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DISRUPTIVE TECHNOLOGIES

IN HIGHER EDUCATION: CHALLENGES, OPPORTUNITIES, AND DIGITAL TRANSFORMATION

TECNOLOGÍAS DISRUPTIVAS EN LA EDUCACIÓN SUPERIOR: RETOS, OPORTUNIDADES Y TRANSFORMACIÓN DIGITAL

Mohammad Narimani[1]
E-mail: narimani@uma.ac.ir
ORCID: https://orcid.org/0000-0003-4671-3893
[1] University of Mohaghegh Ardabili. Iran.

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ABSTRACT

Digital transformation and the adoption of disruptive technologies in higher education represent a topic of increasing relevance, given their capacity to redefine teaching, institutional management, and the student experience in environments of high uncertainty and constant change. This study aimed to analyze the challenges, opportunities, and implementation strategies of these technologies, considering their pedagogical, administrative, and organizational impact in various institutions. To this end, a qualitative methodology based on a systematic literature review was applied, integrating empirical and theoretical studies, as well as multivocal reviews published between 2012 and 2026, selected from academic databases such as Web of Science, Scopus and Google Scholar. Thematic analysis allowed for the grouping of contributions into categories that include benefits of digitization, barriers and limitations, emerging trends, implementation strategies, and institutional sustainability. The findings demonstrate that disruptive technologies, such as artificial intelligence, machine learning, online teaching platforms, and data analytics, facilitate personalized learning, expand educational access, optimize administrative processes, and strengthen pedagogical innovation. However, significant challenges persist, such as resistance to change, digital skills gaps, insufficient infrastructure, and financial limitations, which can generate inequalities among institutions and students. The analyzed contributions underscore that the strategic integration of disruptive technologies not only improves educational quality but also enhances the sustainability, equity, and adaptability of universities in the face of contemporary challenges.

Keywords:

Disruptive technologies, higher education, digital transformation, pedagogical innovation, institutional sustainability, personalized learning.

RESUMEN

La transformación digital y la adopción de tecnologías disruptivas en la educación superior representan un tema de creciente relevancia, dada su capacidad para redefinir la enseñanza, la gestión institucional y la experiencia del estudiante en entornos de alta incertidumbre y cambio constante. Este estudio tuvo como objetivo analizar los retos, oportunidades y estrategias de implementación de estas tecnologías, considerando su impacto pedagógico, administrativo y organizativo en diversas instituciones. Para ello, se aplicó una metodología cualitativa basada en revisión sistemática de literatura, integrando estudios empíricos, teóricos y revisiones multivocales publicados entre 2012 y 2026, seleccionados a partir de bases de datos académicas como Web of Science, Scopus y Google Scholar. El análisis temático permitió agrupar las aportaciones en categorías que incluyen beneficios de la digitalización, barreras y limitaciones, tendencias emergentes, estrategias de implementación y sostenibilidad institucional. Los hallazgos evidencian que las tecnologías disruptivas, como inteligencia artificial, aprendizaje automático, plataformas de enseñanza en línea y análisis de datos, facilitan la personalización del aprendizaje, amplían el acceso educativo, optimizan procesos administrativos y fortalecen la innovación pedagógica. Sin embargo, persisten desafíos significativos, como la resistencia al cambio, brechas en competencias digitales, infraestructura insuficiente y limitaciones

financieras, que pueden generar desigualdades entre instituciones y estudiantes. Las aportaciones analizadas subrayan que la integración estratégica de tecnologías disruptivas no solo mejora la calidad educativa, sino que también potencia la sostenibilidad, la equidad y la capacidad de adaptación de las universidades frente a los desafíos contemporáneos.

Palabras clave:

Tecnologías disruptivas, educación superior, transformación digital, innovación pedagógica, sostenibilidad institucional, aprendizaje personalizado.

INTRODUCTION

Higher education is undergoing an unprecedented transformation due to the emergence of so-called disruptive technologies, a term that refers to innovations that not only improve existing processes but radically transform them, generating profound changes in how organizations operate and individuals learn (Baute-Rosales et al., 2026). These technologies, such as artificial intelligence, machine learning, online learning platforms, and data analytics, are called "disruptive" because they break with traditional models of teaching and academic management, introducing new forms of interaction, assessment, and administration that can redefine the very structure of institutions (Antonopoulou et al., 2023). Disruption involves not only the incorporation of digital tools but also the creation of more flexible, personalized, and competency-oriented learning environments for the 21st century, generating significant opportunities and, at the same time, challenges for higher education.

Antonopoulou et al. (2023) emphasize that digital transformation is not only a strategy to maintain institutional competitiveness, but also an indispensable response to environments of high uncertainty, such as those caused by economic and social changes.

The global health crisis highlighted the limitations of traditional educational models and accelerated the adoption of digital tools, driving a process of change that would otherwise have been gradual (Scholkmann et al., 2024). Universities that were able to adapt quickly implemented online learning platforms, academic management systems, and hybrid teaching strategies. Conversely, those that faced technological infrastructure problems, a lack of digital skills, and resistance to change encountered significant difficulties. This scenario underscores that digitalization is not simply a technological addition, but a comprehensive transformation that affects pedagogy, assessment, interaction between teachers and students, and institutional management (Fernández et al., 2023).

Despite the opportunities these technologies offer, institutions face significant barriers. Singun (2025) identifies challenges such as limited digital literacy among teachers and students, a scarcity of financial resources, platform interoperability issues, and cultural resistance to change. These barriers not only slow the implementation of innovations but also generate inequalities in access to quality education, a critical issue in emerging and developing contexts. On the other hand, the potential benefits of digital transformation include personalized learning, access to global educational resources, streamlined administrative processes, and the creation of more sustainable and resilient educational models to address future changes.

The specialized literature shows that effective digital transformation requires a comprehensive approach that combines technological infrastructure, ongoing professional development for academic staff, innovative pedagogical strategies, and clear institutional policies. Fernández et al. (2023) point out that successful initiatives often arise from a strategic commitment involving all stakeholders within the institution, including administrators, faculty, students, and support staff. This multivocal perspective allows for the identification of best practices and the adaptation of solutions to specific contexts. Similarly, Scholkmann et al. (2024) emphasize that the pandemic acted as a catalyst for disruptive changes, but that the consolidation of these changes depends on universities' ability to institutionalize innovations beyond immediate contingency situations.

In this context, disruptive technologies are not only seen as tools for optimizing existing processes, but also as pathways for rethinking learning and academic management, promoting more flexible, inclusive models focused on digital skills (Baute-Rosales et al., 2026). Recognizing both the challenges and opportunities of this transformation allows educational institutions to overcome immediate obstacles and anticipate future needs, strengthening their resilience and competitiveness. Furthermore, the strategic integration of these technologies contributes to ensuring a quality, accessible, and equitable education, prepared to face the challenges of a dynamic and complex global environment.

This work aimed to analyze the challenges, opportunities and processes of digital transformation in higher education through the study of disruptive technologies, identifying both the barriers to their implementation and the strategies that allow their effective and sustainable adoption.

METHODOLOGY

This study employed a qualitative approach based on a systematic literature review. Recent and relevant academic sources addressing the adoption of disruptive technologies, digital transformation, and challenges in higher education were selected, including articles from indexed journals, institutional reports, and multi-voice reviews. The information search was conducted in academic databases such as Scopus and Web of Science, Scopus and Google Scholar.

Empirical, theoretical, and systematic review studies published between 2012 and 2026 were included, providing evidence on the pedagogical, administrative, and strategic impact of disruptive technologies. Subsequently, a thematic analysis of the findings was conducted, grouping the information into categories such as: opportunities of digitalization, barriers and limitations, emerging trends, implementation strategies, and effects on institutional sustainability.

This approach allowed for the integration of diverse, multi-vocal perspectives, contrasting experiences in global and emerging contexts, as well as theoretical and applied research approaches. Furthermore, criteria of relevance, currency, and methodological rigor were considered to ensure that the findings accurately reflected the trends, challenges, and best practices in the digital transformation of higher education. This methodological procedure guarantees that the resulting conclusions are supported by solid evidence and provide strategic input for the management of educational innovation.

DEVELOPMENT

The adoption of disruptive technologies in higher education has led to a profound transformation in the pedagogical, administrative, and organizational dynamics of universities. According to Antonopoulou et al. (2023), these technologies have enabled institutions to navigate highly uncertain environments, offering flexible alternatives in the face of unforeseen situations such as economic or health crises. Online teaching platforms, virtual laboratories, educational data analysis systems, and remote collaboration tools have redefined teaching and learning processes, promoting a student-centered approach and personalized learning.

Key disruptive technologies and trends include:

- **Artificial Intelligence (AI) and Machine Learning:** Tools like ChatGPT, chatbots, and intelligent tutoring systems provide personalized learning paths, instant feedback, and 24/7 support, allowing students to learn at their own pace.
- **Virtual and Augmented Reality (VR/AR):** These technologies create immersive "hyper-classroom" experiences, enabling students to explore, for example, Ancient Rome or complex 3D anatomical structures in real time.
- **Blockchain and Micro-credentialing:** Blockchain securely manages academic records, while badges and micro-credentials offer alternatives to traditional degrees, recognizing specific skills and competencies.
- **Big Data Analytics:** Allows educators to track student progress in real time, enabling immediate intervention and personalized, data-driven instruction.
- **Cloud Computing and Mobile Learning:** Facilitates flexible, anytime-anywhere learning through virtual classrooms, MOOCs (Massive Open Online Courses), and mobile apps.
- **3D Printing and Robotics:** Hands-on tools that foster creativity, turning digital designs into physical objects and promoting experiential learning.

Digital transformation initiatives have intensified, especially since the COVID-19 pandemic, when universities were forced to implement technological solutions to ensure educational continuity (Scholkmann et al., 2024). This rapid adoption highlighted both the advantages and limitations of digitalization. Among the key opportunities are improved administrative efficiency, access to global educational resources, and the possibility of experimenting with innovative methodologies, such as hybrid teaching and virtual laboratories. On the other hand, the speed of implementation also revealed significant gaps in technological infrastructure and digital skills among academic staff and students, underscoring the need for ongoing training and support strategies (Fernández et al., 2023).

Another key aspect of adopting disruptive technologies is the sustainability of the implemented processes. Universities that strategically integrate technology not only optimize teaching but also transform institutional management, enabling more efficient use of resources, greater transparency, and a stronger capacity to respond to new educational challenges (Baute-Rosales et al., 2026). This comprehensive approach involves not only incorporating innovative hardware and software but also reviewing and redesigning educational policies, curricula, competency assessments, and teacher-student interaction.

The adoption of disruptive technologies in higher education has generated profound transformations affecting the pedagogical, administrative, and strategic processes of universities. According to Ndaba & Naidoo (2024), digitalization has been fundamental to ensuring educational continuity after the COVID-19 pandemic, allowing institutions to adapt quickly to highly uncertain environments. However, significant barriers persist, such as insufficient technological infrastructure, the digital skills gap among faculty and students, and organizational resistance to change. These findings highlight the need for a comprehensive strategic approach that ensures the long-term sustainability of digital transformation.

Accordingly, Flavin (2012) argues that disruptive technologies are characterized by their ability to replace traditional teaching models with more efficient and accessible solutions. This technological disruption not only optimizes existing processes but also generates new learning opportunities and fosters pedagogical innovation. In this way, digitization becomes a catalyst that allows universities to expand educational access and serve students previously marginalized by geographical or economic limitations.

Huls (2022) also highlights the financial impact of disruptive innovation in universities, noting that technological adoption can reduce operating costs and diversify revenue streams, thus contributing to more sustainable business models. This perspective demonstrates that digital transformation not only has pedagogical implications but is also intrinsically linked to the resilience and economic viability of institutions.

Furthermore, Mabotha & Ngcamu (2026) present a systematic review that identifies common patterns in the implementation of disruptive technologies, emphasizing that success depends on a combination of technological infrastructure, development of digital skills, committed institutional leadership, and clear policies that align innovation with the university's strategic objectives. This comprehensive approach reinforces the idea that digital transformation is not an isolated project, but rather an organizational process that requires coordination and planning.

Mhlanga (2024) complements this view by analyzing the introduction of asynchronous learning tools linked to the Fourth Industrial Revolution in emerging markets. His study shows that, although these technologies offer significant opportunities for educational expansion, they face limitations related to connectivity, digital literacy, and economic resources. This underscores the importance of contextualizing technological solutions to maximize their impact in constrained environments.

Similarly, Marette (2021) emphasizes that digital transformation allows for meeting evolving educational needs, including flexibility in course delivery, accessibility for remote students, and personalized learning. Her analysis reinforces the notion that digitization must be accompanied by pedagogical innovation, ensuring that the incorporation of technology effectively improves academic outcomes and the learning experience.

Purcărea (2021) argues that disruptive technologies not only modify teaching processes but also transform the administrative structure of universities, generating new opportunities for information management and institutional strategic planning. This perspective aligns with Fahey (2025), who identifies key disruptive trends such as artificial intelligence (Sattari-Ardabili & De Hoyos-Guevara, 2026), augmented reality, data-driven learning, and online education platforms, emphasizing the need for universities to adapt their pedagogical and organizational strategies to remain competitive in a dynamic environment.

Mohamed Hashim et al. (2022) emphasize that strategic planning is key to effective digital transformation, indicating that universities must combine institutional leadership, clear policies, faculty training, and continuous evaluation to ensure sustainable results. Along the same lines, Aquino et al. (2025) show that technology adoption varies according to the preparedness of faculty and students, underscoring the importance of training and change management as critical factors for consolidating digital transformation.

Additionally, Dhameria et al. (2025) demonstrate that the integration of educational applications and online learning not only optimizes teaching but also strengthens institutional management, increasing administrative efficiency and educational accessibility. This view is complemented by Kurshan 's (2020) proposal, who argues that technological disruption must be accompanied by a cultural shift that fosters innovation, agility, and an entrepreneurial mindset throughout the university community.

Paños-Castro et al. (2024) reinforce this perspective through a case study demonstrating how digital transformation enables the implementation of innovative pedagogical methodologies, improving student participation and learning outcomes. Finally, Lucas (2016) offers a historical conceptual framework that allows us to understand technological disruption as a gradual process combining technological innovation and institutional reorganization, emphasizing that the success of digital transformation requires strategic integration, a long-term vision, and institutional commitment.

However, the implementation of disruptive technologies is not without its challenges. Singun (2025) highlights barriers such as resistance to change, limited digital literacy among teachers and students, and a lack of sufficient financial resources to maintain high-quality technological infrastructure. These limitations affect both the initial adoption and consolidation of digital solutions, generating inequalities among institutions with varying levels of access to technology. Furthermore, interoperability between platforms and academic management systems presents a crucial challenge, as technological fragmentation can negatively impact the learning experience and administrative efficiency.

Despite these challenges, evidence shows that the adoption of disruptive technologies can lead to significant positive change when accompanied by strategic planning, teacher training, and institutional support (Fernández et al., 2023; Scholkmann et al., 2024). Integrating digital solutions not only facilitates teaching and assessment but also fosters the development of 21st-century skills, such as digital literacy, critical thinking, and remote collaboration, strengthening students' preparedness for an increasingly digitalized work environment.

Furthermore, disruptive technologies have opened up opportunities for educational research and innovation. Analyzing large volumes of data generated in virtual environments allows for the identification of learning patterns, the evaluation of academic performance, and the design of personalized interventions to improve educational outcomes (Antonopoulou et al., 2023). In this way, digitalization not only transforms teaching but also fosters an evidence-based approach that enables institutions to

anticipate needs, improve decision-making, and optimize available resources.

multivocal experiences allow for the identification of best practices and the adaptation of strategies to specific contexts, ensuring that digital transformation is inclusive, sustainable, and scalable. Only through a comprehensive institutional commitment, combining technological innovation with training and clear policies, can the full potential of disruptive technologies be harnessed to transform higher education in a sustainable and equitable manner.

Disruptive technologies have profoundly transformed higher education, impacting both teaching and institutional management. Their adoption has allowed universities to adapt to highly uncertain environments, offering flexible learning alternatives, administrative optimization, and educational personalization. Furthermore, these tools have fostered pedagogical innovation, facilitating new methodologies and expanding access for students who previously faced geographical or economic barriers.

The implementation of these technologies not only improves educational processes but also strengthens financial sustainability and institutional efficiency. Digital transformation demands strategic integration that combines technological infrastructure, teacher training, committed leadership, and clear policies, ensuring that the benefits are sustained in the long term. However, challenges persist, such as resistance to change, the digital skills gap, and limited resource availability, especially in emerging contexts.

Furthermore, current disruptive trends, including artificial intelligence, data-driven learning, augmented reality, and online platforms, require universities to adapt their pedagogical and organizational structures to remain competitive. Digitalization also opens opportunities for evidence-based research, improving decision-making and optimizing academic performance through the analysis of educational data.

Ultimately, the success of digital transformation depends on a comprehensive approach that engages all members of the university community, fosters cultural and pedagogical innovation, and incorporates strategic planning and change management. In this way, disruptive technologies not only represent tools for innovation but also become catalysts for more inclusive, efficient, and sustainable learning, capable of responding to the emerging needs of contemporary higher education.

CONCLUSIONS

The systematic review demonstrates that disruptive technologies represent a fundamental catalyst for the transformation of higher education, not only optimizing pedagogical and administrative processes, but also generating new opportunities for educational innovation and institutional sustainability. Digitalization allows universities to adapt to highly uncertain environments, facilitate personalized learning, expand access to global resources, and strengthen administrative efficiency, while fostering the acquisition of critical digital skills for the 21st century.

However, the implementation of these technologies faces significant challenges, such as resistance to change, digital skills gaps, limitations in technological infrastructure, and financial constraints. The reviewed literature underscores that the success of digital transformation depends on a comprehensive approach that combines strategic leadership, clear policies, ongoing teacher training, adequate technological infrastructure, and the active participation of all institutional stakeholders. It also highlights the importance of contextualizing technological solutions, adapting them to the specific needs of each institution and considering the socioeconomic and cultural conditions of the environment.

Finally, the effective integration of disruptive technologies not only transforms teaching and institutional management but also enhances pedagogical innovation, evidence-based research, and educational equity. These tools offer a strategic framework for universities to address current and future challenges, consolidating more flexible, inclusive, and sustainable educational models. Consequently, the findings of this article reinforce the need to carefully plan, coordinate, and monitor digital transformation processes, ensuring that disruptive technologies contribute effectively to the comprehensive development of higher education.

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Conflicts of Interest:

The author declares no conflicts of interest.

Author Contributions:

Mohammad Narimani: Conceptualization, data curation, formal analysis, investigation, methodology, supervision, validation, visualization, original draft writing, and writing, review, and editing.

Ethical statement:

The study was based on the analysis of documentary sources and publicly available data, and therefore did not involve the direct participation of human subjects. No personally identifiable information was handled.