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Situated digital ecosystems: the key to driving the AI revolution in Education

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Abstract

This reflective conceptual paper explores the imperative need to create integrated and situated institutional digital ecosystems for the effective and transformative implementation of artificial intelligence (AI) in Higher Education. This article presents arguments demonstrating the failures of fragmented approaches to AI adoption and advocates for an integrative digital ecosystem that harmonizes technological, pedagogical, organizational, and ethical-legal dimensions. It emphasizes the importance of contextualizing these ecosystems within specific educational environments. The analysis reveals that the transformation toward integrated digital ecosystems is a strategic imperative for the reinvention of educational institutions. Such ecosystems are essential for leveraging the disruptive potential of AI technologies and aligning with the new paradigms of Education 4.0. The reflective conceptual paper underscores the critical role of AI and digital ecosystems in bridging the gap toward necessary radical changes in Higher Education, offering a novel perspective on the strategic integration of these technologies in educational settings.

Keywords: Artificial Intelligence. Higher Education. Digital Ecosystems. Education 4.0. Educational Transformation.

1 Introduction

Artificial intelligence (AI) is not just another technology; it is a truly disruptive revolution that is fundamentally transforming almost every sphere of human

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Received: Oct. 01, 2025
Accepted: Mar. 03, 2026

endeavour. The Education sector, far from being an exception, is in the midst of these profound and unstoppable changes. According to Gartner's analysis of Higher Education trends, Yanckello y Brown (2023) report that more than 40% of leading universities worldwide are actively experimenting with AI tools. However, numerous studies indicate that the current social, economic, and educational dynamics require not only the adoption of these emerging technologies but also the unleashing of a true systemic transformation at the very heart of traditional educational systems and models (Fernández-Cruz; Rodríguez-Legendre; Sainz, 2024; Mohamad *et al.,* 2024; Mthanti; Msiza, 2023; Peña-Ayala, 2021; Ramírez-Montoya; Portuguez-Castro, 2024).

Similarly, Abella García y Fernández Mármol (2024) emphasizes that the integration of Education with AI must go beyond simply adding new technological resources to traditional methods. It should foster educational transformation processes through the design of new learning experiences that lead integrally to the transformation of knowledge, cognition, and human cultures. In this regard, it is worth mentioning that this approach is increasingly becoming one of the main fields of research for current educational environments.

Rather than presenting empirical results or a formal literature review, this reflective conceptual paper offers a critical examination of why AI in Higher Education can only become educationally meaningful and institutionally sustainable when embedded in situated digital ecosystems, a challenge that must be understood within the urgent reinvention envisioned by Education 4.0.

1.1 Education 4.0: An Urgent Reinvention

Seen from this perspective, Education 4.0 is not simply another label for technological modernization, but an urgent call to reinvent Education in light of the disruptions associated with the fourth industrial revolution. As Souza and Debs (2024) argue, this transformation demands both the development of essential 21st-century competencies and a radical rethinking of outdated pedagogical paradigms. In a similar vein, Elhussein *et al.* (2020) in the *Schools of the Future* report, stress that educational institutions must evolve if they are to prepare learners for critical thinking, creative problem-solving, digital literacy, and lifelong learning. Accordingly, Education 4.0 should be understood as a systemic educational project that requires institutions to redesign the pedagogical, organizational, and technological arrangements through which learning is enabled in increasingly digital and AI-mediated contexts.

Considering the above, the advent of truly disruptive technologies such as AI opens an unprecedented array of opportunities; however, it also requires a profound holistic restructuring of educational systems as we know them, which must integrate not only new technologies but also innovative pedagogical methodologies that enable students to develop adaptive and transferable competencies. Thus, the implementation of AI in Education not only comes with promises of educational improvement in terms of personalized learning but also in facilitating the assessment and tracking of student progress more precisely and efficiently (Zainal Abidin *et al.,* 2023).

Furthermore, according to Karsen *et al.* (2022), the transition to Education 4.0 requires a collaborative and multidisciplinary approach involving governments, educational institutions, the private sector, and civil society, which is crucial to overcoming its financial and technological challenges and ensuring that all students have access to quality Education that prepares them for future challenges. In this regard, it is necessary to promote inclusive educational policies that consider socio-economic and cultural differences, thus ensuring equitable implementation of new technologies. On the other hand, continuous teacher training is an essential component of this transformation, as educators must be trained not only in the use of new technologies but also in pedagogical methodologies that foster active and participatory learning (Quintero; Magdaniel; Peñaloza, 2021). In this sense, teacher training should be an ongoing process that allows educators to adapt to rapid technological and pedagogical changes, thereby ensuring relevant and up-to-date Education for students.

Yet the promise of Education 4.0 cannot be discussed apart from the profound asymmetries that characterize today's world. The capacity to adopt AI and to build meaningful digital ecosystems is unevenly distributed across institutions, regions, and countries, largely because access to infrastructure, funding, connectivity, high-quality data, and specialized human talent remains deeply unequal. Under these conditions, the discourse of innovation may unintentionally obscure the fact that some universities are better positioned than others to experiment, adapt, and benefit from AI-driven transformation. For this reason, any serious educational reinvention must recognize that the transition toward Education 4.0 is not only a pedagogical and technological challenge, but also a political and ethical one, since without deliberate attention to structural inequalities, digital transformation may end up reinforcing rather than reducing existing forms of exclusion and marginalization.

1.2 Challenges on the path to educational transformation

Educational transformation faces multiple complex barriers and challenges that must be overcome to achieve its ideal. One of the main challenges is ensuring equitable access to quality devices and connectivity for both students and teachers. This challenge extends to the need for institutions to have robust technological infrastructure, including servers, data systems, and networks capable of supporting advanced applications (Celik, 2023; Perchik *et al.,* 2023).

Additionally, it is essential to address the continuous training and capacity development of academic staff in the didactic integration of AI. According to United Nations Educational, Scientific and Cultural Organization – Unesco (2023) constant teacher training is essential for effectively integrating AI into educational practices. This training should not only be technical but also pedagogical, allowing educators to use AI in a pedagogically effective manner.

Similarly, challenges related to access to quality data, effective governance, and privacy protection are critical, as AI heavily depends on data. Without proper management and protection of this data, it is impossible to maximize its potential in the educational field (Memarian; Doleck, 2023). In this regard, data privacy is a particularly sensitive aspect, requiring the establishment of standards and policies that protect individuals without hindering access to necessary data for improving educational systems. In the curricular domain, developing study plans that organically incorporate AI and align with real-world needs represents another significant challenge.

In this regard, Elhussein *et al.* (2020) emphasize the importance of designing curricula that not only include AI as a topic but also use its capabilities to personalize learning and improve educational outcomes. This requires constant updating of content and teaching methods to keep up with technological advances.

Additionally, there is the challenge of designing appropriate evaluation systems and metrics to monitor the real impact of these technologies on educational processes. In this area, Jafari and Keykha (2024) highlight the need to develop assessment tools that can accurately measure student performance and progress in an AI-supported learning environment.

Moreover, integrating AI into Education faces challenges beyond technical skills, such as significant issues related to the lack of basic competencies in literacy, arithmetic, digital skills, coding, and social and ethical skills. Although efforts are being made to include ethical and social competencies in educational

programs, their effective implementation faces difficulties due to cultural and socioeconomic differences, potentially leading to an increase in digital divides. This issue is exacerbated by the rapid obsolescence of technology, underscoring the need to reconsider more sustainable approaches (Abella García; Fernández Mármol, 2024).

1.3 The need for an integrative digital ecosystem: a race against time

The current need for advancing the formation of situated digital ecosystems is urgent and unavoidable. The latest Unesco (2023) global report on AI and Education warns that institutions that fail to develop and institutionalize these types of comprehensive ecosystems will be left behind, unable to train the talents demanded by 21st-century jobs and challenges. In this sense, it is pointed out that in an increasingly automated, digital, and volatile environment, the gap between rigid and outdated educational systems and changing socio-labour realities could exponentially worsen. Additionally, the financial investment necessary to provide hardware, software, cloud services, and training programs can represent a considerable barrier for many institutions with limited resources (Kshetri, 2023).

It is also crucial for this digital ecosystem to consider organizational aspects that facilitate continuous adaptation and innovation, and to have an organizational structure flexible enough to respond to rapid technological changes and new educational demands. This requires efficient resource management and a strategic vision that fosters collaboration and knowledge exchange among different educational actors.

Similarly, the ethical-legal dimension cannot be ignored in the creation of these digital ecosystems. From this perspective, the implementation of advanced technologies in Education must be accompanied by a regulatory framework that guarantees data privacy and security, as well as the ethical use of AI (Stahl, 2023). So, it becomes imperative to establish clear and transparent policies that protect students and teachers, ensuring a safe and equitable learning environment.

Finally, creating an integrative digital ecosystem requires a collaborative and multidisciplinary approach in which educational institutions must work together with governments, technology companies, and civil society organizations to develop innovative and sustainable solutions. Cooperation among these actors is essential to overcome financial and technological barriers and to ensure that all students have access to quality Education that prepares them for future challenges.

This collaborative vision, however, cannot be reduced to a merely functional coordination between institutions and external partners. Within Higher Education itself, the development of a situated digital ecosystem depends on the complex relationships among faculty, administrators, students, and technologies. Faculty members are not simply end users of innovation, but key pedagogical mediators whose professional judgment largely determines whether AI is meaningfully integrated into teaching and learning or remains superficial and resisted. At the same time, administrators play a decisive role in enabling or constraining transformation, since institutional strategies may either support educational purposes or impose technocratic agendas disconnected from the realities of academic work. Students, in turn, are not passive recipients of digital change, but participants whose learning conditions, agency, and access to support are shaped by how these institutional decisions are made. For this reason, the success of AI in Higher Education cannot depend solely on the availability of tools, but on the quality of the human, pedagogical, and organizational relationships through which those tools are interpreted, governed, and enacted.

1.4 Central Claim of this Conceptual Paper

Considering the aforementioned points, the central claim of this reflective conceptual paper is as follows: To achieve effective and transformative implementation of AI in Higher Education, the existence of an integrated and situated institutional digital ecosystem is required. So, What is an Integrated and Situated Ecosystem?

An integrated and situated institutional digital ecosystem refers to a cohesive environment within an educational institution that combines various technological components and practices to improve educational processes in a contextualized manner. This ecosystem is characterized by the integration of digital technologies such as online learning platforms, AI, and cloud services, allowing these tools to operate synergistically to support both teaching and learning. Moreover, it encompasses innovative pedagogical methodologies that use technology to enhance the quality of Education, promoting personalized and project-based learning.

This contextualized approach also involves adapting the digital ecosystem to the specific characteristics and needs of the institution and its environment, considering socio-economic, cultural, and geographical factors. Collaboration among different stakeholders, such as students, teachers, administrators, parents, and the community, is essential for the development and sustainability of the

ecosystem. Furthermore, the sustainability and adaptability of the ecosystem are crucial, requiring strategic planning and continuous investment in infrastructure and training.

The benefits of an integrated and situated digital ecosystem are numerous, including improved educational quality, equitable access to high-quality educational resources, personalized learning, operational efficiency, and preparing students with the skills needed to face the challenges of the 21st century.

2 Addressing the central claim of the Paper

The following are the main central arguments that support the need to design a situated digital ecosystem in Higher Education organizations:

2.1 Argument #1: Fragmented implementation of AI leads to failure

Despite the enormous transformative potential that AI has for Higher Education, numerous case studies and research show that attempts to incorporate these technologies in isolation or fragmented have a high risk of failure or at least difficult implementation (García-Peñalvo, 2023; Karan; Angadi, 2023; Qian, 2021; Wang, 2022).

In this regard, Patiño *et al.* (2023), Ojeda *et al.* (2023) and Sprockel Diaz *et al.* (2023) address the panorama of AI implementation in Education, where they point out various initiatives in several countries that sought to implement AI tools such as virtual assistants, intelligent tutoring systems, automatic assessment, etc. As part of their findings, it is shown that in the vast majority of cases, when these technologies were incorporated in a disjointed manner from other processes and without a systemic vision, they ended up being underutilized, abandoned, or their effectiveness ended up being irrelevant.

Similarly, Lara *et al.* (2023) and Zamora Varela and Mendoza Encinas (2023) indicate that studies on the state of AI in tertiary institutions in different countries show that in those cases where AI solutions were only adopted reactively without redefining their academic and operational models, they rarely achieved a significant impact on learning improvement.

These examples illustrate how the deeply disruptive nature of AI requires a holistic and integrated implementation that goes beyond buying and installing software

or devices. In that sense, profound systemic transformations are needed for this technology to express its full potential in Higher Education.

2.2 Argument #2: An integrated digital ecosystem enables optimal utilization of AI

Precisely, to overcome the limitations of fragmented approaches, various studies point to the need to create integrated institutional digital ecosystems that articulate all the components required for a transformative implementation of AI.

In this regard, Teixeira (2023), notes that within the framework of digital transformation processes, it is essential to integrate various key aspects to ensure a better user experience for students. He emphasizes that these aspects include certain key dimensions, among them technological, pedagogical, organizational, and ethical-legal dimensions. It is interesting to recognize that as a synchronized integration of these components is achieved, it will be possible to harness the capabilities and promises of AI in university training processes.

This perspective is supported by Liu *et al.* (2024) who analyzed evidence published both in specialized journals and from the Horizon Report on educational technology trends. They highlight that the educational institutions that have been most successful in the transformative adoption of AI are those that have implemented an ecosystem approach that includes a combination of multiple resources and also face processes of updating their digital infrastructure, curricular renewal, data governance, and the creation of aligned and integrated institutional policies.

In this same line, studies such as those by Zhou (2023), Irfan *et al.* (2023) and Alenezi (2023) show the advantages and possibilities of implementing AI through integrated ecosystems that included aspects such as cloud resources, teaching innovation processes, AI ethics committees, and digital literacy plans for the entire community, among other components. These examples illustrate how an integrated digital ecosystem approach that coherently amalgamates all technological, pedagogical, organizational, and ethical facets is indispensable for enabling optimal utilization of the potential of AI in transforming tertiary Education.

2.3 Argument #3: The "situated" nature of the ecosystem is key to its effectiveness

However, it is not enough to create integrated digital ecosystems for AI; these must also be of a situated and contextualized nature within the specific educational

environment. Otherwise, there is a risk of implementing them in a manner disjointed from institutional realities and needs.

In this regard, cases such as those addressed by Lukkien *et al.* (2023) highlight the importance of considering the particularities or singularities of an educational institution for the success or failure of initiatives to implement disruptive digital technologies, in this case, AI.

In this sense, it is suggested to undertake integral and holistic transformation processes of Higher Education Institutions, permeating dimensions such as teaching, infrastructure, curriculum, research, administration, digital transformation governance, and marketing, among others.

Finally, Aderibigbe (2023) and Pan and Nishant (2023) present multiple challenges and opportunities for AI implementation that take into account the local context, in fields beyond Education but apply to it, emphasizing the need to create sustainable solutions that align with real-world conditions and the context where they are implemented.

2.4 Argument #4: AI and integrated ecosystems as bridges to Education 4.0

One of the main drivers making the creation of integrated digital ecosystems for harnessing AI imperative is the transition towards new paradigms known as Education 4.0. In this new era, educational institutions must reinvent themselves to train students in the skills and competencies demanded by the Fourth Industrial Revolution.

As noted by Elhussein *et al.* (2020) in their report, some of the key skills for 21st-century Education include critical thinking, complex problem-solving, digital literacy, collaboration, creativity, and continuous learning, among others. In this regard, strategically used AI has enormous potential to catalyze the acquisition of these skills (Ariyarathna; Rajapakse, 2024; Caro *et al.,* 2023; Geramani *et al.*, 2022).

However, as Ramu *et al.* (2023) and Jamaludin *et al.* (2020) caution in various cases, restructuring curricula, methodologies, and educational ecosystems to organically integrate AI is a significant challenge for institutions. For this, a situated digital ecosystem approach is a key facilitator to deeply implement the required curricular, pedagogical, and organizational changes.

In this line, Hannon *et al.* (2019), present various cases of learning ecosystems framed within the considerations addressed so far in this reflective conceptual paper. From this perspective, the relevance of understanding these ecosystems in an integrated manner, considering the particularities of the local context, is emphasized to effectively respond to the demands of 21st-century Education and what we understand by Education 4.0.

Similarly, Alenezi (2023) mentions four main objectives when discussing transformation in digital educational ecosystems: 1) improving the student learning environment, 2) increasing operational efficiency, 3) enhancing computing power for cutting-edge research, and 4) stimulating innovation in Education. According to the above, these elements should be reconsidered within the teaching and learning methods in Higher Education institutions, integrating digital tools into their current systems, thereby enriching their traditional pedagogical approaches and the overall educational system. This is foundational for the necessary institutional transformations in facing a complex reality that educational institutions navigate, marked by issues such as declining enrollments, increasing operational costs, and changing educational demands, among others.

Beyond conceptual reasons, the effective implementation of AI in Higher Education, facilitated by integrated digital ecosystems, emerges as a pragmatic bridge to transition towards the new paradigms of Education 4.0. For example, Bulathwela *et al.* (2024) suggest that strategically applied AI has the potential to become the disruptive catalyst that provides the initial push to unleash long-desired educational transformations. AI solutions offer radically new and innovative ways to address everything from personalized teaching to adaptive content creation, comprehensive assessments, online social learning, advanced analytics, and a vast array of possibilities.

3 Conclusions

This reflective conceptual paper has highlighted the relevance and necessity of advancing towards the configuration of an integrated and situated institutional digital ecosystem for the effective implementation of AI in Higher Education. The importance of this proposal lies in the recognition that AI is not an isolated technology, but a disruptive transformation with the potential to profoundly reshape teaching and learning models.

The arguments developed throughout this reflective conceptual paper underscore the pertinence of such a transformation. Fragmented attempts to implement AI tend to be ineffective; therefore, the key lies in the holistic and systemic

incorporation of these technologies. From this perspective, the creation of an integrated digital ecosystem is essential to fully harness the possibilities of AI in Higher Education.

At the same time, this ecosystem must be situated and contextualized within the specific educational environment. This is crucial to avoid the disjointed replication of solutions developed for other institutions, which may lead to limited results or even failure. In this sense, the analysis has shown that a situated ecosystem approach provides a more coherent way of addressing the challenges involved in the transition towards Education 4.0, a transition that demands the reinvention of educational institutions.

Significantly, this reflective conceptual paper also emphasizes that the creation of integrative digital ecosystems for AI is imperative for educational innovation. Such transformation is essential if educational institutions are to respond effectively to 21st-century demands, while also contributing to competency development and collaborative learning through personalized learning experiences and real-time feedback, both of which are crucial for improving educational outcomes (Mena-Guacas *et al.,* 2023; Mese, 2023).

Finally, AI and integrated digital ecosystems may be understood as fundamental bridges towards Education 4.0. In an increasingly digital and volatile world, the ability of educational institutions to adapt and reinvent themselves through these disruptive technologies will be crucial for their survival and success. At the same time, it is essential to recognize that the rapid adoption of AI in Education also presents ethical and practical challenges, including data protection, privacy concerns, and the potential impact of AI on individuals' fundamental rights and freedoms (Adiguzel; Kaya; Cansu, 2023; Berendt; Littlejohn; Blakemore, 2020), all of which must be carefully considered when promoting these technologies in educational contexts.

In conclusion, this reflective conceptual paper underscores the need for educational stakeholders to take on the challenge of advancing decisively towards the creation of these digital ecosystems, so that the full transformative potential of AI may unfold in Higher Education in ways that are pedagogically meaningful, institutionally coherent, and ethically responsible.

Ecossistemas digitais situados: a chave para impulsionar a revolução da IA na Educação

Resumo

Este artigo de reflexão conceitual explora a necessidade imperativa de criar ecossistemas digitais institucionais integrados e situados para a implementação eficaz e transformadora da inteligência artificial (IA) na Educação Superior. O artigo apresenta argumentos que demonstram as falhas de abordagens fragmentadas para a adoção da IA e defende um ecossistema digital integrador que harmonize as dimensões tecnológicas, pedagógicas, organizacionais e ético-legais. Enfatiza a importância de contextualizar esses ecossistemas em ambientes educacionais específicos. A análise revela que a transformação em direção a ecossistemas digitais integrados é um imperativo estratégico para a reinvenção das instituições educacionais. Esses ecossistemas são essenciais para aproveitar o potencial disruptivo das tecnologias de IA e alinhar-se aos novos paradigmas da Educação 4.0. O ensaio destaca o papel crítico da IA e dos ecossistemas digitais na superação das lacunas rumo às mudanças radicais necessárias na educação superior, oferecendo uma nova perspectiva sobre a integração estratégica dessas tecnologias nos contextos educacionais.

Palavras-chave: *Inteligência Artificial. Educação Superior. Ecossistemas Digitais. Educação 4.0. Transformação Educacional.*

Ecosistemas digitales situados: la clave para impulsar la revolución de la IA en la Educación

Resumen

Este artículo de reflexión conceptual explora la necesidad imperativa de crear ecosistemas digitales institucionales integrados y situados para la implementación efectiva y transformadora de la inteligencia artificial (IA) en la Educación Superior. El artículo presenta argumentos que demuestran las fallas de los enfoques fragmentados para la adopción de la IA y aboga por un ecosistema digital integrador que armonice las dimensiones tecnológicas, pedagógicas, organizacionales y ético-legales. Se enfatiza la importancia de contextualizar estos ecosistemas dentro de entornos educativos específicos. El análisis revela que la transformación hacia ecosistemas digitales integrados es un imperativo estratégico para la reinvención de las instituciones educativas. Dichos ecosistemas son esenciales para aprovechar el potencial disruptivo de las tecnologías de IA y alinearse con los nuevos paradigmas de la Educación 4.0. El ensayo destaca el papel crítico de la IA y los ecosistemas digitales en la superación de las brechas hacia los cambios radicales necesarios en la educación superior, ofreciendo una nueva perspectiva sobre la integración estratégica de estas tecnologías en contextos educativos.

Palabras clave: *Inteligencia Artificial. Educación Superior. Ecosistemas Digitales. Educación 4.0. Transformación Educativa.*

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Authors´ contributions: All authors participate in diverse processes including the literature review, manuscript preparation, and text writing. Besides the above, Andrés Chiappe is corresponding author.

Data: The set of data that supports the results of this review can be found directly in the sources stated in the article.

Conflict of interest: The authors declare that he has no commercial or associative interest that represents a conflict of interest concerning the manuscript.

Financing: Universidad de La Sabana (Project EDUPHD-20-2022).

Acknowledgements: We thank Universidad Libre and Universidad de La Sabana, Campus Universitario Puente del Común, KM 7 Autopista Norte de Bogotá, Chía, Cundinamarca, Colombia, for the support received in the preparation of this article.

Use of AI: ChatGPT version 5.2 has been used solely for the improvement of writing, tone of voice, and style.

Editors responsible for this article:
Cândido Alberto da Costa Gomes (Associate Editor)
Cassio Cabral Santos (Evaluator ad hoc)