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Original article

CREATING CAPACITIES: TOWARDS INDUSTRY 5.0 IN THE TRAINING OF INDUSTRIAL ENGINEERS

CREANDO CAPACIDADES: HACIA LA INDUSTRIA 5.0 EN LA FORMACIÓN DE INGENIEROS INDUSTRIALES

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Abstract

The objective of this paper, based on the characterization of Industry 5.0 and its implicit Education 5.0, is to deal with experiences with industrial engineers in training, in the Cuban university context, associated with the competencies to be developed in the process of "active learning", in the transition towards an industry 5.0 in Cuba. This Education 5.0 implies two aspects of competences: those of high cognition of technologies or work processes and those of organizational management. They will be developed through Education 5.0 associated with the enabling technologies of that evolved Industry 4.0 or 5.0. Observation was used as a method, covering both documentary analysis and the participant made

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by teachers and students in "active learning". As results of the investigation, the characteristics of this Industry with its Education 5.0 and the peculiarities that are evident in the training of industrial engineers are expressed.

Keywords: industry 5.0, job skills, active learning

Resumen

El objetivo del artículo, partiendo de la caracterización de la Industria 5.0 y su implícita Educación 5.0, es tratar experiencias con ingenieros industriales en formación, en el contexto universitario cubano, asociado a las competencias a desarrollar en el proceso de "aprendizaje activo", en el tránsito hacia una industria 5.0 en Cuba. Esa Educación 5.0 implica dos vertientes de competencias: las de alta cognición de tecnologías o procesos de trabajo y las de gestión organizacional. Las mismas se desarrollarán mediante la Educación 5.0 asociadas a las tecnologías habilitadoras de esa Industria 4.0 evolucionada o 5.0. Como método se utilizó la observación, abarcando tanto el análisis documental como la participante hecha por profesores y estudiantes en el "aprendizaje activo". Como resultados de la investigación se expresan las características de esa Industria con su Educación 5.0 y las peculiaridades que se evidencian en la formación de ingenieros industriales.

Palabras clave: industria 5.0, competencias laborales, aprendizaje activo

Introduction

The Fourth Industrial Revolution or Industry 4.0, publicized as a strategy for the first time at the Hannover Fair, Germany, in 2011, emerged as a disruptive change to stay, expand and evolve in all countries of the world and in all economic and social sectors. , meaning interconnecting all the parts of a company by digitizing its production processes and services, giving rise to effective automation, creating a more intelligent company.[1-7] Closely related to this concept of Industry 4.0, even a basic link , education has had it together with the development of job skills or competencies.[1, 8-14]

The previous reference to the "evolution" of Industry 4.0 once it emerged as a disruptive change, to which Education 4.0 corresponded, was well envisioned by its pioneer advocates,[2,5] for which it would gradually change in its modalities. or stadiums. However, barely a decade later, not a few studies refer to Industry 5.0, where a fundamental characteristic has been to place the human factor at the center and on a higher level, while considering its social relationships as the essence of what is human.[15-21]

In this location of the human being in the center, undoubtedly, the level of awareness reached about the effects of climate change has influenced along with its consequences, mainly from the COVID-19 pandemic, and the positioning of humanity on the border of the Anthropocene, as proposed by the United Nations Development Program (UNDP) in 2020.[22] And although in its conceptual evolution it can continue to be called Industry 4.0 (since it does not respond to a new disruptive or revolutionary paradigm), it does correspond with an education that implies a radical change by placing the human being in the center and on a higher plane than technologies and machines. And in its relationship with a new required education, different, in particular with higher education (universities), it should be recognized as Education 5.0.

It is the objective of this article to signify the new characteristics that the transit and establishment of an evolved Industry 4.0 must take in its gradual and necessary change, together with its consubstantial Education 5.0 to assume. In this evolved Industry 4.0 (or 5.0) implying Education 5.0, the human factor (understood in a more complete or holistic expression by referring to it as "people and their internal and external relationships" or human resources or human talent or human capital in its planetary context) becomes its center and on a higher level of management over technologies and machines.

And, in addition, with a view to the necessary transition towards an industry 5.0 in Cuba, based on the experiences acquired in the training of the author teachers and Cuban students in Germany, with technologies that enable Industry 4.0, experiences with industrial engineers in training will be referred, in the context of Cuban higher education associated with the skills to be developed in the active or "experiential" teaching process, highlighting its peculiarities.

Methodology

The method of observation was used through documentary analysis, using bibliography on Industry 4.0 and its evolution together with the corresponding education and its labor competencies involved, and that same method of observation was also used including the authors, trying with participant observation "learning in practice" or "experiential" in companies and universities in Germany, including with special relevance students of the Industrial Engineering degree at CUJAE, aware of the strategic priority that the training of these young people has for the transit and establishment of this industry 4.0 in Cuba, as was referred to in a previous work published in the *Cuban Magazine of Digital Transformation*.[23]

This method of participatory observation was carried out by teachers and students in companies and laboratories (*UNITAX and the Mixed Reality Lab "Elbedome" at Fraunhofer IFF*) and universities in Germany such as *the Magdeburg-Stendal University of Applied Sciences* and the *Technical University of Applied Sciences Wildau, TH-Wildau* – which was outlined in a note from the Ministry of Foreign Affairs of Cuba[24] in 2021, where its professionals and university professors worked with technologies that enable Industry 4.0: Additive Manufacturing - 3D Printing, Artificial Intelligence, Augmented Reality, Big Data, Block Chains, Cloud Computing, Drones, Internet of Things, Collaborative Robotics, Simulation[23] in the transit and establishment of that Industry 5.0, and where they also pursued higher education.

The latter made possible an agreement with TH-Wildau (Brandenburg, Germany) where a group of Industrial Engineering students from CUJAE underwent training that allowed them to advance in their training through competencies and win a prize in an international competition.[23,25] In addition, the Cuban professors, from that "learning in practice", and together with German professors, began tutoring young Cuban professors to obtain doctorates, based on training and courses developed jointly with *TH-Wildau*, and all this with a view to the establishment at CUJAE of an Industrial Engineering Laboratory where the environment addresses the real life cycle of a productive link in the supply chain, evolving to be an Industry 4.0 simulator involving essential support for the Education 5.0 that is intended.

Results

The United Nations Development Program (UNDP) began its 2020 Human Development Report, noting:

> *"Under the long shadow of COVID-19, 2020 has been a dark year… Human beings have achieved incredible things, but we have also pushed our planet to the limit. Climate change, flagrant inequalities, unprecedented numbers of people who are forced to leave their homes due to conflicts and crises [...] In fact, the pressures we exert on the planet are already so great that scientists are studying whether the Earth has entered a completely new geological epoch: the Anthropocene, the age of human beings. This means that we are the first people to live in an era defined by human choices, in which the dominant risk to our survival is ourselves [...] The next frontier of human development will be to promote this development by removing planetary pressures. To survive and thrive in this new era, we must chart a new path of progress that respects the intertwined destinies of people and the planet…"* [22, p.iii]

Awareness has been raised about these pressures and together with the practice of Industry 4.0, the characteristics of Industry 5.0 have been derived. Since 2017, scattered academic efforts have been pushing for the introduction of the Fifth Industrial Revolution.[15,20,26,27] In 2021, the European Commission formally called for the Fifth Industrial Revolution or Industry 5.0,[15, 28] as a result of the Commission's consensus Union on the need to better integrate social and environmental aspects, where the COVID-19 crisis had highlighted the need to rethink existing working methods and approaches, including the vulnerability of global supply chains, with the aim of make their industries more future-proof, resilient, sustainable and human-centred.

In line with all of the above, recognizing the turbulence and disasters in the world, which require quick, practical and dynamic solutions[29] and requesting cooperation and solidarity by removing walls and building bridges, putting human beings (the people) at the center and highlighting the strategic transcendence of the digital economy, for the sake of the post-COVID-19 era, at the 2022 World Economic Forum - proverbial promoter of Industry 4.0 -, Xi Jinping expressed:

> "We must guide the reform of the global governance system in accordance with the principles of fairness and justice, defend the multilateral trading system centered on the WTO, as well as develop, based on full consultation, effective and generally acceptable rules for intelligence artificial economy and the digital economy, among others, with a view to creating an open, equitable and non-discriminatory environment for scientific-technological innovation."[30]

The fundamental characteristics of Industry 5.0, which has become a transcendental technological innovation, are to recognize the power of the industry to achieve objectives beyond employment and growth, to become a resilient provider of prosperity by making production respect the limits of our planet and to place the well-being of the industry worker at the center of production.

Industry 5.0 focuses on three interconnected core values: human-centric, sustainability, and resilience. The human-centered approach puts fundamental human needs and interests at the heart of the production process, moving from technology-driven to progressing toward a completely human- and societal-centered approach. As a result, workers in the industry will develop new roles as a value change, from considering workers as "cost" to "investment". Technology is to serve people and societies, which means that the technology used in manufacturing is adapted to the needs and diversity of workers in the industry.[15,26]

A safe and inclusive work environment must be created to prioritize physical health, mental health and well-being and, ultimately, safeguard the fundamental rights of workers, that is, autonomy, human dignity and privacy. Industrial workers must continue to upskill and retrain themselves to improve career opportunities and work-life balance.[15]

For the industry to respect planetary boundaries, it must be sustainable. You need to develop circular processes that reuse and recycle natural resources, reduce waste and impact on the environment, and ultimately lead to a circular economy with better resources, efficiency and effectiveness. Resilience refers to the need to build a higher degree of robustness into industrial production, better arming it against disruption and ensuring it can provide and support critical infrastructure in times of crisis. The industry of the future must be resilient enough to quickly navigate geopolitical changes and natural emergencies.[15,16,19,20]

Together with the enabling technologies of Industry 4.0, previously referred to and specified in articles by the authors referring to their training work in higher education,[23,31] now those that are standing out in the evolved Industry 4.0 (Industry 5.0). They are not considered an addition to the previous ones, but customization or specification of peculiarities in tune with evolution. These enabling technologies[15] for the achievement of Education 5.0 and the evolved Industry 4.0, are the following:

1. Individualized human-machine interaction technologies that interconnect and combine the forces of humans and machines.
2. Bio-inspired technologies and smart materials that allow materials with sensors to be integrated and with improved functions and to be recyclable.
3. Digital twins and simulation to model complex systems.
4. Data transmission, storage and analysis technologies that can handle interoperability of data and systems.
5. Artificial intelligence to detect, for example, causalities in complex dynamic systems, leading to actionable intelligence.
6. Technologies for energy efficiency, renewables, storage and autonomy.

In these enabling technologies, the scientific disciplines that are taught in higher education associated with the Industrial Engineering career, related to ergonomics or engineering psychology, occupational safety and health, work organization (work methods and time study), logistics in its different modalities, effective communication and labor compensation. The authors Xu, Lu, Vogel-Heuser & Wang emphasize in 2021[15] that Industry 5.0 is not a revolution driven by technology, but rather an initiative driven by values that push technological transformation with a particular purpose, demanding agile, interrelated and systemic policies including: a) profitable, scalable economies with management models; b) ecology with CO2 reduction and circular economy; c) and changes in society centered on the human being.

In the literature on the subject of education and skills[2,10,13,32] and even without referring to the evolution signified by Industry 5.0, where the need to continue investing in education stands out, it is argued that the job skills that will mark the imprint of the transit and consolidation of this Industry 4.0, will be comprised of two major aspects or macro skills: high cognition skills on technologies or work processes and skills in organizational management. This is highlighted in particular in the 2018 WEF report (in *The Future of Jobs Report 2018*). The former involves originality, creativity and innovation; systemic and critical analytical thinking; learning in practice; complex reasoning and problem solving; as well as design and programming. The second related to management, include leadership, cooperation, commitment and development; the management of interpersonal relationships and work teams and emotional intelligence. It is noteworthy that in the aforementioned analysis of the WEF, among the growing competencies, "Active learning" or learning in practice stands out. It is necessary to express that in the research of the *McKinsey Global Institute*,[13] also in 2018, there is coincidence in the increase of these competences, only in a much longer period (from 2016 to 2030); and they do not express the "decline" of skills in such a short term.

It should be noted that in the scientific literature subsequent to that 2018 WEF report, and especially that which refers to Industry 5.0 and its Education 5.0 and its competencies, these two great aspects or macro competencies are reaffirmed: those of high cognition over technologies or work processes and those of organizational management, breaking down those of high cognition on technologies into hard and digital, and those of organizational management -with greater emphasis-- into soft and emotional intelligence.

In this sense, a typology of competencies already involved in the Education 5.0 phase is the one argued by Flores et al. in 2020,[15] which is distinguished from the competences previously stated by the WEF by locating them in the context of concepts and technologies of that already evolved Industry 4.0 (Industry 5.0), with essential coincidences with other authors. Flores et al. They present five groups of skills that enable Human Capital, which will be detailed below due to their methodological importance in training according to Education 5.0.

1. *Soft workforce, including flexibility and soft skills*. Soft skills are playing a key role for future jobs. They will exhibit the opportunity for social responsibilities, such as quick adaptation or cooperation, which may well lead to successful outcomes. These skills will allow interconnectivity, self-adaptability and decentralization of the jobs sought by the Industry. 4.0 at the human capital level. A clear need for this competence is that multiculturalism and collaborative skills have been considered relevant in future networks of intercultural organizations. The skills included there are: communication, teamwork or cooperation, leadership, willingness to learn, self-development, negotiation and flexibility or adaptability. The authors Flores, Xu and Lu,[19] call the breakdowns or dimensions of these five competences of their typology skills. And at the end of the characterization of each of them, they will refer in their breakdowns that they consider them components called skills.

2. *Hard work force, including professional competencies and skills*. That is where the authors Flores et al. in 2020 noting that it should come as no surprise that many of the new hard skills can be classified under the “digital skill” category as well. For example, "programming" can be both a technical and a digital skill, but "surfing the web" could be a digital skill without being a technical skill required for a job. Furthermore, in the case of "programming", and other similar competencies in "hard digitization", it

would be safe to assume them by mixing different types of competencies, which come from the interdisciplinary approach of a physical and digital world necessary for the evolved Industry 4.0.

The workforce, which is professional and skilled, must tackle the next group of the most discussed technical skills of future jobs. The pool of competencies here covers: industrial organization, industrial processes, understanding of standards, problem-solving techniques, software design, human-machine interactions, digital network configuration, digital security, and coding or programming.

3. *Cognitive workforce, comprising intelligent and analytical competencies*. The importance of cognitive skills increases with the level of complexity of the tasks or systems. Therefore, future jobs in this Industry will be affected by this classification, since the integration of new concepts and technologies is generating complex and interconnected networks and systems. Human labor will have to learn to use and interact with new software (eg systems, platforms, cloud) and new hardware (eg equipment, machines, mobile devices) that will be built to incorporate digital integration. Although technological efforts are developed to support human adaptation to new systems, still humans will need to keep learning. Further developing cognitive skills in the workforce will be required to support worker autonomy, which is another goal of Industry 4.0.

The competencies of the cognitive workforce, which is intelligent and analytical, are divided into three aspects: aspect one, verbal aptitude (i.e. vocabulary, spelling and reading), aspect two, numerical aptitude (i.e. mathematics, arithmetic) and aspect three, spatial aptitude (ie, coordination, memory, decision making, problem-solving thinking, abstract reasoning, and analytical thinking).

4. *Emotionally intelligent workforce comprising self-awareness and empathy competencies*. Addressing the importance of this competency for new roles should smooth the transition from existing business models to new Industry 4.0 models. Emotional intelligence can provide future jobs with responses to stress, fatigue, and the work-life balance that this Industry aspires to. Additionally, since Emotional Intelligence is linked to influencing employee drive and motivations, considering and leveraging this competency can potentially support existing challenges. For example, the demographic concern of an aging population could be answered by lifting the spirits of older employees and persuading them to stay longer in their career paths.

Additionally, this competition could be a tool to address the workload and sense of anxiety that has been reported to come from human-robot collaboration. The competencies that have been identified for the emotionally intelligent, self-aware and empathic workforce are: self-awareness, self-control, positive attitude, empathy, orientation and achievement motivation.

5. *Digital workforce including digital literacy skills and digital interactivity*. The impact of digital skills is absolute for jobs in the Industry. The elements of the digital world mean the bloodstream for the whole idea of Industry 4.0 itself. Therefore, learning and mastering these skills could not be an option for the future of human work. Therefore, the workforce will be forced to adopt these competencies. The most common set of competencies sought after for the digital workforce, which is digitally literate and interactive, is trend to maintain professional level.

The list of competencies here includes: programming, cybersecurity, digital networks, cloud computing, databases, web, development and also the management of enabling technologies of this Industry 4.0, that is: Internet of Things, Big Data analytics, 3D printing, Simulation, Augmented and virtual reality. It should be noted that most of these digital skills, as they are also skills required to perform a job, could also fit into the classification of hard or technical skills.

The educational trend in universities that face Industry 4.0 in its evolution and already requiring Education 5.0,[8,9,17,18,33] point towards the concept of an innovative university that has its main axis in research. developmental. This investigative approach addresses two relevant planes: on the one hand, research is used for scientific and technological innovation, thus providing new knowledge; on the other, research is used in academic innovation helping to redefine teaching and learning practices. Innovation is very diverse and complex,[34] which requires a process of continuous cultural change and in Industry 4.0 this dynamism is even more relevant, particularly in the training of professionals oriented towards competencies. And all of the above should result in a university management model characterized by a dynamic feedback between these two essential levels.

Consequently, higher education -and in the case that will be illustrated, associated with the Industrial Engineering career- will have to focus, not only on training all the members of its community in the basic knowledge of the disciplines or work, but also in stimulating the development of multiple skills, typical of the needs of the technological context, so that, from management or soft skills such as collaborative work, creativity and critical thinking, graduates are prepared with a vocation towards innovation and technological management, from the various areas of knowledge or scientific disciplines, but with strong support in digital and analytical tools supported by the processing of large volumes of information and technological development.

Discussion

Next, the proposal made (and already started with the *TH-Wildau* in Germany) for the development of skills in Industrial Engineers is argued, assuming the characteristics of Education 5.0 mentioned above, with the purpose of transiting and implementing Industry 4.0 evolved in Cuba.

According to Deepa, S., & Seth, M. in 2013,[35] 80% of professional performance is determined by soft skills (Soft) and only 20% by hard skills (Hard), at the same time there is a consensus in that soft skills or abilities are generally difficult to teach in the traditional educational environment, which has resulted in a large part of the graduates not having the necessary skills to deal effectively with real-life processes, such as it is demonstrated in published field studies on the subject.[36,37]

Leading Massachusetts Institute of Technology scholar of organizational learning Peter Senge (1992) stated at the beginning of his book The Fifth Discipline:

> "From an early age we are taught to analyze problems, to fragment the world. Apparently, this makes complex tasks easier, but unknowingly we pay a huge price. We no longer see the consequences of our actions; we lose our intrinsic sense of connection to a larger whole. When we try to see the "big picture", we try to put the fragments back together, number and organize all the pieces. But, as physicist David Bohm says, this task is futile: it's like piecing together the

> shards of a broken mirror to see a true reflection. After a while we give up trying to see the whole".[38, p.2]

One of the educational trends to address this deficit is game-based learning (GBL), where, integrated into the flow of educational stimuli, it "fits" with the functioning of the nervous system of feeling-thinking-doing. GBL also matches the natural "needs" of the brain. Game-based learning puts the brain in control, offers fun, play, and rewards, and accommodates the need to save energy by having a consistent story.[39]

According to the new Cuban constitution, society expects universities to actively contribute to the development of the country. This does not cover only social aspects, but economic development aspects as well. According to what is referred to in the Bases of the National Plan for Economic and Social Development to 2030 in Cuba[40] (PNDES, 2017), the country prioritizes the insertion in the international sphere of chains, production and marketing of new products and import substitution, all supported by a productive chain strategy in the national economy. In addition, the plan recognizes the need to ensure that universities offer well-prepared professionals.

The insertion of Cuba in global supply chains is a real challenge41 and new skills must be developed.[42] The Industrial Engineering degree in Cuba, following the current Plan "E" approved in 2018, focuses on preparing students to evaluate, design, operate, control and improve production and service processes in the supply chain with the aim of achieving high effectiveness and sustainability.

Industrial engineering is the only career in Cuba that includes, in the same plan: logistics, human capital in processes, supply chain, production management, studies of the work environment, transformation of processes through the use of new technologies and informatics, quality management, simulation and operations management, statistics, administration and finance, among others, and all this in the basic curricula. This is intended to train industrial engineers who understand the complex, dynamic, diverse and evolving nature of modern and global supply chains. This directly impacts the positive development of the university and the country. Although the curriculum meets the requirements for the development of the country and Latin America, Industrial Engineering in Cuba must be updated to achieve international competitiveness in terms of planning and execution of content. In addition to that, there are limitations in the technical and technological aspects of the race, including Industry 4.0.

This reality, and the curricular approach of industrial engineers, specifies that they must be trained in contact with enabling technologies, because although other disciplines such as automation, computer science, dominate and develop them, in the opinion of these authors, an implementation is not in sight. neither fast nor effective in various environments in Cuba, because by curricular design, the industrialist is directly in the design and organization of the processes, if this professional does not know how technologies can help in practice, he will not promote their use.

In practice, it is necessary to develop learning environments that guarantee that the training is carried out with a practical sense, being a prototype of the reality that the human is in the real work environment. In Cuba, it is currently not possible to develop training in work environments that guarantee that students fully understand the potentialities of using the enabling technologies of Industry 4.0, because, although there are advances, in general the knowledge and applications of the same are isolated. The technologies exist in some companies, but their use is not yet fully deployed in manufacturing processes. This does not favor the ideal training environment to be in the company, therefore, it is necessary to develop this development capacity at the University.

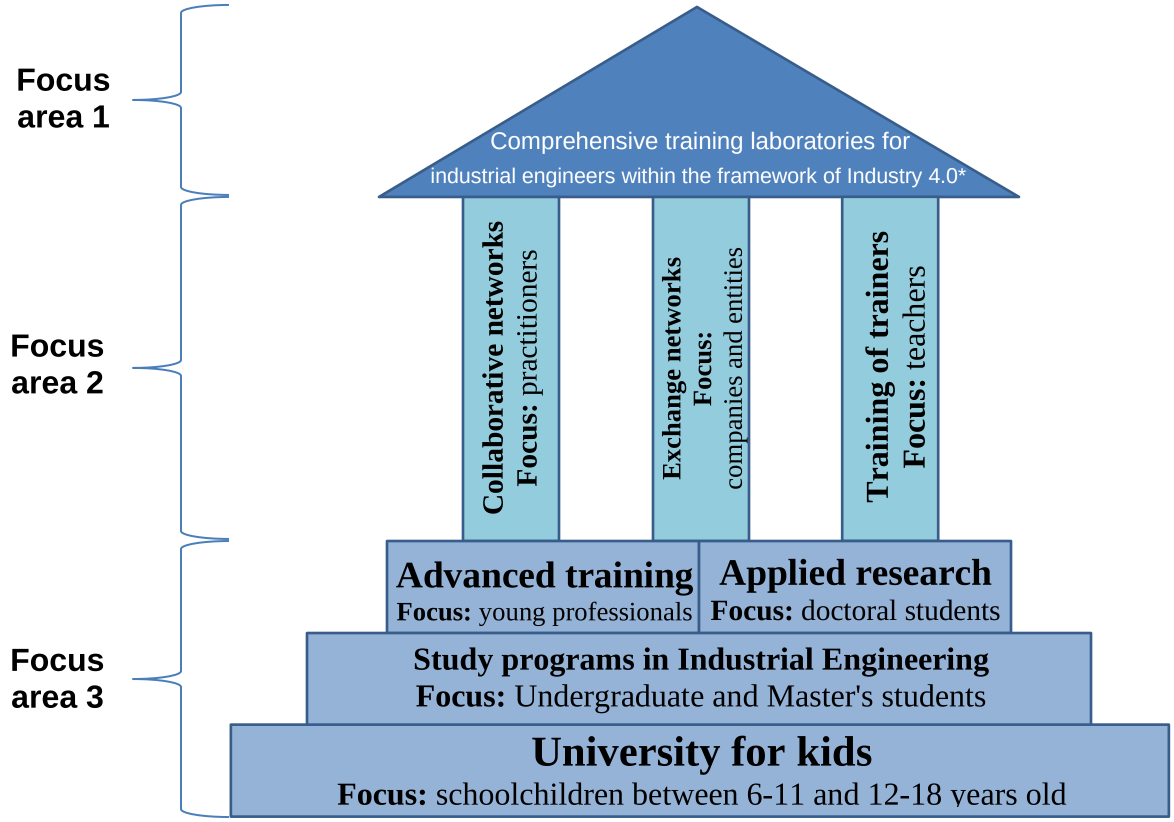
As stated in Lopes et al. in 2022,[23] if active or experiential learning is encouraged, through experiences that can be implemented through international cooperation, and the creation of laboratories similar to Learning Factories, which simulate in detail or in a general way a realistic and comprehensive environment of a manufacturing environment, it is possible to develop what is stated in Günther et al. in 2020[18] according to Education 5.0 that puts "the human at the center and at the top" of technology and machine management.

Faced with this scenario, the CUJAE Faculty of Industrial Engineering has begun to train our engineers in these technologies, since industrial engineers have, or should have, in organizations, from their work on processes (and it is underlined), a important transformative capacity, since the basis of organizations are work processes and the application of any technology of this type in them implies that the processes are designed and function properly. We recall here those rules referred to by Bill Gates in 1995,[43] to keep in mind in the advancement of digitization required by the evolved Industry 4.0 and its Education 5.0: the first, that the automation of an effective process will increase efficiency; and second, that automating an inefficient process will increase inefficiency.

The complexity increases when, in addition to the need to train students and staff who currently work in the processes, there is a basic and essential element in this process, and it is the transformation of the trainers, the teachers, which is a limitation for accelerate the necessary transformation, however, the flexibility and timeliness of the study plan.

The experience that is being developed, especially with a joint collaboration project with *TH-Wildau* and CUJAE, focuses on training with students and professors of the CUJAE Industrial Engineering career, consistent with the skills to be developed in them, associated with "active learning", the use of high cognition or technical or digital skills and also organizational management (collaboration, teamwork and emotional intelligence), linked in particular to achieving interaction in practice with technologies that enable learning. Industry 4.0.

Figure 1 represents the structure that supports the comprehensive training of industrial engineers within the framework of evolved Industry 4.0.



* located in CUJAE and supported by TH Wildau (Germany)

Figure 1. Comprehensive training of industrial engineers within the framework of Industry 4.0
Source: self-made

The proposal for the implementation of the strategy in the Faculty of Industrial Engineering is divided into three fundamental areas:

• *Focus area 1 (development of academic capacity at CUJAE)*: includes actions to update and extend training in industrial engineering at CUJAE and prepare CUJAE professors/faculty for teaching in the enhanced industrial engineering curriculum. Within this area, the contents of the subjects of the base curriculum and the existing curriculum of the Faculty of Industrial Engineering are improved and updated. It is planned to develop and implement new subjects of the optional/elective curriculum that contribute to train students in a certain area of knowledge with a focus on continuous improvement, to allow industrial engineers to ensure sustainability and responsibility in the processes and supply chains in Cuba.

The results will be evaluated frequently as a basis for presenting proposals for the transformation of the subjects before the National Career Commission. The modifications and/or improvements will be presented for discussion and future approval by the National Commission of Industrial Engineering with national impact.

It is necessary, as a priority, to qualify the professors / teachers of the CUJAE in the content of subjects and didactics for teaching, and to attract the students themselves, the result of this training, as future teachers of the Faculty. The enhanced industrial engineering curriculum is developed and executed while a variety of train-the-trainer events will take place. CUJAE faculty will not only be prepared for teaching in industrial engineering, but will also become part of a network of experts in best practices with professors and professionals to ensure the continuous transfer of knowledge.

The groups directly involved in the project are:

1. CUJAE professors, who have access to cutting-edge knowledge in industrial, engineering, logistics and supply chain management, high-quality teaching materials and modern university-level didactics (for example, problem-based learning, combined, gamification, etc.), experience working on team projects. Participation or holding of training events for trainers, practical workshops, networks of experts, scientific events or similar that strengthen hard and soft skills of teachers.
2. Students, who jointly benefit from learning materials and study programs adapted to the current state of knowledge and the requirements of the local and global labor market.

• *Focus area 2 (preparing for a multinational network of experts)*: all activities can only be successful if they are integrated into a network of industrial engineers and experts, companies such as technology providers and users, organizations within supply chains and including political actors.

The groups indirectly affected by the proposed project belong to companies and organizations outside the participating universities:

- Companies from different sectors in Cuba benefit from future graduates.
- Companies benefit from knowledge transfer events such as workshops and seminars.
- Schoolchildren of different ages have the opportunity to get in touch with engineering issues, mainly in a practical way, either in practical workshops led by CUJAE students in the laboratory environment or in special workshops outside CUJAE, guaranteeing a concrete social impact.

• *Focus area 3 (development of institutional structures at CUJAE)*: includes actions to establish an Industrial Engineering laboratory environment with a focus on processes and visualizing preparation using enabling technologies for Industry 4.0 at CUJAE, as the basis for the sustainability in the training of Industrial Engineers, but prioritizing the teaching of the processes in an appropriate manner, regardless of the level of digitization that is available.

The concept of the laboratory is training directly in process prototypes, based on the following phases that are the foundation of its spatial distribution: 1. Input, 2. Storage, 3. Production and 4. Output.
It is a laboratory that produces one or more defined final products, and from their structure the processes are designed and executed in each phase, with a training version without the use of technologies, and from that conceptual and practical basis, Technologies are being integrated, among which are the enablers of Industry 4.0 to show their use and impact on the processes.

In short, the laboratory is not a technology showroom, nor is it just a computer lab, it is an environment intentionally created to simulate in a general way the business practice common to any type of industry or service, the level of use of technologies being scalable. but based on the proper functioning of the processes.

Conclusions

The disruptive processes and technologies of Industry 4.0 lead to the need for a transformation of human talent, this within the framework of Education 5.0 that puts "the human at the center and at the top" of technology and machine management.

Industrial engineers in Cuba have the potential to support and work in a multidisciplinary way in the deployment of the use of enabling technologies of Industry 4.0, assuming the demands of Education 5.0, given its influence on the processes, but it is necessary to integrally transform the system of training, including students and teachers.

Training (Education 5.0) within the framework of Industry 4.0 must be based on the development of high cognition skills in technologies or work processes and in organizational management. The enabling technologies in the evolved Industry 4.0 must be present in this educational environment in such a way that active learning is possible, by experience or experiential, through laboratories that simulate real processes and become learning factories, and transversal incorporation of the contents of digital transformation in all the subjects of the career, from a multidisciplinary vision.

The possible technologies to include in the training of the Industrial Engineer must be contextualized in the active teaching-learning processes of the students, being necessary to have well-prepared teachers or trainers, which can be supplanted with intra- and inter-institutional support.

In higher education in general, more content will be required in ergonomics, health and safety, work methods, communication, simulation, compensation and motivation, technological innovation, all in its connection with logistics, production management and the need for development of circular economy concepts as a basis for sustainability.

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Conflict of interests

The authors declare no conflicts of interest

Authors contribution

- Igor Lopes Martínez: Conduct of the research project, research and development of conceptualizations and methods. Writing and revision of the article.
- Armando Cuesta Santos: Research and development of conceptualizations and methods. Writing and revision of the article.
- Gaby Neumann: Research and development of conceptualizations and methods. Writing and revision of the article.
- José Villalta Alonso: Research and contribution of experiences. Writing and revision of the article.
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