Preface

In the past decades, Higher Education Institutions have had to respond to various changes in the social, economic and political environment, both nationally and internationally. Challenges arising from an increase in the number of students demanding Higher Education, reduced public funding or less support from the private sector, increased operating costs, geopolitical conflicts or the COVID-19 pandemic, have forced the Higher Education sector to adapt and evolve. Another relevant factor of change has been, and will continue to be, the drive of digital technologies.

The progress of digital technologies can be seen as a series of successive technological waves that, driven by the development of one or more technologies, have been changing the economy and society. First came the large mainframes, then personal computers, local area networks, the emergence of the Internet and so on. Since approximately 2008-2010, society has been adapting to the wave of change brought about by four major technological developments. This is what is known as the SMAC stage: S for social networks; M for Mobile, mobile computing devices and mobile access to the Internet; A for Analytics, referring to the analytics techniques that can be applied on the large amount of data that users and connected machines constantly generate; and C for Cloud Computing (Malcolm, 2012).

During this SMAC period, the thrust of these digital technologies has modified entire sectors of the economy that have adapted, better or worse, to this technological disruption. There is no doubt that it caused a turning point in the audiovisual content, press, music and banking industries. Certainly, it also affected the Higher Education sector.

The process of digitization never stops and by the time we have settled in and become comfortable in using one new technology there is already another set of emerging technologies breaking through. In 2019, the acronym DARQ was coined for the next wave of technology-enabled change (Safavi, Kalis & Thompson, 2019): D stands for Distributed Ledger Technology, among which the best known in Blockchain that is giving rise to cryptocurrencies and a multitude of applications in other fields; A is for Artificial Intelligence, especially Machine Learning and Deep Learning technologies with applications to image and video recognition, Natural Language

Processing (NLP), etc.; R is for Reality, in reference to augmented and extended reality, i.e., the coming Metaverse; and finally Q is for Quantum Computing, which can represent a qualitative jump in our computational capacity.

These four groups of technologies are raising a new wave of digitalization, which will change society again in the next decade, but perhaps what is developing faster is Artificial Intelligence and its applications to all areas of the economy, also in the Higher Education sector.

WHAT DO WE CALL ARTIFICIAL INTELLIGENCE?

The term "Artificial Intelligence" is attributed to John McCarthy, assistant professor of mathematics at Dartmouth College, who included it in the name of the meeting he organized in the summer of 1956 at Dartmouth College, located in Hanover, New Hampshire (United States), considered as the germinal event of Artificial Intelligence as a field of activity. Alan Turin's 1950 article "Computing machine and Intelligence" (Turin, 1950) and Marvin Minsky's 1961 article, "Steps toward an Artificial Intelligence" (Minsky, 1961) are considered the seminal articles of this field of study. Since then the field has been developing in different waves (and winters) until today (Buchanan, 2005), in a process of convergence of several sub-disciplines of computer science, mathematics and statistics, among which Deep Learning stands out (Almaraz-López, 2020).

We are not referring to Artificial General Intelligence (AI general or AGI), which aims at machines that can deal with any intellectual task and which is a specific field of research with very limited progress (Pennachin & Goertzel, 2007). We refer to the so-called narrow or limited Artificial Intelligence.

We understand narrow Artificial Intelligence as the set of software applications that can perform some tasks similar to those that humans can perform thanks to their human intelligence (Russell, & Norvig, 2003).These software applications can interact with human users and the environment, either installed on a general-purpose computer (e.g., a conversational bot or a recommendations application) or being part of a specific-purpose device (an autonomous car or an industrial robot).

What distinguishes what we call narrow AI applications from preceding software applications is a certain autonomy to execute tasks in complex situations without constant direction from a human and the ability to progressively adapt the execution of tasks by learning from their own experience.

Each new technological wave is supported by technologies consolidated in previous waves. Thus, today's Artificial Intelligence is possible thanks to the support infrastructure provided by the continuous increase in computer processing capacity, Cloud Computing and high-speed Internet access, also from mobile devices, as

well as the development of sensors that has made Internet of Things (IoT) possible. On top of these previous developments, which provide them with the appropriate support infrastructure, the techniques that characterize the core of what we now call Artificial Intelligence are:

- Machine Learning
  - Deep Learning
  - Neural Networks
  - Reinforcement Learning
  - Supervised Learning
  - Unsupervised Learning
- Rules-based reasoning (mostly developed in the first wave of AI)
  - Decision making
  - Expert systems
  - Knowledge representation (knowledge graphs and their application to NLP)
  - Planning and scheduling
  - Search and optimization

These techniques, sometimes combined with converging technologies such as augmented and virtual reality and machine vision, are yielding multiple applications. Among them:

- Text, speech, image and video recognition.
- Natural language processing
- Biometric, facial and gesture recognition.
- Recommendation systems.
- Predictive systems (maintenance, retail, trading, etc.).
- Generative product design.
- Augmented research (marketing, medicine, science, etc.)
- Autonomous vehicles and drones.
- Intelligent agents.
- Extended reality.

Artificial Intelligence applications are very efficient in automating repetitive jobs, especially if they involve pattern recognition in large amounts of data. With adequate computer processing power, a large amount of data and suitable human feedback, an AI system can distinguish a human face in a crowd, translate text into different languages accurately, or identify breast cancer early.

The notion to be emphasized is that, as a whole, AI is a general-purpose technology with a great transformative capacity and potential impact on our lives that some authors compare to that of the steam engine or electricity in the past (Firth-Butterfield, 2019).

Ideally, these are systems intended to work with people, not to replace them, but it is inevitable that a paradigm shift will occur that will change the role of many current jobs. To use one example, the day seems not far when autonomous vehicles will be able to transport goods. If that happens, the profile of the trucking job will surely change from driver to remote supervisor of transport convoys (Talbott, 2021, February 12).

In any case, we approach our analysis by considering Artificial Intelligence as a set of technological applications aimed at making organizations smarter. All types of organizations, including Higher Education Institutions.

ARTIFICIAL INTELLIGENCE AND HIGHER EDUCATION INSTITUTIONS

In this book we describe the current situation of Artificial Intelligence in Higher Education Institutions and analyze some relevant aspects that its implementation raises.

In the first chapter, the team of researchers from UNESCO IESALC (Instituto Internacional para la Educación Superior en Latinoamérica y el Caribe), Daniele Vieira, Jaime Roser Chinchilla, Bosen Lily Liu, Clarisa Yerovi and Diana Morales, review current applications of AI in Higher Education Institutions. Practical examples of AI use in teaching and learning in Higher Education are revised, such as applications to personalization of learning, automatic grading or virtual teaching assistants. Also included are examples of applications of AI to the management of Higher Education Institutions such as those dedicated to easier access to information for students, student retention or staff recruitment. The authors review as well the main issues, controversies and problems associated with the implementation of AI in Higher Education institutions.

The availability of data and analytical capabilities underlies the application of AI in organizations. Universities have a large amount of data on students, faculty, courses, facilities, etc. on which AI technologies can be applied. This is why we dedicate the second chapter to an in-depth review of the role of Analytics in Higher Education. Hamid Mahroeian, School of IT, Whitireia and WelTec (New Zealand), explains in detail how Analytics is generally conceptualized in Higher Education Institutions, the opportunities it provides and how Big Data can help universities overcome the challenges faced by the Higher Education sector.

University Boards of Directors have the same responsibilities with respect to AI as those of any other institution, including defining the appropriate strategy for the adoption of AI technologies, overseeing the processes in which it is introduced to improve efficiency and productivity, assessing the risks associated with AI, and defining a system of AI governance in the institution (Firth-Butterfield, 2019). Also important in all organizations is the human and cultural component, that is, getting AI and people working together smoothly. However, this aspect is even more important in universities, since in many of them there is a deep-rooted sense of a university community made up of students, faculty and administrators. And since it will be the members of the community who will be directly affected by the introduction of AI, they should be able to reflect, experiment, and have their say in the use of AI in university activities. In this regard, in Chapter 3, Alice Watanabe of the Hamburg University of Applied Sciences (Germany) stresses the need for faculty involvement in creating the discourse on AI in Higher Education, which is not happening to any significant extent so far. Despite the fact that the use of AI in educational settings will change their work in many ways and that their experiences could lead to entirely new applications of AI, university professors remain on the sidelines of the debate. For their part, Benjamin S. Selznick and Tatjana N. Titareva, James Madison University (United States), reflect in Chapter 4 on the relationship between AI and administrative leadership within Higher Education Institutions, exploring the circumstances under which administrative work may be affected by AI and drawing conclusions about it.

The profound impacts on societies, the environment, and human lives that will be brought about by widespread uses of AI raise concerns about fairness, accountability, explainability, misuse, and unintended social consequences. AI algorithms may reproduce and amplify biases already present in society, for example, those related to gender or race. Similarly, if AI systems are allowed to make certain decisions without any oversight (human out-of-the-loop) we may face a situation where groups of people are systematically being discriminated against. Likewise, if the way in which an algorithm arrives at its results cannot be explained enough so that we can know its possible biases, how can we trust it? This is a real problem because, as AI becomes more advanced, then the harder it becomes for people to understand how the algorithm has arrived at a result. It becomes a "black box" that is impossible to understand.

Ethical considerations such as those mentioned above have led in recent years to a wide range of companies, national and regional governments, supranational organizations, NGOs, academic groups, standardization organizations and public interest bodies, including UNESCO, to publish codes of ethics for the use of AI. This is an area of concern also in Higher Education Institutions that has different strands, two of which are collected in the fifth and sixth chapters of the book.

Without detracting from the current normative trend, Jeremy Knox, The University of Edinburgh (Great Britain), Tore Hoel, Oslo Metropolitan University (Norway) and Li Yuan, College of Education for the Future, Beijing Normal University (China), highlight in Chapter 5 the need for the definition of AI ethics to be carried out within HEIs in a participative manner, through continuous processes of debate and exchange involving the various stakeholders. Amongst the AI applications that may directly affect students in Higher Education are those related to the selection of candidates for admission to universities or those that predict academic performance. Birte Keller, Marco Lünich, and Frank Marcinkowski, from Heinrich Heine University Düsseldorf (Germany), the authors of Chapter 6, focus on the latter. Based on a prior concept of organizational justice, they define a comprehensive framework that includes all aspects of AI fairness as perceived by students.

Predictions suggest that the impact of Artificial Intelligence in the coming years may affect most professions and economic sectors. Financial analysts are expected to coexist with algorithms capable of performing complex financial analysis to detect market trends. Some time-consuming and tedious tasks performed by lawyers, such as reviewing and evaluating contracts or researching court records, can be performed much more quickly with the help of appropriate AI software. Journalists already work with systems capable of writing press releases or detecting trending topics. These are just a few examples. Most professions will be affected to a greater or lesser extent. This trend directly challenges Higher Education. One of the primary missions of the University is the education of professionals in all areas: medicine, law, biology, science, business administration, etc. Given the foreseeable substantial impact of Artificial Intelligence in all of them, how should Higher Education evolve? Should a basic transversal training common to all careers be included in all curricula? Would it be better to have a specialized training for each profession? Or should we rethink the entire Higher Education model that was designed for a bygone era? This is what José Carlos Machicao of the Universidad Continental (Peru) explores in Chapter 7, and it is not a minor issue. It is probably the greatest challenge facing the current model of Higher Education.

Teaching and research are not the only domains of activity of Higher Education Institutions. HEIs are complex organizations with multiple dimensions ranging from campus management to communication or marketing (Almaraz-Menéndez, Maz-Machado & López-Esteban, 2017). In all these dimensions the influence of Artificial Intelligence will be felt, or is already being felt. If we look, for example, at the physical infrastructures, we can see that most universities are built and organized according to the idea of a university campus or university city. Whether isolated from urban centers, attached to them or fully integrated into a town or city, the university campus is structured as a small city with several thousand citizens (students, professors and administrative staff), a few dozen buildings and thousands of square meters

to manage. Energy efficiency and mobility issues are vital for many universities and will be affected by the implementation of Artificial Intelligence and related emerging technologies. Of note is the project launched in 2018 by the University of Michigan (US), for mobility on its campus with autonomous vehicles, one of the most developed AI applications. With two driverless shuttles transporting students, faculty and staff on the U-M campus, the project was designed for data collection to understand vehicle performance, road interactions and passenger attitudes. The ultimate goal was to support the long-term deployment of autonomous vehicles in the real world. Chapter 8 addresses another relevant topic related to university campuses: air quality in university buildings, a particularly sensitive matter due to the COVID 19 pandemic. The team of authors from the University of Valladolid (Spain), María A. Pérez-Juárez, Javier M. Aguiar-Pérez, Miguel Alonso-Felipe, Javier Del-Pozo-Velázquez, Saúl Rozada-Raneros and Mikel Barrio Conde, explain in this chapter some use cases of the main emerging technologies, such as Artificial Intelligence, Big Data, Internet of Things or Edge Computing, in the field of air quality assurance in university buildings.

The pandemic has had another notable consequence. Due to the periods of confinement, many universities have had to adopt non-face-to-face or hybrid teaching models. While before COVID 19 most universities had virtual campuses for on-line teaching or to support face-to-face teaching, the recent health emergency has forced all of them to become familiar with on-line teaching. This teaching model generates a large amount of data on the activity of students and professors. It is the most appropriate terrain for the application of Artificial Intelligence algorithms. Steven Van Vaerenbergh, from the University of Cantabria (Spain) and Adrián Pérez-Suay, from the University of Valencia (Spain) explain in Chapter 9 the concept of Intelligent Learning Management System (ILMS). They use examples from Mathematics Education that are transportable to any other branch of knowledge.

Artificial Intelligence is already a reality in society. It is time to act. Higher Education Institutions cannot postpone an internal reflection on how they will face the transformation promised by this set of technologies. It will be necessary to explore the implications of AI, integrate it into strategic plans and set progressive goals for AI adoption. Where to start? A general recommendation is to start small, but start. Choose a few initial projects to build momentum and learn first-hand what is needed to introduce AI into the university's key processes. How? We address this question in the last chapter of the book. The authors, Dawn Coder, Meng Su and Ryan Wellar of The Pennsylvania State University (United States), provide a question-answering guide to deciding what organizational processes are appropriate for these early projects, how to choose the right technologies, and how to select the right fellow travelers, i.e., the most suitable technology partners.

ORGANIZATION OF THE BOOK

The book is organized into 10 chapters. A brief description of each of the chapters follows:

Chapter 1: Beyond the Chatbot – How Are Universities Using AI Nowadays?

This chapter presents a review of current practical applications of AI in Higher Education Institutions (HEIs), especially in the areas of teaching, learning, and administration. The revision of real use cases can help HEI executives and policy makers to clearly understand what practical benefits their organizations can obtain from the implementation of AI. The major issues and controversies associated with the implementation of AI systems are also reviewed. AI is expected to bring about profound change to the Higher Education sector, which undoubtedly represents numerous opportunities for the future of Higher Education Institutions, but also serious and urgent challenges. The chapter concludes with a number of practical recommendations for harnessing the opportunities and addressing the challenges.

Chapter 2: The Role of Analytics Within the Higher Education Institutions

Higher Education Institutions are increasingly accumulating a significant amount of data on students, teachers, facilities and curricula, which has resulted in the use of new tools and technologies to capture, store, distribute, manage, analyse and visualize larger-sized datasets with diverse structures. Analytics, with the emerging research paradigm of Big Data and the rising of AI Analytics, has become an important part of the educational technology area. This chapter presents how Analytics is generally conceptualized and deployed in Higher Education and how it can help address the major challenges academic institutions face (globalization, student retention, teaching quality assurance, optimal resource management, etc.), with functional and strategic initiatives. The chapter also analyses the existing barriers to the adoption of Analytics in Higher Education Institutions and the difficulties related to institutional wide deployment of Analytics projects.

Chapter 3: Let's Talk About Artificial Intelligence – How Scholarship of Teaching and Learning Can Enhance the AI Scientific Discourse in Higher Education

Although the interest in applying AI technologies in Higher Education is growing rapidly, the focus is primarily on the AI applications that need to be transferred to Higher Education contexts. This chapter, however, focuses on analyzing how university agents can grasp the complexity of AI and how the exchange of experiences on AI implementation in Higher Education can be reinforced. The concept of Scholarship of Teaching and Learning (SoTL) is presented as a possible basis for strengthening the discourse on AI among teachers and researchers. The chapter first discusses different aspects of AI in Higher Education and then shows how AI projects can be structured. This is followed by an introduction to the SoTL concept and by an analysis of the extent to which SoTL can be used to process AI projects and to enhance the AI discourse in Higher Education.

Chapter 4: Postsecondary Administrative Leadership and Educational AI – An Ethical Shared Approach

AI decisions and strategies of HEIs must be made taking into consideration their complex effects on university ecosystems and all their individuals, including those who do administrative work. This chapter explores the explicit relationship between AI technologies and administrative leadership within HEIs. The chapter offers initial definitions and considerations for AI in Higher Education Institutions set against the context of theory and literature, then introduces an integrated perspective of ethical shared administrative leadership and provides a comprehensive framework for addressing Artificial Intelligence in Education (AIEd) leadership in HEIs. Next, it comments on contemporary examples of AIEd confronting administrative leaders, like chatbots, data analytics for profiling, prediction and retention or smart campus applications. This leads to the main part of the chapter: the parameters for an ethical discourse, one that is mission-responsive, transparent/accountable and equity-minded. The chapter closes by providing practice implications for *doing* ethical shared administrative leadership in three areas: taskforces and knowledge sharing, educational policy making and a student-centered ethic of care.

Chapter 5: From Principles to Processes – Lessons for Higher Education From the Development of AI Ethics

The development and understanding of AI ethics is especially significant for Higher Education research and practice, particularly when the deployment of data-driven

technologies in universities is increasingly impacting educational pathways and outcomes. In recent years, a large body of ethical codes for the use of AI has been published, showing a convergence on certain universal and definitive principles. However, less attention has been paid to developing a participatory co-design of AI ethics, including ongoing processes of multi-stakeholder discussion, participation and exchange. This chapter takes this approach to suggest ways in which Higher Education might better address "ethics by design", established around two key ideas: situating ethical issues in existing social and historical contexts and formalizing the teaching of critical data literacy.

Chapter 6: How is Socially Responsible Academic Performance Prediction Possible? Insights From a Concept of Perceived AI Fairness

This chapter focuses on a promising area of the use of Artificial Intelligence systems in Higher Education: Academic Performance Prediction (APP), which is expected to provide individual feedback for students, improve their academic performance, and ultimately increase graduation rates. However, using an APP system also entails certain risks of discrimination against specific groups of students, so taking into account the fairness perceptions of the affected students becomes a relevant concern. This chapter raises many critical questions regarding the design and implementation of a socially responsible APP system at Higher Education Institutions by using a framework that highlights specific issues regarding the input, throughput, and output phases of the APP implementation process. It sheds light on potential (un-)fairness perceptions from the students' point of view, using a four-dimensional concept of organizational justice.

Chapter 7: Artificial Intelligence as a General Resource for All Professions – Towards a Higher Education Pedagogy Framework

Artificial Intelligence is so rapidly establishing itself as a multi-purpose discipline in society, that the education of tomorrow's professionals would be incomplete without the skills to take full advantage of AI and its opportunities. This chapter reflects on how universities might adapt to the challenge of integrating AI and to respond to the demands of preparing professionals for a society in which AI plays a role in almost all activities. The author explores the foundational concepts of learning, intelligence, Artificial Intelligence, Higher Education and professions, in the search for a pedagogical framework that can help Higher Education Institutions to find a role in training professionals for a society in which algorithms perform some cognitive

functions, on the basis that AI is not just an additional new technology on which to teach, but impacts the very definitions of professions and learning. The conclusions point out that universities must move from playing a traditional role, focused on industrializing the existing knowledge process, to being the main cognitive agent in a humanity with AI-enhanced cognitive capabilities.

Chapter 8: Emerging Technologies to Increase Energy Efficiency and Decrease Indoor Pollution in University Campuses

Emerging digital technologies, such as Artificial Intelligence, Big Data, the Internet of Things or Edge Computing, impact all dimensions of the activity of Higher Education Institutions, not only in the teaching-learning process. They can also impact the university campus itself, where a key element is the quality and comfort of the air (including temperature, degree of humidity and purity), which is related to two issues of great importance: energy efficiency and indoor pollution. This chapter calls attention to the importance of maintaining adequate air quality and comfort in the buildings of Higher Education Institutions, and highlights the contribution of emergent technologies to better achieve energy efficiency and consequent cost reduction, and subsequently to improve the well-being and health of the entire university community by reducing, as much as possible, air pollutants in university campus buildings. University leaders have a responsibility to protect professors and students' health by using technological applications that allow otherwise unthinkable results.

Chapter 9: Intelligent Learning Management System for Mathematics Education

Intelligent Learning Management Systems (ILMS) combine traditional Learning Management Systems (LMS) with predictive modeling and interactive capabilities provided by Artificial Intelligence (AI). This chapter gives an overview of current LMS and the different functions they cover in the context of Higher Education and discusses several standard AI paradigms for solving different automated tasks. Both sides, LMS and AI, combine into Intelligent Learning Management Systems, which extend standard LMS with AI-based capabilities for prediction, modeling and interactive tasks that are useful in online educational settings. Examples of Learning Analytics (LA) and Intelligent Tutoring Systems (ITS) in the context of mathematics education are discussed as use cases of ILMS. The chapter concludes with some reflections on the future possibilities of integrating the latest AI developments into ILMS.

Chapter 10: Considerations When Choosing Artificial Intelligence to Meet Business Needs in Higher Education Institutions

Many Higher Education Institutions are beginning to experiment with their first AI projects. The AI solutions sector is relatively recent, with many new companies and innovative services constantly emerging. This chapter provides guidance on identifying the right processes to start using AI and on choosing the right partners. Three sections provide an in-depth look. The first focuses on the questions to ask when deciding whether an AI solution meets organizational objectives. The second section describes AI technologies to consider. The final section gives advice on best practices to use to identify the right AI service provider to build an AI solution that meets the organization's needs. The chapter is an invaluable guide for university managers looking for guidance to begin applying AI in their organizations.

Fernando Almaraz-Menéndez
University of Salamanca, Spain

Alexander Maz-Machado
University of Cordoba, Spain

Carmen López-Esteban
University of Salamanca, Spain

Cristina Almaraz-López
ArcelorMittal Global R&D, Spain

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