



Correlation of Mental Health in Programmers Who Develop Artificial Intelligence Technology and Their Operational Yielding Using Internal Marketing to Increase His Labor Behavior in the Electronics Industry of Tijuana, Mexico

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Abstract – The development of programming systems for artificial intelligence activities that are applied in industrial processes of the electronic industry of the city of Tijuana is of great relevance for the development of specialized computer programs that greatly support obtaining maximum levels of productivity. and quality of the products manufactured in an electronic industry in this industrialized city and with high-level personnel regarding the programming of industrial equipment and machines used in manufacturing areas. Only, on occasions, an action of mental fatigue or even some mental health symptom has been generated that can cause a complicated health situation in the programmers of this type of actions in the industry. This is why a correlation analysis was developed between the level of productive performance of the programmers of artificial intelligence activities and mental health actions that they generated in the investigation period in 2023. In this correlation, it was observed that the high managers and heads of the programmers, could understand the workers' need for these relevant activities, have rest spaces in the company where the research was made and for some periods of time in their respective homes, with the aim of achieving better productive performance in the electronics industry evaluated. In this investigation was utilized specialized actions of internal marketing to improve the behavior of programmers and their operative yielding.

Keywords: Mental health, electronics industry, productive performance, programmers, artificial Intelligence, internal marketing.

1. INTRODUCTION

Industrial operations are of great relevance in the manufacturing actions of the products that we use in daily life, so the development of manufacturing processes efficiently is of great importance (Bouanba et al, 2022; Jan et al, 2023). It's just that the development of these industrial operations requires great mental effort from workers in manufacturing areas, from operational personnel to the management and management level. Worldwide, technology is exceeding the expectations of manufacturing operations, but this is based on personnel who perform the programming functions of equipment, machinery and industrial systems, which carry out the activities in an automated manner. These actions are helping to improve working conditions and increase the productivity and quality of manufactured products, essentially, only those workers in programming functions, especially those who work with robots and artificial intelligence technology, may suffer from fatigue. mentally, if they are not given some type of rest (Joksimovic et al, 2023). The owners of industrial companies, management and management personnel are responsible for being able to support this type of workers, so that their mental health is not affected. This investigation consists of an analysis in 20 industrial companies located in the Tijuana city, where was analyzing as a first factor, the working conditions of the personnel who prepare the programming of the functions of the programming of industrial devices, equipment and machinery, to improve it and not generates a lot mental fatigue in programmers and originates a negative effect in his mental health (Gadecki et al, 2018; Ojala, 2011). The second factor analyzed evaluated was the operative yielding of the industrials systems mentioned above with artificial intelligence programmed. The third factor was the correlation analysis of the negative effects on the mental health of programmers by the excess of mental fatigue, making the analysis with visits to general doctors and specialists' doctors and psychologists to determine the mental health status of workers who work in these 20 evaluated industries, and be applied specialized strategies of internal marketing to convince to programmers to make its job functions with high quality and improve its labor conditions. The three factors of this investigation are observed in figure 1 (Villegas et al, 2021; Frank et al, 2019).

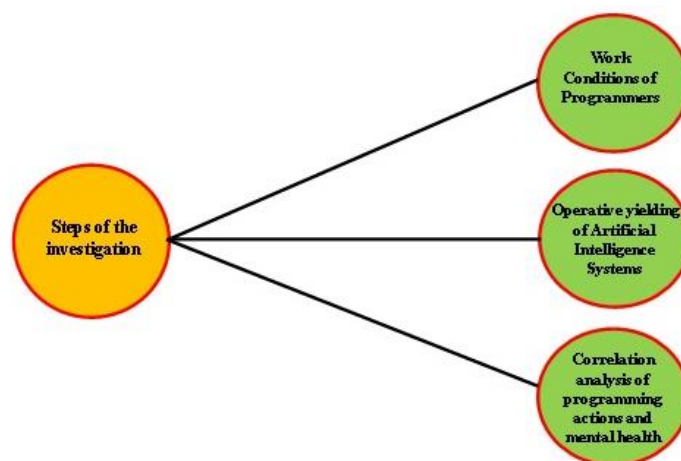


Fig -1: Steps of the investigation
Source. Analysis of information



1.1 Industrial Activities

The city of Tijuana is an industrialized area in the northwest of the Mexican Republic, where 350 industries are located (AIMT, 2023), which manufacture various types of products that are marketed worldwide and in this region of great importance in the national market. and international (especially with the state of California in the United States, which is an area focused on the global market). In these industries, a wide variety of industrial activities are carried out, which are fundamental in the main functions carried out in manufacturing industries worldwide for the processing of raw materials into the products that we use in daily life (Ribeiro et al, 2021). Industrial operations in manufacturing areas are essentially of two types, the first being simple operations, which can be carried out manually or with industrial equipment, machinery, or systems, where basic processes are applied and specialized personnel are not required. only with a low level of training (Li et al, 2023). The second type of industrial operations are the so-called complex industrial activities, which are carried out in a meticulous manner, either manually or automated with specialized personnel and equipment, machinery and systems. In this type of activity, it is required that training actions be constantly carried out to avoid any complicated situation that could cause a minor or drastic accident or illness. In this scientific study, it refers to the analysis of industrial operations, where the operational personnel who program the industrial equipment, machines and systems participate, which are considered functions of the second type of industrial activities, such as complex operations. This analysis involved, with reference to this section, the evaluation of the programming times of the robots and artificial intelligence systems and the visits to the internal and external doctors of the companies evaluated, as well as the days that the programmers were disabled due to mental fatigue. that affected his mental health (Saranya et al, 2023). The main types of industries in Tijuana city are shown in table 1.

Table -1: Main types of industries and manufactured products in Tijuana (2023)

Types of Industries	Essential Manufactured Products
Aerospace	Autopilots for aircraft, Wiring for aircraft control, filters for oxygen exchange in aircraft, Turbines for aircraft
Agricultural	Parts for agricultural equipment and machinery, mainly mechanical shock absorbers, electrical cables, Diesel Filters and Parts for repair of electric starters.
Automotive	Automotive Alternators and Electric Starters, Automobiles, Automotive Dashboard Control Wiring, Crash Impact Sensors,
Biomedical	Catheters, Syringes, Pacemakers, Hoses for medical activities, Blood Pressure Meters and Oximeters.
Electronic	Accessories for music devices (mainly headphones), car and home alarms, cell phones, computers and televisions
Metallic	Construction structures and parts of aircraft and automobiles, Autopilots for water heaters
Plastics	Housings for computers and televisions, Hoses for automobiles and aircraft.

Textile	Fabrics for aircraft and automobile seats, tablecloths for social events and clothing.
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Table 1 shows the principal industries and the essential products manufactured in this industrialized and technologic city, where need specialized workers to make the basic and complex industrial operations. These essential fabricated products are utilized in a lot activities in the daily life in this city and in at worldwide.

1.2 Artificial Intelligence

These types of systems represent specialized actions through computing functions and mathematical algorithms, which generate human-like activities, through robotic systems, which wish to simulate and achieve the closest thing to human thinking and intelligence. These types of operations are very complex, due to the objective of reaching the highest standards that lead to the similarity of thought and intelligence of human beings, and sometimes even feelings; through specialized systems that imitate the actions of robots, indicating that they could be the same actions as people, especially industrial workers. The programming of robotic systems with levels of artificial intelligence is fundamental in the actions of industrial robots, which is why long periods of time are required for operational personnel to program artificial intelligence systems (Xu et al, 2021). In addition, the neural system of the programmers must be constantly used, which is why sometimes it generates at least mental fatigue and other times mental health problems for programmers who work in industries of any type. In this research, a correlation analysis was made of the long periods of time used by programmers who work in the 20 industries of the city of Tijuana that allowed this scientific study to be carried out, and the effect on mental health. Artificial intelligence systems are divided into four types, which are expressed in figure 2 (Patange et al, 2023).

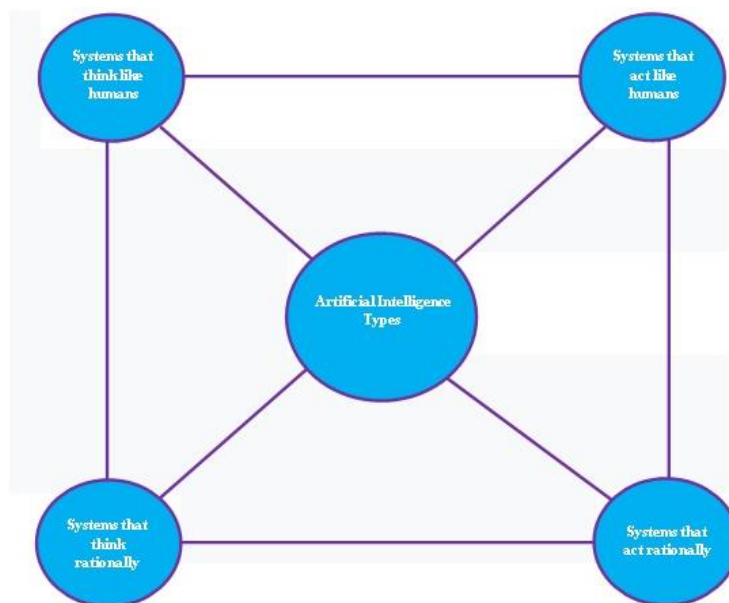


Fig -2: Types of artificial intelligence
Source. Analysis of information



Figure 2 shows the types of artificial intelligence that are explained below (Ahmed et al, 2023):

- Systems that can think like humans:** They have the ability to emulate people's thinking, a main example being neural network systems, which can support thinking, making decisions and obtaining immediate solutions.
- Systems that can generate actions like humans:** These systems simulate human behavior to generate activities, for example, robotic systems.
- Systems that can think rationally:** They are those that can imitate the way of thinking of humans, being expert systems that perceive, reason and act according to actions that surround them.
- Systems that can act rationally:** These systems can emulate human behavior, for example, intelligent robot systems that detect objects.

1.3 Mental Health: Cases in Industrial Operations

It is part of the conditions of behavioral and social balance of people, where the sociocultural and emotional environment is evaluated, to have the ability to achieve goals and obtain solutions in an effective way and are disturbing the state of mental or other health. This type of actions is very recurrent in industrial activities, because it is necessary to act immediately to obtain instant solutions, when human errors or errors occur in uncontrolled and regulated industrial devices, equipment or machinery in manufacturing processes. According to the United Nations (UN), mental health is part of the mental, physical and social well-being of people, without evaluating addictions or any health symptoms. In this research, the way negative effects are generated on the mental health of workers who work programming industrial systems with artificial intelligence in the 20 industries of Tijuana, which allowed the development of this scientist, after observing the accumulation of medical visits to social security institutions in this border city, with 350 national and foreign industrial companies. The main actions of the medical visits were due to mental fatigue of the programmers, the most common causes being mental exhaustion due to excessive work activity with respect to mental thinking, and the most essential consequences can be expressed immediately in table 2 (Perez et al, 2019).

Table -2: Principal symptoms of mental fatigue in the industries evaluated in Tijuana (2023)

Behavioral Actions	Essential Manufactured Products
Discomfort in carrying out work activities.	When mental exhaustion occurred in the programmers of industrial systems with artificial intelligence, a hostile environment was generated, where the programmers felt uncomfortable being able to continue working, so they did not develop their functions or did so inadequately and a discussion arose. with their bosses at work.
Change in the behavior of programmers.	When what was mentioned in the previous aspect occurred, the programmers generated a behavioral change, which did not allow them to bond with their co-workers in the same area or with other areas of the companies evaluated.
Preparation of activities without control of the programmers.	Once the two previous actions occurred, the programmers developed inappropriate behaviors, such as not greeting their coworkers at any time during their work period and sometimes getting easily annoyed with their coworkers in their area, with their area



manager. or with other colleagues from other areas and heads of other work areas of the industries where the research was made.

Table 2 shows the necessity of this scientific study to demonstrate to directive and managers people of the 20 industrial companies evaluated and all industries of the world as commercial industries to generates good conditions to all workers, specially to programmers of industrial systems with artificial intelligence and improve the operative yielding of them.

1.4 Internal Marketing

This theme has the function of selling the idea of developing job functions to all workers in any type of industry, and is especially applied in national and foreign industrial companies located in our country, with the aim of convincing operational personnel, essentially those in manufacturing areas, where there are complex, repetitive industrial operations or risks to the safety of workers. In this investigation, specialized strategies were applied to ensure, with working conditions that would avoid mental fatigue, that programmers of industrial systems with artificial intelligence would develop their programming functions efficiently and thus be able to increase their operational performance.

2. METHODOLOGY

This investigation was made in three steps, which determined the necessity of elaborate this scientific study, and were explained now:

- Evaluation of the labor conditions of the programmers that programs the industrial systems mentioned above and were utilized artificial intelligence actions.
- Analysis of the operative yielding of the industrial systems with artificial intelligence that was programmed by the programmers in the industries evaluated.
- Evaluation of mental health of programmers and application of specialized strategies of internal marketing to increase its operative yielding and the productivity and quality indices of the industries evaluated (IMSS, 2023).

3. RESULTS

This investigation illustrated relevant information to the industrial companies of this region where is located the Tijuana city, and also in all places of the world, which use industrial systems with artificial intelligence and need of programmers to program these industrial systems, to have the best labor conditions to them and all people of the industrial companies located in the worldwide. In the next sections will show the results and the importance of these.

3.1 Analysis of Labor Conditions of Programmers

In this section of the investigation was made an evaluation of the level of discomfort of the labor conditions of workers that programming the industrial systems mentioned above and have parts of robotized structures with artificial intelligence. This is illustrated in figure 3, where the principal discomfort actions of the programmers were the excessive periods that passed the programmers making its functions without a resting time. Then was, followed by the inadequate computer equipment and furniture, with small screens

without filters to the view, small chairs and desks where was the computer systems, and not ergonomic keyboards, presenting some discomforts in some times and in other times big discomforts. Finally, the third major discomfort presented in this scientific study was the software not updated, where programmers need made more instructions in the old software and need think more, generating fatigue in his view and mental actions.

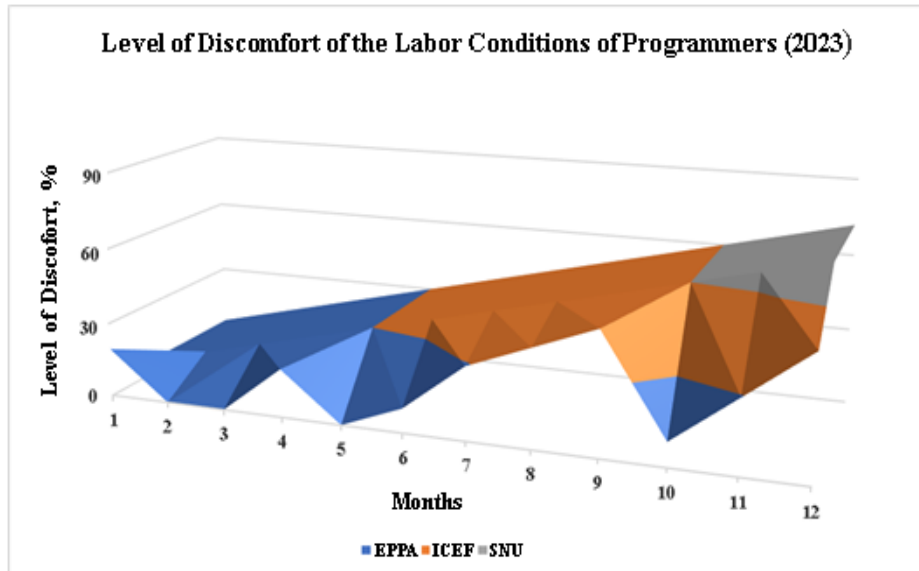


Fig -3: Evaluation average of level of discomfort of programmers of the industries evaluated (2023)
 Excessive periods of programming activities (EPPA)
 Inadequate computer equipment and furniture (ICEF)
 Software not updated (SNU)

Figure 3 illustrates the principal discomfort of labor conditions (DLC) of programmers, being the major DLC the excessive periods of time that programmers spent to make it programming functions, followed by the inadequate computer equipment and furniture and finally by the software not update; generating the discomforts. In this investigation were presented other discomforts in the programmers, but with less level of fatigue, indicating that in the 20 industrial companies was necessary improve the labor conditions of the programmers, to avoid the constantly visits to medical attention and improve its operative yielding and of the industrial systems with artificial intelligence actions.

3.2 Evaluation of Operative Yielding of Industrial Systems With Artificial Intelligence

This investigation, in this moment following the analysis of the labor conditions of the programmers, being a relevant evaluation to improve the productivity and quality indices of the industrial companies evaluated in this important city and all cities of the world that use artificial intelligence actions. For this reason, was made an evaluation of the operative yielding in the 20 industries of Tijuana, where was made this scientific study and be an example to other industrial companies where use the artificial intelligence actions. Table 3 shows the operative yielding of industrial systems, programmed by the programmers.

Table -3: Analysis of operative yielding of industrial systems with artificial intelligence in industries evaluated in Tijuana (2023)



Industry	Type of Industry	OYIS, %		Industrial Devices, Equipment and Machinery with Artificial Intelligence
		NLC	ILC	
1	Aerospace	56	79	Electronic and Electromechanical Systems
2	Aerospace	58	83	Electronic and Electromechanical Systems
3	Aerospace	62	80	Electronic and Electromechanical Systems
4	Agricultural	49	87	Electromechanical and Hydraulic Systems
5	Agricultural	50	85	Electromechanical and Hydraulic Systems
6	Biomedical	55	86	Electronic and Electromechanical Systems
7	Biomedical	59	82	Electronic and Electromechanical Systems
8	Biomedical	65	80	Electronic and Electromechanical Systems
9	Electronic	61	87	Electronic and Pneumatics Systems
10	Electronic	67	89	Electronic and Electromechanical Systems
11	Electronic	59	90	Electronic and Pneumatics Systems
12	Metallic	55	86	Electromechanical, Hydraulic and Pneumatics Systems
13	Metallic	52	84	Electromechanical, Hydraulic and Pneumatics Systems
14	Metallic	59	88	Electromechanical, Hydraulic and Pneumatics Systems
15	Plastics	60	86	Electromechanical, Hydraulic and Pneumatics Systems
16	Plastics	62	88	Electromechanical, Hydraulic and Pneumatics Systems
17	Plastics	64	89	Electromechanical, Hydraulic and Pneumatics Systems
18	Textile	60	90	Electronic and Electromechanical Systems
19	Textile	50	85	Electronic and Electromechanical Systems
20	Textile	59	87	Electronic and Electromechanical Systems

NLC-Normal Labor Conditions, ILC- Improvement Labor Conditions; OYIS-operative Yielding of Industrial Systems programmed by Programmers

In this section was made a comparative evaluation, between use the normal labor conditions of the programmers and the improvements in the labor conditions, where was observed a big difference between it labor conditions, being around a 20% of increased of the operative yielding, and with this the increase of the productivity and quality levels. The improvement labor conditions of the programmers were pass some times of the period of work of the programmers in dynamic activities without use any type of computer of electronic systems as cell phones, tablets of other type of electronic devices to play of make other actions. Also was improved the computer systems and furniture with ergonomic conditions in chairs, desks and

keyboards, and also was update the software to the programming activities. These improvements reduced the discomfort of programmers and with this the medical visits.

3.3 Evaluation of Mental Health and Specialized Strategies of Internal Marketing

Once the previous analyzes were made, it was made an analysis of the mental cases of programmers that was obtained by the medical visits to the internal medical services of industrial companies and external to medical institutions (regularly the Instituto Mexicano del Seguro Social-IMSS, Mexico and particular medical services paid by programmers as extra cost of them, when industries debit support for this relevant action.

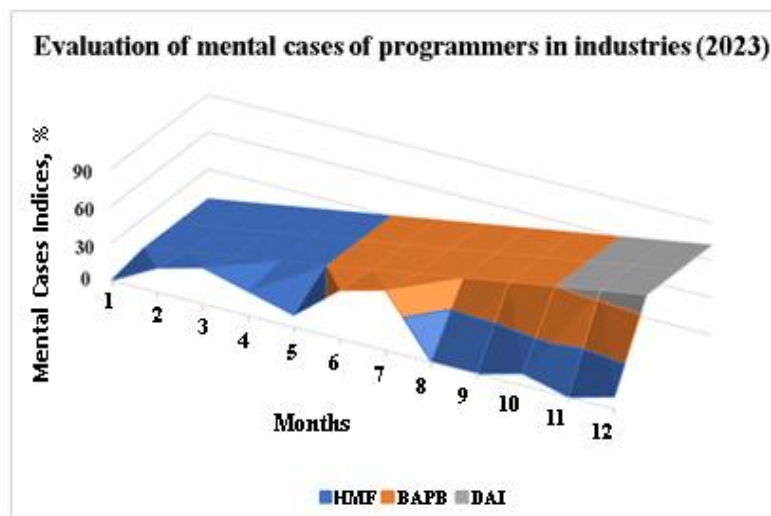


Fig -4: Analysis of average of level of mental cases of programmers of the industries evaluated (2023) Headache and mental fatigue (HMF); Bad attitude with work partners and bosses (BAPB); Development of activities inappropriately (DAI)

The mental cases are showed in figure 4 with the more frequently medical cases that occurred in the period of this scientific study, observing that the main bad actions of programmers were the bad attitude with his work partners and boss. Then, was followed by the presence of headache and fatigue in body (neck, head, eyes and back), that generated those programmers not works, reducing with this his operative yielding and of the industrial systems with artificial intelligence. Finally, was presented those programmers not works inadequately, originating errors in the programming actions and functions of the industrial devices, equipment and machinery.

3.4 Internal Marketing Evaluation

The last activity in this investigation, was an analysis of the internal marketing applied to programmers to improve his operative yielding and with this the operative yielding of the industrial systems with artificial intelligence, being important this section of this scientific study, because the programmers retrained to made their activities efficiently, once their working conditions were improved, because some wanted to quit or work for shorter periods of time. This part of the research was very relevant to improve the levels of productivity and quality in the industrial companies evaluated. In base of this activity, was increased the behavior of programmers and they made his functions with major efficiency.

Table -4: Analysis of internal marketing applied to programmers in industries evaluated in Tijuana (2023)

Industry	Type of Industry	OYIS, %		Industrial Devices, Equipment and Machinery with Artificial Intelligence
		NBP	IBP	
1	Aerospace	43	89	Electronic and Electromechanical Systems
2	Aerospace	38	93	Electronic and Electromechanical Systems
3	Aerospace	45	90	Electronic and Electromechanical Systems
4	Agricultural	47	94	Electromechanical and Hydraulic Systems
5	Agricultural	42	95	Electromechanical and Hydraulic Systems
6	Biomedical	29	92	Electronic and Electromechanical Systems
7	Biomedical	36	90	Electronic and Electromechanical Systems
8	Biomedical	30	95	Electronic and Electromechanical Systems
9	Electronic	40	90	Electronic and Pneumatics Systems
10	Electronic	45	93	Electronic and Electromechanical Systems
11	Electronic	44	89	Electronic and Pneumatics Systems
12	Metallic	48	88	Electromechanical, Hydraulic and Pneumatics Systems
13	Metallic	42	90	Electromechanical, Hydraulic and Pneumatics Systems
14	Metallic	44	94	Electromechanical, Hydraulic and Pneumatics Systems
15	Plastics	48	92	Electromechanical, Hydraulic and Pneumatics Systems
16	Plastics	50	90	Electromechanical, Hydraulic and Pneumatics Systems
17	Plastics	46	93	Electromechanical, Hydraulic and Pneumatics Systems
18	Textile	41	90	Electronic and Electromechanical Systems
19	Textile	42	88	Electronic and Electromechanical Systems
20	Textile	44	89	Electronic and Electromechanical Systems

NBP-Normal Behavior of Programmers, IBP- Improvement Behavior of Programmers; OYIS-Operative Yielding of Industrial Systems programmed by Programmers



4. CONCLUSIONS

This investigation was relevant in this industrialized city and can be to any city of the world where are necessary utilize programmers to programs industrial systems with artificial intelligence. Actually, in all industries, are changing the labor conditions of workers, but some activities not are considered as important to change the labor conditions, but the functions of the programmers are of great interest, because from they depend the operation of industrial systems, especially those who utilize artificial intelligence, which can regulate the productivity and quality indices. For this reason, is very important that directive and managers of the 20 industrial companies, where was made this scientific study, to improve the labor conditions of programmers to make its functions as the best action efficiently, and can increase the productivity and quality indices, where all directive and managers are concerned for these relevant aspects in all industry. The work of researcher's students were important in the tasks of this investigation.

REFERENCES

- [1] Ahmed T., Karmaker C. Nasir S., Maktadir M., Paul S. (2023). Modeling the artificial intelligence-based imperatives of industry 5.0 towards resilient supply chains: A post-COVID-19 pandemic perspective. *Comput. Ind. Eng.* 2023, 177, 109055.
- [2] AIMT (2023). Asociación de la Industria Maquiladora de Tijuana. Anuario Estadístico 2023.
- [3] Bouanba N., Barakat O., Bendou A (2022). Artificial Intelligence & Agile Innovation: Case of Moroccan Logistics Companies. *Procedia Comput. Sci.* 2022, 203, 444–449.
- [4] Frank M., Bessen J., Brynjolfsson E., Cebrian M., Deming D. (2019). Toward Understanding the Impact of Artificial Intelligence on Labor. *Proc Nat Acad Sci.* (2019) 116:6531–9.
- [5] Gadecki J., Jewdokimow M., Zadkowska M. (2018). New Technologies and Family Life in the Context of Work at Home. The Strategies of Work–Life Balance. *Studia Humanistyczne AGH.* (2018) 17:77–89.
- [6] IMSS– Instituto Mexicano del Seguro Social–Mexico (2023). Reporte Estadístico de Casos Mentales de trabajadores de industrias (2020–2023).
- [7] Jan Z., Ahamed F., Mayer W., Patel N., Grossmann G., Stumptner, M., Kuusk A. (2023). Artificial intelligence for industry 4.0: Systematic review of applications, challenges, and opportunities. *Expert Syst. Appl.* 2023, 216, 119456.
- [8] Joksimovic S., Ifenthaler D., Marrone R., De Laat M., Siemens G. (2023). Opportunities of artificial intelligence for supporting complex problem-solving: Findings from a scoping review. *Comput. Educ. Artif. Intell.* 2023, 4, 100138.
- [9] Li J., Herdem M., Nathwani J., Wen J. (2023). Methods and applications for Artificial Intelligence, Big Data, Internet of Things, and Blockchain in smart energy management. *Energy AI* 2023, 11, 100208.
- [10] Ojala S. (2011). Supplemental Work at Home Among Finnish Wage Earners: Involuntary Overtime or Taking the Advantage of Flexibility? *Nordic J Work Life Stud.* (2011) 1:77–97.
- [11] Patange G., Pandya A. (2023). How artificial intelligence and machine learning assist in industry 4.0 for mechanical engineers. *Mater. Today Proc.* 2023, 72, 622–625.
- [12] Pérez J., Falótico A. (2019). Various Perspectives of Labor and Human Resources Challenges and Changes Due to Automation and Artificial Intelligence. *Academicus.* (2019) 20:106–8.
- [13] Ribeiro J., Lima R., Eckhardt, T., Paiva S. (2021). Robotic Process Automation and Artificial Intelligence in Industry 4.0—A Literature review. *Procedia Comput. Sci.* 2021, 181, 51–58.
- [14] Saranya A., Subhashini, R. (2023). Systematic review of Explainable Artificial Intelligence models and applications: Recent developments and future trends. *Decis. Anal. J.* 2023, 7, 100230.
- [15] Villegas O., Nandayapa M., Azuela J., Franco E., Linares G. (2021). Artificial Intelligence for Industry 4.0 in Iberoamerica. *Comput. Sist.* 2021, 25, 761–773.
- [16] Xu X., Lu Y., Vogel-Heuser B., Wang L. (2021). Industry 4.0 and Industry 5.0—Inception, conception and perception. *J. Manuf. Syst.* 2021, 61, 530–535.