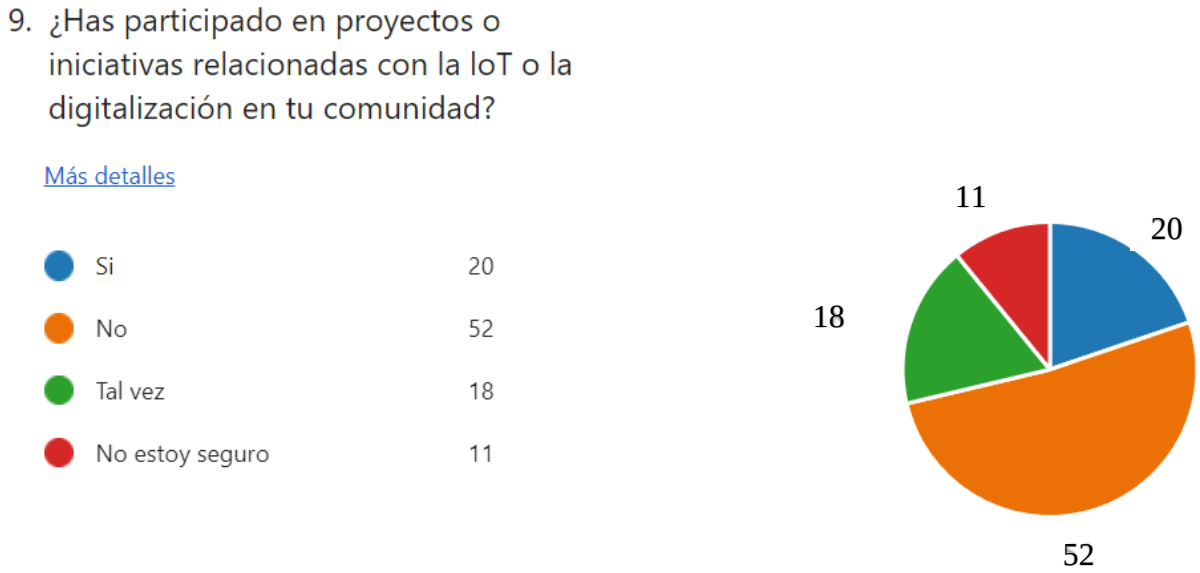
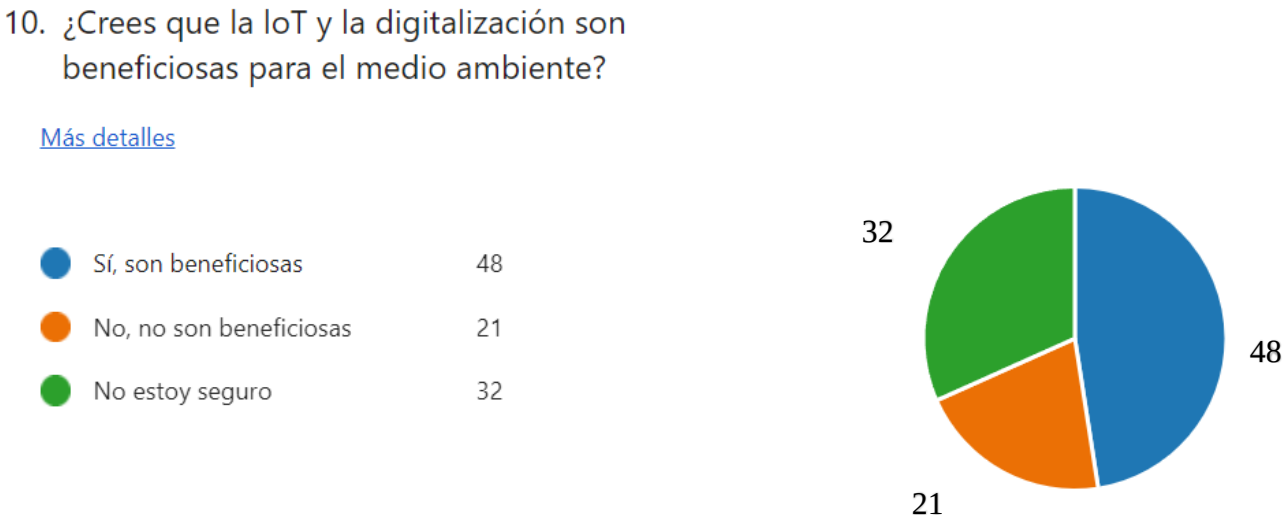
Figure 15. Community projects



Source: self made

Figure 16. Benefit for the environment



Source: self made

Discussion

This research addresses fundamental aspects around the Internet of Things (IoT), industry 4.0, artificial intelligence, energy efficiency, cybersecurity, industrial robotics and the impact on employment, among others.

As for the Internet of Things (IoT), it has emerged as one of the most disruptive technologies of the contemporary era, which promises to connect devices, collect data and improve efficiency in various industries and applications. However, as the IoT expands and evolves, significant challenges arise that must be addressed to reach its full potential. One of the most urgent issues in the field of IoT and industry 4.0 is security and privacy, since with the proliferation of connected devices the risk of vulnerabilities and cyber attacks increases. Therefore, it is crucial to establish solid security standards and protocols to preserve data integrity and user privacy.

Another relevant issue relates to the adoption of 5G networks and their impact on IoT, since their speed and reliability are driving the viability of applications that require minimal latency, such as telemedicine and autonomous vehicles (González and Salamanca, 2016). Likewise, it can be indicated that the convergence of artificial intelligence (AI) also plays a fundamental role in the advancement of this technology, since it allows the analysis of massive data generated by IoT devices and decision making in real time, which It is essential in industrial supervision and automation applications, among others. According to Rozo-García (2020), the work carried out is similar to the ideas raised in this article, where reference is made to the impact of new technologies in the industry, as mentioned in the economic field. This brings with it a development in production processes, although also the possible risk of being completely automated. In summary, the people surveyed demonstrated knowledge about the impact of the Internet of Things and Industry 4.0, with some exceptions.

Conclusions

Industry 4.0, also known as the Fourth Industrial Revolution, is a comprehensive approach that seeks the digitalization and automation of manufacturing and production processes. Its essence lies in connectivity, real-time data collection and analysis, artificial intelligence and the interaction between cyber and physical systems, which has allowed companies to increase their efficiency, quality and flexibility, as well as optimize production. and reducing costs.

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For its part, the Internet of Things (IoT) is an essential component of Industry 4.0, as it is based on the interconnection of devices and sensors in manufacturing and other industrial sectors. These devices can monitor and control a variety of variables, from temperature and humidity on an assembly line to the location and status of products in transit, enabling more informed and reactive decision making, as well as greater efficiency and better resource management.

One of the most notable conclusions of this convergence between IoT and Industry 4.0 is the creation of safer and more collaborative work environments, as automation and collaborative robotics have reduced workers' exposure to dangerous environments and improved working conditions. jobs in the industry. Additionally, collaboration between humans and machines has become more effective and efficient, resulting in an increase in product quality and customer satisfaction.

However, not everything is smooth sailing in this industrial revolution. An example of this is the lack of cybersecurity, since the massive interconnection of devices and systems exposes organizations to risks of cyber attacks, which can affect the integrity of data and the continuity of operations. Protecting infrastructure and data has therefore become a top priority, requiring significant investments in security measures and increased awareness of cyber threats.

In addition, it should be taken into account that digitalization and automation can have implications for employment, since although on the one hand these technologies can improve productivity, they can also result in a reduction in the workforce in some areas. Consequently, companies and governments must address these changes strategically to provide retraining and training opportunities for affected workers.

Future lines of research

1) Security and privacy in IoT and AI:
    - It is about developing advanced methods to guarantee the security and privacy of data in IoT and AI environments.
    - Analyze emerging security challenges with the rise of connected devices and intelligent systems in Industry 4.0.
2) Ethics in automation:

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- It consists of investigating the ethical implications of increasing automation in Industry 4.0, especially in terms of autonomous decisions made by artificial intelligence systems.
- Examine how ethical principles can be integrated into the design and development of IoT and AI systems to minimize ethical and social risks.

3) Impact on employment and vocational training:
    - Assess how the implementation of technologies such as IoT and AI affect the workforce and how potential negative impacts can be mitigated.
    - Explore training and retraining programs to prepare workers for emerging roles in Industry 4.0.
4) Technology integration:
    - Investigate effective strategies to integrate IoT systems and AI platforms into manufacturing processes and industrial operations.
    - Analyze case studies on successful implementations that improve efficiency and productivity.
5) Social and economic impact:
    - Assess the socioeconomic impact of the adoption of IoT and AI in Industry 4.0 in different sectors and regions.
    - Analyze how these technologies can contribute to economic growth and improved quality of life.

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