THE CHALLENGE FOR HIGHER EDUCATION IN THE LIGHT OF INDUSTRY 4.0

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SUMMARY: I. *Introduction.* II. *Industry 4.0 in Public Higher Education Institutions.* III. *Collateral Damage of Industry 4.0.* IV. *The Case of a Public State University and its Challenge to Access Industry 4.0 //Industrial Engineering Program.* V. *Conclusions and Comments. VI. Research Sources.*

I. INTRODUCTION

Within the framework of the so-called Industry 4.0, the challenge of higher education to deal with this trend is analysed. The general aspects of Industry 4.0 are discussed in a documented review of the response of public higher education to the upcoming Fourth Industrial Revolution. While not yet real, these aspects represent a risk that will mark changes that will not only affect the industry, but also entail social, economic and educational transformations in the years to come.

Some of these changes may be good for people, economic development and respect for the environment. However, there are also disadvantages associated with this industrial transformation. Literature recognizes the difficulty of organizations, including educational ones, to adapt to the new proposals. If this is worrying for the industry, it is even more serious for the training of professionals to fulfil the needs of the production process. This concern is partly because the technological changes on which Industry 4.0 is based are dynamic and because it calls into question the fact that what

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higher education offers is not only not in line with the needs of professionals but may also be seriously lagging behind.

Among other aspects, attention should be given to the balance of power, since innovation and access to resources in developed countries can lead less developed countries to excessive and even dangerous changes in employment conditions and in meeting workers' needs.

While the speed at which the industry advances can lead to greater inequalities and social fragmentation, it might not be such a concern for Mexico since, on one hand; Industry 4.0 has an enormous technological dependence given the fact that the machinery requires a high level of specialization. It is also possible that Mexico may not be able to obtain the capital to adapt to such machinery due to the economic cost involved and the need to consider the return on investment.

This trend calls for an intensive use of the Internet and cutting-edge technologies. It is mainly aimed at the development of industrial plants and more intelligent and environmentally friendly ways to generate energy. This is technically consistent with production chains that are much better connected to each other, to supply and demand, and to the need to promote sustainability.

The new processes require personnel with greater specialization, which is not always available; and if it is, these workers seek higher remuneration. It is precisely here where one of the niches of opportunity for higher education institutions can be found. Therefore, functions and characteristics are analysed, with emphasis on the social responsibility of the university that guides the training of professionals within the framework of Industry 4.0.

The case study included herein is set within an institution whose philosophy lies in humanism and the competency-based model. The conclusions are ambivalent, expectations are high, and conditions are ambiguous. Hence, Mexican public higher education will have to take giant steps in order not to fall further behind and take even bigger steps if it is to train the human capital that will be required in the coming years.

II. Industry 4.0 in Public Higher Education Institutions

In a review of the literature, we find an analysis on the impact of Industry 4.0 with notorious differences according to countries' economic development. In this regard, Ricardo Swain Oropez[1] describes the evolution of industrial revolutions and their relationship with higher education, stressing that such advances have been of little use in Mexico. He presents a proposed curriculum for the field of engineering with a strong element of the student's comprehensive training. In addition, the university-business relationship is considered a fundamental aspect of his program. He builds his proposal on a challenge-based educational approach.

In his article, Jaime Humberto Carvajal Rojas[2] focuses on the need to:

> ...review the technologies embodied in the Fourth Industrial Revolution where automation, robotics, information technologies and telecommunication technologies stand out as a whole or as a multidisciplinary [sic] engineering unit to formulate or re-formulate new production instruments, new means of production, new production methods and new production systems, in the city and in the country, that will require new actors for their successful and efficient operation.

This means that the need to train new technicians, technologists and professionals in ways of doing research that will revolutionize higher education activities in the world, and especially in Latin America, is essential because of the technological dependence that has historically prevailed in countries that have made do with being assembly plants.

Quoted by Carvajal,[3] Festo states that:

> ...ensuring the skills evolution of qualified personnel and junior employees for current and future changes in the workplace will require employees who are 4.0 specialists and possess interdisciplinary skills uniting classic mechatronics with sound IT knowledge and high levels of social competence to qualify for digital production.

1 Swain Oropeza, Ricardo, "Modelo Educativo para la Industria 4.0", *Academia de Ingeniería* México, 2017, *https://es.slideshare.net/ AcademiaDeIngenieriaMx/modelo-educativo-para-la-industria-40*

2 Carvajal Rojas, Jaime Humberto, "La Cuarta Revolución Industrial o Industria 4.0 y su Impacto en la Educación Superior en Ingeniería en Latinoamérica y el Caribe", 15th LACCEI International Multi-Conference for Engineering, Education, and Technology: Global Partnerships for Development and Engineering Education, 19-21 July 2017, Boca Raton, FL, United States.

3 Carvajal Rojas, Jaime Humberto, *op. cit.*, p. 2.

What he presents is a proposed curriculum for engineering that responds to the expectations of Industry 4.0. This proposal will be appraised in a study program from a Mexican public state university since *industry and services must be able to influence university and vocational training curricula to identify training interests because of the impact of digitalization in all sectors and industries.*[4]

Another view of the effects of Industry 4.0 has to do with employment. In a state of knowledge of the issue analysing challenges pertaining to public policy and the impact Industry 4.0 has on labor and training, Raül Blanco, Jordi Fontrodona and Carmen Poveda[5] found that *automation has a replacement effect: it eliminates job vacancies in certain sectors and occupations. But there is also a complementarity effect: there are jobs in which automation complements human work, thus increasing productivity and remuneration.* In addition to these two effects, *technological innovation widens the boundaries of production: with the same resources, more can be produced [… but] in order to deal with the consequences of industrial digitalization in the workplace, ongoing training will be essential for people* (p. 155). This continuous vocational training is an outlay more than an expense; it could even be considered an investment.

Higher education has the responsibility to provide continuing education. However, higher education institutions, especially public ones, are under pressure to respond to human capital formation in a way that meets *the changing needs of the global labor market* without *neglecting the learning needs and interests of local communities* from a more social and less economistic perspective.[6] According to Vargas, this perspective is part of a long deliberation process of the United Nations Educational, Scientific and Cultural Organization (UNESCO) which, since 1973, has strived for the comprehensive formation of individuals and has *set out to bridge the gap between education and employment and create flexible pathways between education, employment, leisure and retirement* (p. 2).

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4 Secretaría de Estrategias Industriales, "La digitalización y la industria 4.0 Impacto industrial y laboral", 2017, *CCOO Industria*: Spain.

5 Blanco, Raül, Fontrodona, Jordi and Poveda, Carmen. "La Industria 4.0: El Estado de la Cuestión", *Revista Economía Industrial*, No. 406, pp. 151-164, 2017, *http://www.minetad.gob.es/Publicaciones/Publicacionesperiodicas/EconomiaIndustrial/RevistaEconomiaIndustrial/406/BLANCO,%20FONTRODONA%20Y%20POVEDA.pdf*

6 Vargas, Carlos, "El aprendizaje a lo largo de toda la vida desde una perspectiva de justicia social", *Objetivos de Desarrollo Sostenible*, Serie de documentos temáticos sobre Investigación y Prospectiva en Educación, No. 21, Paris, Organización de las Naciones Unidas para la Educación, la Ciencia y la Cultura, 2017, *http://unesdoc.unesco.org/images/0025/002500/250027s.pdf,* date of consultation: September 15th, 2018.

A review of the investment made in higher education to deal with the challenges of Industry 4.0 shows that in Germany,[7] the country driving this Fourth Industrial Revolution, the quality of education is more important that its quantity. Therefore, it is necessary to reconsider the consequences of Mexico's education policies of which's main axis since the 1970s has focused on expanding coverage with "*good intentions*" so that the education provided is of quality.

In the case of Mexico, the National Association of Universities and Higher Education Institutions (ANUIES) is a plural organization that analyses higher education policies. The section on University Social Responsibility in *Agenda SEP – ANUIES for the development of higher education*[8] was aimed "to consolidate a learning community." As analysed below, it poses the risk of a neoliberal approach while at the same time allowing institutions to be studied in order to make decisions regarding:

> […] the type of professionals, citizens and people it trains; the type of knowledge it produces, its social relevance and its recipients; the democratization of access to knowledge, particularly for disadvantaged groups; university community mechanisms for participation and liaison with social groups to work on projects with local or regional impact to ensure collective learning and progress in addressing important problems; the consequences and effects of their processes and performance.

This would have made it possible to readjust the training of professionals needed by the Fourth Industrial Revolution without losing sight of the social function of public universities. One of the expected results of Project 3.1 in the section on the Model of University Social Responsibility was to have a *National Liaison Program between Universities, Businesses and Social Innovation Management*. However, the time frame for this agenda has run out and the program was not designed.

In summary, Industry 4.0 will reveal the seriousness of technological dependence and will continue with or widen the gaps in personnel qualifica-

[7] Secretaría de Estrategias Industriales, *op. cit.*

[8] ANUIES, "Agenda SEP - ANUIES para el desarrollo de la educación superior", Mexico, 2015, *http://www.anuies.mx/media/docs/Agenda_SEP-ANUIES.pdf*, date of consultation: 19 September 2018.

tions needed for digitalization, if higher education does not assume its role in training qualified and ethically responsible people.[9]

III. Collateral Damage of Industry 4.0

1. *The Speed of Progress and its relation to social fragmentation*

The International Labour Organization (ILO) has two positions regarding the influence of technological progress: one it calls pessimistic, which endorses the idea that technology displaces manpower and therefore causes unemployment, and an optimistic one that holds that technology consolidates jobs. The optimistic position is based on the results of predictions that failed to materialize in the 1970s and on studies showing that production in the target country *benefits the localization process, helping national industries to recover all the processes in the value chain (botsourcing), propitiating, in turn, the creation of jobs in the country*.[10]

However, in both positions, this same organization recognizes that technological changes have social consequences. This is partly due to the fact that automation is closely associated with increased productivity and lower production costs, which leads companies[11] to seek new technologies to achieve this relationship. Therefore, without it being a linear equation, competitiveness eliminates more jobs than those created by digitalization.

The ILO issue note shows alarming data. Quoted by the ILO, Frey and Osborne:

> […] explored the potential automation of occupations, that is, the technical easiness or feasibility of computerizing occupations. They estimated that 47 per cent of total US employment is technically in a high risk category "over

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9 As Humberto Bustince states (quoted by Secretaría de Estrategias Industriales, Ibidem, p. 43), "in fifteen years, the production chains of any company will change. In Germany, out of every hundred jobs, around eighty mechanics will be replaced by machines." He goes on to affirm that "we are not socially prepared for the revolution that is coming." Therefore, public universities will have to analyze and propose measures that conciliate the advent of digitalization and the short-term consequences that could result in social outbursts associated with unemployment and uncertainty on the one hand, and to prepare its students to deal with a hitherto unknown world of managing their economic income, on the other.

10 Secretaría de Estrategias Industriales, *op. cit.*, p. 2.

11 Spanish experience suggests that within the framework of Industry 4.0, it is thought that the company sustaining society is a healthy combination of large companies and SMEs.

> the next decade or two". The comparable estimate for the UK is 35 per cent, and studies for Germany and France produced similar results. An ILO study has recently produced a much higher estimate for ASEAN countries: about three in five jobs face "a high risk of automation" (Chang and Hyunh, 2016), thus raising important questions about regional variations in job destruction.

And it is not only the elimination of jobs that is worrisome, but also the fact that most of the good jobs or those that social security calls decent employment may be lost.[12] According to *Secretaría de Estrategias Industriales*,[13] *the role of the State is decisive* for *[…]concentrating economic and human resources, and coordinating actions with the same objective: for this process of technological, digital and productive change to become a reality* and on the other hand, it will tend to prevent it *from deepening the precariousness of employment, inequalities among workers and, above all, for it to contribute to social and territorial cohesion.*

Unfortunately, although the impact of technological innovation allows significant gains in productivity, the resulting profits are not distributed among the general population. These profits go to the owners who developed or patented said innovation, which leads to greater inequality[14] and in the case of underdeveloped countries, the poor are more and more numerous and even poorer.

Employment income is polarized. On the one hand, some skilled workers receive high amounts for their work while others are unemployed, and on the other hand, unskilled workers barely earn enough to survive. Therefore, one concern of the emergence of the Fourth Industrial Revolution is the escalation of social inequality through sustained technological progress.[15]

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12 Lifelong learning under a *social justice approach would reconcile economic growth and social cohesion and maintain the latter […] as the enhancement of everything collective, common and social, including a sense of community. For the State, this would imply a policy approach centered on addressing inequalities in and through education, and providing learning opportunities that, at the same time, encourage the development of skills and competencies for a decent work*, which is the social function of public education, and especially of public universities. Vargas, Carlos, "El aprendizaje a lo largo de toda la vida desde una perspectiva de justicia social", op. cit., p. 12.

13 Secretaría de Estrategias Industriales, *op. cit.,* p. 4.

14 International Labour Organization (ILO) The Future of Work Centenary Initiative, 2015, *http://www.ilo.org/wcmsp5/groups/public/---ed_norm/---relconf/documents/meetingdocument/wcms_370408.pdf*

15 International Labour Organization (ILO), "The Future of Work Centenary Initiative", *op. cit.*

2. *Technological Dependence and the Demands on Countries with Limited Development*

It is a fact that technological progress leads to the outsourcing and fragmentation of production processes. This has a negative effect on jobs, even in developed countries because with new technologies to improve productivity in both logistics and communications, companies have specialized in specific tasks where routine work done by workers in low-skilled jobs that have not been automated yet is sent to underdeveloped countries in which workers there receive even lower wages than in developed countries. This, in turn, leads to the unemployment of unskilled workers in developed countries. "… developed economies have specialized in high-skilled tasks such as R&D, design, finance and after-sales services...".[16]

Other conditions in developed countries imply the advent of new jobs to cater to other activities, like entertainment, as working hours get shorter and there is more time for leisure.

On the other hand, emerging economies can capitalize on the positive effects of technology, which generate new jobs as a result of innovations in intelligent machines that require the appropriate infrastructure, as well as systems, transport and communication equipment, without necessarily opening up opportunities for qualified personnel.

Therefore, underdeveloped countries like Mexico have a two-fold challenge: to temporarily provide unqualified workers for routine jobs, which will tend to decrease or disappear with automation and, in the future, to have professional profiles that will take on the activities for operating within the framework of Industry 4.0 (globalization).

The production of knowledge to meet the challenges mentioned in the previous paragraph does not necessarily lead to an analysis of the "academizing" tendency of universities in terms of their focus on research. This has perverted researcher evaluation systems in higher education institutions, resulting in an overproduction of academic papers of which contribution to knowledge is debatable since they respond to the need of professor-researchers to be promoted or even to keep their jobs.[17]

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16 International Labour Organization (ILO), Issue Note, *op. cit.*, p.5

17 Altbach, Philip G, and de Wit, Hans, "The problem is the publishing system, not the scholars", *University Word News the global window on Higher Education,* September 18th, 2018, *http://www.universityworldnews.com/article.php?story=20180918080942756,* date of consultation: September 20th, 2018.

3. *Professionals for Industry 4.0*

The ILO recognizes that transformations in the world of work apply to productive chains, but also to institutions that train human capital and generate knowledge, including universities and other institutions, to thus develop new technologies to increase productivity and lower costs.

The truth is that the transformations stemming from technological advances imply modifying the training of the population in general. In addition, to process automation not only requires digital literacy,[18] but also the ability to train people for new jobs and for the transformation of existing jobs.

This leads us to ask ourselves the types of workers that will be needed in the light of the transformations taking place. Since jobs will become more complex, *[c]ollaborative worker-machine interaction requires a higher level of autonomy of operators and designers, shifting focus from rule-following to value-finding.*[19] Hence, the training needs to go beyond the use of technology.

Managers who rely on intelligent machines to *support day-to-day management decisions and take over routine decisions require more soft skills acquired mainly through experience, such as good judgment, creativity and problem solving.*[20] This entails new ways of manager training that responds to *exceptional circumstances highlighted by increasingly intelligent algorithms, and learning to cope with ambiguity.*[21]

The jobs of the future require young people to have a *solid theoretical foundation, good practical training and to be in contact with the world of hardware and software. Finding junior profiles with training in these two languages is becoming more and more difficult*.[22]

Moreover:

18 By digital literacy, we mean "teaching and evaluating the basic concepts and skills of information technology so that people can use information technology in their daily lives and develop new social and economic opportunities for themselves, their families and their communities." Blog Educativo que Promueve las Destrezas de Literacia Digital en Puerto Rico Alfabetización digital, 2018, *https://literaciapr.wordpress.com/2008/06/28/definicion-de-alfabetizacion-digital*

19 International Labour Organization (ILO). *The Future of Work Centenary Initiative*, *op. cit.*, p. 8.

20 *Idem.*

21 *Idem.*

22 Secretaría de Estrategias Industriales, *op. cit.*, p.3.

> New occupations will emerge, in particular at the intersection of professions, software and machines, such as big data architects and analysts, cloud service specialists, software developers and digital marketing professionals (Frey, 2016). Susskind and Susskind (2015) predict that a range of new legal roles will be created at the intersection of software and law, such as legal knowledge engineer, legal technologist, project manager, risk manager, and process analyst.[23]

While this seems to support the optimistic position on the consolidation of new jobs, it is likely that the need for managers to have more skills for these new jobs, especially in terms of the above-mentioned soft skills that the ILO says can only be acquired through experience, will contribute to greater social inequality in developing countries.

> The challenge […] is not technological, but people management through social dialog and collective bargaining, with new rights and incorporating new digital skills; managing the change in work organization, occupational safety and health, skills; working hours and workplace and, ultimately, labor legislation.[24]

4. *The Capacity of HEIs to Train Professionals for Industry 4.0*

As quoted by the ILO,[25] Nübler reports that in comparison with Germany, *the net job loss in manufacturing employment as a share of total employment was much lower when compared to the US* although the latter had a lower rate of robots. This makes it possible to infer that the conditions of each country are subject to their particular circumstances. So, academic and research infrastructure is an element that is available to train the professionals required by Industry 4.0.

The strategy Mexico could take advantage of to improve its conditions regarding the professionals that can close the gap of technological dependence[26] is training engineers in the necessary soft and digital skills and

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[23] International Labour Organization (ILO). *"The Future of Work Centenary Initiative,"* *op. cit.*, p. 9.

[24] Secretaría de Estrategias Industriales, *op. cit.*, p.4.

[25] International Labour Organization (ILO). *"The Future of Work Centenary Initiative"*, *op. cit.*, p. 7.

[26] Technological dependence is measured "according to the sales of royalties and technical support regarding the payments made abroad for the acquisition of the same concepts."

training researchers in other fields of knowledge, like law. This is in line with the objectives of Mexico's science, technology and innovation education policies, specifically for the purpose of *Contributing to the training and building of high-level human capital*[27] through postgraduate scholarships, postdoctoral scholarships and programs such as repatriation of researchers. This program aims to incorporate Mexican researchers residing abroad, higher education institutions or research centres to strengthen existing research groups and consolidate the training of researchers by connecting the scientific capacity of public, private and social sectors.

IV. The Case of a Public State University and its Challenge to Access Industry 4.0// Industrial Engineering Program

The diagnosis of the conditions of Science, Technology and Innovation (STI)[28] in terms of the institution under study reports that Morelos is a state that ranks 5th nationwide in aspects such as: 1. Academic and research infrastructure; 2. Human resources training; 3. Teaching and research staff; 4. Investment in STI; 5. Scientific and innovative productivity; 6. Business infrastructure; 7. Information and communication technologies; 8. Institutional component; 9. Gender in STI and 10. Economic and social environment. Its main strengths lie in numbers 3, 4 and 5.

Meanwhile, an important component that guides the study plan under review is its adherence to its institutional mission, which seeks to:

> [...] comprehensively form citizens as well as free, critical and socially responsible professionals, capable of purposefully constructing their own life project; of contributing to building democracy and living in a world without frontiers [that are] uncertain and paradoxical, recognizing themselves as members of the human race and as part of nature; of acting ethically with communication and cooperation to contribute to solving the problems and satisfying the

Consejo Nacional de Ciencia y Tecnología, "Informe General del Estado de la Ciencia, la Tecnología y la Innovación", Mexico, Conacyt. 2014, p. 86.

27 Secretaría de Energía, Secretaría de Educación Pública, Consejo Nacional de Ciencia y Tecnología, *Programa Estratégico de Formación de Recursos Humanos en Materia Energética*, Mexico, Sener-SEP-Conacyt, s/f.

28 Consejo Nacional de Ciencia y Tecnología, *"Informe General del Estado de la Ciencia, la Tecnología y la Innovación,"* Mexico, Conacyt, 2014.

> needs of the different sectors and population groups of the State of Morelos and, in general, of the globalized society of which they are part.[29]

The Industrial Engineering educational program is based on humanism, an approach that guides the University Model of the institution in question. Its study plan is from the School of Chemical and Industrial Sciences and was restructured in 2015. This reorganization recognizes the speed with which knowledge and technological change are generated, which can be consistent with training professionals under the competency model. It uses the 2013–2018 Sectorial Education Program (PSE) of the Ministry of Public Education, the 2013–2018 State Development Plan (PEDE) and the 2012–2018 Institutional Development Plan (PIDE) as references. The tendency towards a lifelong learning approach with neo-liberal nuances can be observed in these documents stemming from the 2012-2018 National Development Plan.[30]

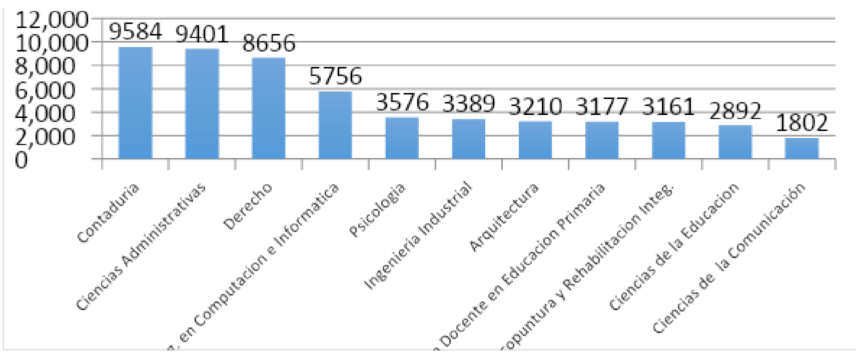
According to data from the National Employment Service, a position as an industrial engineer pays more than the national average (although the national average only comes to $11,200 Mexican pesos a month).[31] While it is not a very flattering picture, it shows its importance in the labor market, as it occupies the sixth place among the professions with the highest demand in terms of jobs. This makes it possible to assume that employment opportunities for engineering in the state are high in comparison to other professions (See Graph 1).

29 FCAEI, *"Ingeniería Industrial, Plan de Estudios 2015"*, Mexico, UAEM, 2015, pp. 10-11.

30 Vargas, Carlos, *El aprendizaje a lo largo de toda la vida desde una perspectiva de justicia social*, *op. cit.*

31 In real terms, the income received from practicing a profession is equivalent to the income received by unqualified personnel in developed countries.

GRAPH 1.
PROFESSIONS WITH THE HIGHEST DEMAND IN MORELOS (2010)



Source: FCAEI, Industrial Engineering, 2015 Study Plan. Mexico: UAEM. 2015

The proposed curriculum's r*ationale* considers the growth needs of the state where it is located, as well as regional and national needs, in order to *train highly qualified engineering professionals capable of competing in a globalized world through the development of their professional skills.*[32] In contrast, there is only one high-tech company of all the innovative companies in the state under study, revealing that it is, at best, an assembly line state where small and medium enterprises predominate.

The basic reason for restructuring the plan[33] was because:

> The globalization of economies is marked by a fast, progressive, accelerated and uneven expansion of (virtual and real) cross-border flows and movements of goods, services, money, technology, ideas, information, cultures and population. This process makes use of technological resources, especially electronic information and communication resources, to increase productivity, creating information networks that make it possible to carry out more efficient actions.[34]

This justification shows a willingness to meet the requirements of qualified personnel for Industry 4.0 with a study plan based on four main aspects:

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[32] FCAeI, *Ingeniería Industrial, Plan de Estudios*, *op. cit.*, p. 5.

[33] *Ibidem*, p. 8.

[34] Bold added by author.

1) a globalizing approach to emerging issues in the field
2) an innovative and interdisciplinary approach
3) a learner-centred approach based on professional competencies[35]
4) stress on professional profile guidelines according to the demands of the social and productive sectors in the state and country.[36]

However, the same document citing the results of the Consulting Scientific and Technological Forum A.C. (FCCyT) recognizes that even when they are in charge of training the scientific, technological and humanistic cadres in the country, public higher education institutions do not innovatively generate and apply knowledge or train researchers in a way that lowers technological dependence.[37] Nor is it possible to establish a liaison between schools and workplaces, a situation that can be traced back to a dual education model.[38]

According to the National Agency of Quality Assessment and Accreditation of Spain (ANECA),[39] the structure of the curriculum should provide the foundations of the training at the beginning and the most technologically specialized courses at the end. With this approach, professionals can be provided with the necessary flexibility and adaptability for conditions in the near future.

In line with this, the study plan proposes to:

- […] technological solution alternatives through planning, design, evaluation of production management systems and services using continuous improvement methodologies in organizations.

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35 Within the framework of the specific core disciplinary competencies for the *Tuning para América Latina* project report (Beneitone, et. al., 2007, quoted in FCAeI, *Ingeniería Industrial, Plan de Estudios*, *op. cit*.

36 FCAeI, *Ingeniería Industrial, Plan de Estudios*, *op. cit*.

37 FCCYT, *Diagnósticos en Ciencia, Tecnología e Innovación*, Morelos, 2012, *http://www.foroconsultivo.org.mx/home/*

38 Dual vocational training systems "are being strengthened (EU and ILO) in order to counteract youth unemployment. Inspired by the German model, dual training refers to training in which apprentices, young people up to around 19 years of age, undergo structured, long-term training that combines periods in the classroom and in the company, leading to accreditation (diploma or certificate). The process is structured through a specific work-training contract and is often driven by labor unions and the business community." Secretaría de Estrategias Industriales, *op. cit.,* p.71.

39 Agencia Nacional de Evaluación de la Calidad y Acreditación de España, *Informe sobre el estado de la Evaluación Externa de la Calidad en las Universidades Españolas 2016*, Spain, 2017, *http://www.aneca.es/Sala-de-prensa/Noticias/2017/Informe-sobre-la-evaluacion-de-la-calidad-en-las-universidades-espanolas-2016*

- Organize and manage interdisciplinary work teams that lead to the development of improvement projects that exceed customer's expectations and apply different manufacturing tools while taking into account cost-benefit parameters.
- Manage logistics and supply chain operations nationally and internationally through the use of ICT.
- Implement national and international standards in a productive setting and establish the commitment to the conservation of natural resources and sustainable development.
- Have the ability to adapt to different environments.[40]

The professional competencies of the Specialized Cycle (see Table 1) of the educational program are those that would provide certain aspects of training including the development of competencies that allow making administrative decisions using soft skills, creativity and problem-solving skills that define an Industry 4.0 professional since such skills lead the trainee to:

a) Manage projects in industrial plants and companies
b) Plan, supervise and lead multidisciplinary teams
c) Use industrial diagnostic techniques to measure a company's functional efficiency
d) Select and adapt the technologies needed in production processes to increase production capacity
e) Develop projects to promote a better quality of life in society, taking its technical, economic and sustainable feasibility analysis into account
f) Manage logistics operations and supply chains nationally and internationally through the use of ICTs
g) Implement national and international standards in a production setting and establish the commitment to the conservation of natural resources and sustainable development
h) Formulate projects based on marketing, technical, administrative and financial aspects.[41]

40 FCAeI, *op. cit.*, p. 39.
41 *Ibidem*, p. 46.

TABLE 1
STUDY PROGRAM SPECIALIZED CYCLE SUBJECTS FOR INDUSTRIAL ENGINEERING

Code	Name	Type of Course	Type	Hours per Week	
				Theory	Practice
IIN17	Strategic Planning	Subject	Theoretical	4	
EAD05	Marketing	Subject	Theoretical	4	
IIN18	Project Engineering	Subject	Theoretical	4	
IIN19	Logistics	Subject	Theoretical	4	
IIN21	Lean Manufacturing	Subject	Theoretical	4	
IIN20	Green Engineering	Subject	Theoretical -Practical	2	2
	ELECTIVES				
PRO01	Product Design	Subject	Theoretical	4	
PRO02	Process Optimization	Subject	Theoretical	4	
PRO03	Ergonomics	Subject	Theoretical	4	
PRO04	Sustainable Processes	Subject	Theoretical	4	
LCS01	Purchasing	Subject	Theoretical	4	
LCS02	Supply Chains	Subject	Theoretical	4	
LCS03	Packaging Engineering	Subject	Theoretical	4	
LCS04	Reverse Logistics	Subject	Theoretical	4	
CAD01	Equipment Uncertainty and Calibration	Subject	Theoretical	4	
CAD02	Problem-Solving and Continuous Improvement	Subject	Theoretical	4	
CAD03	Six Sigma	Subject	Theoretical	4	
CAD04	Information Systems Engineering	Subject	Theoretical	4	

Source: FCAEI, Industrial Engineering, 2015 Study Plan. Mexico: UAEM. 2015

However, it is noticeable that, although some subjects regarding these aspects are mentioned, almost all of them are theoretical subjects that do not involve the student in decision-making. Moreover, there is no training for research, except in the case of developing industrial products, processes and methods since the recommended educational activities limit the possibility of carrying out research-development+innovation and attaining technological independence from developed countries.

Industry 4.0 is identified with the term the Internet of Things (IoT) and the Internet of Services. A study plan aimed at these elements should necessarily include:

> Advanced analytical skills (Big Data), Advanced Simulation and Virtual Plant Modelling, Computer Engineering Skills, Man-Machine Interface Skills, Integrated Closed-Loop Quality, Process and Product Management, Logistics and Inventory Optimization, Physical and Virtual Computer Integrated Manufacturing Design[42]

Teaching methodology should focus on innovation and the curriculum design should be flexible, "interdisciplinary, intelligent, modular and re-shapeable,"[43] constantly updated and achieving international accreditation.

The nine technologies for Industry 4.0, which in turn require specific skills and are deemed absent from the study plan in question, are:

1) *Big Data*: The ability to collect, store and analyze large amounts of data to identify inefficiencies and bottlenecks in production
2) *Autonomous Robots*: Skills for human-robot interaction at the workplace
3) *Simulation*: The ability to conceive, model, implement, operate and optimize products and processes in virtual settings
4) *Universal System Integration*: The ability to integrate all the production systems in the Digital Factory physically and virtually, and horizontally and vertically
5) *Industrial IoT*: The ability to have an industrial Internet connection in real time with devices, plants, offices and companies to share information
6) *Cybersecurity*: Skills in Information System (IS) and Telecommunication System security techniques

42 Carvajal Rojas, Jaime Humberto, *op. cit.*, p. 1.

43 *Idem.*

7) *Cloud Computing*: IoT and Big Data cloud computing capability
8) *Additive Manufacturing*: 3D design and printing capability for small batches and quick design changes, reduced material stacking and low transportation costs
9) *Augmented Reality*: The ability to merge physical elements with virtual elements to create an augmented reality in real time in the Digital Factory[44]

Furthermore, although one of the lines of action outlined in the Comprehensive Institutional Strengthening Program (PIFI) includes the *management of opening full-time positions that contribute to gradual improvement in activities like peer work, academic administration, school evaluation and group assistance and tutorials*[45], this contrasts with the Spanish experience that prefers professors with direct experience with companies.

This aspect of the composition of the academic personnel needs to be reviewed because in the proposed curriculum, experience is an unnecessary or little desired condition for most areas of knowledge and it is only required in the case of Applied Engineering (see Table 2).

44 *Ibidem*, p. 2.
45 FCAeI, *op. cit.*, p. 64.

TABLE 2.
DESIRED PROFILE FOR ACADEMIC STAFF ACCORDING TO THE ACCREDITATION COMMITTEE FOR EXACT SCIENCES AND ENGINEERING (CACEI)

Fields[46]	*Academic Background*		*Professional Experience*	*Work Schedule for the Program*	*With knowledge in:*		
	Origin	*Level*			*Applied Research*	*Tech. Dev.*	*Design & Project*
Basic Sciences and Mathematics	Bachelor in Engineer-ing or in Specialty	Post-Graduate desirable	Not necessary	Full-time Part-time	Desirable in area or teaching research		
Engineering Sciences	Bachelor in Engineer-ing	Post-Graduate	Desirable	Full-time	Necessary	Desirable	Necessary
Applied Engineering	Bachelor in Engineer-ing	Updated	Vast	Part-time Full-time depending on specialty	Necessary	Desirable	Necessary
Social Sciences and Humanities	In the field	Bachelor	Desirable in field and/or academic area	Part-time			

Source: FCAEI, Industrial Engineering, 2015 Study Plan 2015. Mexico: UAEM. 2015

46 In order to perform the general functions of their profession, undergraduate students in engineering need specific basic knowledge in the fields of Basic Sciences and Mathematics, Engineering Sciences, Applied Engineering and Social Sciences and Humanities.

The above situation is somewhat contradictory. On the one hand, it suggests that a professor who teaches subjects like basic sciences and mathematics may not necessarily have professional experience and can hold a position as a full-time or subject-based professor while applied research activities are simply desirable. In other words, the personnel who prepare learning experiences for training students are exempt from having to deal with the work experiences their students will face.

Concern in the curriculum design is more in line with the recommendations of study plan accreditation bodies than with the requirements emerging in the labor market.

The adjustments made to the 2015 plan as seen in the curriculum are dictated by the above-mentioned organizations and not in terms of their relevance to the labor market:

> […] the comparative analysis of the General Basic Stage of the 2002 Study Plan regarding the recommendations issued by the evaluating and accrediting bodies; particularly those indicated by the Inter-institutional Committees for the Evaluation of Higher Education (CIEES), as well as those of the Accreditation Committee in Engineering Education (CACEI) and the National Center of Evaluation (CENEVAL).[47]

And not only that, but it also failed to gather information on the expectations of the employers of future graduates of the profession being analysed.

In light of this scenario, it is necessary to question the institution's social responsibility since it is a much-discussed position that includes the analysis of applicability in the training of higher education students. The UNESCO states that: "*Higher Education as a public good is the responsibility of all stakeholders, especially governments.*"[48] In this specific case, this public good is committed to seeking the good of society, since:

> […] university influences the training of young people and professionals, their scale of values, their way of interpreting the world and of behaving in it. It also influences professional ethics and – knowingly or not – guides the definition of professional ethics for each field and its social role. A responsible university asks itself about the type of professionals, citizens and people it

47 *Ibidem*, p. 31.

48 UNESCO, *World Conference on Higher Education,* 2009, Paris, p. 2.

> educates, and about the proper teaching structure to guarantee a socially responsible education of its students.[49]

In this vein, university social responsibility is tied in with the need for the training of professionals to respond to the social function of the profession; that is, to the social needs beyond the processes of coverage, permanence and quality that graduates must meet to achieve their objectives, among which should be to satisfy the demands of Industry 4.0.

In summary, the Industrial Engineering study plan is an academically consistent program with a differentiated academic load that is similar to that of other higher education institutions, but which's relevance can be seriously questioned if the school teaching the curriculum disregards the conditions that will emerge with the Fourth Industrial Revolution.

V. Conclusions And Comments

Industry 4.0 is a process that is underway and affects the countries implementing it, as well as those that are technologically dependent.

Studies in Latin America on the suitability of higher education systems to give emerging economies an opportunity to incorporate their qualified personnel to this production trend are limited.

Public higher education institutions in Mexico can commit to the education of the personnel required by Industry 4.0 with the advantage of not only addressing technological considerations, but also with ethical training and social responsibility that reduces the gaps of inequality.

The institution and educational program studied show that while there are intentions of providing an education consistent with current conditions and times, the possibilities are limited because they prioritize strictly academic recommendations and disregard the components that liaise with businesses, innovation and research development.

The study plan prepares students for a labor market that is limited to the implementation of technological development techniques and processes that come from other backgrounds, and does not encourage research and

49 *ZARATE RUEDA, Ruth and GARCIA RINCON, Sonia Cristina. La cultura socialmente responsable de la UIS: una perspectiva desde el ámbito educativo y social. Encuentros [online]. 2014, vol.12, n.2 [cited 2019-06-26], pp.105-120. P.108. Available from: <http://www.scielo.org.co/scielo.php?script=sci_arttext&pid=S1692-58582014000200008&lng=en&nrm=iso>. ISSN 1692-5858.*

development with innovation, which would set the tone for a better quality of life for the Mexican population.

Faced with the complexity of the issue, the possible strengths the public university wields, like that of having full-time staff, becomes a weakness since such exclusive involvement in university activities limits their participation in companies dealing with the challenges of professional training, which is a common situation if these companies want to be competitive.

Although the paid work to which industrial engineering professionals have access is considered "high", compared to the earnings of other occupations in Mexico, their wages are considered similar to those of unskilled personnel in developed countries. Moreover, prevalent working conditions in Mexico marked by uncertainty and the lack of social security are disappointing for professionals who have graduated from public higher education.

The economic, social and political conditions that currently define the world of work in Mexico reveal a lack of social justice towards professionals. Situations of injustice are visible and can become a cause of social instability, especially because peace is threatened. The ILO aspires to ensure that *every working man and woman can claim freely and on the basis of equality of opportunity their fair share of the wealth which they have helped to generate.*[50] For almost 100 years, the ILO has not changed this principle, but nor has it been attained. Hence, in view of educational research on student learning, it is necessary to urge governments, employers and workers to act on this demand for social justice. And what better way to do so than through a critically constructive analysis that can shift curricular design to meet the future demands of the labor market, prioritizing equality over efficiency and giving education the status of a public good.

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