YOUNG PEOPLE AND THEIR INTEGRATION INTO INDUSTRY 4.0

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I. Introduction

The world is changing rapidly and is becoming increasingly more complex as a result of technological advances and convergence, which are having a multifaceted impact by changing production, consumption, transportation, the way of living and interacting in a digital, hyper-connected world. It is therefore transforming work, jobs, ways of doing work-related activities and the work environment. While these implications are already underway, they will escalate in the coming decades.

In addition to gaining importance, technological change, as well as one of its concepts, "Industry 4.0", are posing challenges in all areas and, specifically, in the integration and participation of young people in today's society.

The issue of education in relation to work provides a broad vision because both concepts cover a wide scope in terms of their objectives, rationale and dynamics. Throughout history, the relationship between these two fields has been complex and ever-changing because this link is conditioned by economic, political and social contexts. Indeed, demographic trends, changes in the world of work and economic crises have had unique and complex manifestations for the young population. Today, a high percentage

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of young Mexicans cannot enter the labor market, while the participation of others is usually marked by precariousness, instability and lack of protection.[1]

Thus, in view of the changes that are coming and within a framework of discussion, it is important to identify the aspects on which Industry 4.0 will have an impact in this already difficult transition from school to work.

In light of this, this paper begins by giving an account of the trends on Industry 4.0, and goes on to describe the professions, skills and type of training that are profiled for this industry. It then examines the national youth context to see whether the education-work nexus will be able to take on the challenges of the new industrial era, what steps have been taken and what actions are needed to effectively face it and ensure the insertion of young people in the workforce in the best conditions.

II. Industry 4.0: Transition from School to Work

1. *Concept*

The idea of "Industry 4.0" and its strategy were presented at the Hannover Trade Fair in Germany in 2011, stemming from a project to be carried out by a working group, which submitted its recommendations to the government in 2012. The project focuses on the digital dimension of future industrial structures (smart factories that quickly and autonomously adapt to market needs in order to integrate customers and suppliers, as well as to produce small customized series in a short time).[2]

Other terms are also used to describe this technological change: *Industrial Internet* (United States of America), *Made in China* 2025 (China), the Internet of Things (IoT),[3] digital economy, the new era of industrial automation, digitalization, computerization, the Second Machine Age[4] and the Fourth Industrial Revolution,[5] among others.

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1 Saraví, Gonzalo, "Desigualdad en las experiencias y sentidos de la transición escuela-trabajo", *Papeles de Población,* vol. 15, No. 59, 2009.

2 Schroeder, Wolfgang, *La estrategia alemana 4.0: el capitalismo renano en la era de la digitalización*, Madrid, Friedrich-Ebert Stiftung, 2017, p. 17

3 Krull, Sebastián, *El cambio tecnológico y el nuevo contexto del empleo. Tendencias generales en América Latina*, CEPAL, 2016, p. 7.

4 This term was coined by Erik Brynjolfsson and Andrew McAfee in *The Second Machine Age. Work, Progress, and Prosperity in a Time of Brilliant Technologies,* W.W. Norton & Company, 2014.

5 The First Industrial Revolution of the eighteenth century came about with the intro-

Industry 4.0 is driven by technology and includes: *digital information*, process *automation*, smart connected products, value chain *connectivity* through information and communication technologies (ICT) and *digital access to the consumer*.[6] This means there is flexibility in the production process tailored to each customer, greater speed reducing the time needed to place the product on the market and greater efficiency through data analysis that allow digitalization and the Internet of Things. Its scope is wider because of its interaction with physical, digital and biological technologies.[7]

The main elements of Industry 4.0 are individualization, decentralization and networking. The first refers to the optimization and customization of products on a massive scale to be produced through flexible processes and the inclusion of the members of the supply chain in the value chain. Decentralization is the form of productive organization in which certain operations of the production process are entrusted to third parties. This feature enables mass production of individualized products. Networking involves all the relationships between the factors that interact to create a 4.0 environment and includes universities, and technical and training institutions, because they prepare the new workforce and should liaise with companies through models like the Triple Helix Model, which will be discussed below.[8]

2. *Ideological Positions*

Literature on the subject states that Industry 4.0 will generate changes in all fields, with major consequences. In this regard, three ideological currents can be identified: technological determinism, perfect market and nuanced ideology.

duction of mechanical production equipment powered by water and steam energy. The Second Industrial Revolution began in the late nineteenth and early twentieth century and was characterized by mass production arising from the division of labor and the use of electricity. This period was greatly influenced by the ideas of Frederick W. Taylor in which production was increased by reducing workers' qualifications. The Third Revolution began in the 1960s and involved the use of electronics and information technologies to boost automated production. This period is also known as the Digital Revolution: computing, personal computing (1970-1980) and the Internet (1990).

6 Schroeder, *op. cit.*, pp. 3-4.

7 Schwab, Klaus, *La cuarta revolución industrial,* Mexico, Debate, 2017, p. 14.

8 Fernando Franco, David, *Utilización del Modelo de Triple Hélice para el desarrollo de nuevos sectores productivos en el contexto de la Industria 4.0*, Master Degree Dissertation, Facultad de Ciencias Económicas y Empresariales, Universidad del País Vasco, 2015, p. 5.

a) Technological determinism.[9] According to this current, Industry 4.0 will imply: radical changes at great speed, scope and depth that occur simultaneously; diversification of the fields to which it is applied; reduction of production costs; the emergence of more highly skilled professions;[10] occupations with a greater degree of complementarity with robotization and/or digitalization; and the progressive elimination of occupations requiring repetitive, low-skilled tasks easily susceptible to being automated or replaced by robots, mainly in the manufacturing and service industries.[11]

b) Perfect market. This approach assumes that supply and demand will compensate for the creation and elimination of jobs. It notes that the debates on the adverse effects of Industry 4.0, and specifically on the world of labor, are very similar to those of the 19th and 20th Centuries, which means that such concerns are not new.[12] Previous industrial revolutions have historically shown that after the initial shocks, technological change leads to improvements in the quality of work and does not necessarily entail losses in the overall number of jobs. Thus, this current argues that technology destroys professions, but not the opportunity to work because jobs will continue to exist, although the skills needed to perform them will be different and, in some cases, will include a more or less in-depth knowledge of some of the new fields. This position also holds that some of the new professions will simply be specialized, updated or transformed from existing ones[13], for example, data scientists emerge from mathematicians; multimedia engineers or UX experts from computer engineers; communication managers from public relations, and so on.

c) Nuanced ideology. This position assumes that despite the uncertain scenario, the consequences will depend on macroeconomic dynamics, political and institutional factors including State action; public institutions; the education system; forms of work organization; existing labor regulation;

[9] Brynjolfsson, Erik, *op. cit.*

[10] The number of jobs in the fields of research, development and support for new technologies will increase.

[11] These include transportation, sales, work in offices and administrative areas, among others.

[12] Krull, Sebastián, op. cit., p. 10.

[13] Morrón, A, Will the fourth industrial revolution come to Spain?, CaixaBank Monthly Report MR02, vol. 398, pp.36-37, cited by Pernías Peco, Pedro A., "Nuevos empleos, nuevas habilidades: estamos preparando el talento para la cuarta revolución industrial?," *La economía Digital en España*, ICE, September-October 2017, No. 898, pp. 59.

union organization; and the capacity to create spaces for collective bargaining and social dialogue.[14]

3. *School-Work Nexus*

Regardless of the accepted position on Industry 4.0, the truth is that technological change will bring profound changes in education and in the world of work due to the accelerated transformations that it implies in all the areas of human life,[15] in the generation, application and validity of knowledge[16] and uncertainty as a daily occurrence.

Within this framework, Industry 4.0 requires a 4.0 education that trains the professionals of today and of tomorrow. Such education should have the following aspects: the creation of new professions; the enhancement of certain skills; a more technical profile stemming from dual vocational training or university education in collaboration with companies, mainly in innovation and development centres; and continuous learning.

A. *Industry 4.0 Professions*

New professions in Industry 4.0 will be linked to science, technology, engineering and mathematics (STEM) where more importance will be placed on cyber-physical systems (CPS: industrial objects connected by sensors and actuators),[17] computer science, robotics, data management, and computer security, among others. Thus, the following professions can be given as examples:[18]

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[14] The ECLAC (*Linkages between the social and production spheres: Gaps, pillars and challenges,* Santiago, UN, 2017) and the ILO (*The Future of Work We Want: A Global Dialogue*, Geneva, 2017) focus on this position.

[15] This means increased access to goods, services and information in real time via the internet or digital platforms.

[16] Knowledge advances at an accelerated pace, is generated and transferred in different spaces: universities, research centers, companies and civil society organizations.

[17] CPS can be applied in many sectors, such as manufacturing, energy, health, transportation, smart cities, and so on.

[18] Schwab, Klaus, *La cuarta revolución industrial,* Mexico, Debate, 2017; Cabarcos, Rafael and Ponz, Carlos S., "Ganar mayor resiliencia: de la integración con la tecnología al cambio radical del modelo económico y social: retos de futuro para España en el albor de la 4ª Revolución Industrial", Instituto Español de Estudios Estratégicos, August 2017, www.

- Robotics technicians or engineers
- Mechatronics technicians or engineers
- Senior 3D animation technicians
- Internet of Things or cloud platform programmers
- Information technology technicians
- Digital content curators
- Cybersecurity experts
- Big data experts[19]
- Nanotechnology experts
- Statisticians
- Drone pilots
- Tele-surgeons
- Augmented reality architects

Likewise, education will have to strengthen the professions that will remain in place. These professions are those that involve human interaction and creativity: social workers, psychologists, therapists, physicians, nurses and all health professionals, as well as those that involve manual and non-routinary tasks.[20]

B. *Skills*

Industry 4.0 will require a burgeoning influx of highly skilled professionals who, in addition to the specific skills of the corresponding professional field, will need to acquire and develop multidimensional skills that enable future workers to maintain their relevance in the workforce; successfully navigate and adapt in a constantly evolving work environment; or undertake independent projects.[21] These skills have different names,[22] including the following:[23]

revista-rio.org/index.php/revista-rio/article/wiew/215 ; KAHALE CARRILLO, Djamil Tony, "La formación (española e italiana) en la industria 4.0," labor *Law Issues*, LLI, vol 2, No. 2, 2016; *https://www.forbes.com.mx/que-nueva-habilidades-requeriran-las-nuevas-profesiones/* date of consultation: August 9th, 2018.

19 These experts are able to collect, store and analyze large amounts of data to identify production inefficiencies and obstructions.

20 Schwab, Klaus, *op. cit*, p. 63.

21 These skills should be encouraged and acquired from the basic levels of education as core elements from which students can build upon to reap greater benefits in terms of future professional development.

22 The term "skills" is used in the areas of both education and labor. In the first, they are called competencies/skills of knowing, doing, being and coexisting while in the second, they are transferable and technical skills.

23 Pernías Peco, Pedro A., "Nuevos empleos, nuevas habilidades: estamos preparando el talento para la cuarta revolución industrial?," *La economía Digital en España*, ICE, September-October 2017, No. 898

a) Transversal Cognitive Skills. These are skills that are developed in all fields of knowledge. They consist of different types of skills, such as: digital skills (managing information and communication technologies), working with data and making decisions based on these data, solving complex problems (as a result of automation); procedural (communicating, listening to other people's ideas), critical thinking (questioning ideas by applying the scientific method, which includes the formulation of hypotheses and experimentation); computational thinking[24] (a form of reasoning that uses computer tools and methods to solve problems of any kind, reframing an apparently difficult problem into one that we know how to solve, possibly by reduction, integration, transformation or simulation), mathematical thinking, connected algorithmic-coding thinking, heuristic-approximation thinking/imagination (related to problem-solving using scant information with scenarios that are not very clear), design-disruptive thinking/hacking, creative and innovative-prospective thinking and knowledge of foreign languages.

b) Soft Skills.[25] These consist of attitudes and skills for socializing, teamwork, leadership, passion for change, emotional intelligence,[26] teaching others, persuasion, self-learning, resilience (the ability to adapt to new circumstances and current challenges, especially in a changing environment), networking and assertive communication, creativity, entrepreneurship, management[27] and others. These types of skills are called soft skills[28] and are a key complement to the skills needed for the digitalization of work and Industry 4.0.

In short, Industry 4.0 requires skills to apply knowledge in new contexts, as well as skills that cannot be performed by robots.

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24 In 2006 Janet Wing developed the concept of computational thinking, *Cfr. "Computational Thinking", Communications of the Association for Computing Machinery (ACM)*, vol. 49, pp. 33–35, cited by Pernia, *op, cit,* p. 66.

25 ILO, *The Future of Work We Want: A Global Dialogue,* Geneva, 2017, p. 13. Pernías, *op. cit.*, p. 73.

26 Emotional intelligence helps be more innovative; enables to be an agent of change; involves self-knowledge, self-regulation, motivation and empathy; as well as becoming more agile and flexible.

27 These are skills that are difficult to automate and provide the flexibility to move from one job to another.

28 Weller, Jürgen. "Youth Employment: Characteristics, tensions and challenges." CEPAL Review, 2007.

C. *Technical-Vocational Training/Dual Training*

Technical-vocational training or dual training will be key in Industry 4.0 because it will make it possible to acquire the skills to handle the new characteristics of jobs and new qualification needs associated with technological change processes, given the closeness to companies and their demands. Moreover, it is a system with more than 100 years of proven effectiveness in the employability of young people.[29]

The dual model trains students in professions and trades through coordinated participation of the school, the company and the government. The student receives theoretical training at school and practical training in the workplace. The contents of the training are determined jointly by the government, institutions and representatives from business organizations. It implies double mentoring. The company trainer organizes learning and defines the objectives. Meanwhile, the school teacher is a counsellor and facilitator who guides the student and the company to preserve the connection between the trainee's professional experience and the training program. Funding for the system is shared between the government and the employers. Grades are assigned through written and practical examinations, which are developed and evaluated by external examiners. After obtaining their degree, students can apply for work with their employer or another company.[30]

Theoretical and practical knowledge are indispensable to performance in the world of work because they allow young people to have their first

[29] The dual training system originated in the medieval craftsmen's guilds, which sprang up mainly in central Europe. The system was based on the idea of "learning by doing" under the supervision of a master and was adapted throughout the nineteenth and twentieth centuries to give way to the merging of the educational and productive areas. *Cfr.* Adimad, *Formación profesional sistema dual. Análisis, reflexión y propuesta para un debate*, Madrid, 2012.

[30] *Cfr.* International Labour Organization, *The youth employment crisis: A call for action*, Geneva, 2012; ILO, *Resolution concerning youth employment: Pathways for decent work for youth*, Geneva, 2005. ILO, *Global Employment Trends for Youth. A generation at risk,* Geneva, 2013, R. European Commission, "The dual training system: Integration of young people in the labor market", *News*, June 7th, 2013; Tiraboschi, Michel. "Young People and Employment in Italy: The (Difficult) Transition from Education and Training to the Labor Market", *The International Journal of Comparative Labor Law and Industrial Relations*, the Netherlands, vol. 22, No. I, 2006; (Coord.), Youth Unemployment and Joblessness: Causes, Consequences, Responses), Adapt Labor Studies Book-Series, UK, T.E., *Modelo de formación profesional dual,* Madrid, CC00 Enseñanza, No. 328, 2011; Morales Ramírez, María Ascensión, "¿Sistema de aprendizaje dual: una respuesta a la empleabilidad de los jóvenes? "*Revista Latinoamericana de Derecho Social,* Mexico, Instituto de Investigaciones Jurídicas, No. 19, July-December, 2014, pp. 87-110.

work experience and, thereby, to assume the responsibilities that professional life entails. In addition, this knowledge aims to raise the company's level of productivity and competitiveness. Thus, work experience through student training tied in with the labor market can enhance the employability of young people entering specific niches of Industry 4.0.[31]

D. *Higher Education Institutions 4.0*

Industry 4.0 requires universities and higher education institutions to partner with companies in order to design specialized training programs that respond to technological changes, new professions and skills, real projects and applications for a real world.[32] To this end, they need:[33]

- To increase the quality in internationally competitive undergraduate and postgraduate degrees in science, technology, engineering and mathematics.
- To align curriculum skills and standards with actual market conditions and digital transformation: curriculum design that is open, flexible, interdisciplinary, modular, innovative, interconnected and reconfigurable with international accreditation, which makes it possible to train highly qualified workers capable of overcoming technological challenges.
- To implement new models of active self-centred training with a focus on quality and permanent innovation (creativity and innovation) where learning takes place in various spaces: linked to productive units, social spaces and problem-solving in the environment, i.e. learning based on projects and with the experience of real undertakings.
- To introduce technology as an enabling and transformative tool for learning.
- To assume that the university professor's new role is that of mentor and educational *coach*.

31 ECLAC, *Linkages between the social and production spheres: Gaps, pillars and challenges,* Santiago, UN, 2017, pp.68-69,

32 Universities and research centers no longer have a monopoly on knowledge and innovation.

33 *Cfr.* Cataldi, Zulma, Dominighini, *Claudio*, "La generación millennial y la educación superior. Los retos de un nuevo paradigma", Buenos Aires, *Revista de Informática Educativa y Medios Audiovisuales,* vol. 12 (19), 2015, pp. 14-21.

- To combine online and face-to-face training.
- To promote research and innovation with public and private support, as a means for training with internationally competitive standards.
- To introduce and/or consolidate the Triple Helix Model[34] with strategic alliances between universities, governments and productive sectors,[35] and the culture of innovation in all areas of academic work that promote, *inter alia,* the development of digital platform ecosystems; technological entrepreneurship and the socio-productive sphere (the creation of employment and wealth).

E. *Lifelong Learning*

Technological changes, especially those coming from Industry 4.0 with a culture of constant innovation and reinvention, require and will require training processes that will accompany people throughout their active lives. Thus, continuous training will play an important role in responding to changing technological requirements while ensuring adaptability and increasing workers' employment opportunities at the same time.

Now that the minimum bases required by Industry 4.0 in the school-work nexus have been described, it is time to begin an analysis on the real scope of Mexico's case.

III. National Youth Context

The country is in a somewhat discouraging position to face Industry 4.0. Generally speaking, this is due to conditions of poverty, inequality and social exclusion, particularly because of the youth's current situation within a context of low economic growth.

34 *Cfr.* Etzkowitz, Henry, *The Triple Helix: University-Industry-Government: Implications for Policy and Evaluation,* Stockholm, Science Policy Institute, 2002.

35 The model was proposed by Loet Leydesdorff and Henry Etzkowitz to stimulate innovation and therefore development through relations and interactions of the university with other producers of scientific knowledge (the first blade), with companies and industry (the second blade) and with the government or public administration (the third blade). The premise is that innovation does not emerge by itself. Therefore, the model enables the public planning of actions and decision-making in industry, education and research.

In the fourth quarter of 2017, the National Survey on Occupation and Employment reported that young people between 15-29 years of age numbered 31.03 million,[36] representing 25 per cent of the total population. Of this figure, 50.9 percent were women and 49.1 percent were men.[37] This social group faces serious problems in the transition from school to work.

1. *Education System*

The education system presents several problems, but three are especially important:

A. *Educational Deficit*

This phenomenon has been a problem throughout the country's history. The 2015 Intercensal Survey[38] indicated that 1.2 per cent of young people did not have any schooling and 1.6 per cent had three or fewer years of schooling, which translates into 2.8 percent of functional illiterates.[39] Educational deficit is greater in the poorest states,[40] a situation that prevents access to higher levels of education. In 2015, the average number of years of schooling for the population aged 15 or older was 9.2 years of basic education, despite the progress that has been made.

Coverage at the secondary and higher levels of education is still low. As to higher education, the country is 37.3 percent behind countries that have far exceeded the 50 per cent threshold. Moreover, this figure is below the average for Latin America, which in 2015 stood at 43 per cent.

[36] In Mexico, according to Article 2 of the Youth Law, the youth population comprises those between the ages of 12 and 29 (37.5 million people, or 31% of the total population). However, the Federal labor Law allows persons to work starting at the age of 15, which is why youth employment studies focus on the population between 15 and 29 years of age.

[37] INEGI, *Estadísticas a propósito del día internacional de la juventud*, Mexico, INEGI, 2017.

[38] INEGI, *Encuesta intercensal EIC 2015*. Database, Mexico, 2016.

[39] UNESCO defines functional illiteracy as a person's inability to use his or her ability to read, write and calculate efficiently in everyday life situations. In other words, although persons may know how to read and write simple phrases, they do not have the necessary skills to succeed both personally and professionally.

[40] These states are Chiapas, Veracruz, Michoacán, Oaxaca, Guerrero and Puebla.

B. *Quality of Education*

The situation of youth shows that there has been a lack of quality in the teaching-learning process because young people do not acquire the skills that enable them to enter the world of work more effectively, or to be prepared to engage in independent ventures and not out of necessity.

While the education system does have an evaluation and accreditation system, data focuses more on input and process indicators than on the results and impact of quality improvement. In terms of the evaluation and accreditation of higher education institutions, only 16 per cent (458) have credited at least one program by organizations recognized by the Council on Higher Education Accreditation; 43.1 percent (1,677,596) of the students are enrolled in quality programs and 17.3 per cent (4,593) programs have valid quality recognition. At postgraduate level, only 11.2 per cent (157) of the institutions have a quality program from the National Council of Science and Technology (Conacyt).[41]

C. *Financing*

Public investment (federal and state) in higher education is very low: 0.91 per cent of the Gross Domestic Product (GDP). Investment in science and technology stands at 0.54 percent of the GDP, far below the OECD country average (between 2.3 and 4.25 per cent), as well as in comparison with Brazil, Argentina and Costa Rica.[42] Likewise, ties with the productive sector in research and innovation are minimal (one out of every four companies participates with an educational institution).

There is no existing legal framework for higher education and science and technology since the current one is fragmented, inaccurate and insufficient.[43] Similarly, the budget does not have a long-term projection. This allotment is uncertain because there is no guarantee that it will continue, and the amounts approved in the Federal Expenditure Budget every year

41 ANUIES, *Visión y acción 20130. Una propuesta de la ANUIES para la renovación de la educación superior en México. Diseño y concertación de políticas públicas para impulsar el cambio institucional*, Documento de Trabajo 1.0., Mexico, 2017, pp. 63-66

42 CONACYT, *Informe general del estado de la Ciencia, la Tecnología y la Innovación*, Mexico, 2011, pp. 27-28.

43 ANUIES, *op. cit*, p. 85.

do not correspond to the growth in enrolment nor do they reflect actual institutional operations, because this financing also covers staff salaries and operating expenses.[44]

2. *Employment*

Addressing the educational deficit involves creating opportunities for decent employment. In this category, the number of young people in the economically active population in 2017 was 16.4 million and can be classified into three critical groups:

a) Employed. 15.4 million young people were employed (9.7 million men and 5.67 million women). 60 percent of this group (9.2 million) had informal jobs, working in activities and companies associated with low-productivity sectors, with minimum wages (one and up to two minimum wages), a lack of social protection or stability. Young people with lower incomes and lower levels of schooling are usually found doing this kind of work[45] although in some cases this phenomenon also applies to young people with secondary and higher education (dependents and self-employed),[46] despite them having greater skills than those needed to perform the job.[47] This situation charts the life and work trajectory of young people.
b) Unemployed: 970,000 young people are found in this situation.[48] This group includes young people with a professional level, technical studies, high school and middle school diplomas. Of these, 19.8 percent lack work experience, a requirement established by the productive sector, in addition to a series of skills that this social group does not have.

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44 *Ibidem*, p. 90.

45 This inequality is exacerbated by socio-economic, gender, ethno-racial and territorial situations that are entrenched over the years.

46 IMJUVE, *Panorama de la ocupación juvenil en México*, Gobierno de la República, Sedesol, Año 1, No. 4, October-December, 2017

47 The higher the level of schooling, the less likely they are to find employment consistent with their vocational training.

48 IMJUVE, *op. cit.*, p. 12.

c) No schooling, no job. Nine per cent of men and 35 percent of women are in this situation.[49] This group usually includes young people who do household chores or care for others (mainly women).

The above situation regarding levels of education and the possibilities of youth employability shows the weakness of the school-work nexus. Those who manage to complete their basic education and enter a higher education institution face the challenge of remaining in school and successfully finishing their studies. However, having a diploma does not ensure successful incorporation into a workplace with labor and social security rights. They are threatened by unemployment because in many cases they lack the abilities or skills required by the productive sector. This affects the quality of employment, the income and job mobility. This situation reveals, on the one hand, that the university curriculum does not correspond to the needs arising from technological changes and, on the other hand, that the country's low economic growth does not generate employment opportunities for young people.

3. *Actions Undertaken*

Despite the regrettable scenario described above, various actions have been carried out over time, albeit with slow progress, so far. These actions include following:

A. *Dual Vocational Training*

In 2013, the Mexican Dual Training Model was implemented as a pilot program in technological and technical vocational high schools and this model was formalized in 2015.[50] To date, it is taught at 104 schools[51] in 15 states with the participation of 400 companies from the Mexican Employ-

[49] In its study *Out of School and Out of Work: A Diagnostic Study of Ninis in Latin America*, the World Bank reports that there are 4.2 million young people in this situation in Mexico.

[50] On 11 June 2015, Secretarial Agreement No. 06/06/15 was published in the Federal Official Gazette, establishing dual training as an educational option for secondary level education. SEP, CONALEP, *Modelo Mexicano de Formación Dual*, Mexico, 2013. *www.conalep.edu.mx/academia/Documents/mmfd/prsntcn_mmfd.pdf*

[51] At schools from the National College of Professional Technical Education (CONALEP), Centers of Scientific Technological Education (CECYTES), Industrial Technologies

ers' Association (Coparmex). The model currently operates for 13 industrial and service degrees.[52]

Industrial degrees	*Service degrees*
1. Electromechanics 2. Tooling machines 3. Mechatronics 4. Plastics processing 5. Autotronics 6. Industrial maintenance	1. Tourist hospitality services or lodging services or hotel services 2. Food and beverages or food and beverage preparation 3. Accounting 4. Telecommunications 5. Management or administrative management processes or sales or logistics or human resources administration 6. Information technology or programming, or computer equipment support and maintenance 7. Trucking services

In the implementation of the model, the following goals were set: to have 10,000 students by 2018, and to attain national coverage and greater participation of companies in all the country's productive sectors.

In November 2017, the subject "digitalization and Industry 4.0" was incorporated into the model programs, as well as a degree in "industrial engineering", as part of an agreement between Mexico and Germany, with the backing of Siemens. A pilot program was also developed at the National College of Technical Professional Education schools to certify young people in digital skills, in order to identify which skills are more demanded by the productive sector and thus develop and implement specific programs to close the gap between supply and demand, and the impact on employability and competitiveness of young people.[53]

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and Services Studies Centers (CETis), under the *General Office of Industrial Technology Education* (DGETI) and the General Office of Agricultural Technology Education (DGETA).

52 SEP, *Información de la Subsecretaría de Educación Media y Superior de la SEP, http://www.sems.gob.mx/es_mx/sems/avances_ubicacion_mmfd*

53 The Digital Skills Certification Committee was formed with the participation of the Business Coordinating Council, BSA and CONOCER, representatives from the Undersecretary of Higher Secondary Education of the Ministry of Public Education, CONALEP, General Office of Work Training Centers (DGCFT), University of Valle de México (UVM),

However, this model faces stigmatization and has yet to show whether it responds to the needs of companies in strategic areas of the country. Moreover, one of the difficulties this model faces is the fact that in Mexico, 90 percent of the companies are small and medium enterprises. It is therefore necessary to evaluate the model so as to correct or reinforce the course to be followed in the school-work nexus and, where appropriate, to recognize and further its real dimension with all the necessary transversality.

B. *Higher Education*

This level of education underwent several changes covering aspects such as:[54]

- Growth in enrolment: 4,430,249 students: 134,000 new places in schools a year
- Diversification processes of institutions: federal universities and institutions, state public universities; technological institutes coordinated by the National Technological Institute of Mexico; technological universities; polytechnic universities; intercultural universities; institutions for training basic education professionals; public research centres and other public institutions[55]
- Deconcentration and decentralization of options to access the system: school-based, mixed, open and distance modalities in both undergraduate and postgraduate studies
- Evaluation of individual and institutional performance
- Evaluation approach and accreditation criteria[56]
- Implementation of new governance and management systems and modalities
- Presence of private investment

CANIETI and AMITI, International Youth Foundation, Mexico Exponencial, Autodesk, Adobe, Dell and Microsoft, and the United States Embassy.

[54] ANUIES, *op. cit.*, p. 34.

[55] Although there is no functional system that connects the different types of higher education institutions, it provides a clearly articulated and differentiated range; common rules, incentives and aids, and a long-term vision and program.

[56] This covers the evaluation of programs, academics, students, institutions and administrative processes.

- Development of alliances between universities, companies and government or citizen organizations
- Internationalization of the curriculum and student and professor mobility.
- Generalization of quality assurance platforms
- Flexibilization of university curriculum
- Design of learning-centred educational models geared towards acquiring professional skills

Likewise, many higher education institutions already offer degrees linked to Industry 4.0 (Science, Technology, Engineering and Mathematics), such as information systems, biomedical systems, nanotechnologies, technologies and biotechnology, as well as robotic, information, mechatronic, computer, and smart systems engineering, among others. However, the percentage of these professions and enrolment are still low, especially in terms of women's participation.

Hence, it is possible to observe new Industry 4.0-related degrees being offered at universities and technological institutions of higher education, as well as some traditional degrees focusing on activities in a setting of the Fourth Industrial Revolution: the National Autonomous University of Mexico offers degrees in Biomedical Engineering, Mechatronics, Nanotechnology and Information Technologies in Science; the Autonomous University of Zacatecas teaches Industrial Electronics Engineering centred on Robotics and Digital Systems[57] and Computer Technologies Engineering centred on the Internet of Things (IoT).[58]

The Autonomous University of Aguascalientes describes the skills of an "engineer in smart technologies" will have mathematical and theoretical bases of computer science, artificial intelligence, and software industry through the design and creation of environments, facilities and innovative computer applications, base software and application development, the formulation of theories and practice of models of complex realities and undertakings to provide efficient computational solutions to real and complex problems, as well as to assimilate and adapt new technologies."[59]

57 *http://campusjalpa.uaz.edu.mx/iei* date of consultation: April 27th, 2018.

58 *http://campusjalpa.uaz.edu.mx/itc* date of consultation: April 27th, 2018.

59 *http://www.uaa.mx/direcciones/dgdp/catalogo/ciencias_basicas/ing_computacion_inteligente.pdf* date of consultation: April 10th, 2018.

Universities have also signed agreements with various industrial chambers to train human resources specialized in cutting-edge technology although they are still few. Similarly, industrial chambers have some programs that apply to young people, such as the Network of Training and Innovation Centres of the Mexican Cement Chamber (CANACEM) in which the government, companies and higher education institutions participate in the training of professionals with up-to-date knowledge concurrently with the development of technological knowledge in the field.[60] The National Chamber of Textile Industry (CANAINTEX)60 gives courses along the same lines, such as "LECTRA Be Fashion/able: Integral Solution 4.0".[61] While these courses are not exclusively for young people, the programs are open to young people and active workers alike. The Mexican Chamber of the Publishing Industry (CANIEM) has a Professional Training Centre , unique in Latin America and offers training and refresher courses.[62]

The National Chamber of the Electronics, Telecommunications and Information Technologies Industry (CANIETI) even has scholarships for Mexican students to prepare for postgraduate programs in areas related to the most innovative and cutting-edge technologies in the sector, such as: Internet of Things, Mobile Internet, Big Data analysis, Automation of Knowledge Work, Cloud Computing, Advanced Robotics, Autonomous Vehicles, 3-D Printing and so on.[63]

60 *http://www.alianzafiidem.org/centros_formacion.html* date of consultation: April 17th, 2018.

61 *http://www.canaintex.org.mx/curso/ date of consultation:* April 18th, 2018.

62 *http://www.caniem.com/es/capacitacion* Date of consultation: June 10th, 2018.

63 *http://www.canieti.org/servicios/ProgramaTexasCANIETI.aspx* Date of consultation: April 18th, 2018.

Industry 4.0 Professions In Mexico

University	*Degree*	*Enrollment*
National Autonomous University of Mexico	Biomedical Systems Engineering	Not available
	Electrical and Electronics Engineering	1594 men and 177 women
	Mechatronics	21 men and 27 women
	Computer Science	670 men and 119 women
	Informatics	462 men and 171 women
	Nanotechnology	Indirect admission
	Technologies	Indirect admission
	Information Technologies in Science	8 men and 6 women (new admissions)
	Computer Engineering	4,533 men and 1,064 women
National Polytechnic Institute	Industrial Robotics Engineering	1228 men and 199 women
	Computer Engineering	1380 men and 373 women
	Computer Systems Engineering	2493 men and 411 women
	Biotechnology Engineering	303 men and 260 women
	Mechatronics	1201 men and 110 women
	Control and Automation Engineering	1901 men and 303 women
Metropolitan Autonomous University	Information Technologies and Systems	190 men and 52 women
	Electronics Engineering	1236 men and 64 women
	Computer and Telecommunications Engineering	No information available
	Biomedical Engineering	403 men and 262 women
	Computing	377 men and 306 women
	Computer Engineering	1059 men and 219 women
	Computer Sciences	No enrollment information available

University	*Degree*	*Enrollment*
Autonomous University of Mexico City	Software Engineering	581 men and 219 women
	Industrial Electronic Systems Engineering	592 men and 158 women
	Energy Systems Engineering	156 men and 80 women
Autonomous University of Aguascalientes	Intelligent Computer Engineering	159 men and 34 women
	Computer Systems Engineering	456 men and 111 women
	Informatics and Computational Technologies	No enrollment information available
	Industrial Statistics Engineering	112 men and 82 women
	Renewable Energy Engineering	76 men and 44 women
	Robotics Engineering	200 men and 39 women
	Manufacturing and Automation Engineering	68 men and 19 women
Autonomous University of Baja California	Computer Science	73 men and 15 women
	Computer Engineering	952 men and 191 women
	Mechatronics	930 men and 133 women
	Nanotechnology	33 men and 54 women
	Aerospace Engineering	No information available
Autonomous University of Baja California Sur	Information Technology Management	No information available
	Software Development Engineering	No information available
	Computational Technologies Engineering	232 men and 27 women
Benito Juárez University	Technical Innovation Engineering	No information available
	Computing	113 men and 33 women
Del Carmen University	Computer Engineering	29 men and 8 women
	Computer Systems Engineering	164 men and 51 women
	Mechatronics	177 men and 25 women

University	*Degree*	*Enrollment*
Autonomous University of Coahuila	Information and Communications Technologies Engineering	1737 men and 364 women
	Computer Systems Engineering	308 men and 168 women
Autonomous University of Colima	Mechatronics	212 men and 38 women
	Electronics Technologies Engineering	29 men and 6 women
	Electronic Systems and Telecommunications Engineering	57 men and 2 women
Juárez University of the State of Durango	Chemical Biotechnology	58 men and 83 women
	Computer and Administrative Systems Engineering	90 men and 31 women
University of Guadalajara	Computer Engineering	1606 men and 253 women
	Biomedical Engineering	88 men and 64 women
	Informatics	1010 men and 219 women
	Nanotechnology Engineering	330 men and 96 women
	Mechatronics	694 men and 59 women
	Electronics and Computer Engineering	408 men and 97 women
	Food Engineering and Biotechnology	154 men and 263 women
Universidad de Guanajuato	Computing	246 men and 65 women
Autonomous University of Guerrero	Computer Engineering	350 men and 144 women

University	*Degree*	*Enrollment*
Autonomous University of the State of Hidalgo	Computer Systems	121 men and 51 women
	Computer Engineering	127 men and 36 women
	Industrial Automation Engineering	75 men and 9 women
	Software Engineering	63 men and 26 women
	Information Technologies	No information available
	Nanotechnology Engineering	24 men and 8 women
Michoacán University of San Nicolás de Hidalgo	Electronics Engineering	234 men and 28 women
	Computer Engineering	262 men and 46 women
	Technical Innovation Engineering in Materials	No information available
Autonomous University of the State of Morelos	Robotics and Industrial Manufacturing Systems Engineering	No information available
	Technology for Applied Physics and Electronics	No information available
	Molecular Design and Nanochemistry	No information available
Autonomous University of Nuevo León	Aeronautical Engineering	1737 men and 364 women
	Electronics and Automation Engineering	963 men and 77 women
	Mechatronics	3,490 men and 380 women
	Software Technology Engineering	1,263 men and 225 women
	Information Technology Security	400 men and 101 women
	Genomics and Biotechnology	416 men and 458 women
Autonomous University of Querétaro	Software Engineering	312 men and 47 women
	Information Technology Management	23 men and 8 women
	Nanotechnology Engineering	127 men and 46 women
	Automation Engineering	297 men and 70 women

University	*Degree*	*Enrollment*
Autonomous University of San Luis Potosí	Computer Engineering	255 men and 53 women
	Computer Engineering	212 men and 65 women
	Intelligent Systems Engineering	30 men and 23 women
	Electrical and Automation Engineering	No information available
Universidad de Sonora	Electronic Technology Engineering	146 men and 12 women
	Computer Science	109 men and 13 women
	Information Systems Engineering	512 men and 62 women
	Mechatronics	1029 men and 293 women
Autonomous Juárez University of Tabasco	Computer Science	No information available
	Computer Systems Engineering	43 men and 14 women
	Administrative Informatics Engineering	178 men and 194 women
	Computer Systems	363 men and 127 women
	Information Technologies	19 men and 23 women
Autonomous University of Tamaulipas	Computer Systems Engineering	773 men and 219 women
	Production Systems Engineering	114 men and 73 women
Veracruzana University	Computational Technologies	145 men and 33 women
	Software Engineering	159 men and 23 women
	Electrical Engineering	944 men and 130 women.
	Electronics and Communications Engineering	199 men and 52 women
	Biotechnology Engineering	90 men and 193 women
	Computational Technologies Engineering	99 men and 33 women
	Computer Engineering	142 men and 30 women
	Mechatronics	262 men and 48 women
	Computer Networks and Services	102 men and 34 women

University	*Degree*	*Enrollment*
Autonomous University of Yucatán	Biotechnology Engineering	100 men and 76 women
	Mechatronics	256 men and 32 women
	Computer Engineering	134 men and 21 women
	Software Engineering	200 men and 30 women
Autonomous University of Zacatecas	Industrial Electronics Engineering Centered on Robotics and Digital Systems	No information available
	Computer Technologies Engineering Centered on the Internet of Things (IoT)	

Source: Developed by author from websites of Higher Education Institutions. Enrollment data obtained from the 2017 ANUIES Annual Report.

IV. The Way Forward

The scenario described in this paper on the transition from school to work forces us to consider appropriate measures, strategies and policies to avoid even more undesirable consequences for young people. Said measures must be seen from different angles, not only industrial and technological policies to meet the requirements of Industry 4.0, but also inclusiveness and integration; that is, educational and employment opportunities so that those born in impoverished households can better their economic situation and thus break with the vicious cycle that social origin decides a person's destiny. Changes in the education system must go hand in hand with greater opportunities of decent employment, since there is little point in training young people if the labor market does not have the capacity to accommodate them (especially those in poverty, vulnerability or living in remote areas).

Actors at different levels and national and international agencies have spoken out on transforming the circumstances of young people through a comprehensive approach. This means that the problems to be solved and their possible solution have been identified.

The National Institute for Education Assessment (INEE) has identified the following important issues that require attention: the strengthening of teacher training colleges; the strengthening of schools, the assessment and revision of study plans, educational research, parent participation, equal educational services (disadvantaged communities), education, productivity and work (providing skills for work and life), autonomy in education; material conditions, problems of governance in the education system, funding for education and the sole basis of official information.

The National Association of Universities and Institutions of Higher Education (ANUIES) has proposed five main lines of action to strengthen higher education:

1) Ensuring better governance for the development of the higher education system (regulatory framework and a national higher education system);
2) Expanding coverage with equality and quality; reduce drop-out rates and broaden the range of educational modalities, that is, to continuously improve the quality of higher education;
3) Creating a national evaluation and accreditation system at this level and stimulate its internationalization;
4) Fostering social responsibility: to strengthen the quality and relevance of their functions, extend their contribution to regional development and participate in a more prosperous, democratic and just society;
5) Acknowledging the strategic nature of higher education, science, technology and innovation through a State policy with a medium- and long-term vision.

The 2030 Agenda for Sustainable Development considers several goals related to education:

- Ensuring inclusive and equitable quality education and promote lifelong learning opportunities for all;
- Ensuring equal access for all women and men to affordable and quality technical, vocational and tertiary education, including university;
- Eliminating gender disparities in education and ensure equal access to all levels of education and vocational training for the vulnerable, including persons with disabilities, indigenous peoples and children in vulnerable situations;
- Providing the necessary skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship;
- Substantially increasing the number of scholarships available at all levels of education, including vocational training and technical, sci-

entific, engineering, information technologies and communications programs; substantially reducing the number of youth who are not employed nor receiving education or training; and having an evaluation and accreditation system that focuses on the learning process; that is, on the outcomes and impact to ensure quality education;

— Increasing scientific research and innovation through public and private funds.

As seen from the above proposals, the important items to be addressed are clearly identified: equal opportunities, the education deficit, the quality of education; allocating a larger budget and a long-term vision to finance higher education and increasing investment in science, technology and innovation in order to channel it to projects with greater growth potential. Furthermore, it is important to:

- Strengthen and consolidate dual training as an option to facilitate early and effective transitions to work, mainly for lower-income students. It is also important to increase ties with the productive sector, using labor market prospects to direct education supply towards the demand of this sector locally, regionally and nationally.
- Promote the participation of women in professions associated with science, engineering and mathematics to reduce the gender gap, empower the coming generation in these fields and avoid replicating traditional roles.
- Regulate the various ways of acquiring work experience before completing studies (internships, professional practices and dual training) from the educational and work spheres because there is a lack of comprehensive regulations that establish the minimum bases to protect students from the possible divergences or abuses of a covert job.
- Celebrate agreements among institutions, companies and trade unions to ensure that the skills acquired match those requested by the productive sector and, therefore, that quality employment is offered.

Lastly, whenever there are diagnoses and possible solutions, it is necessary to act on them; that is, to implement them with a view to making the school-work transition socially fair and respectful of fundamental rights, particularly labor and social security rights. In other words, the aim is to seek the social dimension of technological change in order to influence its path. All the above must take place within a framework of sustained, inclusive and sustainable economic growth with full and productive employment, and decent work for all, as stated in Goal 8 of the 2030 Agenda for Sustainable Development.

V. Conclusions

Currently, the school-work relationship as a means for personal and social progress is being seriously questioned by the high percentage of young Mexicans who are unable to enter the workforce. This condition also exposes an institutional framework that is incapable of dealing with Industry 4.0.

It is the time to take the necessary steps, because if not, the consequences will be even greater. The insertion of young people into Industry 4.0 requires improving all levels of education to produce benefits of subsequent professional development, solving the problem of dropping out of school at an early age, bringing the added value to the workforce that Industry 4.0 is seeking. It is particularly important to inspire the next generation of women leaders in science and technology.

With the new industrial era and advanced, intelligent technologies, intelligent legal frameworks are also needed. As for the education sector, 1.5 percent of the GDP should be earmarked for education and 2.5 per cent for science, technology and innovation. In terms of employment, adequate legislation on mechanisms for acquiring work experience prior to graduation is needed: internships or professional practice contracts and dual training, under a system of alternating paid work activities in a company and training activities in the education system, as well as probationary and training contracts as provided for in labor law, so that they can effectively have an impact on decent work, productivity and, consequently, wages.

The industry is recognized as an important player in the economy: it is a cornerstone of research, innovation, productivity, job creation and exports. Therefore, a vision shared by the government, the business community, universities and research centres are needed at these times in order to build 4.0 industrial ecosystems centred on persons and 4.0 talent, and thus stimulating innovation.

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