Advances, Opportunities, and Challenges in the Digital Transformation of HEIs in Latin America

José Humberto Serna Gómez, Flor Nancy Díaz-Piraquive, Yasser de Jesús Muriel-Perea, and Alejandro Díaz Peláez

Abstract The information society is characterized by the information data conversion and the information in knowledge to support the decision making and the human development. In this sense, the digital transformation implies not only the use of technology to store data, but also a change of processes and organizational culture, allowing the entry of knowledge management into the new economy of the intangibles. This transformation has changed the game rules of socio-technical systems of organizations and their interrelationships, impacting different components of organizations. Advance in adapting the transformation in organizations has not been symmetrical in all sectors and regions of the world. Previous research shows that in education in Latin America the degree of incorporation has been less than in other economic sectors and zones of the world. That is why, the objective of study is the identification and analysis of the progress achieved by the Higher Education Institutions (HEIs) of the region, concerning digital transformation of their academic and management processes, besides recognizing their opportunities and challenges in the context of the Fourth Industrial Revolution. The methodology includes a qualitative approach. To collect the information, the document analysis technique is used, and the main factor is the searching through reference database and complete text. Data analysis is made in accordance with the pillars of the Fourth Industrial Revolution, central and management, digital transformation enablers of missionary, and support processes of the HEIs. The results show that, while it is true that the HEIs in Latin America lag behind their peers in other countries, it is found that, from 2018, the progress on the digital transformation of processes of the HEIs in Latin America has been very significant. The main impact is given in the incorporation of pillars of industry 4.0 in: graduation, using blockchain; teaching, collaborative virtual reality;

J. H. Serna Gómez · F. N. Díaz-Piraquive (✉) · Y. de J. Muriel-Perea · A. Díaz Peláez
Fundación Universitaria Internacional de La Rioja, Calle 100 No. 19-61 Piso 8, Bogotá, Colombia
e-mail: flornancy.diaz@unir.edu.co

J. H. Serna Gómez
e-mail: josehumberto.serna@unir.net

A. Díaz Peláez
e-mail: alejandro.diazpelaez@unir.net

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artificial intelligence to assist students; university management, through virtual assistants; and research supported by robotic. Improvement of cyber-physical and big data systems is not evident. It is concluded that digital transformation of the HEIs in Latin America is in the phase of early adoption, with some successful cases of the main reference HEIs, top-ranked in the academic ranking of the region, which will probably be imitated by other HEIs. The main challenges for the digital transformation of the HEIs in Latin America are related to culture, resistance to change, the hierarchical government, and the understanding that information is the key asset of the knowledge society. A new opportunity emerges for the digital transformation of HEIs in Latin America and for the researchers of the topic.

Keywords Digital transformation · Higher Education Institutions (HEIs) · Industry 4.0 · Latin American HEIs · Management in HEIs · Socio-technical system in HEIs

1 Introduction

The digital transformation (DT) is the organizational alignment between processes, people, and technology with the aim of complying efficiently with all the relevant activities of the company, to satisfy the needs and expectations of interested public around the Industry 4.0. The DT goes beyond the digitalization of process, and it is a deep transformation of the organization activities, processes, competences, and patterns to face challenges and take advantage of the emerging technology opportunities and its accelerated impact on society (Gobble, 2018). The DT includes people, processes, strategies, structures, and competitive dynamics (Wade, 2019).

The DT's scope comprises all sectors of society and therefore includes the Higher Education Institutions. In Latin America, there are 4.065 universities (Webometrics, 2020), and there is enough evidence of contributions they make to human, social and economic development of people and regions. For example, in the economical aspect, an exercise that modeled the impact of education in fifty countries between 1960 and 2000 found that one additional year of education could increase the income of a person in about 10% and the annual average gross domestic product (GDP) in about 0.37% (Hanushek, 2008).

The purpose of this research is to identify the progress, opportunities, and challenges in the digital transformation of the Higher Education Institutions (HEIs) in Latin America.

The document is organized as follows: preliminarily, the methodology, socio-technical system of the digital transformation, and the digital transformation in the management of the HEIs in Latin America; then, the management of universities in Latin America, the organizational structures, and the digital transformation in the HEIs; and finally, the digital transformation in the management of universities in Latin America and the technological dimension of digital transformation.

2 Methodology

This study applies a qualitative approach For the selection criteria of cases, it was considered that the HEIs were recognized or ranked in the first places of QS universities of Latin America. To access documents and relevant information, for the research, it mainly used the referential Scopus database, since it is one of the most recognized platforms of scientific information worldwide. The searching was done in English since it is the language in which most publications are found and with the aim of reducing bias. Following is the search equation:

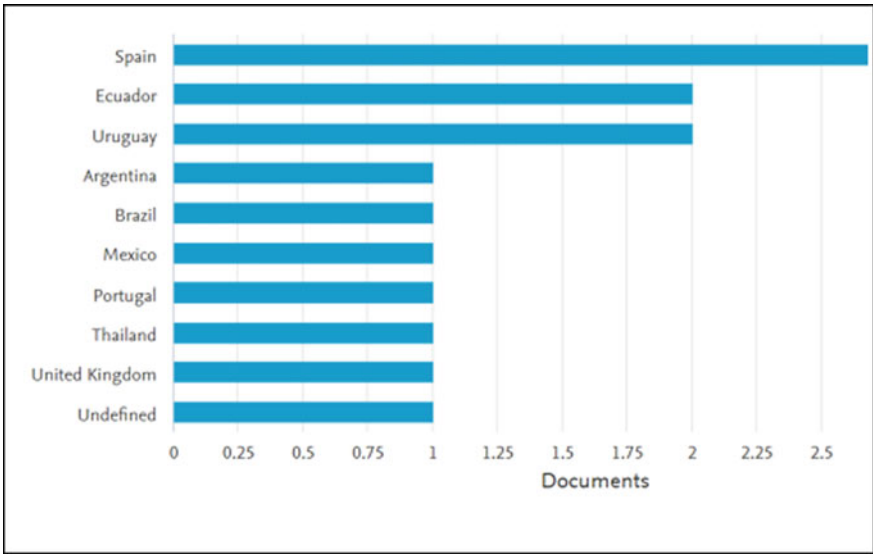
TITLE-ABS-KEY (digital AND transformation AND in AND Latin AND America AND universities).

Countries and universities that have done most of research in digital transformation are shown in Tables 1 and 2, respectively (DT = digital transformation and HEIs = Higher Education Institutions).

3 Socio-technical System of Digital Transformation

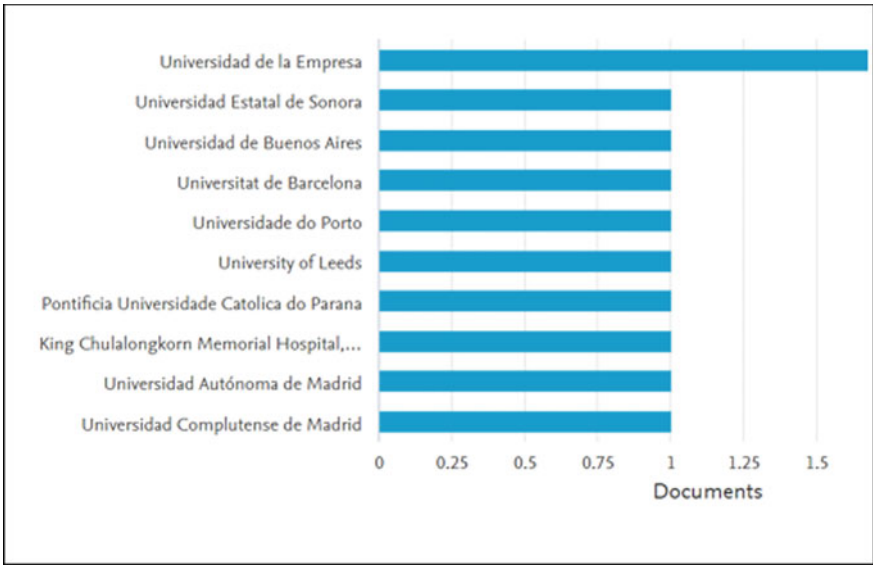
The university is a social artifact which is introducing digital innovations in the market, as well as in the academy and in research, and therefore, it drives the technological and social change with its implications. In this chapter, the relationship of the technical sub-system in interaction with the social sub-system is considered. The

Table 1 Research by countries



Source Scopus (2020)

Table 2 Relationship of HEI that have done most of the research on DT



Source Scopus (2020)

conceptual socio-technical pattern with the technical and social dimensions is found in mutual interaction.

> It is assumed that there are agreements between the parties involved for the achievement of their interests, which are represented in the different work structures and systems, necessary for the management of the organization, which are generally based on technological tools. Within the Organizational Technological System, the concepts of Core Technologies and Management Technologies are displaced, intended to serve as shock absorbers to prevent Core Technologies from being affected by contextual situations. (Díaz, 2020)

There is a reciprocal influence between the transformation and the organizational culture. From one side, it implies changes in the organizational structures that makes its culture to be impacted; in some cases, some people are empowered in the company; in other cases, they are disempowered due to the digital transformation. On the other hand, the organization's culture may cause that the resistance groups that emerge facing innovation, whether they are small or big, join the company in a normal or conflicting manner, because of the digital transformation.

3.1 The University as a Socio-technical System

The Tavistock Institute developed a research action project, related to the spreading of its work practices which produced an increase in productivity. This work was assigned the concept of "socio-technical approach" referring to the new paradigm of

organizational work, by which it becomes necessary to find a new balance between requirements of the social and technical systems (Trist et al., 1963).

3.2 Organizations as Socio-technical Systems

According to the concept of a socio-technical system, organizations can be characterized from the existence of two large dimensions: the technical dimension whose rationality is the generation of products (goods and services) for the satisfaction of purposes for which universities were created, and the social dimension whose rationality is to ensure that interpersonal/social relationships are focused to satisfy an adequate interaction between people making part of the university and the requirements of the technical system.

The dynamics between the two sub-systems is complex, and it is considered of reciprocal influence: the technical system influencing the social system and vice versa. The technical system should impact the social system encouraging a change in the university culture and vice versa, but this is overly complex. This is due to multiple reasons such as: number of people participating as teachers and employees, and their high connection, by their interaction levels, by the kind of university decisions, or by the number of activities at the university.

3.2.1 Technical Sub-system: Core Technologies and Management Technologies

Thompson (1976) cited by Felcman and Blutman (2020) characterized the technical sub-system based on two types of technologies: core technologies and management technologies. Technology is the knowledge used by organizations to transform inputs into goods and services, to satisfy the purposes for which organizations were created. This knowledge can be "incorporated" in an artifact such as internet, a computer, etc., or also when it is "disincorporated", when it is found in the patents, in the building blueprints, in the mind of those who have that knowledge (a teacher, a researcher or an executive from the university, etc.).

Also, technologies can be core technologies: those which are designed to meet the main objectives of the organization, such as educational technologies for teaching; the research and transfer of knowledge, or the TIC infrastructure; or management technologies: those designed to "isolate from context" or generation of "uncertainty" conditions for core technologies, as the university administration, communication, marketing, or the administration of the university campus.

Following this approach, complex organizations such as universities are social artifacts created on purpose to reach objectives that generate certainty within an uncertain context with which they interact. Under rational regulations, universities seek to "isolate" their core technologies from the context influences, protecting them

with the provision of components of input/output to absorb the environment influences, leveling of transactions of input/output throughout anticipation of contextual changes, by planning and programming of activities, rationing when all of the above was not effective at the moment of protecting core technologies (Thompson, 1967).

3.2.2 Social Sub-system

For Felcman and Blutman (2020), in the social sub-system, while there are several concepts that can be highlighted as components, emphasis is made in one which is considered the base of the others: the organizational culture and the university culture. Organizational culture is defined as a "pattern of made basic assumptions, discovered or developed by a group focused on learning how to face their problems of external adaptation and internal integration, who have had enough influence as to be considered valid and, as consequence, be taught to new members as the correct way to perceive, think and feel those problems" (Schein, 1988).

Schein identifies and distinguishes three levels of the organizational culture: A visible level is composed of artifacts as objects, written standards, rituals, symbols, and the labor environment; a second level is composed of values, which are the preferences that members of an organization have, with respect to certain organizational issues over others (remunerations, social benefits, spare time, interaction with other members of the organization, satisfaction with tasks being performed, compromise, self-realization, progress); the basic assumptions are the deepest and "invisible" beliefs that make up the "organizational collective unconscious."

3.3 Internet as a Social and Technological System

When speaking about the knowledge society, we speak about a socio-technical transformation, since all societies are of "knowledge." In this case, it is about a society in which the conditions to generate knowledge and information processing have been considerably altered by a technological revolution, focused on information processing, to the generation of knowledge through the information technologies (Castells, 2003).

Internet is a cultural creation that allows the emergence of a new economy and the development of innovation and economical productivity. But Internet is revealed as a culture through a social practice that conceives cultural diffusion, a dimension referring to a visible level composed of devices, a value level, and a belief and way level to mentally constitute the university community, which is decisive in the generation of ways of these technologies and which is a key factor paradigm. The fact that Internet is a culture that allows the creation of new conditions for organization and innovation, as a support of the new economy, reorganized in networks and innovated regarding capabilities of new ways to create added value, is only possible thanks to

the network technology. Those universities use Internet to organize their network operation from the innovation of new digital technologies (Castells, 2003).

3.4 Governance of the Socio-technical Model

The corporate government identifies the strategic actors who get involved in the university processes, for the university to comply with its purposes, through theories such as the agency, the company, and management of knowledge.

It is considered that the university is an economic entity whose purpose is to maximize the economic profits through costs of its transactions. The university management implies some costs which are not absorbed by prices, such as: the cost of search for students and teachers, cost for differentiation of tuition costs, cost of contract negotiation to carry out its transactions, and the cost to guarantee that what is agreed in the programs is fulfilled, as well as costs to devise the different programs; these are commonly called transaction costs.

However, there is still another theory defined with respect to cost saving for coordination of the teacher training in the university, which establishes the duration and restrictions of such costs that is determined by teacher incentives. Therefore, the promoting of low-powered incentives in the university is as well an important factor to inspire cooperation and coordination (Díaz, 2020).

On the other hand, power delegation/responsibilities should be considered, between an agent and executive (dean, academic vice-rector, etc.) for the teacher to do on his behalf teaching activities through the contract theory.

Finally, for Tarziján (2003), cited by Díaz (2020) to operate efficiently, the university needs specific physical assets as well as human resources (they constitute an intellectual capital stock), which generates what is called the theory of the firm, based on knowledge (technology). These are investments in human resources, language, particular routines of the university, tacit and explicit knowledge, common ideas, etc.

> Governance is how the groups are organized in the university to make or implement decisions in common agreement between the members that make up the corporate government, to accomplish their objectives, to arbitrate their discrepancies and exercise their rights and legal obligations, to comply with the university goals. This is what determines the north of the university, through the system of strategies, policies, values, regulations, practices, mechanisms, and processes that set up the restrictions for the administration of its economic, political and social issues inside and outside of it. Also, there are two essential elements: The Government Codes which are the adopted methods (tacit and explicit), to specify the governance processes, and the Governance Tools which are the instructions or instruments that operate the methods and define the options to implement them out (Díaz, 2020).

Going back to the socio-technical model, the purpose of the social sub-system is to ensure that interpersonal/social relationships are aimed at the adequate interaction between people that are part of the organization and the requirements of the technical system. In this sense, coherence is the logical relationship between the two parties

or realities, so that no contradiction nor opposition is generated between them and keeps them in the same position.

In other words, in the universities, due to the consolidation between the administrative patterns, the type of governance is created, the type of culture that has been generating a coherence. This coherence has been around for years because, between the administrative model, governance, technology, and the university culture, such coherence was present.

With the advent of the new digital technologies, the rupture of coherence has occurred. This happens when the logical relationship between realities is broken, which produces contradiction. The university has been managed according to a technological structure and the vision of conceived university since its beginning. With the arrival of the Fourth Industrial Revolution, as it was expected, the university vision changed, and consequently decisions are to be made according to the organizational culture and corporate government. It is expected that this causes the coherence rupture.

From the university culture, it is expected that the university promotes the development of the soft skills, which tend to disappear with the technology massification. From the corporate government, training must be formalized in the new digital technologies, as well as in core and management technologies.

4 Management of Latin American Universities

Management in Latin American universities, since nineteenth century, is originated and supported by several administrative theories which make emphasis on the basic functions that integrate the management process, the labor division, the definition of authority levels, the discipline, the control unit, the subordination unit, the remuneration, centralization, hierarchy, order, equity, personnel stability, initiative, binding results; all this originates the concept of administrative process and departmentalization, and ends up in the achievement of the organization results.

Díaz (2020) synthesizes the administrative theories as well as their evolution through corresponding patterns. Table 3 shows how those patterns are reflected at that moment.

Table 3 Organizational theories

Theories and organizational patterns	
Theory of scientific administration • Organizational pattern of continuous improvement (Uran, 1961; Crosby, 1979)	Human resources theory • Organizational pattern (Adhocratic & Mintzberg, 1979)
Theory of bureaucracy • Pattern of bureaucratic organization (Max Weber, 1922)	Classic theory of administration • Organizational pattern of competitiveness (Porter, 1990)

Source Díaz (2020)

Administrative management is the process by which the organization schedules, plans, organizes, leads, controls, and evaluates the results; all this depends on each organizational pattern (model).

Organizational patterns, from these theories, are classified as hierarchical, adhocratic, clan, or market type, while their structures can be matrix, by processes, or in networks. They can be high or flat, depending on the decision and control levels defined by the institution.

5 Organizational Structures of Universities in Latin America

Rodriguez-Moscoso (2020) states that Latin America started a specific pattern of university, from the Córdoba Reform of 1918, characterized by the autonomy of its institutions, with a management framework based on the modality of co-government. The dominant pattern in Latin America is basically similar to the Napoleonic pattern. The autonomy, co-government at the institution with the participation of students, teachers, graduated with voice and vote in the governing bodies make of this a democratic and participative pattern.

However, the university government is hierarchical, Pyramidal, and departmentalized, with authority levels and control clearly defined in statutory rules. Autonomy is clearly a characteristic of the public and private university management in Latin America. It keeps a structure of hierarchical organization by substantial functions of the university and a structure by processes of the support areas. Organizational structures of Latin America are matrix structures. The organizational pyramid, for the university management, is implicitly aligned with the institutional pedagogical pattern, which leads to the functional missions and to the support processes, with reliable and timely information for decision making that ensures the achievement of the university goals.

The Government of Latin American universities has not changed significantly, and it remains hierarchical, in both public and private universities. What has changed is the way of generating impact in remote regions. In the case of teaching and learning activities for distant populations from the headquarters, previously education was developed through the radio, execution of physical guides, self-training validated by the state, or regional distant education centers—RDEC.

Today, although the distance modality still persists, the academic activities developed through the virtual modality have increased exponentially. In this modality, the pedagogical models supported by the use and appropriation of ICTs have made it possible to bring knowledge, virtual classrooms, and self-managed development to remote places where students are. Therefore, the methods and means of reaching distant places have evolved: first, self-learning; then radio and television; and later, with the appearance of the Internet as a hyper-transformer and inducer of a fundamental change, the classroom was brought to the student.

In the virtual mode, on the one hand, the administrative activities required to support academic activities are generally carried out centrally. On the other hand, academic activities can be developed in a centralized or decentralized manner depending on the policies of the IES. Centralization is reflected, for example, in the hiring of teaching staff from the headquarters to teach academic activities in the virtual mode, regardless of the geographical location of the students. Decentralization occurs when both students and teachers are relocated far away the headquarters of the HEIs.

6 The Digital Transformation in the Management of University Institutions of Latin America

Digital transformation is understood as the process by which a Higher Education Institution breaks the management paradigms of the past and reinvent them through a creative disruption, supported by the utilization of digital technology, with the aim of achieving a more effective management, generating relational capital with its reference groups, and the institutional positioning. That is why the digital transformation is not only the use of technology to store data, but above all, a change in the existent organizational culture, to allow and facilitate the entry into knowledge management, in the economy of its intangibles.

The political decision of the world countries to open their frontiers removed the geographic barrier. Technology and communications evolved and wired together, which at the end produced digitalization, leaving a global world with no frontiers, without barriers, with communication accessible to all, and becoming a right of all humanity.

This reality is described by McLujan (1962, 1994) when he says that in the beginning there were no communication means as we know them today, nor the way they were at the end of twentieth century. For Fridman (2005), the globalization forces have emerged in economic, commercial, and political structures, changing from being rigidly vertical to be frankly horizontal; that is how the world is flattening, leading to a new era of collaboration between individuals and communities as never seen before, which is affecting the way of doing business, as well as the role governments play.

For Guajardo (2020), the digital transformation, in the Latin American universities, is not only a solution to common challenges of universities, but also a change of mentality that creates more efficient processes in the management and pedagogical experience.

6.1 Management of the Higher Education Institutions in the Digital Transformation

Guajardo's research (2020) clearly shows the digital retardation of universities, where it is evident that only one-third of them become digital explorers. The Enterprise Resource Management (ERP) emerges as a response to a culture of silos management, in which, for each process of the organization, it was used an information system, generating problems of redundancy and integrity of information. The ERP is the response to that tendency of development of information systems defined as "silos," in which every problem of the organization was solved through an isolated information system, generating redundancy and lack of integrity in the information. Until the beginning of the twentieth century, the information was obtained and processed manually. Digitalization arrived with functional solutions, for a university management supported not only on data and reliable and timely facts, but also on analysis, interpretation, and applications for the decision making that generate new knowledge.

6.2 Impact Areas of Digital Transformation

Emerging digital technologies can have an important impact on the digital transformation of universities in Latin America. Duparc (2013) states that the real digital transformation is achieved when all the organization assumes the importance of the digital culture and makes it her own at all levels. Besides this, he says that it is not a technology problem but a people and structure problem, and he confirms that the real digital transformation is achieved when all the organization assumes the importance of a digital culture making of it her own culture at all organizational levels, adopting a new model of management that must be incorporated systematically throughout the following components:

6.2.1 Sustainability of the University Campus

It is necessary to incorporate technology to support the institutional policy about care and conservation of environment.

6.2.2 Infrastructure of the Communications and Information Technology (CIT)

Emerging technologies may have an important impact on traditional technological infrastructures of universities.

6.2.3 Infrastructure for Information Processing

The digital transformation has implications in the data processing centers of universities.

6.2.4 Communications Infrastructure

The digital transformation has influence in digital technology development in the telecommunication structures of universities.

6.2.5 Administration

The Higher Education Institutions are complex organizations, and as such, they need to manage the information. Digital transformation supposes a new "turn of the screw" on using CIT for the administration of universities.

6.2.6 Processes of University Management

It is necessary to analyze the impact of emerging digital technologies in the process automation of university management, with a future vision in the knowledge and the emergence of the economy of intangibles.

7 The Technological Dimension in the Digital Transformation of the Higher Education Institutions in Latin America

The technological dimension of digital transformation is made up of data, software, hardware, and communication networks. Data processed and converted into information are the source of knowledge for decision making in the organizations (Loshin, 2012); therefore, they represent an input for the information to become a key asset of companies, and they are essential for the analysis, diagnosis, and the generation of early warnings in the organizations.

Regarding software, hardware, and communication networks, there are several types of tools and information systems that allow the incorporation of digital transformation, in the business processes of organizations. Among the main types of tools are ERP—Enterprise Resource Management, CRM—Customer Relationship Management, SCM—Supply Chain Management, ERM—Enterprise Risk Management, and KM—Knowledge Management, among others. Nevertheless, at the moment, the digital transformation is mainly supported by technologies of the Fourth Industrial

Revolution. That is why, in this abstract progress on digital transformation is analyzed regarding the Higher Education Institutions in Latin America, from the main pillars of the Industry 4.0, whose fundamental concepts are presented below.

7.1 The Technological Pillars of Digital Transformation

Industrial revolutions are understood as disruptive changes affecting all sectors of society (Schwab, 2016). According to Schwab (2016), along the history, four industrial revolutions are recognized: The first one took place on the eighteenth century, and it was characterized by passing from manual production to mechanized production; the second one was originated on the nineteenth century, and its main characteristic was the generation and use of electric power; the third one arose with the electronic computer on the middle of twentieth century; the Fourth Industrial Revolution arose on 2011 in Hannover, Germany, and it was strengthened on 2016 at the World Economic Forum—WEF—from where it has been promoted. The main characteristics of the Fourth Industrial Revolution are the cyber-physical systems, which consist of the imbrication of physical and digital processes.

Incorporation of innovations in the companies, from the Fourth Industrial Revolution onward, depends, in great measure, on pillars: artificial intelligence, Internet of things, cloud computing, business intelligence, big data.

Artificial intelligence is referred to intelligent behavior in artifacts (Nilsson, 1998).

Internet of things is the relationship between the things—products, services, places, etc., and people and processes made possible through technologies connected by different platforms (Schwab, 2016).

Cloud computing is external provision of technology information (TI) services of the business accessed via Internet, Massachusetts Institute of Technology (MIT, 2012).

Business Intelligence means the conversion of data in information and information in knowledge for decision making in the organizations (Loshin, 2012).

Big data is the management of large information packages characterized by volume, variety, and speed (González et al., 2013).

Cybersecurity, meanwhile, is about ensuring confidentiality, integrity, and availability of the information in the cyberspace (Sutton, 2017).

The pillars of the Fourth Industrial Revolution support the efficiency of the value chain of organizations. In this sense, they may be considered, according to Thompson's classification, as being core technologies as well as management technologies or both. The tendency is for technologies to respond and behave in accordance with the business processes; the core and support processes of companies are interconnected through the information, and the valuable activities, likewise, technologies tend to be less specialized, and on the contrary, they support as many processes as possible of organizations.

7.2 The Digital Transformation in the Higher Education Institutions of the World

The first four economic sector leaders in adopting the pillars of the Fourth Industrial Revolution are in order as follows: telecommunications, insurance, advertising, and financial services (STATISTA, 2019). As observed, education is not among them; nevertheless, we cannot deny the importance that this represents for the development of regions and people, and the worldwide progress in this sense. The 4.0 education is a phenomenon that changes the rules of the game in the education sector, placing the student at the center of the ecosystem, and changing the teaching focus to learning (FICCI, 2018), it goes from massive learning to personalized learning, according to characteristics of students and not independent from them as it was before. Some of the main cases have occurred in Higher Education Institutions of the USA, Australia, and Japan.

In the USA, it is relevant in the case of the State of Georgia University, which uses data analytical and predictive systems with more than 800 pre-established alerts to track the students' behavior on a daily basis, and so have an early detection of possible dropouts (Georgia State University, 2019). During the last 10 years, the main impacts of the project are as follows: increase of the number of graduations in about 22%, USD 15 million savings in tuition payments, comparing year 2016 with year 2012 (FICCI, 2018).

In Australia, the case of Deakin University is important, and they use artificial intelligence and machine learning through the Watson IBM tool to help the students find easy and quick information. The tool is called "Deakin Genie," and it provides answers to the students about the following topics: admissions, course registration, financial aid, student residences, skills evaluation for work and extracurricular activities, among others (FICCI, 2018).

In Japan, the University of Hong Kong implemented an inter-institutional collaborative project called "Connect Ed Program." The main purpose of the project is, through a cloud platform, to facilitate the ideas and information interchange between the students at the university, in England and other countries on topics related to the health area (FICCI, 2018).

7.3 Preparing of Countries in Latin America for the Industry 4.0

On 2018, the World Economic Forum (WEF) produced the first version of the competitiveness index 4.0, which is made up of a series of new emerging factors that determine productivity in the period of the Fourth Industrial Revolution (WEF, 2018; FEM, 2018). In accordance with the WEF, the index, whose qualification goes from 0 to 100, has 98 indicators organized in 12 categories: institutions, infrastructure, adoption of information and communication technologies, macroeconomic stability,

health, people skills, product marketing, labor market, financial system, market size, business dynamism, and innovation capacity.

All categories are important; however, the one directly related to the technological dimension of digital transformation, using the pillars of the Fourth Industrial Revolution, is the adoption of information and communication technologies. The factor is made up of 4 indicators: cell phone subscriptions, mobile broadband Internet subscriptions, fixed broadband Internet subscriptions, optical fiber Internet subscriptions, number of users in Internet (WEF, 2018; FEM, 2018). In the 2018 version, 7 regions of the world and 140 countries were compared.

Regarding world regions, the first 5 places in the global index of competitiveness 4.0 are: USA with 85.6 points, Singapore with 83.5, Germany with 82.8, Switzerland with 82.6, and Japan with 82.5. The average of North America and Europe is 70 points, the average for Eastern Asia and the Pacific is 69 points, while for Latin America is 56 points. As it can be seen, there is a huge gap between Latin America and the leader countries in the required conditions to adopt technologies in the Industry 4.0.

Regarding the comparison between the Latin American countries, the first places in the ranking are for Chile, Mexico, and Uruguay, with 33, 46, and 54 points, respectively. Then, next places are for Costa Rica, Colombia, Perú, and Panamá with 55, 60, 63, and 64 points, respectively. Then appears, Brazil, Dominican Republic, Ecuador, Paraguay, Guatemala, El Salvador, Honduras, Nicaragua, Bolivia, Venezuela, and Haiti. These two last countries are in places 127 and 138, respectively, out of the total of 140 countries. Just as there are gaps between the regions of the world and Latin America, there are also gaps in the interior of the regions to comply with the conditions for the implementation of the 4.0 technologies.

7.4 The Digital Transformation in the Higher Education Institutions of Latin America

There is evidence of progress in the incorporation of pillars of the Industry 4.0, for the digital transformation of academic and support processes of the Higher Education Institutions. For the analysis, out of those institutions were taken into account those ranked in the first 10 places of the QS Ranking Latin America according to its most recent version (QS, 2020). Therefore, for the study cases, universities from Chile, Brazil, Mexico, Colombia, and Argentina were considered.

In Mexico, the "Tecnológico de Monterrey", in 2018, for the first time did a class using collaborative virtual reality between students from several university campus, in an experience 100% of virtual immersion (Tecnológico de Monterrey, 2018). The class has the same academic credit value as a face-to-face class. Likewise, since 2006, the "Universidad Nacional Autónoma de México" (UNAM) designed the Robot Justina, which on 2019 ranked the second place during the worldwide innovation event RoboCup 2019; the robot is used for research (UNAM, 2019). In addition,

"Universidad Insurgentes" is a success case in the use of business intelligence for higher education; the strategy was supported on ERP (Ellucian, 2020).

In Colombia, the case of "Universidad del Norte" of Barranquilla is relevant, which uses artificial intelligence to advise students, through the Robot Steve. According to the university, the students can query Steve (the robot), about administration and business topics, initially in English, and the machine learns based on the previous questions and answers presented (Universidad del Norte, 2019). In the same way, the "Universidad de los Andes", in 2019, bought from the Japanese company Softbank the robot they called Opera. The robot, similar as the one from "Universidad Nacional Autónoma de México" (UNAM), participated in RoboCup 2019 and it is at the present time being used for research. According to the university, the robot is being programmed to support and guide the students in the induction processes and guide the students to any place in the university (Andes, 2019).

In Argentina, the "Universidad Provincial del Sudoeste de la Provincia de Buenos Aires (UPSO)," in 2018, became the first public university in Argentina to use blockchain to guarantee authenticity of diplomas of its regular and continuing education programs (UPSO, 2018).

8 Accelerators of Digital Transformation

The digital accelerators are environmental, cultural, and behavioral aspects of the digital economy, which favor digital activities or initiatives (Accenture, 2020). Governments and ironically the current COVID-19 are among them.

Regarding governments, if the first Latin American countries in the competitiveness 4.0 index are observed, they are countries where there are stated policies through development plans, CONPES, decrees, or laws that create conditions for the digital transformation to become a reality in those countries, such as in the case of the first five ranked countries: Chile, Mexico, Uruguay, Costa Rica, and Colombia.

About Chile, the development national plan 2018–2022 includes among its strategic objectives the strengthening of the digital infrastructure of the country, facing the challenges of the technological revolution (Observatorio Regional de Planificación para el Desarrollo, 2020). Regarding Mexico, the Development National Plan of Mexico 2019–2024, although it is not explicit about digital transformation strategies, it does state an interest to massify the Internet coverage for the whole country (ILPES, 2020). Regarding Uruguay, in its development national strategy Uruguay 2050, it considers the guideline to take advantage of the opportunities of digital economy, strategy which seeks to "make of Uruguay a model of the new digital economy, promoting the Technology, Information and Communications (TIC) not only as a productive complex in itself, but also as an innovation vector acting as a support and a development engine for all sectors" (CEPAL, 2020, Section guideline 2).

In the Costa Rican case, one of its objectives is "to promote the digital transformation of the country through the development and evolution of international mobile telecommunication system (IMT), to enable the generation of innovating services, and promote competitiveness" (United Nations, 2020, Innovation Section, competitiveness, and productivity). In the case of Colombia, its National Development Plan 2018–2020 includes the agreement for the digital transformation in Colombia and states that government, business, universities, and households will be connected with the Age of Knowledge, and that "we will encourage a state policy for the digital transformation and to benefit from the fourth industrial revolution" (DNP, COLOMBIA, 2020, p. 132). The international mission of Experts 2019 proposed a strategy about financing the information technology (to improve the educational model and the regional development based on the generation and use of knowledge (Presidencia de la República de Colombia, 2019). In the same way, in Colombia, the National Economic and Social Policy Council of the Republic of Colombia—CONPES, 2021–2030, indicates that it is necessary to adapt the environment for the adoption of Industry 4.0 technologies.

As it is seen, in countries where governments show real interest in promoting the digital transformation, the progress is considerable. It is all the opposite to see what happens in other countries of the region such as Cuba, Venezuela, and Bolivia, where lags are evident and where there is no evidence of massification and appropriation of the technology information and communications, at least the way done by countries that in this sense are ranked in the first places.

Besides governments, other circumstances that have driven the digital transformation are ironically the current pandemic COVID-19 that has considerably accelerated a wide range of digital processes, not only in Colombia but in the rest of the world. Quarantines and other mobility restrictions triggered the use of digital solutions, for the most diverse activities of daily life. The scourge persists. Although the present crisis did not generate the necessary digital transformations in all sectors, the struggle measures against the new coronavirus, worked out as a catalyst of technologies, habits, costumes, and consumption.

The Organisation for Economic Co-operation and Development (OECD) published its Index of Digital Government (IDG) for this year, and Colombia ranked the third place, behind South Korea and the UK. This scale measures the grade of "maturity" of digital policies in the governments of the different OECD country members, which include several of the richest countries of the world. The remarkable performance of the country reflects the compromise of the national government, with an agenda of digital transformation, led by the tightest circle of the Nariño House. The above facts do not mean that the task in this front is accomplished. It is all the opposite, and it confirms that the more advanced countries in digital transformation count with the frames of public policies, the institutional actors, the private sector, and the vision to go on.

9 Discussion and Conclusion

The master study in which progress has been presented, in the digital transformation of the HEIs, in Latin America, focused on making more efficient their mission and management processes, and it is found that, from year 2018 on, the incorporation of pillars of the Fourth Industrial Revolution has been intensified. Applications are found to support management, as the blockchain case, for the issuance of diplomas and the virtual assistants to give responses to general inquiries from interested public. In the same sense is found the application of artificial intelligence, to support research processes, give responses, and solve doubts of the students on specific topics of certain subjects. This progress is causing the modification of the business models of the HEIs. Nevertheless, more than digital transformation, what we find now is the digitalization of processes, cultural change is still needed. The main barrier for the digital transformation in HEIs is the culture, in the same way as previous studies have shown, it also happens in the education sector of other regions as Europe, where it is found that the main restriction is the insufficient technological resources and the conservative culture (Vicente et al., 2020).

Regarding resource availability, the main income source of most of the HEIs of Latin America is the tuition payments from students, with a participation of more than 90% in the private HEIs. In public HEI, financing depends on the government with limited resources; this explains why more relevant progress comes from HEI of recognized quality but also because of their resources. Therefore, although they present progress, there are investment restrictions in technology information and communications (TIC). Regarding cultural issues, the HEIs of Latin America have the same conservative culture of the world's HEI. The economic aspects can be solved easily, but not likewise the aspects concerning culture.

Therefore, the main challenges of the HEI of Latin America, for the incorporation of the digital transformation, are the management of the organizational cultural change of the HEI sector, the progress in the same proportion of the social and technical systems, together with the gradual change of style of hierarchical government, departmentalized and pyramidal, to a more horizontal one, in which government and governance coexist. Governments play an important role as accelerators of digital transformation.

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José Humberto Serna Gómez Dl Universidad de Antioquia, M.A. Stanford University, ED, D Harvard University, Associate in education Harvard University, P Associate professor (r) at Universidad de los Andes, Associate professor at Fundación Universitaria Maria Cano, Researcher Emeritus.

Flor Nancy Díaz-Piraquive Doctor in Computer Engineering: Information and Knowledge Society. Systems Project Management Specialist and Project Preparation and Development. Economist. Director of the Strategy, Creativity, and Innovation Research Group of the Fundación Universitaria Internacional de La Rioja.

Yasser de Jesús Muriel-Perea Master's Degree in Systems Engineering. MBA. University Teaching Specialist. Systems Engineer. Researcher.

Alejandro Díaz Peláez Doctor in Administration, Universidad Católica de Argentina. MSC System, University pf Sherbrooke. Statistician, Universidad de Medellín. Researcher at Fundación Universitaria Internacional de La Rioja.