

The Industrial Revolution: From IIoT to Industry 4.0

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ABSTRACT

The following work explains a tool used to diagnose the level of industry 4.0 of Baja California's industries (Mexico). The evaluated industries are interested in increasing their technological level to take advantage of the benefits of this fourth industrial revolution. For this work, one of the participating companies was chosen to demonstrate how their answers were analyzed to define their technological level, easily detecting their strengths and weaknesses.

Keywords:

Revolution, industrial, diagnosis, technology, analysis

1 INTRODUCTION

The world entered an era of constant changes in an exponential way, where new technologies dominate the market, and automation, information and communication technologies (ICT) are not enough to meet the expectations of increasingly demanding customers. That is why it is necessary to adapt the technologies that led to the "Fourth Industrial Revolution" (I4.0), that goes further than the intelligent and connected machines and systems, its scope is much wider than the foundations of previous revolutions, from gene sequencing to nanotechnology, from renewable energy to quantum computing. This revolution relates to the union of Internet of Things (IoT), the internet of people (IoP), and the internet of Everything (IoE). [1].

With the incursion of technologies such as advanced material, big data, simulation, visual and augmented reality, cloud, cyber security, internet of things, blockchain, system integration, robotics, artificial intelligence and additive manufacturing, as shown in Figure 1. These technologies help to make manufacturing processes more efficient to reduce time, make decisions, reduce defects, among others [2]. The impact of these technologies on society and the planet are still unknown but the fact that they will bring profound and rapid change seems all but certain [3].

The digital tsunami is affecting almost every industry in the world for just over a decade, reshaping the economy and society, producing disruptive changes at an unprecedented speed [4], for these reasons, it is crucial that industries make a technological transition.

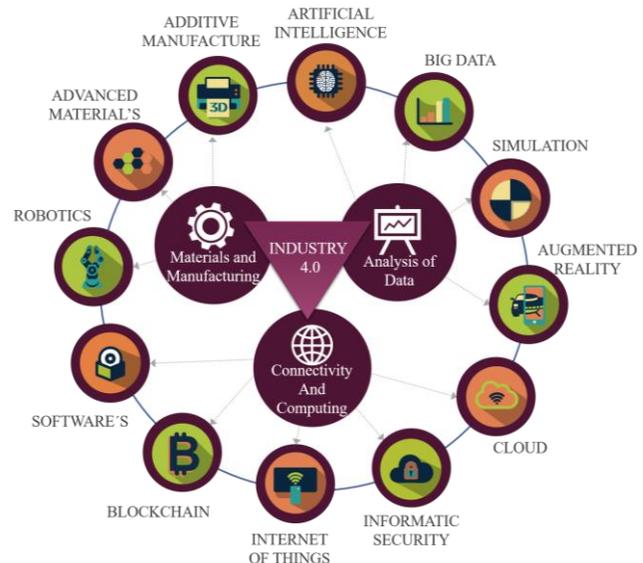


Figure 1 Industry 4.0 technologies

Nowadays there are several countries around the world dedicated to exploiting the potential of new technologies and they are having a big impact into the fourth industrial revolution, such as: Germany with "Industrie 4.0" [5], China with the program "Made in China" [6] and USA with "Smart Manufacturing Leadership Coalition (SMLC)" [7]. These strategies clarify that innovation and technology are an important pillar to grow as a country; take advantage of tools such as the industrial internet of things (IIoT) can make a company stand out, since he is responsible for linking the virtual to the physical world [8]. The industrial Internet of things provides a way to obtain better visibility and a insight into the company's operation assets thought integration of machines sensors, middleware, software and backend cloud compute and storage system [9].

That is why we created the diagnostic tool called "BC 4.0". This tool is designed for those companies that seek to increase their industrial technological level and thus become an Industry 4.0 (I 4.0). It is designed to define what is necessary to advance technologically and guide companies towards the experts in the necessary technologies to reinforce and increase the potential of the value chain. However, this is not a simple process, since it is essential to know what is the technological level of the company (unconscious, conscious, beginner, partial, standardized and optimized)

and many of them fear taking the next step due to lack of information.

The tool “BC 4.0” was implemented in industries located in Baja California (BC) state in the northern of Mexico and seeks to provide the industry with an easy and quick way to identify what it is needed to take the next technological step. Based on a series of questions, we want to identify a response variable for each of the possible options of the companies that use the tool. This response variable contains the technological level of the company, its technological strengths and weaknesses, to reach the next technological level.

2 MATERIALS AND METHOD

The tool is a questionnaire conducted by email through the application of the Google form, for the convenience of the participants, however, a printed document has been prepared for the case of visits to the company.

BC 4.0 consists of 54 questions (with 177 reagents) which are divided into six categories according to the 20 parameters to be considered, in which the 12 technologies of I4.0 are distributed according to their category (see Figure 2).

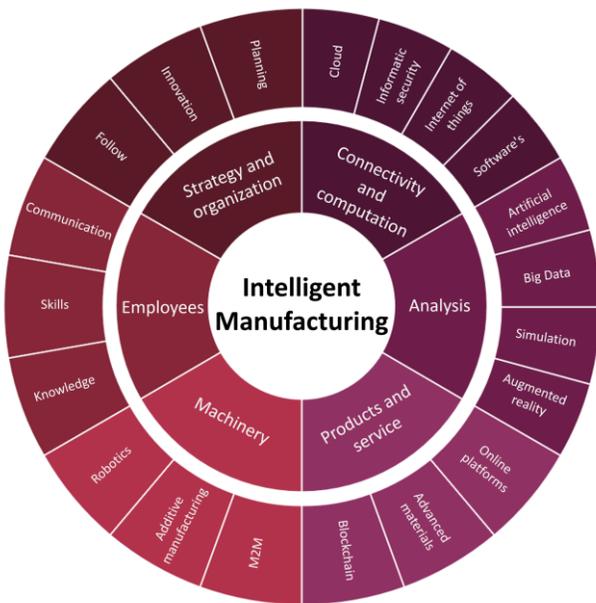


Figure 2 Categories and parameters

As previously mentioned BC 4.0 consists of six levels of analysis (see Table 1).

- Unconscious: The company does not have the concept of Industry 4.0 in mind.
- Conscious: The company has a slight knowledge of Industry 4.0.
- Beginner: The company has knowledge about Industry 4.0 and has some elements in practice.
- Partial: The company has the tools of Industry 4.0 in practice.

- Standardized: The company has the tools of Industry 4.0 in practice in a standardized way.
- Optimized: The company has in practice the tools of the Industry 4.0 standardized and with techniques of continuous improvement.

Table 1 Levels of Industry 4.0

Level	Concept	Score
5	Optimized	1780-2130
4	Standardized	1424-1779
3	Partial	1068-1423
2	Beginner	712-1067
1	Conscious	356-711
0	Unconscious	0-355

2.1 Analysis

There are five classifications for the weighting of the questions, and each question has a degree of relevance which is considered at the time of being evaluated, likewise, the questions that have more weighting are those related to the technologies of industry 4.0 (see Table 2).

Table 2 Clasfication of the weighing of the questions

Weighing			
General	1	Blockchain	2
Diffusion	3	Advanced materials	2
Application	9	Artificial intelligence	2
Development	12	Big Data	2
Definition	6	Simulation	2
		Augmented reality	2
		Cloud	2
		Informatic security	2
		Internet of things	2
		Software's	2
		Robotics	2
		Additive manufacturing	2

There are three types of answers for the analysis of the questions, in this manner, there are three categories of possible answers to define the score of the participating company (see Table 3, Table 4, Table 5).

Table 3 Type A responses

%	Concept
0%	We do not have
25%	It is not used but it is planned to implement it
50%	It is used without being standardized
75%	It is used and has standardized
100%	It is used, it is continuously controlled and optimized

Table 4 Type B Responses

Percentage	Concept
0%	Null
25%	Basic
50%	Intermediates
100%	Experts

Table 5 Type C Responses

Percentage	Concept
100%	Yes
0%	No
50%	In process

To calculate the score of the participating company, the following equation is used:

$$Score = \sum_r(a)(c)(it) \quad (1)$$

Where:

- r = Reagents
- a = Response percentage
- c = Weighting according to the classification of the question
- it = Weighting of I4.0 technologies

The number obtained will be verified in the table of levels (see Table 1) to detect the level of the corresponding company.

3 EXPERIMENTAL PART

Currently the tool has been sent to different companies, however, we will use as an example the case of a recognized industry in the city of Ensenada, B.C., Mexico.

Once the participant company sent the answers of the tool, the data were emptied into a spreadsheet (see Table 6), where the reagents was analyzed to define the response percentage and multiply with the corresponding weights according to the reagents.

Table 6 Section of the spreadsheet with the obtained data from the tool

Category	Parameter	Reagent	A. Type	Weighing		Score
				Classification	W. I4.0	
Employees	Communication	1	B	6	1	3
		2	B	6	1	1.5
		3	B	6	1	1.5
		4	B	6	1	1.5
		5	C	9	1	9
		6	C	9	1	9
		7	C	9	1	0
		8	C	9	1	9
		9	B	12	1	0
		10	B	12	1	3
		11	B	12	1	3

4 RESULTS AND DISCUSSION

With the methodology mentioned above, each of the reagents of the participating company was analyzed obtaining a total of 257.25 (see

Table 7) achieving a "level 0" entering at the category of 0-355 category, i.e. it is defined as: Unconscious; The company does not have the concept of Industry 4.0 in mind.

Table 7 Category results

Intelligent manufacturing	%	Score
Employees	33%	63.75
Strategy and organization	28%	34.5
Connectivity and computing	10%	48
Analysis	2%	15
Products and services	10%	42
Machinery	15%	54
Total	11%	257.25

The Figure 3 showed the percentage reached by each one of the categories and which of these were those that were closer to 100%, as can be seen the section of employees and strategy and organization are the strongest, however, are below 50% , therefore, there is still much to work within the company to improve each of its categories.

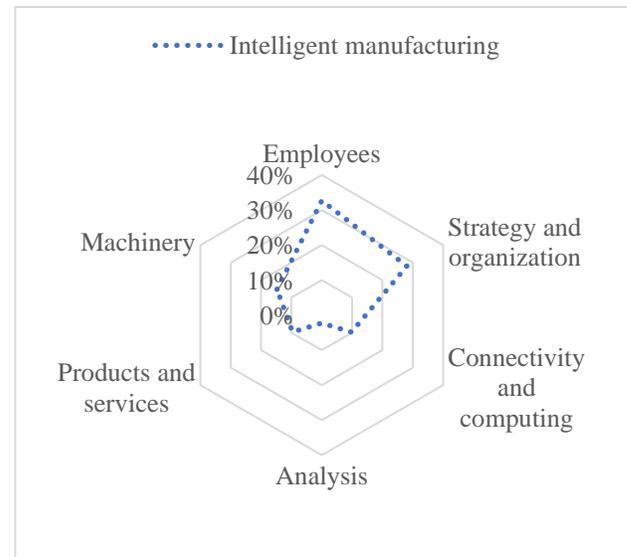


Figure 3 Category results

Likewise, we can see in the Figure 4 that there is a big gap between the result and the wanted score, which is conformed with the maximum rating of each of the reagents. For this reason, it is easy to identify that most of the parameters are not only far away from the objective, but also below 50%, making clear the lack of knowledge of the company about the I4.0.

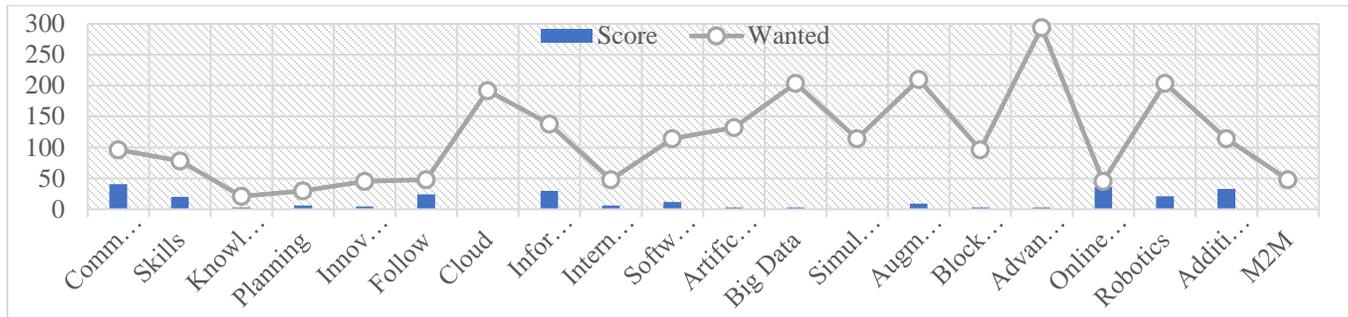


Figure 4 Parameters results

Table 8 Parameters results

	%	Score
Employees	33%	63.75
Communication	42%	40.5
Skills	26%	20.25
Knowledge	14%	3
Strategy and organization	28%	34.5
Planning	20%	6
Innovation	10%	4.5
Follow	50%	24
Connectivity and computation	10%	48
Cloud	0%	0
Informatic security	22%	30
Internet of things	13%	6
Software's	11%	12
Analysis	2%	15
Artificial intelligence	2%	3
Big Data	1%	3
Simulation	0%	0
Augmented reality	4%	9
Products and services	10%	42
Blockchain	3%	3
Advanced materials	1%	3
Online platforms	80%	36
Machinery	15%	54
Robotics	10%	21
Additive manufacturing	29%	33
M2M	0%	0

However, the score per parameter was calculated to identify the areas to be reinforced within the company as showed in Table 8 where it shows that the highest percentage belongs to the platform parameter with the 80%.

5 CONCLUSIONS

According to the results previously shown, the company is at the lowest level of industry 4.0, however, its strongest category turned out to be “employees” since senior managers are aware of some concepts of I4.0, similarly, it

was possible to identify that the lowest category was the one of “analysis” which has four parameters about the I4.0.

Within the parameters the company highlighted the section of “online platforms” reaching 80%, being this one of the key point of the internet of things to provide a better service. Also, the cloud and M2M obtained 0% since the company does not have and has no knowledge about these technologies.

Therefore, it was concluded that the company should focus on the diffusion of the technologies that come with the I4.0, not only in the top management, but also in the other personnel before entering the new technologies to the company for a better acceptance. Also, it is recommended to focus on those technologies that were low in BC 4.0, since services such as the cloud are essential for any company seeking a technological change within the company.

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