Industry 4.0 – Training and Education Implications

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Abstract: Education is one of the most important tools for building the human skills needed to cope with the economic, social and technological transformations of the 21st century. Thus, it can be said that, in the contemporary world, Education 4.0, which focuses on innovation and on the acquisition of innovation skills, is the main provider in training these skills. The competences of the 21st century, oriented both towards innovation and learning and towards the formation of social-affective skills, must be based on educational contents aimed at producing innovations. However, the studies and discussions about the educational and managerial processes and the practices that should be implemented to equip students with these skills are still quite weak. Therefore, this article aims to support the debate on how education and innovation should be combined in order to contribute to the training of 21st century skills in line with the requirements of education. In order to achieve this objective, we aim to further clarify some aspects related to the content, processes and practices corresponding to Education 4.0.
Keywords: Education 4.0, Digital skills, Industry 4.0, Training, Technological transformation

INTRODUCTION

The main consequence of this unprecedented technological development from the recent years is the beginning of a process of digitalization of all the sectors of socio-economic life from all the states of the world. We are in the midst of a technological revolution in which artificial intelligence, virtual reality, 3D printing and other technologies are rapidly entering every industry and economy in the world (The World Economic Forum, 2016). It is expected that many of these transformational factors that currently affect the global economy will also have a significant impact on jobs and labor productivity. Step by step, this process leads to the change of the nature of work and imposes radical decisions on the future of the workforce. Technology creates new jobs in a dynamic that far exceeds old jobs which become inoperative and disappear, and the workforce keeps up with these transformations. Unfortunately, people are often completely unprepared for new occupations and most governments in the world do not do enough to reduce the skill gaps and to align the workforce with the employment needs in the near future.

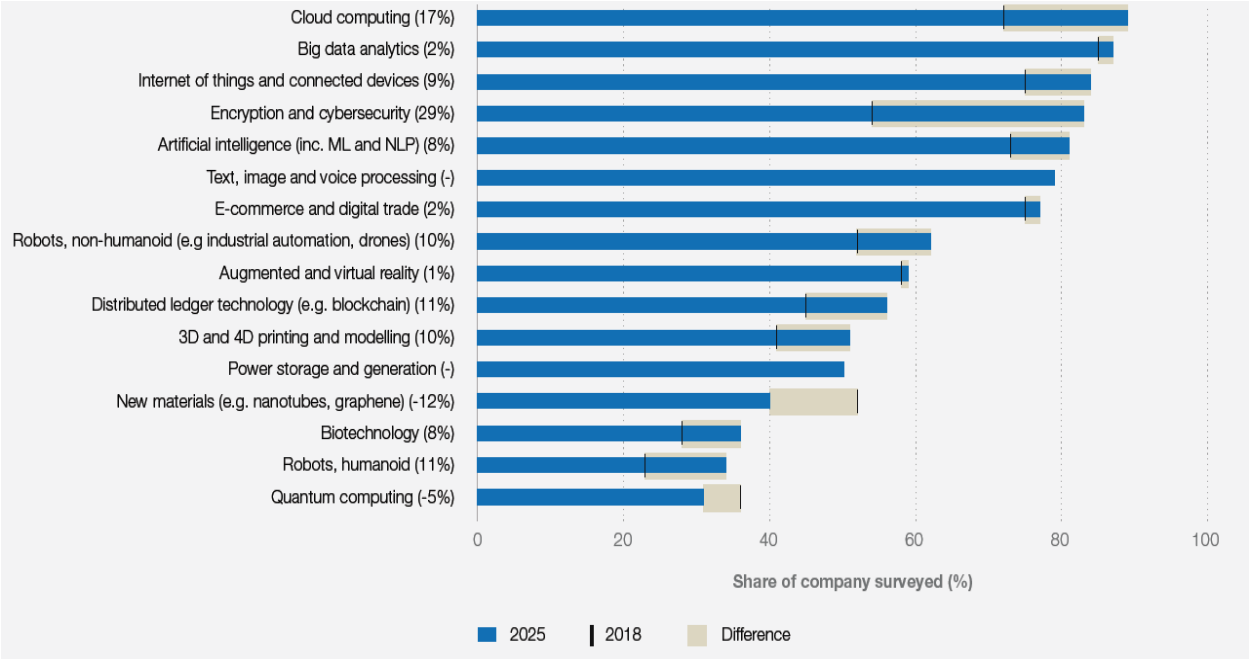

Fig. 1: *Technologies likely to be adopted by 2025 (World Economic Forum, 2020)*

INTRODUCTION

It can be stated without reservation that the training of workers for the jobs imposed by the fourth industrial revolution becomes an extremely important challenge which can be likened to that determined by the industrial revolution of the nineteenth century. The Industrial Revolution 4.0 will also affect the role that education and training institutions will play in meeting the needs of training this new environment all over the world.

To take full advantage of the opportunity created by advanced technology we need a similar revolution in education - not only to meet the needs of the industry, but also to ensure the best possible student experience, use of employee time and investments in education.

WHAT IS INDUSTRY 4.0?

Market globalization, internationalization and emerging economic competitiveness due to the unprecedented development of digital technologies led to the emergence of the so-called fourth industrial revolution. This concept follows three other stages of technological transformation in the history of mankind, delimited as follows: Industry 1.0 - due to the advent of the steam engine - the power of steam becoming the transforming power of the nineteenth century; Industry 2.0 - due to electricity - the power of electricity becoming the transforming power of the twentieth century and Industry 3.0 - due to the emergence and development of computers in the ,70s. The fourth industrial revolution is based on the development of a fully automated and intelligent production, able to autonomously communicate with important corporate actors. Industry 4.0 is based on the integration of both horizontal and vertical production systems and their operation through real-time data exchange so as to ensure a flexible and customized production. The fourth industrial revolution will lead to complex and complete processes of digitization and automation and to the employment of electronics and information technology (IT) in all the areas of production and services.

The McKinsey Global Institute defines the Fourth Industrial Revolution as the age

of cyber systems - systems that integrate computer, physical, and network processes using countless digital technologies, including mobile devices, the Internet of Things (IoT), artificial intelligence (AI), robotics, cyber security and 3D printing (McKinsey Global Institute, 2015).

In the Fourth Industrial Revolution, Schwab K. shows that the fourth industrial revolution is developing at an exponential pace, not linear, which changes not only what and how we do things, but also who we are (Schwab, 2016). The concept of Industry 4.0 has brought and will continue to bring profound changes in the global economy, changes that will be visible in variables such as investment, consumption, growth, employment, trade, etc. But among the areas most affected by Industry 4.0 innovations training and employment will certainly be at a central point.

The term Industry 4.0 was first introduced in Germany, in 2011, and it was used to promote a new approach in Germany's economic policy based on high-tech strategies (Mosconi, 2015). The introduction of this concept has produced a number of positive effects which show that the highest levels of implementation of Industry 4.0 can be observed in Germany, especially in multinational technology corporations. Companies such as Siemens, General Electric and Mitsubishi already have a wide portfolio of production and automation solutions of this type. Manufacturers and developers of high-class digital technologies such as Wittenstein, Bosch, Rockwell, Schneider, and others already offer many Industry 4.0 technologies and solutions on the market (Rodič, 2017). Since 2011, the term has been widely used not only in Germany and not only in the field of engineering, where it was first introduced, but also in economics and management. In fact, the relevance of this concept has led to a fundamental change in the way companies are structured and managed. The need for this change has been underlined by many administrative reports but especially by a series of academic researches that have analysed the content of the Industry 4.0 concept and presented detailed descriptions of it, as well as assessments of possible future developments (Pan et al., 2015). Given that the purpose of this article is not to analyse the concept of Industry 4.0, but to identify its implications in the field of training and employment, we will not insist on its theoretical approach. However, for a common understanding of the field underlying this research, we will present two of the definitions attributed to the concept of Industry 4.0.

In Applying Industry 4.0 to the Jurong Island Eco-industrial Park, Pan et al. (2015) show that Industry 4.0 allows industrial components to communicate with each other, and Gy Kovacs and Sebastian Kot, in their paper New Logistics and Production Trends as the Effect of Global Economy Changes (Kovacs & Kot, 2016) state that the essence of the Industry concept 4.0 is the introduction of intelligent networked systems (people, machines, equipment and products that communicate with each other) to provide self-regulated production. Even if the literature is quite rich in reports and analyses that focus on the major changes in business management models and major components of companies, the academic discussion about Industry 4.0 still deserves attention. In this context, the main purpose of this article is to analyse what changes are needed for the education and training system so that it meets the requirements of the practical implications of the Industry 4.0 concept.

WHAT IS EDUCATION 4.0?

The changes produced during the Industrial Revolution led to radical transformations of the entire socio-economic life of mankind. As the new characteristics of industrial production demanded new skills of the labour force, social life was forced to adapt accordingly. In this sense, John Moravec equates this adaptation with what he deduces as Society 1.0, Society 2.0, Society

3.0, accordingly with Industry 1.0, Industry 2.0 and Industry 3.0 (Moravec, 2013). All the subsystems of the society have been affected by this transformation, education being one of them. Thus, changes in the production process have left their marks on social life, and, in their turn, social transformations have led to changes in the concept and content of education. Some authors have named these transformations as Education 1.0, 2.0, 3.0 and 4.0 (Harkins, 2008; Moravec, 2013). Education 1.0 was the type of education that met the needs of agricultural society. The knowledge was used to be transferred from teacher to student, who had to focus on the teacher's explanations. Education 2.0 has been promoted to meet the needs of industrial society. The learning process focused on teaching the newly industrial technologies that were to be used in the professional activity. Then Education 3.0 came, which had to meet the needs of the computer society, being recognized as knowledge-producing education. Based on this perception, the concept of Education 4.0 has been developed, which is expected to meet the needs of the digital innovation era. A. M. Harkins incidentally calls Education 4.0 a process of producing innovation and believes that some concepts such as "technology", "teaching", "schools" and "teacher" need to be redefined (Harkins, 2008). Consequently, the meaning of education must be built through practices focused on innovation, facilitated by individuals or super-professional teams.

Through the contributions of students and teachers, technology is constantly changing and this has a crucial role in the process of producing innovation. Thus, teaching can be continuously improved with the help of positive feedback loops of innovation. At the same time, teaching acquires a continuous appearance in every moment of daily life, the learning cycle and professional life. In this way, schools are no longer seen as physical infrastructures brought to life by pupils/students and teachers, but they become living bodies globally interconnected. This approach transforms schools into innovative entities that replace classrooms with truly evolving and globally connected innovation labs, with teachers and students being the main sources of innovation.

Education 4.0 is a new paradigm in which the concepts of school, learning, pupil/student, and teacher are redefined according to the needs of Industry 4.0. The teaching-learning processes are put into practice through innovative teaching and learning procedures as part of Education 4.0, and the inverted class model is increasingly used. In inverted classrooms, students can gain the knowledge they need from traditional classrooms, but with access to digital sources related to the lesson (presentation materials, videos, electronic materials, etc.), and also from outside of school. Therefore, class time can be used to train pupils in activities such as discussions, analysis and problem solving (Youngkin, 2014). Thus, inverted classrooms allow for mixed learning processes, by combining online learning materials with traditional ones, which increase their efficiency. In addition, the inverted classroom is a teaching-learning model that provides students with individualized educational opportunities, and these opportunities to learn anywhere and anytime makes them responsible for their own learning process. Even if the inverted class model resembles the distance education model specific to Education 3.0, this model still differs from the previous stage in that it overcomes the inconsistency between schooling and information technologies. Education 4.0 truly integrates education and technology and gives rise to a continuous process of innovation.

In shaping the human skills needed to cope with the economic, social and technological transformations of the 21st century, education is one of the most important tools. In this context, Education 4.0, which focuses on innovation and on the acquisition of innovation skills through education, is

becoming the main provider in training these skills. The competencies of the 21st century, oriented both towards innovation and learning, and towards the formation of social-affective skills, must be based on educational contents aimed at producing innovations. However, the studies and discussions about the educational and managerial processes students with these skills are still quite poor.

Therefore, this article aims to support the debate on how education and innovation should be combined so as to contribute to the training of 21st century skills in line with the requirements of Industry 4.0. In order to achieve this objective, we intend to further clarify some aspects related to the content, processes and practices corresponding to Education 4.0.

BASIC CHARACTERISTICS OF EDUCATION 4.0

Indeed, there are not many studies that present a formal definition of the concept of Education 4.0. In general, the authors of such studies have been concerned either with identifying the characteristics of Education 4.0 or with what the education model of this concept should look like, and less with finding a formal definition of it. In the current system, students aspire to obtain a graduate diploma as a result of completing a prescribed curriculum, based largely on traditional educational processes and practices (i.e. on training in amphitheatres and academic laboratories). The curriculum is prescribed by external entities (i.e. by universities and their professors and validated by accreditation agencies) and this means that students must learn materials that others prescribe. The educational processes take place according to an established schedule (i.e. in established time slots, semesters or quarters and following a prescribed structure of requirements). After completing three or four years of curriculum, students become graduates with a higher education diploma and join the workforce. Current education is based on the empty container paradigm. So, it is assumed that students start a certain course without knowing anything about the subject and, in time, the knowledge taught in that course will be directed to them, as in an empty container. In this paradigm, learning takes place individually, the emphasis is on the transmission of basic knowledge according to pre-established requirements, and assessment is based on test scores rather than on the acquisition of a skill. This is a linear learning process that has a major disadvantage, namely that of the great amount of time between the moment when a concept is learned and the moment when the student starts to use it in practice. During this interval, students forget a lot of the material and, therefore, cannot connect or connect with difficulty the learned material with its practical application.

In order to meet this great shortcoming, a series of studies have been carried out to analyse the need to adopt a new paradigm in education, a paradigm that provides guidelines on what needs to be changed and aligned with the requirements of the Industry 4.0 concept. Among these studies, we find the report of the World Economic Forum in 2016, entitled New Vision for Education: Unlocking the Potential of Technology (World Economic Forum, 2015), which addresses the pressing problem of skills shortage in the 21st century and ways to address it through technology. This report defines a set of 16 crucial competencies needed in the 21st century, divided into three categories, core literacy, competencies and character qualities (World Economic Forum, 2015). In 2016, the World Economic Forum also published a report on the future of jobs, listing the top 10 skills needed for the future workforce (World Economic Forum, 2018).

In order to identify the educational needs arising from Industry 4.0 in Europe, a project called Universities of the Future (University of Future) was carried out in the European Union. In addition, this project aimed to identify the skills needed to succeed in Industry 4.0. In the final report, the authors developed a list

of technical skills and soft-skills needed to be successful and productive in Industry 4.0 (Universities of the Future project, 2019). Those competencies are divided into two categories. The first category is that of field-specific skills, which refers to the skills needed to hold a certain job. They are further divided into engineering, business and management skills and skills specific in design and innovation. The second category is that of transferable competencies, which refer to competencies that can be applied in different contexts. Field-specific skills apply only to a small part of the workforce, as opposed to transferable skills that are applicable beyond the boundaries of the professions.

These are two relevant examples that highlight Industry 4.0 - specific labour market requirements and therefore, when analysing the characteristics of education and training of future employees, we must start from the analysis of these skills. At the same time, in training the future workforce, the evolution of technologies, especially the digital ones, must be considered, which, through automation and digitization, will lead to the elimination of low-skilled jobs. In this context, universities and continuous vocational training centers will play a vital role in meeting the educational needs of Industry 4.0 experts. But, in order for this role to be fully assumed, universities and continuous vocational training centers should adapt both their educational content and the methods of developing professional skills so as to be in line with the requirements of the new generations of employees. Peter Fisk defines a new vision for the future of education as Education 4.0 considering the following parameters:

- responsibility for the needs of Industry 4.0, which redefines the human-machine relationship to create new opportunities;
- capitalizing on the potential of digital technologies, personalized data, open source content and the new type of humanity of this globally connected and technology-powered world;
- designing a plan for the future of lifelong learning, from kindergarten to lifelong learning in the workplace (Fisk, 2017).

Peter Fisk characterizes future education as personalized, repackaged, peer-to-peer and continuous. According to Fisk, in the near future, the learning process, whether in class or at work, online or offline, structured or unstructured, taught or learned, standardized or not, certified or uncertified will change old mindsets (Fisk, 2017). Prospective graduates need relevant skills to adapt quickly to innovation cycles, and IT is the main driver of innovation in the future industrial context. Therefore, universities and vocational training centers should focus on building specific capacities for new roles and adapting their curriculum to the realities of Industry 4.0. In addition, they should encourage the development of soft skills that enable graduates to be open to the continuous development of their own skills, interdisciplinary collaboration and innovation.

The main problem will be related to the structuring of university programs that will have to be done in such a way that the training of skills based on innovation and entrepreneurial management is among the main objectives. Regarding the IT skills, the curriculum of universities should include topics such as: cloud computing, data analysis, artificial intelligence, machine learning, virtualization, etc. In addition, e-learning technologies such as gamification, virtual labs and learning analysis should support the education and training process at all the levels. Therefore, in order to meet the requirements of Industry 4.0, universities need to organize their specific educational processes in accordance with the requirements of economic agents. It should also be taken into account that some Industry 4.0 specific jobs require experts trained in individual courses or with special technologies, which introduces the idea of personalizing the education process, at least for some disciplines. These customized technologies better contribute to

the requirements of the job and, as a result, correspond to a better quality.

The advantage of such training programs is obvious. They develop versatility for learners and transparency in the teaching process, which can lead to improved management and better-quality control (Watkins et al., 2002). In addition, these programs combine personalized technology with computer-assisted learning and highlight the effectiveness of graduates; both technologies support students' independence in choosing the learning path for the specific job. At the same time, the good quality of the teaching material and the transparency of the teaching process contribute to the continuous development of students' intelligence through meta-cognition. Personalization of the educational process, at least in the last years of study, can contribute to the students' professional development by improving learning through technology (FitzGerald et al., 2018).

With this in mind, Peter Fisk identifies the following features of Education 4.0:

1. *independence from time and location*: students will be able to learn at different times and in different places, e-learning becoming a critical component of the education system. The concept of the inverted classroom will have to be widely implemented for students to learn the theory themselves and do practical work applied during laboratory sessions;
2. *personalized learning*: students must be able to learn at their own pace. Learning tools need to be adaptable so that students with advanced abilities can move faster and perform more difficult tasks, while beginners need time to train their primary skills before moving on. Students need to receive positive support and encouragement so that they can move forward with confidence;
3. *free choice of learning style*: individuals' learning styles are different, so it is necessary for students to be able to freely use their own combination of learning tools and methodologies. They will learn differently with the help of different technologies, programs and techniques based on their own preferences, such as blended learning, flipped classrooms and BYOD (Bring Your Own Device), etc.;
4. *project-based learning*: learning will need to be project-based and reproduce the real world as closely as possible. Thus, students will become able to use their skills in various situations, including work organization, teamwork, time and project management, etc.;
5. *learning based on field experience*: work experience will be even more important, so the education plan will have to involve more field experience through a variety of means, such as internships, industrial projects and mentoring;
6. *data-based learning*: Today's computers can process larger and larger volumes of data, which is why their analysis and interpretation has gained so much importance. Interpreting data to discover trends and deduce the logic of future developments is becoming a general trend;
7. *the assessment of learning will focus on the examination of competences*: the examination of learning will have as its main purpose the evaluation of the practical application of knowledge and the formation of professional competences and will be done periodically, as learning takes place;
8. *students take responsibility for learning*: students will become responsible for what they learn. They will have a say in the design of curricula and their associated objectives. The critical contribution of students to the elaboration of the content and the establishment of the validity of the courses will become indisputable necessities for the elaboration of an all-encompassing study program;
9. *mentoring will increase in importance*: teachers together with other experts involved in educational processes will have to increasingly take on the role of mentors in order to transform themselves from transmitters of knowledge into facilitators of learning.

These characteristics are schematically presented by Shuvra Das and David Pistrui in their work *Reimagining Engineering Education*: *Does Industry 4.0 Need Education 4.0?* as shown in Figure 2 (Das & Pistrui, 2020).

In a paper entitled *Academic Education 4.0*, Thomas Waller and Gerold Wagner developed a guide to be followed by those who want to promote a new education system that trains students in accordance with the requirements of Industry 4.0 (Wallner & Wagner, 2016). Such an educational system must be individualized, student-oriented, interdisciplinary, treat learning as a social activity, teachers and other experts involved assume the role of mentor, and evaluation is done through reflection (Wallner & Wagner, 2016).

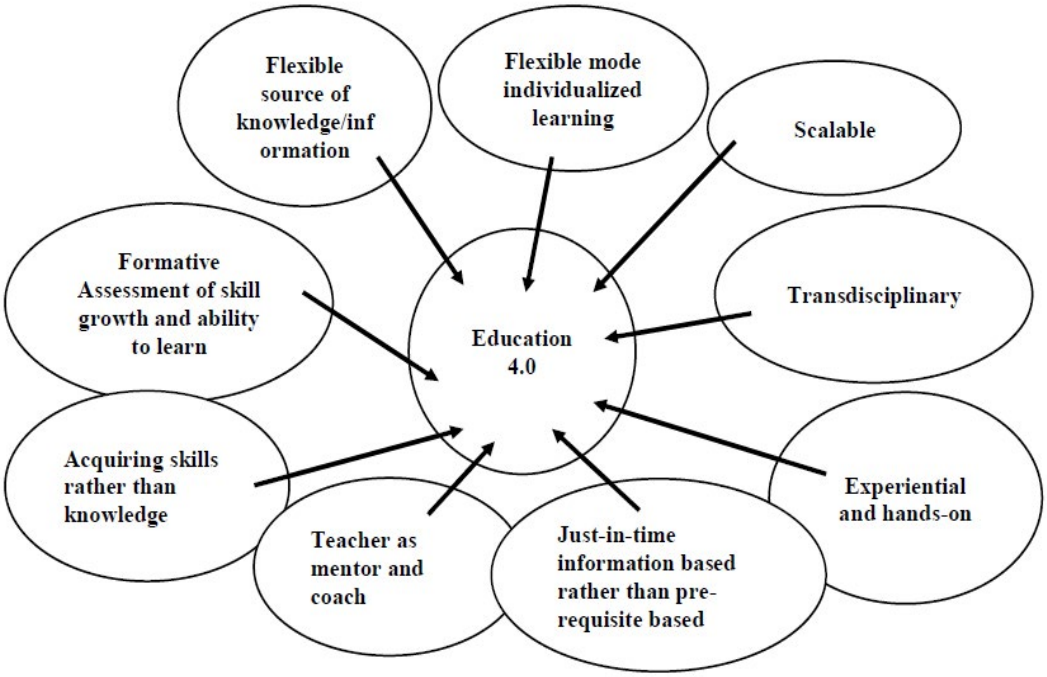

Fig. 2: *Characteristics of Education 4.0 (Das & Pistrui, 2020)*

CONCLUSIONS

The characteristics of the contemporary industrial revolution recognized as Industry 4.0 impose new requirements in the vocational training of the future workforce. There is a strong link between the characteristics of Industry 4.0 and the new requirements of education. If workers in the near future need to have high-tech skills, very good digital skills, be versatile and flexible, then continuing education and training are the main mechanisms for achieving this goal. This means that universities and continuous vocational training centers will play a key-role, therefore, these entities must adapt their activity in the sense of designing their educational processes in accordance with the industrial processes, in developing high-performance education and in training quality control systems. At the same time, considering their autonomy and flexibility, universities must develop their own educational standards taking into account the complexity of each trained person, the possibilities of using various training technologies and the personalization and adaptation of the teaching process to computer-assisted practices. The new era of Industry 4.0 teaching must cover many disciplines and use an increasing number of methods to be adapted to the requirements of Education 4.0.

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