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CONTENT

Beyond the digitalization and digital transformation initiatives that companies in all industries have been implementing for decades, accelerated by the COVID-19 pandemic, there is still a huge digital divide. The education sector, particularly higher education, has not remained unaffected by this.

Universities today have great challenges to face: virtual and physical environments, changing demographics, attractiveness to applicants, improved student experience, data analysis (especially in real time), exploring new business and operating models, and ways to promote research.

The advent of new digital trends represents an opportunity to reduce this digital divide and to provide an appropriate response to the challenges posed; however, many technologies mature progressively; therefore, there are still products and services undergoing a process of evolution with a use case basis and experiences still under construction.

In this edition of the Technological Observatory bulletin, we take a look at technologies that promise to solve diverse needs of higher education. Many of them are ready to be used in the form of commercial products or digital services; others still need to be combined with other technologies or can be validated at an experimental or proof-of-concept phase.

These technologies are expected to help make major leaps in the digital evolution of universities; therefore, it is appropriate to take a first step to understand them and then start testing them directly and confirm if they are the answer to the challenges we currently face.

EMERGING TECHNOLOGIES FOR HIGHER EDUCATION

The technologies covered in this bulletin can be found at the following intersections between the administrative and academic fields of any university.
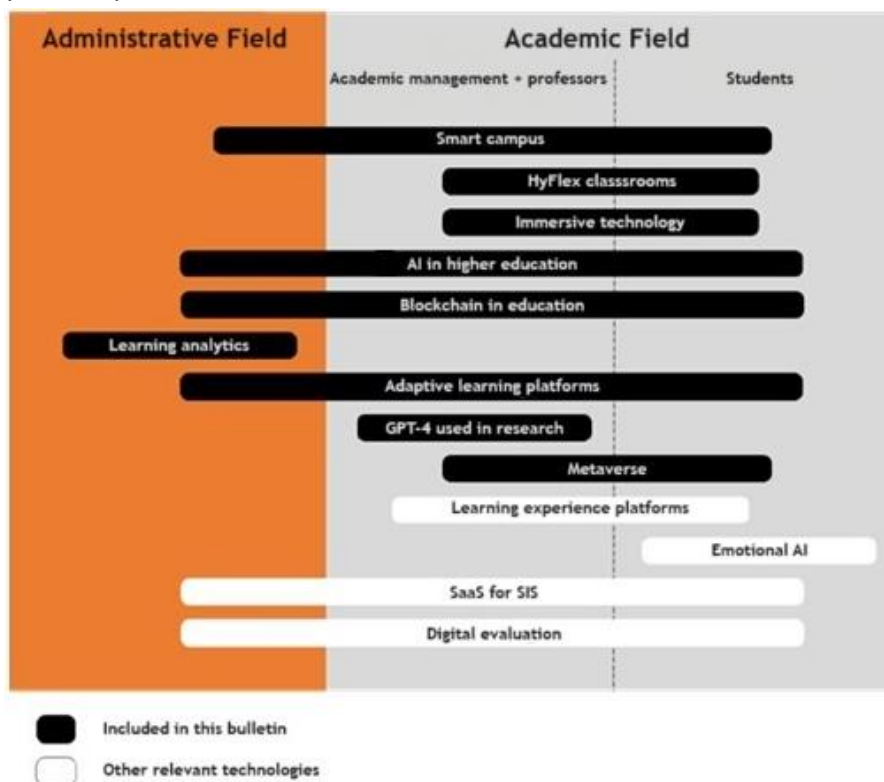
Likewise, the technologies addressed can be associated with the various challenges faced by universities.

Technology / Challenges	Virtual and physical environment	Changing demographics	Attractiveness to applicants	Improved student experience	Data analysis (even in real time)	Exploring new business and operating models	Promoting research
Smart campus	●	●	●	●	□	●	○
HyFlex classrooms	●	●	●	●	□	●	○
Immersive technology	●	○	●	●	□	●	○
IA in higher education	○	●	○	○	●	●	○
Blockchain in education	○	○	○	○	○	●	○
Learning analytics	○	●	□	●	●	●	□
Adaptive learning platforms	○	●	□	●	●	○	□
GPT-4 used in research	○	○	□	□	○	□	●
Metaverse	●	□	●	●	□	●	□

- ● High impact
- □ Medium impact
- ○ Low impact

SMART CAMPUS LINKED TO SUSTAINABILITY

A smart campus is a physical or digital environment in which humans and technology-enabled systems interact to create more immersive and automated experiences for university stakeholders (Costello, 2019).

It is a campus where the university is actively developing and testing new solutions to acquire, transmit, store, analyze, visualize and automate responses to the multitude of data that it manages on a daily basis to improve its business processes in a variety of ways, namely in managing sustainability metrics and identifying efficiencies in operations and maintenance (Sustainable Stanford, n.d.).

Fundamental pillars to build a smart campus (Bonderud, 2022)

Infrastructure
- Wireless and wired high-speed connectivity
- Access to computing capacity for students and professors
- IoT-based deployments

Applications
- Flexible web portals for quick access to institutional services
- Interoperability

Security
- More points of service
- Multi-factor authentication

Biometry
- Intelligent threat detection
- Rapid incident response

Some successful examples:
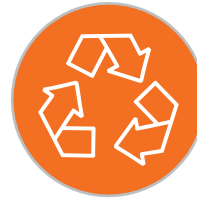
University of Birmingham (United Kingdom)

Nanyang Technological University (Singapore)

University of Wollongong (Australia)

Energy Efficiency
- Sensor implementation
- Energy management systems
- Automation
- Optimization of energy consumption

Smart Waste Management
- Sensors and monitoring systems
- Improved waste management

Smart Building Technology
- Automation and management
- Optimization of energy consumption
- Indoor air quality
- Efficient use of resources

Research and Collaboration
- Promoting research and collaboration on sustainability issues

Benefits of a smart campus versus a traditional campus.
Source: Own elaboration.

HYFLEX CLASSROOMS

HyFlex refers to an educational methodology proposed by Brian Beatty in 2006 and that has become popular after the COVID-19 pandemic thanks to the increased introduction of virtual platforms based on "hybrid-flexible" education.

Its implementation can provide positive psychological benefits in students as it has a positive impact on factors such as autonomy and confidence in their abilities (Mentzer et al., 2023). However, it is important to provide students and professors with an appropriate training in the use of this technology. Both should be familiar with cameras, microphones, chat functions, breakout rooms and online resources to get the most out of the HyFlex learning experience. Similarly, it is important to create an environment conducive to interacting in class (Athens, 2023).

Beatty (2007) presents four principles to explain the methodology with which he hopes to improve, aided by technology, professor-student relationship and student's grades:

Possibility of student choice	Currently, there are different teaching modes such as online, in-person or blended learning.
Equivalency	It is important to remember that online learning is completely different from in-person learning; therefore, teaching and evaluation methods must be different to be effective.
Reuse	The existing material in the different types of teaching modes should be reused for similar topics. It cannot be "disposable."
Accessibility	HyFlex classrooms are intended to give students complete freedom to choose their preferred teaching methodology and thus improve students' access to classes without interfering with their comfort.
Beatty also proposes six aspects for the creation of HyFlex courses:	1. Goals 4. Communication 2. Results 5. Expectations 3. Gathering and creating content 6. Enabling learning environment

IMMERSIVE TECHNOLOGY

Immersive technologies refer to computer systems that enable a more intuitive human-computer interface through devices and sensors that interact with up to the five human senses (Fernandes et al., 2023).

Within the immersive technologies, there are three that are the most popular and currently have the greatest level of development:

Virtual Reality (VR)

VR is a simulated 3D environment that enables users to explore and interact with a virtual surrounding in a way that approximates reality, as it is perceived through the users' senses (Oxford, 2023).

Augmented Reality (AR)

AR superimposes a computer-generated output, such as images or sounds, on a user's view or experience of the real world through any electronic means (Oxford, 2023).

Mixed Reality (MR)

MR is a medium consisting of immersive computer-generated environments in which elements of a physical and virtual environment are combined (Oxford, 2023).

Possible uses in higher education:

Architecture:
Building of virtual cities

Medicine:
Surgery simulator

History:
Dinosaur island adventure

	Virtual Reality	Augmented Reality	Mixed Reality
Environment	3D simulated	Real	Real
Allows interaction with generated elements	Yes	No	Yes
Uses physical elements for the creation of an environment	No	Yes	Yes
Senses used	Sight, hearing and touch	Sight, hearing	Sight, hearing and touch

Comparative table of the types of immersive reality.
Source: Own elaboration.

AI IN HIGHER EDUCATION

Artificial Intelligence (AI) is transforming higher education. By using AI, academic institutions can customize the learning experience to provide students with recommendations and resources tailored to their individual needs. In addition, AI can help educators to analyze large amounts of data, such as student assessments and feedback, in order to identify patterns and trends, which will enable them to adjust their teaching methods and improve the effectiveness of the learning process.

It was demonstrated that the implementation of AI systems in the classroom can significantly improve academic performance, as well as increase student engagement and motivation for learning (Crompton & Burke, 2023), and that more perspectives on this new technology are needed in the educational field because, while it is seen as a promising technology at the moment, it still carries learning risks that educators and classroom designers need to begin to integrate (Zawacki-Richter et al., 2019).

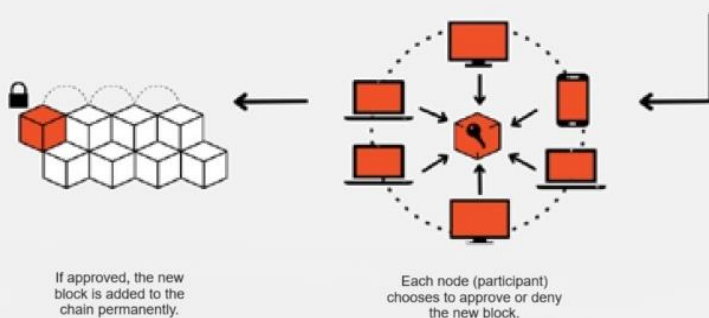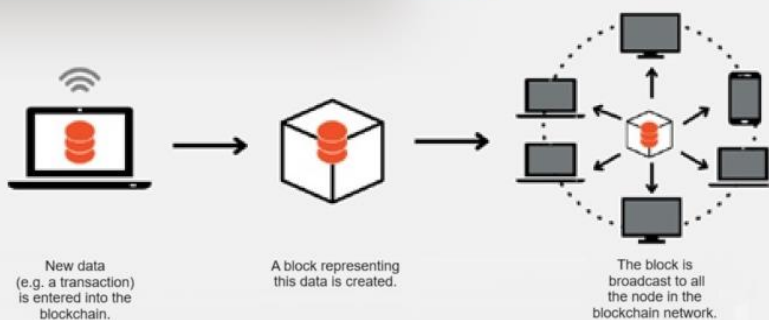| Administrative Field	Academic Field	
	Academic management + professors	Students
Scale education to more areas	Creation of new courses and modules	Customized virtual assistants
Optimize Student Journey	Performance analysis	
Optimize Professor Journey	Creation of multimedia content	
Intelligent Automation for administrative tasks	Promoting research	
Data analysis and automated decision-making		

BLOCKCHAIN IN EDUCATION

Blockchain is a database distributed across a network of nodes used to help maintain a secure and decentralized record of transactions (Hayes, 2023).

Below are some data that could use blockchain for transmission in higher education:

- Accreditations and certifications
- Academic records and transcripts
- Digital and student identities
- Payments and transactions
- Micro-credentials and badges
- Research papers

Blockchain Process

New data (e.g. a transaction) is entered into the blockchain.

A block representing this data is created.

The block is broadcast to all the node in the blockchain network.

If approved, the new block is added to the chain permanently.

Each node (participant) chooses to approve or deny the new block.

Blockchain validation process
Source: Money.com.

Imagine there is a group of five friends gathered in a circle with a coin. Friend 1 passes it on to friend 2 in full view of everyone, so that if either of them is asked who has the coin, they will answer together as one: "Number 2 has it." Friend 2 can pass it on anyone he/she wants or keep it and the others will always know who has it, so that if an outsider comes up and says to number 3: "Number 4 has the coin," he/she will ask the question and will notice that the record is not true and, therefore, a lie: Number 2 has it. Now, if we change friends to nodes, the coin to any data passing through the blockchain and the outsider who approached to a fake record such as a hacker, we can understand why blockchain is considered to be a fairly secure system and how it makes such large transactions with coins, including bitcoin.

LEARNING ANALYTICS

Learning analytics refers to the use of data analysis techniques and AI tools to collect, analyze and visualize information, primarily to understand and improve training and management processes in university education and at all levels (Ouyang et al., 2023).

While the field of AI is constantly evolving, learning analytics is a determining factor in this field as it can analyze a large amount of data to predict undesirable factors and strategic factors in order to contribute to improve the performance of educational processes (Caspari-Sadeghi, 2023).

Because it is a new field, it faces some challenges (Issah et al., 2023):

Legal Issues
The collection and processing of students' data may have legal barriers.
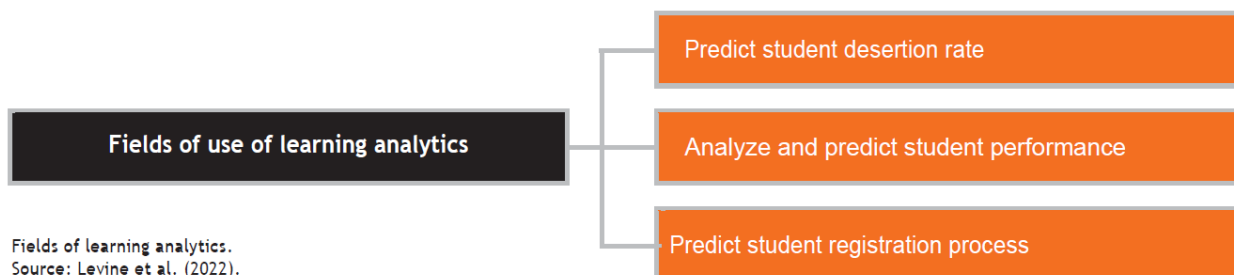
Transparency
Some algorithms lack transparency due to their "black box" nature as data are entered and results are generated, but it is not possible to identify or track what criteria are used to arrive at such results: this is true for machine learning.

Ethics and Privacy
Frequent access to data sources is required about students who have the right to be informed about what data are gathered about them.

The most commonly used methods and algorithms are **classification and decision trees, clustering, fuzzy logic, neural networks, deep learning** and **random forest**.

Fields of use of learning analytics	Predict student desertion rate
	Analyze and predict student performance
	Predict student registration process

Fields of learning analytics.
Source: Levine et al. (2022).

ADAPTIVE LEARNING PLATFORMS

An adaptive learning platform is a software that uses AI and machine learning to customize the learning experience for each learner. This means that the platform adapts the content, assessments and feedback to the students' needs and learning style.

Adaptive learning platforms can be used for a variety of purposes, including the following:

Training of New Skills

It can be used to train new students on course policies, procedures and products.

Continuous Learning

It can used for continuous learning to extend and integrate knowledge and skills from undergraduate to extension and graduate courses.

Adaptive learning platforms offer a number of benefits compared to traditional learning methods, including the following:

Tailored Learning

It customizes the learning experience for each learner, which can help them learn more effectively.

Greater Participation

It can increase student participation by providing relevant content based on their interests and learning style.

Better Retention

It can improve student retention by offering immediate feedback and opportunities to practice what they have learned.

Cost Reduction

It can reduce training costs by providing a more efficient and effective way to deliver training.

Tailored Learning
Customize the learning experience for each learner.

Greater Participation
By providing relevant content based on their interests.

Better Retention
By offering immediate feedback.

Cost Reduction
By providing a more efficient and effective way to deliver training.

Benefits of adaptive learning vs. traditional learning methods.
Source: Own elaboration.

Some of the most popular learning platforms are **Knewton, DreamBox, Smart Sparrow, ALEKS (Assessment and Learning in Knowledge Spaces)** and **Cerego**, among others.

Adaptive learning research is focused on the study of motivation, preferences and learning styles, especially from students (Agreda Montoro et al., 2019). García-Ros and Pérez-González (2011) confirm in their study that students who prefer non-conventional training approaches maintain a deeper and more elaborated learning style as they show greater motivation, high academic self-efficacy and greater appreciation for learning tasks.

GPT-4 USED IN RESEARCH

Perplexity is an AI chatbot similar to ChatGPT. It is another tool that saves part of the time that is usually spent to identify concepts, trends and opportunities on the topic under research, with their respective references. Its main strength is that it searches the Web in real-time, i.e., it offers up-to-date information. Consequently, it can show innovative paths. Another interesting characteristic is that if you consider that the prompt (or query) was very open-ended, before answering it provides a series of alternative paths in the form of checkboxes so that the request can be better delimited.
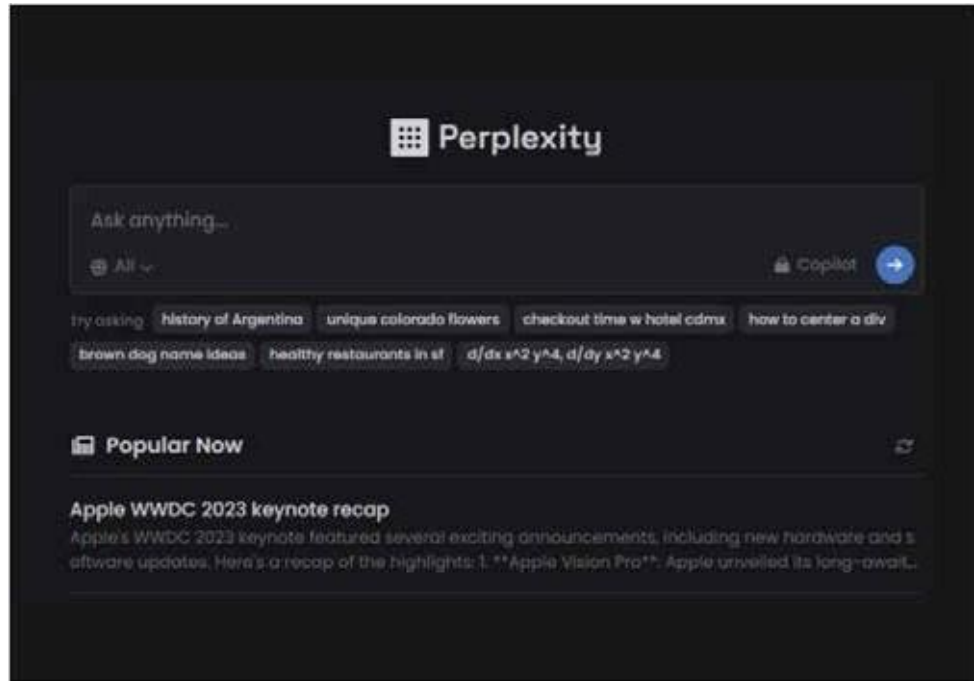
Author: Professor Guillermo Dávila.

In our user experience, we have not seen much inaccurate information as is the case with other generative AI tools. However, like other tools, it has been found to provide inaccurate answers. In some cases, it may not present all the relevant references expected; and in other cases, the information presented may be very general. The creation of a user and the respective feedback we give to the tool can accelerate its learning curve.

Evaluate your productivity with this tool although we do suggest that it does not replace a good literature review process.

Specifications	ChatGPT	Perplexity AI
Purpose	The main purpose of ChatGPT is to interact with users in a conversational way.	Search and answer engine that sends concise answers to complex questions.
Costs	ChatGPT Plus is priced at $20 per month.	It is free of charge for all its users.
Uses	It is used to write codes, make calculations, translate information and more.	It is used to generate text, recognize speed and translate.
Model	It is based on OpenAI GPT-4 model.	It is based on the OpenAI GPT-4 but with a search engine interface.

METAVERSE

Metaverse represents a three-dimensional space shared with other users and implements a "digital reality" parallel to real world.

Metaverse itself is designed to achieve an immersive experience; however, it is possible to create immersive digital solutions without the need for a metaverse.

Examples of metaverse are Meta Horizon Worlds and Horizon Workrooms (Meta, former Facebook), AltspaceVR (Microsoft), Nvidia Omniverse (Nvidia), Roblox (Roblox Corporation), Metaverse City (Second Life).

Examples of immersive technology without using a metaverse necessarily are headsets such as Microsoft HoloLens 2, Oculus Meta Quest 3, Apple Vision Pro, as well as companies such as Alchemy Immersive, Engage XR, IndyLab VR, InstaVR and Nearpod.

The combination of both technologies could achieve a seamless interaction between real world and digital world. For example, we could analyze information from a real environment using augmented reality capabilities to then enter a virtual reality space, in a metaverse, that make it possible to analyze the information in a digital simulation based on reality.

Some opportunities could come in the form of a spatial computing (virtual reality classes), gaming ("serious games" for training), digital humans (student services), virtual spaces (virtual events, congresses and conferences) and shared experiences (immersive meetings), among others.

Why isn't metaverse taking off? Let's compare it with the Internet and the Web in the table on this page.	
Metaverso	**Internet + Web**
Several metaverses, silos, non-interoperable	A single global Internet
Technological fragmentation, various alternatives	Technologies to interoperate: HTTP, HTML, DNS, etc.
Absence of governance of the metaverse	Internet Corporation for Assigned Names and Numbers (ICANN) and other organizations establish definitions and order
To maximize its use, a headset is required	For its use, a PC or a mobile device with at least one browser is required

APPLICATIONS OF AI IN EDUCATION

In order to denote the advancement of AI in education, it is appropriate to identify its intervention in intelligent tutoring systems, educational recommendation systems, adaptive learning platforms, educational virtual assistants, automated feedback of answers, etc. These fields of intervention have given way to the development of applications and knowledge generators designed by AI applied to education. Some examples are presented below.

IBM Watson Education
Artificial intelligence platform that provides virtual assistance to students and professors.

It allows customized learning environments, as well as analysis and processing of large amounts of educational data.

Wolfram Alpha
Computational knowledge engine designed to understand questions in natural language and provide data and algorithm-based answers.

OpenAI GPT-3
GPT-3, which is the architecture of ChatGPT model you are interacting with, can also be used to generate knowledge in an educational context.

Gradescope
Assessment tool that uses AI techniques to reduce and improve the time associated with grading exams, homework and assignments.

SMART Learning Suite
Educational software platform that integrates AI technologies to enhance the learning experience through interactive tools, such as digital whiteboards and educational games, by providing personalized feedback and guidance.

Adaptive Learning Platforms
They use AI techniques to customize the learning experience for each learner. Some examples are Knewton and DreamBox.

Carnegie Learning
Math and science platform that allows to adapt lessons and exercises to the needs and skills of each student.

Educational Recommendation Systems
Khan Academy's Khanmigo virtual tutor uses AI to facilitate and guide students on the platform.

Source: Castro (2023).

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