

# Artificial Intelligence in Higher Education during and After the COVID-19 Pandemic: Need, Transition and Transformation

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## Abstract

The aim of this article focuses on the achievements and challenges of the application of AI (artificial intelligence) based technologies in the field of higher education. Articles on AI-based technologies and their relationship with higher education have been collected from databases such as WOS, Scopus, ProQuest, Ebsco and PubMed. It oriented the analysis to provide the various contributions about technologies, methodologies, processes and learning contexts based on AI that have been emerging during the crisis caused by the Covid-19 pandemic in the university context. This article focuses on the achievements and challenges of the application of AI based technologies in the field of higher education, and we provide a series of relevant data, examples and explicit studies on the titanic potential of AI in its adaptation to higher education, emphasising crucial aspects of the application of new technologies and their aspects in the current scenario.

**Keywords:** higher education, artificial intelligence, digital transformation, COVID-19.

## 1. Introduction

The term artificial intelligence (AI) was first coined by John McCarthy in 1956 following an initial theoretical meeting on the subject; and five years later, Alan Turing published a paper on the idea that machines are capable of mimicking

humans and their ability to do intelligent things, for example, play chess [1]. Regarding, it is worth mentioning that AI explores how technologies train, teach and build new knowledge from a continuous development of innovations [2]. On the other hand, researchers Luckin and Holmes, in 2016,

deduced the potential of AI in the field of higher education, conceiving it as a powerful “black box of learning” [3].

According to Akour, Alshurideh, Al Kurdi, Al Ali, and Salloum [4], the dire circumstances caused by the pandemic led to a series of disruptions in traditional or face-to-face teaching processes, so that numerous students inevitably turned actively to the use of mobile technologies for learning.

The qualitative work of Piyatamrong, Derrick and Nyamapfene [3] with postgraduate students at a number of UK universities showed that learning during the pandemic has been the focus of several dilemmas about future adaptations of online learning. A relevant aspect of the study is that it often disappointed students about their experiences of the effectiveness of online learning, one of the reasons was the absence of adequate levels of interactivity between students due to limited informal opportunities for participation.

The pandemic generated a high disruptive cost of most of the globe in the form of a downward spiral of the world economy and abruptly caught nations off guard with a high global impact repercussion, affecting education and academic processes worldwide [1,6-10]. The impact of the COVID-19 pandemic on the higher education system has had a huge global impact, exposing the shortcomings of the current higher education system. Regarding, research by Maier, Alexa, and Craciunescu [11] revealed that approximately 70% of Romanian students surveyed lacked adequate experience with web-based learning. Thus, there is an urgent need for further training of educators in digital technology to adapt to the rapidly changing global educational climate [7,8].

On the other hand, the sudden closure of campuses, as a social distancing measure to avoid community broadcasting, has led to a shift from face-to-face classes to online or remote learning systems [6,12]. Such a calamitous event has highlighted the essential role of digital technologies in higher education, and a number of dilemmas have arisen regarding the inherent issues of quality in distance education, teaching-learning processes in the current context, and models of knowledge and skills assessment [13,14]. Although some countries tried to solve the problem of distance education, numerous others failed to manage it adequately due to socio-

economic problems and a marked lack of adequate technological infrastructures [15]. There is no doubt that the repercussions generated in this respect forced universities to face one of the largest educational disruptions ever experienced [3]. Such an event generated a mandatory gap in learning modalities and experiences, with a variety of implications for educational quality, such as problems like reduced attention span of students and an increased burden of procrastination. However, Bisem, Arslan, Yildirim and Yildirim [16] mentioned that cutting-edge technological applications, more specifically those in the field of AI, could solve some of the aforementioned problems.

## 2. Methodology

Based on the above, there is an urgent need to investigate the state-of-the-art of the subject of AI in relation to the problems facing higher education during and after the COVID-19 period. For this reason, the present article is a review of trends on the subject of AI in the field of higher education. Researchers consulted databases such as WOS, Scopus, ProQuest, Ebsco and PubMed. Researchers used Boolean operators AND and OR according to convenience to amplify the search for the terms AI (artificial intelligence), COVID-19, higher education, innovations,

These searches generated a considerable volume of results, many of which were of little or no use to the review, but were useful in providing a global overview of the subject matter, thus corroborating the relevance of the subject matter.

The combination of terms that provided the best results when used in the above search engines was the following: (artificial intelligence OR machine learning) AND (COVID-19 OR pandemic) AND (digital transformation) AND ((big data or machine learning) OR (mobile learning-digital learning) OR (academic development OR academic research)). From the above, 316 results were obtained from Scopus; 198 from ProQuest; 123 from Ebsco and 98 from PubMed. As regards the choice of articles, we proceeded to screen them, defining the inclusion and exclusion criteria.

Table. Characteristics of the studies reviewed

Author(s)	Objetive	Methodology	Results
Abuselidze - Mamaladze [28]	Investigate the impact of AI on business based on the world's experience.	Analyses the use and growing importance of Artificial Intelligence 4.0 industry in the context of pandemic constraints in various sectors of the economy and assesses the role in the post-pandemic period.	It provides content analysis of scientific literature, statistical indicators and practical examples from different countries and international organisations.
Bisen et al. [16]	Explore how AI can be used to help students and teachers adapt to the new	Analytical summary of current AI trends in the field of higher education.	By providing more personalised, flexible, inclusive and engaging learning experiences, AI has the

	realities of online learning.		potential to revitalise students and teachers and make virtual classrooms more meaningful and productive.
Islam et al. [35]	Provide a clear overview of AI publishing trends related to COVID-19 using a longitudinal bibliometric analysis.	A systematic literature search was conducted in Web of Science for peer-reviewed articles in English related to the application of AI to COVID-19. A search strategy was developed to collect relevant articles and extract bibliographic information.	The journals that published the most articles on AI related to COVID-19 were: PLOS One (33/729, 4.52%), Chaos Solution Fractals (29/729, 3.97%) and Journal of Medical Internet Research (29/729, 3.97%). The Republic of China (190/729, 26.06%), USA (173/729, 23.73%) and India (92/729, 12.62%) were more prolific.
Alfarsi et al. [2]	Illustrate on the need to introduce higher adoption rate of AI technology in higher education.	Review of existing studies and the type of AI proposed in each class, what kind of challenges it faces.	The result reveals how these teaching, learning, student support and management technologies can be introduced with the development of AI.
Sousa et al. [34]	Understand the potential learning applications based on AI technologies for higher education students in healthcare.	Systematic literature review, contributing to explore to what extent AI technologies are currently influencing learning processes in higher education health and the skills developed during the learning pathway.	AI can be used to enhance the learning process and learning outcomes, especially in laboratory classes, and such contexts are still largely unexplored.
Treve [7]	Investigate the effect of COVID-19 in higher education, specifically the transition from face-to-face sessions to online and interactive systems.	Narrative literature review detailing the challenges that students and teachers have faced with the transition from HEIs to the online sphere.	While COVID-19 was a challenge for students, it also served as a springboard for realistic alternatives such as artificial intelligence (AI), public-private educational collaborations and digitalisation.
Vázquez [9]	To rethink the didactic and pedagogical model in which to support the use of technology, both inside and outside the classroom based on AI-based proposals.	Literature review on the possible applications and functionalities of AI in education.	One of the emerging challenges highlighted in education is to propose models and proposals for the integration of AI in teaching and learning processes, based on sound didactic and pedagogical principles.
Wahyono et al. [31]	Validate the experience of implementing a virtual laboratory based on AI.	This research uses an experimental method in which a virtual laboratory was developed and customised using AI.	The user's ability and willingness were processed by AI to determine the appropriate model, media and materials for the user. The test results of the virtual laboratory obtained accuracy values of 90.8%.
Alansari [1]	Discuss the possibilities of AI in automating the detection of possible viruses.	Theoretical review of works on the development of clinical applications of AI and machine learning in diagnostic protocols.	While AI is vital in many critical cases that need proper consideration, it is clear that there are important benefits but that they are not advertised to the public in a way that is acceptable to them.
Vinichenko et al. [29]	Identify the nature of the impact of the pandemic on the quality of education and the image	The research methodology includes a complex of general and special scientific methods. A questionnaire and a detailed interview have been	The impact of the pandemic on the quality of education and the image of a university using distance education and AI is diverse,

	of a university using distance education and AI.	formed with regard to the indicators of the main qualification systems of higher education.	multifaceted and systemic; the essence and depth of its short- and long-term impact has not yet been studied.
Hooda et al. [23]	Explore the impact of assessment and feedback on student outcomes and performance in the higher education system.	Exploratory and comparative analysis study of how assessment and feedback practices can improve student learning outcomes using AI.	Positive results were found for a number of assessment and feedback practices that can improve the student learning experience and outcomes.
Seren - Özcan [38]	Discuss AI-supported or AI-based education, which is a type of distance education in emergencies such as pandemics or natural disasters.	Literature review on different perspectives in the context of distance education in compulsory cases and also in normal, non-compulsory moments and discuss assisted or artificial AI.	AI-based education should be discussed in depth by stakeholders in all areas and should be organised for the benefit of humans.
Morales et al. [36]	To design a predictive model of AI-based stress in education that includes certain socio-demographic variables, coping strategies and resilience, and to study the relationship between them.	Non-probabilistic snowball sampling, with 337 people (73% women) from the university education community in south-eastern Spain. The Perceived Stress Scale, the Stress Management Questionnaire and the Brief Resilience Scale were administered. Artificial neural network architecture was used.	Stress levels could be predicted by the synaptic weights of coping strategies and the timing of the epidemic (before and after the implementation of isolation measures), with a predictive ability of more than 80% found in the neural network model.
Orr [20]	To analyse the literature on the future of higher education based on big data and machine learning.	Literature review on novel AI trends and innovations in higher education.	Shifts in perspective are referred to issues of digitisation, prioritising technology, over the view that digitisation is always a social innovation.
Piyatamrong et al. [3]	To study the experiences and feelings towards learning under the pandemic through the lens of students.	Qualitative study involving eleven postgraduate students at three UK universities for in-depth semi-structured interviews. Thematic analysis was adopted, interpreting sentiments into three interchangeable themes.	Learning during the pandemic has raised many concerns about future adaptations of online learning. A key finding was that learners are generally disappointed by their experiences of the effectiveness of online learning in pandemics.
Rahim [26]	To investigate education 5.0 and the circumstances of higher education in Afghanistan.	Theoretical review of Education 1.0 to Education 5.0 each in four perspectives of industrial revolution and educational development, teaching and learning methods, learning theories, classification of generations and necessary skills.	In Afghanistan, an essentialist teaching and assessment curriculum is employed. Assessment approaches include 10% class activity and attendance, 10% homework and projects, 20% mid-term exam and 60% final exam indicating exam-oriented education.
Rashid - Yadav [6]	Describe the use of e-learning tools and platforms for effective student engagement.	Theoretical review of the use of e-learning and virtual education can become an integral part of the higher education system.	Universities must plan post-pandemic education and research strategies to ensure student learning outcomes and educational quality standards.
Saleem [8]	To identify the effectiveness of distance learning in the shadow of the coronavirus pandemic in Saudi Arabia.	Qualitative study by distributing an electronic questionnaire to university students to find out their views on distance learning.	The challenges faced by the students and the online learning method was well received by them. All agreed that distance learning saves time and that their

			performance has improved due to increased employment.
Al-Marroof [14]	To explore the effect of the emotion of fear on technology adoption by students and teachers during the COVID-19 pandemic.	The study has made use of Google Meet© as an educational social platform in private higher education institutes. The data obtained from the study were analysed using partial least squares structural equation modelling (PLS-SEM) and machine learning algorithms.	COVID-19 had an effect on the adoption of Google Meet as COVID-19 increases the various types of fear: family confinement situation, fear of educational failure and fear of losing social relationships are the most common types of threats that students and teachers/educators may face.
Subirats et al. [21]	To classify students according to their performance, considering data before, during and after COVID-19 confinement.	Using a field experiment of 396 students, the temporal evolution of students during all academic years from 2016/2017 to 2020/2021 was described.	The data obtained in the last month before the final exam of the subject include the most relevant information for a correct detection of students at risk of failure.
Supriyanto et al. [39]	To discover various technologies that were applied and used by counsellors in the process of counselling services during the Covid-19 pandemic.	A case study method and a qualitative descriptive method were used with a total of 20 alumni of professional teacher education who worked as school counsellors on various islands in Indonesia.	Asynchronous and technology-based synchronous media were found to be the main alternatives for online counselling services during the Covid-19 epidemic.
Ashour et al. [22]	Find out whether pandemic has been a factor in helping to legitimise online teaching and learning as a universal mode of delivery in different fields of study.	A questionnaire was administered to 700 university administrators and professors from three different institutions in the USA	It was found that many of the lessons learned during the period of forced adoption of distance education will be used by universities to improve and expand online learning provisions.
Van Bavel et al. [12]	To discuss issues relevant to the pandemic, including work on navigational threats, social and cultural influences on behaviour, scientific communication, among others.	An online questionnaire was used for 504 university teachers in Malaysia on the role of e-learning during COVID-19.	We identified several ideas for an effective response to the COVID-19 pandemic and highlighted important gaps that researchers must move quickly to fill in the coming weeks and months.
Jacques et al. [13]	The main objective was to examine the assessment of knowledge and skills acquired by distance learners as well as to stimulate debate and reflection on the transformation of teaching in universities.	Follow-up with 81 engineering students in France during various periods of confinement on their satisfaction with the quality of distance learning, the learning process itself and the assessment of knowledge and skills.	The results of the satisfaction surveys showed that for 91.4% of students who had sufficient hardware and software resources, the synchronous approach to e-learning presented few barriers. For 8.6% of the students affected by the digital divide, telephone communications and social networks played an important role in the learning process.
Ho et al. [15]	To investigate important predictors for determining the satisfaction of undergraduate students in emergency remote	425 students were surveyed at Hong Kong University. The data was processed by the development of machine learning models using K-fold	There is a need to review the quality and quantity of modified assessments accommodated for ERL and the delivery of structured classes with the right amount of interactive learning according to the

	learning (ERL) at a self-funded university in Hong Kong.	cross-validation, except for statistical linear regression models.	learning culture and nature of the programme.
Wu et al. [32]	Proposing a novel method combined with program code parsing trees and fuzzy membership function to detect plagiarism.	The dataset was randomly separated into training datasets and test datasets for twenty runs. The average accuracies of the experiment to predict which students will obtain high scores.	The average accuracies of the experiment for predicting which students have high class loyalty are 95.00% and 92.74%. Both experiments show that our proposed method can not only detect plagiarism, but can also be used to detect which students are diligent.
Akour et al. [4]	Investigate the use of mobile learning platforms for educational purposes in higher education institutions in the United Arab Emirates.	A total of 1880 questionnaires from different universities in the United Arab Emirates were analysed. Partial least squares structural equation modelling and machine learning algorithms were used to evaluate the research model based on data from a student survey.	Each hypothesised relationship within the research model was supported by the results of the proposed data analysis.
Maier et al. [11]	To identify students' perceptions of the use of online learning systems provided by their universities.	Implementation of an online survey among 206 Romanian undergraduate and graduate university students.	Approximately 70 % of the students surveyed did not have extensive prior experience in e-learning, the majority of the students in the sample claimed that e-learning platforms enabled them to achieve their assignments faster and also improved the quality of their work to some extent, while having fun studying.
Dewi et al. [37]	To provide an overview of the amount and development of e-learning research in education.	Qualitative descriptive method, investigating the state of an object, situations and processes of thought, function and perception.	According to the findings, e-learning is prominent and marked by an increasing degree of collaboration of authors from diverse subject areas, but with insufficient foreign research collaboration.
Agbo et al. [5]	To examine the research landscape of intelligent learning environments.	A bibliometric approach was applied to analyse the data to obtain a comprehensive overview of the trend, thematic focus and scientific output in the field of intelligent learning environments.	The study provides a useful contribution to the field by clearly presenting a comprehensive overview and critical points of research, thematic focus and future direction of the field.
Xu - Jiang [27]	Propose a personalised recommendation algorithm for online educational resources based on knowledge association.	Development of a personalised recommendation algorithm for online educational resources based on knowledge association.	The resource recommendation accuracy of this method can reach 97%, the recommendation time is less than 5.0 s and users are more satisfied with it, indicating that its recommendation effect is good.
Estriegana et al. [33]	Examine the acceptance of technology by learners and the adoption process of a game-based online learning environment.	Responses to an online questionnaire (n=223) were analysed using structural equation modelling. The study was based on the Technology Acceptance Model (TAM), but included and evaluated other factors such as perceived efficiency, playfulness and	It was confirmed that the TAM extension provides a useful theoretical model to help understand and explain user acceptance of an online learning environment that incorporates virtual laboratory and practical work.

		satisfaction, which are not explained by the TAM.	
Almaiah et al. [19]	To investigate the main determinants that could play a significant role in increasing the use and acceptance of e-learning systems among Saudi students.	The study employed the Unified Theory of Acceptance and Use of Technology (e-UTAUT) model and introduced new constructs to study the acceptance of e-learning systems in the Saudi context.	Course design factors, course content support, course evaluation and instructor characteristics were shown to have a significant effect on the actual use of e-learning systems.
Marks et al. [24]	To explore the maturity of the digital transformation and the post-COVID-19 challenges.	The study triangulates findings from multiple research instruments, including surveys, interviews, case studies and direct observation.	The results show significant variation between respondents' perception of digital transformation maturity levels and the basic requirements of digital transformation maturity.
Nonthamand [25]	To synthesise the literature related to video conferencing education. To study expert opinions on videoconferencing instructional design and use as a guide for instructional videoconferencing design.	Quantitative phenomenology study sample group in this research is 25 experts with an academic position with at least 15 years of experience in teaching technology and educational communication.	The research shows that the instructional design model using videoconferencing consists of connected elements where each element is linked together and becomes an integral part of the other, namely: teaching strategy; instructor preparation; media and technology; case study and group process and; brainstorming activity.
Morchid [17]	To reveal areas of convergence and divergence in the field of technology acceptance research.	The fundamental structures of different models of technology acceptance are presented on a comparative basis describing the progress made from one model of technology acceptance to another.	The results gave evidence of reciprocity and mutual agreement between the models of technology acceptance that were investigated.
Amarneh [30]	To provide insight into trends on the influence of e-learning in times of pandemic.	Analytical literature review of research on the advantages and disadvantages of e-learning.	Due to this pandemic, switching to e-learning platforms became the safest option for continuing the educational process.
Reimers [10]	To support the decisions needed to develop and implement effective educational responses in the context of the COVID-19 pandemic.	Rapid analysis of emerging educational needs and responses in 98 countries, identifying the most salient needs that should be addressed and managed, as well as the thematic areas most likely to present challenges.	The report suggests that those who run educational systems and related organisations develop educational continuity plans to be implemented alternatively during the necessary period of social isolation.
Mahlow [18]	To raise awareness of current trends in digital pedagogy, digitisation and digitisation of learning environments in higher education.	Dialectical analytical description of the development of technologies and their linkages in higher education.	The central task of higher education institutions is to model complex networks of digital skills (critical thinking, media literacy, intercultural competence, etc.) as a basis for creating contextualised learning scenarios in the disciplines.

The criteria for inclusion were empirical research and reviews, conference papers, books or manuals, publications from the period 2019-2022, the period in which the pandemic had its greatest peaks; studies that show the use of AI in the field of higher education; studies with a bias towards

pedagogical innovation; studies that highlight the achievements and challenges generated; studies that explicitly refer to the implementation of machine learning algorithms; studies carried out for lower levels of education; studies that approach the subject of innovation in machine learning algorithms; studies

that are explicitly related to the implementation of machine learning algorithms; studies carried out for lower levels of education; and studies that are related to the subject of innovation in machine learning algorithms.

As exclusion criteria, the following were chosen: studies that explicitly refer to the implementation of machine learning algorithms; those performed for lower levels of education; those that approach the subject of innovation generically; and those that were far from evaluating the issues surrounding AI in the field of higher education or that lacked innovative proposals were excluded.

According to the criteria adopted, and based on the presentation of the title, 114 articles (after the elimination of eighteen duplicates among the databases) were suitable. After scrutinising the abstracts, 75 were discarded because they focused on cases of applications to particular courses where AI was applied ( $n = 39$ ), because they were not empirical studies involved in pedagogical or research applications of AI (23) and those whose contributions did not fall within the time period of the pandemic (13). Finally, 39 articles met the inclusion criteria and were selected for the development of this systematic review

### **3. Development**

#### **3.1 Transformations in higher education**

There is no doubt that developments have the potential to catalyse the transformation of higher education through the adoption and adaptation of digital technologies and online supports [3]. Confinement has highlighted the need for e-learning, which became critical when educational institutions forced to stop their face-to-face teaching and learning practices [11,17] and opt for emergency remote learning [15].

On the other hand, digital transformation is concerned with transforming organisational processes, building new competences and models through digital technologies in a deep and strategic way [18]. According to most studies of technology adoption, a considerable percentage of colleges and universities have experienced problems related to educators' experience with the use of technology for teaching and learning [4,6,19]. According to Orr, Luebcke, Schmidt, Ebner, Wannemacher, Ebner and Dohmen [20], the particular challenge of the 21st century is to ensure that everyone in society benefits from the increasing integration of digitisation into society.

The pandemic has precipitated monumental changes in higher education institutions, forcing them to shift from traditional face-to-face learning to the use of digital systems, including remote learning [7]. In response, the adoption of distance learning has become a widespread model to address the educational need and confinement associated with COVID-19, as this methodology is suitable for use in remote or hard-to-reach environments [21]. On the other hand, Ashour, El-Refae

and Zaitoun [22] reported that many universities have not been able to make strategic changes towards online teaching, but have shifted towards online development using the same curriculum and content as traditional teaching, i.e. only the format has changed, not the content. However, the adoption of technology for distance education is essential for the efficient validation of the conduct of web-based classes.

Jaques, Ouahabi and Lequeu proposed one of the crucial dilemmas of higher education in times of pandemic [13] regarding how can we guarantee that the transmission of knowledge through a distance course is of sufficient quality? In this regard, the aforementioned authors stated that the teaching style specific to virtual environments must necessarily employ the most diverse and innovative methodologies in order to fully involve students and help them achieve the main pedagogical objectives, namely successful learning and the acquisition of relevant skills. While it is true that the teacher will always seek ways to facilitate learning, there are certain negative aspects regarding the effort made by teachers in the process of designing effective virtual classrooms is of paramount importance, such a process is much more time consuming compared to face-to-face teaching leading to a marked burnout [23].

Another dilemma related to the evaluation of developments could be stated as, Is it possible to quantify the level of maturity of digital transformation in higher education institutions? In this regard, the work done by Marks, Al-Ali, Atassi, Elkishk and Rezgui [24] used Deloitte's digital maturity assessment framework and Pekovits' mapping of key megaprocesses; It could evidence a significant variation between the perception and requirements of digital transformation maturity. The institutions examined did not have an adequate digital transformation vision, leadership, strategy, plan, processes, controls, approach, communication or return on investment, and recommended that these aspects be taken into account in order to develop an adequate alignment process.

As a result of the COVID-19 pandemic crisis, mobile learning has become the essential instructional platform in numerous schools, colleges, universities and other educational institutions around the world [4]. On this point, Saleem [8] unveiled the most salient challenges that mobile learning and remote education is exposed to in various locations around the globe, such as students are often distracted, teachers were not sufficiently trained and the technological infrastructure was far from being fully ready to cope with the predicament.

The process(es) of transition to new educational contexts based on the use of technological resources has been far from straightforward or easy to adapt to. There are complications related to adopting technological competences process of students and/or teachers because web-based methods



and resources conducted class sessions, so that the adoption of technologies could affect other teaching and learning factors, such as learning strategies, learning contexts and technology availability [4,6,13]. In addition, we should note that the effort required by the teacher to design effective virtual classrooms is very significant and requires much more time than in the case of face-to-face teaching [13,25].

On the other hand, Rahim [26] has proposed a path for education that is growing with the help of ICT and AI, highlighting Education 5.0 (fifth generation), which should be on a par with the fifth generation of the industrial revolution (IR 5.0), which hypothesises that Knowledge is downloadable, but whose assimilation is still distant for third world nations in relation to experts and adequate technological support, but this hurdle can be overcome as there is no limitation in the advancement of ICT and AI [27]. The analytical-predictive study on the future of higher education focusing on institutional reforms in higher education developed by Orr, Luebcke, Schmidt, Ebner, Wannemacher, Ebner and Dohmen [20] considered technological developments in society as one of the drivers of the future of higher education as the expectations of future higher education can be classified into three different perspectives: (a) economic, where the future of universities would be contingent on the requirements of the labour market; (b) educational, which addresses the role of learning, skills and competences that should be acquired to succeed in the labour market and; (c) the development of ICT.

The digital transformation in education is inevitable. In order to ensure the digital transformation process, higher education institutions must engage experts in order to align institutional requirements with the digital transformation and furthermore establish a clear vision, policies, strategies and plans to support the mature digital transformation. On the other hand, Marks, Al-Ali, Atassi, Elkishk and Rezgui [24] suggested that such transformation should no longer be a task handed over to IT staff or parceled out to data owners. To this end, the difference between automation and digital transformation must be communicated, and it must provide the necessary training and awareness.

### **3.2 AI and its implication for academic development**

The efficiency of higher education institutions began to change due to the different level of development of digital technologies in higher education institutions, the degree of their introduction into the educational process and the use of AI in university management and student training [28,29]. Such aspects tended to affect the quality of education, image and competitiveness of universities as a high-tech educational organisation included in the world map of science [30].

According to Saleem [8], the global pandemic has relegated students to depend on technology for their education

unprecedentedly, which is highly susceptible to be greatly enhanced by AI and machine learning algorithms. Such an event has also forced students to rely on technology for their education unprecedentedly, and these technologies could be greatly enhanced by AI and machine learning algorithms. Thus, AI could help teachers personalise a course curriculum for each student based on their unique abilities and weaknesses, and could also be used to develop more complex and engaging methods of student assessment [16].

On the other hand, virtual tutors and other AI-generated study assistants could help students manage their coursework independently of teacher intervention [16]. According to Wahyono, Putranto, Saryono and Asfani [31], virtual tutoring and other AI-generated study assistants could help students to manage their coursework independently of teacher intervention. They also suggested that AI could help teachers to customise a course curriculum for each student according to their own abilities and weaknesses, as well as being suitable for developing more engaging and complex methods of student assessment.

Digital technology developed based on AI, virtual reality (VR) and simulation software has also been applied to enhance learning experiences [3]. On the other hand, mobile learning technologies offer viable web-based teaching and learning platforms that are easily accessible to teachers and learners worldwide [4]. In this regard, Jacques [13] asserted assertively that the e-learning style of teaching must necessarily employ multiple innovative methodologies in order to fully engage learners and put them on track to achieve the main pedagogical objectives such as achieving successful learning and acquiring relevant skills.

Another issue in higher education during the epidemic that teachers face is having an insight into students' participation and checking whether they have committed plagiarism in their homework, since, in most existing systems, it is difficult to get status updates on a student's learning progress; issues that could be summarised as: what are the best tools to assess the knowledge and skills gained at a distance and how to ensure their relevance? A viable attempt to solve this dilemma was proposed by the work of Wu, Chien, Chien and Yang [32] by employing AI to predict plagiarism in 226 students in a programming course during the pandemic. They designed a novel method that combined program code parsing trees and fuzzy membership function to detect plagiarism combined with a convolution neural network that allowed which students scored high by programming in Python. The data was randomly separated into training data and test data over twenty runs. The average accuracies of the experiment for predicting which students have high-class loyalty are 95% and 92.74%. The experiments showed that the method not only

detects plagiarism, but can also detect which students are diligent.

### **3.3 AI and intelligent virtual laboratories**

Despite the many positive points of the new learning environments, the teaching style of virtual education must make use of various innovative methodologies to engage students and help them achieve the main pedagogical objectives, successful learning and acquire relevant skills [13]. Using ICT in the educational environment has made it possible to facilitate classroom learning and improve students' competences and skills, such as practical skills in using tools in the laboratory [31]. An attractive possibility for improving online learning would be to develop AI-based learning technologies [16]. Vinichenko, Vinogradova, Nikiporets and Rybakova [29] stated that information and digital technologies, active implementation of artificial intelligence (AI), development and competent use of human potential are among the main sources for overcoming crises and achieving high competitiveness; it is undeniable that all these solutions are in the educational sphere.

An illustrative model for the use of AI and virtual reality in learning can be described through applying virtual laboratories. Virtual reality supports comfort in learning practical knowledge, allowing students to feel the authenticity of the devices and stimulating real professional experiences [32]. Lab learning based on the user's requirements and skills as needed is the learning model known as personalisation.

Wahyono, Putranto, Saryono and Asfani [31] conducted research in which they developed a virtual lab under the personalisation model using AI tools for electrical engineering students using AI, where students can interact with the lab according to their skills and preferences. The AI called *Algoritma* used in this virtual lab is an expert system that allows students to be classified according to their abilities and which modules they can use according to their abilities. In addition, students can select, according to their preferences, which module they prefer based on ranking the expert systems. The test results of this virtual laboratory got accuracy values, according to the users, of 90.8%. Therefore, the researchers suggested that there is a need for intelligent virtual laboratories with minimal use of resources that allow students to interact according to their abilities and willingness to practice in these laboratories as they would in real laboratories.

### **3.4 AI and intelligent virtual laboratories**

In recent years, AI has generated increasing interest from both academics and practitioners, which has supported the emerge of new approaches and development opportunities [34]. Significant changes are taking place in the quality of education and the image of universities using distance education and AI [29]. A clear example of AI publication trends related to the

application of AI to COVID-19, is exposed by the longitudinal bibliometric analysis of 729 research articles from the years 2020-2021 conducted by Islam, Poly, Alsinglawi, Lin, Chien, Liu and Jian [35] in which it was referenced that the Republic of China (26.06%), USA (23.73%) and India (12.62%) were the countries that were in the forefront.

Many of the dilemmas that have arisen in higher education because of the pandemic-induced, disorderly transition to online learning (such as students' challenges to self-regulate their learning, the increase in curriculum planning and the administrative overload of teachers' work), losing personalised interaction between students and teachers, and losing the ability of students to interact with each other in a more personalised way, are all factors that have led to the emerge of a new online learning environment, losing personalised interaction between students and teachers) can be addressed by AI and machine learning, as by providing more personalised, flexible, inclusive and engaging learning experiences, AI has the potential to revitalise students and teachers, making the virtual classroom environment more meaningful and productive [16, 38].

The study developed by Morales et al. [36] sought to estimate the design of a predictive model of stress in the educational context based on AI to evaluate and estimate the relationship between certain sociodemographic variables, coping strategies and resilience capacity; for which they worked with 337 Spanish university students selected by non-probabilistic sampling. Regarding the design of the support or architecture of artificial neural networks, they estimated that students' stress levels could be predicted with over 80% using the synaptic weights of coping strategies and the pandemic model (before and after isolation) once the neural network model was estimated. The researchers concluded that, once they identify the variables with the highest predictive power related to stress, it becomes more workable to design prophylaxis processes of considerable efficacy.

## **4. Conclusions**

The COVID-19 pandemic has brought with it several challenges in the higher education sector and a pressing need for solutions, and while many responses were temporary, it has now been established that there is an urgent need for more holistic research to generate models for optimising AI-based online learning systems. Insights into novel learning contexts can shed further light on the role of digital technology in teaching and learning processes and, as the corresponding technological supports are further developed, their potential usefulness will lead to future technology-mediated higher education provision.

The promising field of AI in the education sector, in higher education, is very encouraging and, because of the

plasticity of adaptability to respond to the demands of both teachers and students, the innovative field of improved algorithmic approaches to expert systems will enable AI-based applications to emulate decision making for instructional strategies, assessments and evaluations based on the analysis of context and student needs. Virtual reality designed for entertainment also enables mind-immersive applications to see user engagement. This application allows educators to take advantage of virtual reality technology to induce mental immersion of learners in engaging in learning activities.

Today's organisations operate in a massive connected world, and their stakeholders expect seamless and personalised digital services. It is therefore necessary in the post-pandemic situation to boost the development and use of so-called e-learning and the massification of AI-generated applications so that it can become an integral part of the higher education system. Universities will therefore need to be prepared for a challenging post-pandemic journey, where the choices they make will shape and guide the future of their students. University communities will need to reflect on their educational vision and mission to ensure that student learning outcomes and educational quality standards are not compromised. Higher education institutions and universities need to plan post-pandemic education and research strategies, reinforcing this process with mechanisms linked to AI.

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