

TOWARDS UNIVERSITY 5.0: A LITERATURE REVIEW

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Received: October 8, 2025 Accepted: March 26, 2026 Online Published: June 19, 2026

Abstract

The revolutionary concept of “University 5.0” aims to transform universities into hubs of social and digital innovation. It emphasises creating supportive structures and mechanisms, integrating sustainability and interdisciplinary approaches, and promoting cross-sector collaboration. This vision seeks to address contemporary global challenges and prepare students for a rapidly evolving world. This paper delves into the scientific comprehension and definition of this new concept by exploring how the implementation of a social-oriented quality management approach can potentially bring about the fulfilment of this vision. A literature review was conducted to collect and study previous papers regarding this novel topic. Using the Scopus, Web of Science and Google Scholar databases, articles were obtained based on the following string of keywords: (university OR “university 5.0” OR “university 4.0” OR “smart university” OR “higher education institution”) AND (“social-oriented quality” OR “quality management” OR “sustainable quality”) considering articles published from 2019 to 2025. The results are focused on the main pillars of University 5.0, the potential benefits of its implementation in universities, and finally, the obstacles that may be encountered in the process. The study is limited by the databases referenced and by the consideration of articles written only in English. This paper's findings can be helpful to university practitioners, managers, and other stakeholders as a guide for comprehending the main pillars of University 5.0, the potential benefits of its implementation in universities, as well as the obstacles that may be encountered during the transition process.

Keywords: Higher education; Quality management; Social-oriented quality; Smart university; Education 5.0; Innovation.

1. Introduction

Throughout history, education has consistently transformed in line with the new landscape brought by industrial revolutions (Yakymchuk, 2024). Naturally, higher education institutions (HEIs) transformed accordingly to align with these industrial transformations, which can be explained by the four primary stages of the timeline of the development of university ideas (Ülker & Otrar, 2024):

- Pre-industrial University 1.0 – Based on the standards of the Middle Ages, this first-generation university made higher education a relatively widespread activity. During this period, the first universities were established with an institutionalised structure and were seen as centres of religious knowledge.
- Industrial University 2.0 – In this period, universities became research hubs focused on empirical research, the construction of scientific models, and the design of technologies and tools needed to implement these models. Universities began taking part in the creation of a new industrialised society. University 2.0 divulges a new type of intellectual activity that is free from scholasticism and religious convictions.
- Post-industrial University 3.0 - The third higher education generation represents the era of integration of technological devices as teaching and learning tools favour remote training. During this period, universities are expected to develop an entrepreneurial culture through project work, ensure development, establish science centres and technology companies, and obtain patents and trademarks. The business and humanities departments' instructional and scientific divisions take centre stage in these mechanisms.
- Cognitive-creative University 4.0 – This fourth university generation is the current link in the evolution. As universities are digitalising, HEIs are evolving from traditional education to cloud computing-based, individualised and distance education. Educational materials are becoming more accessible, virtual classrooms and workstations are emerging, and lifelong learning is taking place. Universities are expected to contribute to social progress by raising individuals who can respond to societal issues and deal with complex situations in the current challenging times. University 4.0 creates a highly open atmosphere that serves as a hub for many forms of communication and a node at the nexus of information, social, and activity-related networks. Therefore, with the fourth industrial revolution, universities are expected to turn into institutions that produce knowledge, globalise competencies, and develop advanced technological products.

HEIs are currently facing rapid societal transformations, and to cope, they are undertaking a swift process of adaptation by restructuring their organisational frameworks and internal operational environments. The current educational approach is primarily a practical response to the demands of Industry 4.0 (I4.0) (Ozols et al., 2024; Lawal et al., 2019). However, looking ahead to Industry 5.0 (I5.0), there's a need for a profound shift. I5.0 presents a significant opportunity to transform the purpose of education. Instead of just enabling individuals to "fit and survive" within existing frameworks, the goal will become to "be prepared and contribute" proactively. Achieving this transformative shift

greatly requires a philosophical re-evaluation and redefinition of the current educational strategies (Yilmaz, 2024).

This widespread reshaping of the higher education sector is an integral component of the ongoing fifth-generation revolutions and is referred to as "University 5.0" (U5.0) and "smart university" (Ozols et al., 2024). The practical implementation of these "smart universities" is predicted to gain momentum around the 2030s. To adequately prepare future graduates with the necessary competencies and understanding demanded by I4.0 and I5.0, HEIs must undergo a profound transition towards the U5.0 paradigm (Lose & Jack, 2024).

The attainment of a high standard of tertiary education forms the bedrock of sustainable development across all dimensions. As a crucial aspect of the U5.0 framework, HEIs must inherently foster a balance between environmental, societal, and economic sustainability to successfully navigate the uncertainties of the geopolitical climate and the increasing prevalence of digitisation (Lose & Jack, 2024). These institutions hold a fundamental position as the architects and proponents of new knowledge within society. Consequently, the future trajectory of society is contingent upon the quality of education received by both current and prospective graduates (Eskinat & Teker, 2024). Furthermore, the establishment and refinement of processes that ensure enhanced educational quality will benefit future citizens and promote social progress. In fact, a HEI can be characterised as a sustainable institution if it cultivates high-quality teaching, implements advanced innovative processes that enhance the academic quality of life, and optimises its use of natural resources. Enriching the student learning experience with principles of sustainable development is essential for the establishment of a Society 5.0 and for fulfilling the United Nations' Sustainable Development Goals (SDGs) (Eskinat & Teker, 2023a; Sorini et al., 2025).

The U5.0 paradigm encompasses the ongoing and dynamic collaboration among five key dimensions: industry, government, the university itself, society, and the natural environment. Experts characterise it as an innovative and beneficial ecosystem, centred around human needs, where institutions can collaborate in the creation and dissemination of knowledge, which is crucial for fostering innovative change. To protect this ecosystem of innovation, clear and distinct vision and mission statements must be formulated and subsequently integrated into the HEI's strategic framework, while considering all relevant legal, social, and ethical considerations (Eskinat & Teker, 2023b).

Universities must possess the ability to understand the specific competencies required by their graduates and align their teaching and assessment practices to place students at the heart of the educational process. Research has indicated that empowering students to design and manage their own personalised learning pathways, tailored to their individual needs, aspirations, and creativity, positively influences their academic performance and success (Vesperi et al., 2024). In fact, through the implementation of the digital U5.0 approach, students assume a more central, proactive, and independent role in their education, while teachers and lecturers transition into the roles of mediators and facilitators in this process. This shift places the responsibility on educators to develop appropriate curricula that revolve around digital skills, green literacy, cognitive and metacognitive abilities, social and emotional skills, as well as practical and physical skills that incorporate modern communication technologies (Yilmaz, 2024; Ngwama & Ogaga-Oghene, 2022). Thus, it is necessary to develop and conduct a multi-level analysis of the future fifth-generation university model.

With this study, the state-of-the-art of the literature on the concept of U5.0 has been mapped to attempt to respond to the following research question: What are the main elements of the U5.0 paradigm, and what are the potential impacts and challenges of its implementation? This review contributes to the current research on the topic, as well as serving as a useful tool for university managers, innovators, and policymakers. The article will be structured as follows: section 2 delineates the details of the review methodology implemented; section 3 describes the bibliometric data and keyword analysis obtained from the review; section 4 is composed of a detailed discussion of the five clusters which emerged from the analysis; section 5 portrays the practical implications of the findings identified; and, finally, the conclusions are defined in section 6 of the paper.

2. Methodology

A thorough examination of existing scholarly work concerning the advancement of the U5.0 concept and its possible impact on tertiary education was undertaken. This review was conducted in February 2025, following a structured six-step process as outlined by Barry et al. (2022) (see Tab.1).

Table 1 – The methodological review process.

Stage	Description
Stage 1 Determine the research question.	What are the main elements of the U5.0 paradigm?
Stage 2 Determine timeframe	The term “University 5.0” was coined in 2019.
Stage 3 Finalize the research question according to the timeframe	What are the potential impacts to be expected from the implementation of the U5.0 paradigm?
Stage 4 Develop the article search strategy	The focus will be on finding articles: (i) that discuss the development of the U5.0 paradigm in universities; (ii) that outline the implementation of practices regarding the three aspects of sustainability in HEI strategic planning; (iii) digital transition in the higher education sector.
Stage 5 Analyses	Pivotal moments in higher education management literature will be identified, focusing on the principles of the U5.0 paradigm and the potential impacts and challenges of its implementation.
Stage 6 Reflexivity	A reflexivity description is given to describe how researcher subjectivities shaped the perceptions of the literature analysed.

Source: Authors’ own production; Barry et al. (2022)

Table 2 details the specific protocol employed for this review. The search for relevant literature was conducted using Scopus, Web of Science, and Google Scholar electronic databases. The key terms used for the search (see Tab. 2) were chosen after a brainstorming session and examined within the title, abstract and keywords sections of the articles in the databases. The timeframe of publication was 2019-2025, as the term “University 5.0” was first mentioned in an article published in 2019. Despite the general tendency to exclude conference papers, this particular study chose to include them, along with book chapters, to gather all potential knowledge within this relatively new area of investigation. The selection of papers for the review was based on their contribution to the evolution of the U5.0 concept and its implementation and impacts on the higher education sector. The final set of papers chosen did not include all other forms of grey literature. Additionally, papers were excluded if the research design and arguments presented were unclear. Furthermore, the bibliographies of the identified papers were consulted to broaden the selection of any relevant material.

It was noted that there were very few papers specifically focused on U5.0. However, articles discussing U4.0 and the aspects of sustainability applied to the higher education sector were considered. This is because many of these papers touched upon the potential future directions of the U5.0 concept. The gathered research was independently assessed based on the established review protocol (see Tab. 2). This protocol had been previously checked through a preliminary review of ten articles, where the findings were briefly compared. This step was taken to ensure that the reviewers had a similar understanding and to account for any personal biases in interpretation and reflexivity.

From a total of 338 articles collected in Zotero, the baseline sample of 271 results was obtained after excluding duplicates. Subsequently, through a title and abstract screening, a further 191 were removed to concentrate on only the inclusion criteria, leading to a final set of 81 articles to be reviewed.

Table 2 – Inclusion and exclusion criteria.

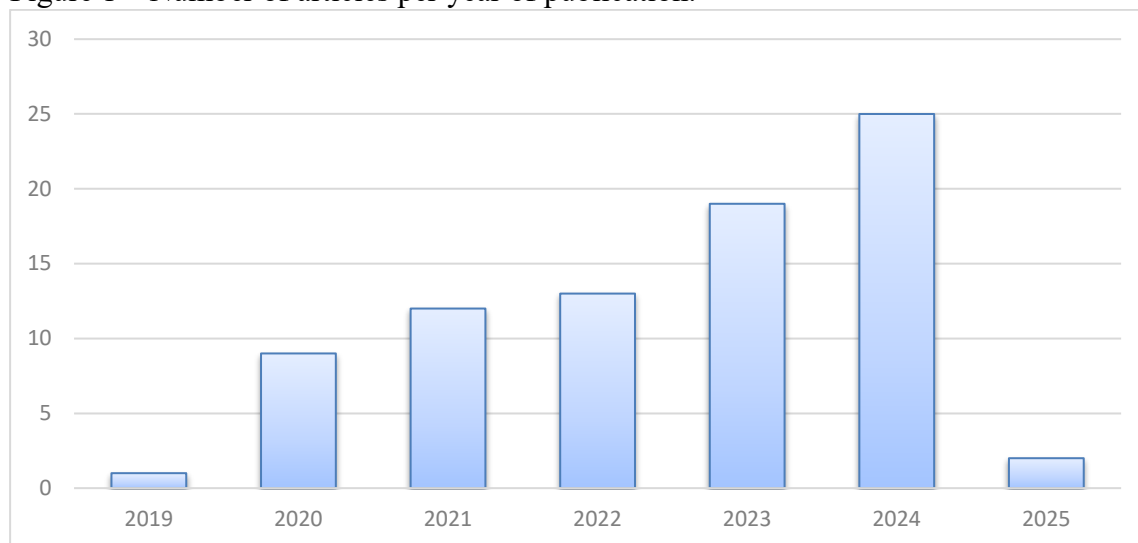
Item	Description
Keywords	Education 5.0, university 5.0, smart university, university 4.0, quality, digital, sustainability.
Inclusion	Papers focusing on the development of the U4.0/5.0 and E5.0 concepts, sustainable quality management in HEIs, integrating practices regarding the three aspects of sustainability in HEI strategic planning and quality management, digital transition in HEIs.
Exclusion	Papers not written in English; papers focused on the concept of Education 4.0/5.0 in primary or secondary education.

Source: Authors’ own production.

3. Results

After analysing the selected articles, the following bibliometric data was obtained. There was a peak of interest in U5.0 in 2024 (25). It can be noted that 2 articles have already been published this year, showing that interest in the topic has not waived (Figure 1).

Figure 1 – Number of articles per year of publication.



Source: Authors' own production.

Examining the nationality of the affiliation of the first author demonstrates that they are located across the main continents of the world: Asia (35), Europe (24), the Americas (11), Africa (9), Oceania (2). From the analysis, a number of recurring themes were identified, and the articles were labelled according to the cluster(s) they were most connected to. The five clusters detected are digitalisation (65), enhanced learning (48), sustainability (17), quality (5), and cyber security (2). These clusters can be classified as the main elements that characterise the U5.0 paradigm. The papers reviewed are reported in Table 3, which summarises the authors and the clusters with which each paper was associated (See Supplementary Material for full references of each paper).

4. Discussion

4.1 Digitalisation

In the contemporary education landscape, the use of technology is pervasive and is continuously advancing and evolving, greatly influencing the learning environment. Digitalisation presents novel opportunities for HEIs and can become one of the main catalysts for institutional transformation. The implementation of information and communications technology (ICT) necessitates a shift in the organizational ethos of universities and dedication from all staff members. The incorporation of ICTs is of paramount importance in the transition towards the U5.0 paradigm, which imagines a state-of-the-art educational setting in which technology is seamlessly incorporated into all facets of learning and teaching, consequently transforming conventional educational frameworks (Azevedo et al., 2023). This transition to a digitalised smart higher education is a direct consequence of the huge technological progress which is taking place with the occurrence of the fourth and fifth industrial revolutions (Al-Shoqran & Shorman, 2021).

In fact, a defining characteristic of a smart university is its strategic application of technology with the objectives of enhancing the student experience, optimising operational efficiency, and cultivating innovation (ElRashidy & ElSabry, 2024). Furthermore, the smart university model aims to elevate scientific output, reduce expenditures, improve

Table 3 – Keywords and clusters of the articles reviewed.

Cluster	Authors
Digitalisation	Nguyen & Nguyen-Dinh (2024); Elrashidy & ElSabry (2024); Escolar et al. (2023); Al-Shoqran & Shorman (2021); Hou et al. (2020); Duda et al. (2023); Akhmetshin et al. (2021); Azarov & Shaposhnikov (2022); Minh et al. (2024); Mitrofanova et al. (2021); Cavus et al. (2022); Azarov & Chekmarev (2022); Pupiales-Chuquin et al. (2022); Pham et al. (2020); Polin et al. (2024); Mohanachandran et al. (2021); Berdnikova et al. (2021); Rico-Bautista et al. (2020); Berdnikova et al. (2020); Kwet & Prinsloo (2020); Alexander et al. (2021); Kerroum et al. (2020); Abdellatif (2019); Chauhan et al. (2024); Ülker & Otrar (2024); Sherstobitova et al. (2021); Daradkah et al. (2023); Hutahaeen et al. (2024); Nikum (2022); Sherstobitova et al. (2021); Meniado (2023); Gowda (2023); Dehbi et al. (2025); Rajagopal et al. (2024); Giang et al. (2021); Kulik et al. (2020); Jugembayeva & Murzagaliyeva (2024); Rocha et al. (2022); Rial-Gonzalez et al. (2024); George & Wooden (2023); Pinheiro & Santos (2023); Jugembayeva & Murzagaliyeva (2023); Huang & Wei (2023); Avrami et al. (2024); Kazieva et al. (2020); Azevedo et al. (2023); Chernaya et al. (2023); Acuña (2024); Nikolova et al. (2023); Elshapasy & Mohamed (2024); Silva-da-Nóbrega et al. (2022); de Moraes et al. (2024); Oughannou et al. (2022); Abnoulgid et al. (2024); Kostepen et al. (2020); Al-Dmour (2023); Habash (2022); Tavares et al. (2022); Babkin et al. (2024); Rosak-Szyrocka (2024); Polin et al. (2023); Gorina & Polyakova (2021); Carayannis & Morawska (2023); Asad & Suleman (2024); Petrescu et al. (2023).
Enhanced Learning	Luna et al. (2024); Skitso & Osypova (2022); Gartoumi & Tekouabou (2024); Hashim et al. (2024); Yakymchuk (2024); Ülker (2025); Vieira et al. (2023); Hamedani et al. (2024); Daradkah et al. (2023); Hutahaeen et al. (2024); Nikum (2022); Sherstobitova et al. (2021); Meniado (2023); Gowda (2023); Dehbi et al. (2025); Rajagopal et al. (2024); Giang et al. (2021); Kulik et al. (2020); Jugembayeva & Murzagaliyeva (2024); Rocha et al. (2022); Rial-Gonzalez et al. (2024); George & Wooden (2023); Pinheiro & Santos (2023); Jugembayeva & Murzagaliyeva (2023); Huang & Wei (2023); Avrami et al. (2024); Kazieva et al. (2020); Azevedo et al. (2023); Chernaya et al. (2023); Acuña (2024); Nikolova et al. (2023); Ciolacu et al. (2023); Akturk et al. (2022); Ramirez-Montoya et al. (2024); Mpofu et al. (2024); Ülker (2023); Melnychenko et al. (2021); Kostepen et al. (2020); Al-Dmour (2023); Habash (2022); Tavares et al. (2022); Babkin et al. (2024); Rosak-Szyrocka (2024); Polin et al. (2023); Gorina & Polyakova (2021); Carayannis & Morawska (2023); Asad & Suleman (2024); Petrescu et al. (2023).
Sustainability	Giesenbauer et al. (2021); Elshapasy & Mohamed (2024); Silva-da-Nóbrega et al. (2022); de Moraes et al. (2024); Ciolacu et al. (2023); Akturk et al. (2022); Ramirez-Montoya et al. (2024); Mpofu et al. (2024); Kostepen et al. (2020); Al-Dmour (2023); Habash (2022); Tavares et al. (2022); Babkin et al. (2024); Rosak-Szyrocka (2024); Polin et al. (2023); Gorina & Polyakova (2021); Carayannis & Morawska (2023).
Cyber Security	Raju et al. (2022); Oughannou et al. (2022).
Quality	Abnoulgid et al. (2024); Ülker (2023); Melnychenko et al. (2021); Asad & Suleman (2024); Petrescu et al. (2023).

Source: Authors' own production.

educational quality standards, and facilitate both teaching and learning irrespective of geographical or temporal constraints (Al-Shoqran & Shorman, 2021). The proliferation of online educational programmes, virtual learning environments, and specialised software applications now affords individuals the latitude to pursue knowledge acquisition at a personalised tempo and in accordance with individually tailored schedules (ElRashidy & ElSabry, 2024).

A smart university includes the emergence of technologies and wireless Internet access in every facet of the academic environment. This concept extends to the notion of a smart campus, or "intelligent campus," which is defined as a demarcated area upon which educational establishments are situated, and which possesses an inherent ability to adapt responsively to new circumstances that arise within its daily operational context (De Moraes et al., 2024). Such smart universities typically incorporate a diverse array of facilities, such as libraries, classrooms, student centres, and recreational areas. Furthermore, a smart learning environment is distinguished by its ability to furnish immediate and personalised support to learners through the analysis of individual needs from multifaceted perspectives (Al-Shoqran & Shorman, 2021). Conventional lecture-based teaching methodologies are increasingly being augmented or, in some instances, replaced by interactive, technology-driven approaches. The widespread adoption of smartphones and laptops facilitates students' rapid and easy access to an immense spectrum of information and educational resources. Moreover, interactive pedagogical tools, such as smartboards and virtual laboratories, furnish practical learning opportunities that were previously absent in traditional classroom settings. These technological innovations serve to enhance the overall learning experience and accommodate a diverse range of learning preferences, thereby fostering equitable opportunities for all students to achieve academic success (Rajagopal et al., 2024).

From the reviewed papers, it can be noted that many studies on the practical application of smart university paradigms are being actively undertaken worldwide, as there is a strong need for a comprehensive approach that aids the design and development of these fifth-generation HEIs (Nguyen & Nguyen-Dinh, 2024). Different models, frameworks, and architectures for the construction of smart universities have been proposed in the current literature (see Table 4; see Supplementary Material for full references of each paper).

4.2 *Enhanced Learning*

The integration of Industry 5.0 and Society 5.0 technologies has instigated structural changes in education, requiring universities to fully embrace their role as educators and knowledge creators. HEIs must adapt to these radical changes by integrating human-machine collaboration and promoting the implementation of ethical green technologies. The Higher Education 5.0 paradigm requires innovation in teaching methodologies to cultivate skills that address industrial and societal demands, with the aim of solving global sustainability challenges. This paradigm is characterised as learner-related, learner-centred, and learner-driven, founded on a relevant curriculum, innovative evaluation, meaningful learning experiences, and transformative knowledge acquisition (Gartoumi & Tekouabou, 2024). U5.0 advocates for the humane application of new technologies, prioritising learners' societal well-being, as well as social and emotional development. Furthermore, universities have a crucial role in fostering human-driven, sustainable, and creative innovation by developing new knowledge. Addressing challenges related to inadequate

infrastructure and the digital skills of both teachers and students remains crucial for effective digital transformation (Hashim *et al.*, 2024).

Table 4 – Smart University models, frameworks and architectures presented in papers reviewed.

Author	Model
Sherstobitova et al. (2021)	Smart model based on networking, collaborative interaction, and cooperation among universities.
Nguyen & Nguyen-Dinh (2024)	Synthesis Model for Smart Universities
Kostepen et al. (2020)	Sustainable and data-driven smart campus framework
Elshapasy & Mohamed (2024)	Smart-Green Digital Campus
Daradkah et al. (2023)	Smart Digital Arab University
Hou et al. (2020)	Smart university data collection and management based on a blockchain network.
Akhmetshin et al. (2021)	Digital University Model – Institutional approach
Rajagopal et al. (2024)	University 5.0 Ecosystem Architecture and ICT Enabled Personalized Learning Architecture
Giang et al. (2021)	Readiness Framework for digital transformation
Mitrofanova et al. (2021)	Model of Smart Universities Integration Interaction
Azarov & Chekmarev (2022)	Optimization Model of Digital Higher Education - SMART University 4.0
Habash (2022)	Next generation learning model manifested through smart technologies
Huang & Wei (2023)	Model of priorities for the strategic development of universities in the era of digitalisation
Pupiales-Chuquin et al. (2022)	Smart Campus Methodology
Pham et al. (2020)	Smart University Model as a Sustainable Living Lab
Polin et al. (2024, 2023)	Smart Campus Framework
Berdnikova et al. (2021)	Smart University Innovation Efficiency Improvement Model
Babkin et al. (2024)	The Chain of Creation of Scientific and Educational Value of the University 4.0 of Russia
Kerroum et al. (2020)	Agile Model for the Digital Transformation of the University Hassan II towards a U4.0
Kazieva et al. (2020)	SMART University 4.0 Model
Abdellatif (2019)	Multi-perspective Internal Control Compliance Measurement Model
Carayannis & Morawska (2023)	Power Capital Super Smart Society for I5.0 and Society 5.0

Source: Authors' own production.

In terms of the learning experience, the central challenge of U5.0 lies in reorienting individuals' knowledge and skills to ensure they are critical contributors in human-machine collaborations. This necessitates the development of various 21st-century competencies, encompassing technical and scientific literacy alongside abilities such as navigating complex systems, demonstrating flexibility, possessing strong communication skills, emotional intelligence, empathy, creativity, and critical thinking. The collaborative interaction between students and educators is crucial for sharing perspectives on the development of novel solutions and approaches (Yakymchuk, 2024). The creation and sustenance of a knowledge-based society are essential for driving innovation through shared knowledge and creativity, particularly in the current climate of uncertainty and global mobility (Ülker, 2025).

A fundamental imperative is the cultivation of a workforce equipped with relevant digital knowledge, skills, and abilities to meet the evolving demands of organisations. This includes not only digital literacy skills, e-skills, internet skills, and media literacy, but also crucial transversal abilities such as autonomy, responsibility, social interaction, personal and professional development, leadership, entrepreneurship, problem-solving, and teamwork (Jugembayeva & Murzagaliyeva, 2022). Universities should develop curricula that offer students practical application of their knowledge and the acquisition of new skills through project-based learning initiatives that address the needs of specific organisations or local communities. It is recommended to shift to innovative pedagogical approaches and curricular flexibility to promote and develop these soft skills and cater for the high degree of interculturality and interdisciplinarity that is manifested in this new digital age (Hamedani *et al.*, 2024).

The concept of U5.0 emphasises personalised education to cater to the diverse learning abilities, speeds, curiosities, and developmental stages of each learner. This necessitates flexible learning processes where students can independently shape their learning trajectories based on their interests and skill development needs. Technology plays a pivotal role in facilitating personalised learning through gamification, flipped classrooms, and project-based learning, enabling the creation of individualised learning pathways (Vieira *et al.*, 2023). Furthermore, the rapid pace of technological change underscores the critical importance of lifelong learning and continuous professional development for both employees and educators. HEIs must foster an understanding of the need for self-education and equip learners with the skills necessary for this pursuit (Rial-Gonzalez *et al.*, 2024).

While online learning offers flexibility, lecturers must strategically incorporate opportunities for live communication to foster the development of these crucial soft skills. Moreover, curricula should integrate interdisciplinary courses, utilise digital portfolios for assessment, and foster industry collaboration to ensure relevance and continuous improvement. This paradigm shift requires HEIs to revolutionise their teaching and learning environments, aiming to develop digitally skilled, industry-ready graduates with higher-order cognitive skills and a global outlook (Acuña, 2024).

In this new fifth-generation university, students are expected to adopt central, active, and autonomous roles in their learning journeys, taking greater ownership of their educational pathways. Consequently, the traditional role of teachers as primary knowledge disseminators is evolving towards that of mediators of learning, while the direct transfer of factual knowledge can increasingly be supported by technology (Giang *et al.*, 2021). Teachers are now tasked with contributing to the moral and ethical development of students, alongside cultivating essential cognitive abilities and practical skills

(Yakymchuk, 2024). The role of professors is shifting away from a purely instructional focus towards that of guides in the learning process. The proactive use of ICT can allow professors to create interactive content in order to better keep students' attention, generating greater interest on their behalf (Meniado, 2023). Additionally, this enables them to personalise teaching by identifying and nurturing students' individual abilities for their future careers, potentially leveraging ICT to create tailored learning plans (Gowda, 2023). Furthermore, interdisciplinary collaboration and the adoption of student-centred approaches, which emphasise empathy and the tackling of real-world problems, are vital components of this novel paradigm (Luna *et al.*, 2024).

4.3 Sustainability

Universities are increasingly prioritising the development of sustainable digital advantages through the application of ethical technology. This strategic focus aims to enhance revenue performance, uphold sustainable priorities, and improve student retention, to align with the overarching vision of U5.0 to create a positive societal impact via educational delivery. The concept of smart campuses emphasises the integration of technology to establish comprehensive and sustainable quality living environments that cater for the needs of stakeholders (Silva-da-Nóbrega *et al.*, 2022).

HEIs are urged to incorporate the United Nations' SDGs into their research and teaching activities. This integration is crucial for cultivating a culture of sustainability, empowering students with essential future competencies, and contributing to the 2030 Agenda. All HEIs must establish sustainability principles as a foundational element of their strategic direction in education. To effectively tackle real-world challenges, it is vital for universities to forge links with external stakeholders such as businesses, civic organisations, and government bodies (Ciolacu *et al.*, 2023).

Despite this, the inherent complexity of sustainable development (SD), which requires a systemic transformation, has slowed down its mainstream adoption in academia. HEIs are being urged to implement SD as a whole-institutional approach to foster transformative practices across all levels. To do so, institutions must develop their capacity to address complexity and ambiguity through a wider perspective (Giesenbauer *et al.*, 2021).

HEIs are increasingly integrating sustainability into curricula and policies. However, mere curricular changes are insufficient; active learning and community involvement are essential. Sustainability policies in HEIs should aim to embed this theme across teaching, research, and institutional practices, positioning them as leaders in promoting sustainable change. Many universities globally now prioritise sustainability in their academic programs. The U5.0 paradigm, centring human well-being and leveraging technology for sustainable development, can further drive these policies. Comprehensive sustainability education should equip individuals with the skills to tackle global crises (Ramírez-Montoya *et al.*, 2024).

Establishing robust sustainability governance is fundamental for HEIs transitioning towards sustainability. This involves creating an organisational structure to measure the impact of sustainability efforts and fostering a culture of sustainability supported by evidence. Effective governance encompasses dimensions like politics, profession, organisation, knowledge, and visibility, engaging students, administrative boards, campus management, and faculty. Key organisational culture characteristics supporting sustainability governance are responsibility for sustainable development, a clear purpose

for HEIs, understanding of sustainability, and significant organisational changes (Tavares *et al.*, 2022).

HEIs significantly influence community and social sustainable development through their economic and social impacts. Monetarily valuing colleges' social impacts helps identify social needs and fosters collaboration with sustainable development stakeholders. Active and responsible community-HEI partnerships are intellectually beneficial for all those involved. Improving local communities' sustainability capabilities is a crucial long-term strategy. Collaborations involving community leaders, university members, and staff facilitate the sharing of knowledge and resources. To lead in sustainability, HEIs must develop cross-disciplinary research plans (Akturk *et al.*, 2022). Furthermore, U5.0 has the potential to enhance accessibility and inclusivity in higher education, ensuring equal access to knowledge and training. Education is crucial for driving social change by empowering educators and students to advocate for equitable practices. Fostering inclusive societies involves cultivating skills in sustainable development and fundamental rights. HEIs must actively promote inclusive learning experiences to aid the elimination of injustice and gender-based violence (Luna *et al.*, 2024). Additionally, organisations should prioritise the provision of fair, safe, and equitable workplace environments for both their employees and stakeholders. This is crucial for upholding workplace ethical conduct. Policymakers should underscore the significant role of human resources in ensuring the sustainability of the HEI and foster innovation aimed at enhancing this. HEIs bear the responsibility of equipping students with essential interpersonal skills to adequately prepare them for the demands of the professional sphere (Ramírez-Montoya *et al.*, 2024).

The environmental sustainability considerations for university campuses encompass environmental impact assessment and management. In planning their grounds, universities should consider the natural landscape and the encompassing environment. Furthermore, campus design should also integrate regional and cultural characteristics into traditional campuses to cultivate a distinctive campus atmosphere (Elshapasy & Mohamed, 2024).

4.4 Quality

HEIs must undergo a significant transformation in their people, processes, and technology to ensure quality education. The concept of U5.0 offers the potential to substantially improve higher education quality by fostering greater accessibility and flexibility in learning (Hamedani *et al.*, 2024). Furthermore, it enables the personalisation of learning experiences, the integration of technology, the development of essential 21st-century skills, and the enhancement of assessment and feedback mechanisms (Abnoulgid *et al.*, 2024).

The quality management systems of HEIs are underpinned by eleven fundamental principles: encompassing a focus on learners and other beneficiaries, visionary leadership, engagement of people, process approach, improvement, evidence-based decisions, relationship management, social responsibility, accessibility and equity, ethical conduct in education, and data security and protection. Universities must actively promote continuous improvement, particularly in ways that lead to positive change. To achieve this, establishing mechanisms for the ongoing systematic collection of feedback from stakeholders is crucial, including gathering data from students and lecturers on their perceptions of education quality, current issues, and potential solutions (Ülker, 2023).

HEIs should be capable of presenting valid and reliable data across all facets of their operations, including teaching quality. Decision-making processes should be evidence-based, facilitating the demonstration of compliance with quality standards and providing a

foundation for new policies and practices. Universities ought to enhance their services for internal stakeholders while effectively addressing the articulated needs of their external stakeholders by integrating these requirements into their quality assurance frameworks (Abnoulgid *et al.*, 2024).

Social responsibility, a core principle of Total Quality Management (TQM), is directly applicable to the educational context, with quality management having a considerable influence on social sustainability and the institution's societal impact. In the context of U5.0, universities should foster open and interconnected environments to address societal challenges and complexity, potentially through research on pertinent topics like sustainable development. The quality of professional exposure is a significant aspect, as the digital transformation spurred by Industry 4.0 and 5.0 necessitates the development of relevant competencies, skills, and work ethics, with the United Nations SDGs and European values supporting business ethics being integrated into modern quality management systems. Ultimately, data, processes, and people within HEIs should collaboratively work towards enhancing overall quality (Ülker, 2023).

The distinctiveness of a HEI's educational program stems from its competitive advantages, which are realised through its mission, strategy, goals, resources, and the educational program itself. Quality educational components, competencies, innovation, interdisciplinarity, and originality are crucial elements. Educational programs are instrumental in establishing an HEI's leadership, brand, and niche in the labour and educational services markets. External quality evaluations and accreditations contribute to the overall image of the HEI. Effective program delivery necessitates quality management systems, a positive academic atmosphere, and a blend of established traditions and innovative approaches (Melnychenko *et al.*, 2021).

Instructional quality is a crucial characteristic for evaluating the effectiveness of teaching and learning within educational systems. While the advent of ICT and the Internet of Things (IoTs) under University 4.0 has enriched learners' experiences, the demand for personalised education, as envisioned by U5.0, necessitates further improvements. The fundamental objective of U5.0 is to foster personalised learning, encourage collaborative practices, and promote overall well-being through the integration of digital tools such as virtual reality and IoTs (Petrescu *et al.*, 2023).

The implementation of personalised learning demands substantial changes within the classroom and is influenced by teachers' attributes and their preparedness for educational transformation. Experienced educators and those benefiting from quality professional development programs with a strong understanding of pedagogical principles may be better equipped to implement personalised learning effectively. Technology-supported personalised learning (TSPL) has emerged as a transformative approach in education, focusing on individual student needs, and could positively impact the overall instructional quality (Asad & Suleman, 2025).

The major components of instructional quality include cognitive activation (CA), supportive climate (SC), and classroom management (CM). CA refers to stimulating learners' higher-order thinking skills and deeper content understanding, which can be facilitated by adopting a TSPL approach, using adaptive technologies that adjust task difficulty based on individual performance, enhancing critical thinking and problem-solving. Tools like virtual labs and simulations also contribute to experiential learning and deeper conceptual understanding, significantly enhancing students' CA. SC pertains to a learning environment that encourages student engagement, motivation, and positive

interactions between teachers and students. Technological platforms can track student progress and provide tailored feedback, fostering more purposeful teacher-student interactions. Educational games and apps can also increase student engagement and motivation, creating a more interactive and positive classroom environment. The third component, CM, involves teachers' methods for organising and managing a productive classroom. Technological support, such as Learning Management Systems (LMS), can streamline administrative tasks like coursework organisation, attendance tracking, and grade management, allowing teachers to dedicate more time to teaching. Furthermore, TSPL tools can aid CM by providing clear expectations and interactive content, minimising disruptions and maintaining student focus. The integration of TSPL strategies into teaching and learning practices has the potential to significantly enhance instructional quality, with strong correlations observed between TSPL and CA, fostering interactive and stimulating learning environments, as well as between TSPL and CM, underscoring its importance in creating well-managed and productive learning environments (Asad & Suleman, 2025).

4.5 Cyber Security

The increasing reliance on cyberspace, amplified since the pandemic, has elevated cybersecurity to a critical concern for individuals and societies alike. This necessitates robust preventive and reactive measures while safeguarding freedoms. HEIs face heightened risks, particularly as undergraduate students, who are avid internet users, are more susceptible to online threats, such as cyber-attacks and phishing, due to their extensive online activities. Consequently, HEIs must fortify their network infrastructure access and educate users to enhance their vigilance in protecting personal data and privacy during online learning engagements (Raju *et al.*, 2022).

The integration of the IoT in smart universities introduces unique data security challenges, especially with unsupervised devices in less monitored areas. Educational institutions are vulnerable to both physical and cyber-attacks due to open-access environments and a lack of awareness among students regarding cyber threats. To preserve their reputation and the confidence of students, parents, and alumni, these institutions must invest in comprehensive security measures across the entire campus. The confluence of increased online dependency and the proliferation of IoT devices underscores the imperative for HEIs to prioritise and strengthen their cybersecurity posture and user education initiatives (Oughannou *et al.*, 2022).

The increasing number of interconnected smart devices and equipment in smart universities presents a significant vulnerability that attackers can exploit as entry points into the network, thereby affecting the overall security of the institution. Furthermore, the distribution and processing of data from sensors through multiple systems increases the risk of tampering or unauthorised alteration. The complexity of these networks and the inherent vulnerabilities of IoT devices also complicate network management and monitoring. Human factors, such as error, lack of skilled cybersecurity personnel, ongoing training, and a robust security strategy, further exacerbate these technical vulnerabilities, making systems more susceptible to attacks. Attackers can leverage these weaknesses to gain access to systems, retrieve confidential data, control operational systems, and target specific wireless communications (Raju *et al.*, 2022).

The main categories of attacks against smart universities include:

- Physical attacks targeting hardware devices like sensors and controllers can be the initial step in a broader attack, using compromised devices as entry points to the wider network. These attacks encompass device theft, social engineering, sleep deprivation attacks, tampering, malicious code injection, RF interference/jamming, permanent denial of service, and device spoofing.
- Software attacks utilise malware such as viruses, trojans, worms, and spyware, as well as scripts, to steal information, deny services, alter data, and even damage smart devices by exploiting vulnerabilities in computer systems.
- Attacks against data confidentiality are critical due to the vast amounts of data generated by devices and applications within smart universities. Protecting this data is crucial given the ease of remote access. These attacks can affect data during collection, suppression, use, and storage, and include inconsistency, breach, and loss of data, account or service hijacking, and unauthorised access.
- Attacks against network availability primarily manifest as denial of service attacks. Given the interconnected nature of smart university components via technologies like RFID, WIFI, and 5G, attackers can exploit network mapping or unauthorised access to overload communication and computing resources, leading to failed or delayed communications and potential disclosure of individual privacy. Network attacks include traffic analysis attacks, clandestine eavesdropping, phishing, SQL injections, man-in-the-middle attacks, RFID spoofing, routing information attacks, selective forwarding, sybil attacks, jamming, hijacking, and sinkhole attacks.
- Encryption attacks pose a significant risk to the confidentiality of cryptographic packages and overall security. Attackers aim to discover the encryption keys used in the encryption and decryption of modules, protocols, and data through methods like cryptanalysis attacks and side-channel attacks.

The combination of these vulnerabilities and attack vectors underscores the need for HEIs to implement comprehensive cybersecurity measures to protect their infrastructure, data, and users (Oughannou *et al.*, 2022).

Integrating security from the initial design and deployment of IoT devices and smart applications is paramount for ensuring adequate cybersecurity. Various security measures can be implemented, including access controls to regulate resource access, authentication to verify users and devices, and encryption for secure, low-power communication. Furthermore, trust management can eliminate malicious nodes, and secure routing protocols to enhance network integrity. Regular security patches and updates, physical security measures, and intrusion detection systems, like firewalls and antivirus software, are also essential. Finally, blockchain technology offers a means to manage large data volumes, secure IoT devices, protect user privacy, and ensure trust, confidentiality, and integrity (Oughannou *et al.*, 2022).

U5.0 emphasises preventative cybersecurity measures also through personalised training tailored to individual student needs using simulations and adaptive platforms. Students gain practical experience via hands-on exercises and collaborative group projects focused on real-world cybersecurity challenges. Addressing the trend of remote work and cloud migration, curricula must incorporate skills in cloud database exploration and the ethical handling of sensitive data. Furthermore, integrating workshops on privacy and data

protection is crucial for developing students' critical thinking skills in tackling cybersecurity issues and achieving digital literacy (Luna *et al.*, 2024).

5. Practical Implications

This study has many important practical and managerial implications, one of which implies the role of professors and educators.

Teachers generally monitor student satisfaction and interest in lectures. In fact, implementing a smart classroom environment allows educators to focus more on student learning needs and to guarantee an enhanced learning experience, as technology enables more efficient class management procedures, such as taking attendance, sharing learning resources, etc. (Abdellatif, 2019).

One of the obstacles to University 5.0 is the need to adapt teaching and learning methods to incorporate Industry 5.0 technologies and to provide students with adequate preparation to enter and compete in the labour market. The difficulty is determining which skills will be necessary in the future, as these novel technologies are part of a continuous, rapid evolutionary cycle. Thus, teacher training must provide sufficient professional readiness and skills to transmit the practical applications of I5.0 to future graduates (Yakymchuk, 2024). Furthermore, professors must aspire to expand their curricular programs to include innovative topics, like robotics, artificial intelligence, and data science, as well as focus on practical learning through projects and workshops (Vieira *et al.*, 2023).

Another fundamental aspect to consider is the unprecedented impact that managers and decision-makers have on the transition towards digitalisation, which obliges universities to provide high-quality training for these professionals. There is a need for efficient, creative, innovative, and forward-thinking management solutions to navigate leadership and institutional responsibility towards sustainable development. Therefore, the development of a manager's transformative intelligence should be addressed through scientific and technological collaborations between HEIs and industry. These interactions enable managers to acquire new competencies and resources to support the evolution towards a fifth-generation university model, incorporating elements of Industry 5.0 and ESG to build cybersocial ecosystems (Babkin *et al.*, 2024).

On the other hand, governments and policymakers are faced with the challenge of securing high-quality, fair, innovative education for all citizens. This requires large financial investments and is complicated by other issues such as population ageing and environmental problems. For this reason, HEIs must become more profitable and cost-effective. Partnerships and strategic collaborations between universities, government agencies, companies, and the community are increasingly being encouraged in order to enhance technological innovation and facilitate a constant update of students, graduates, and workers' competencies. Until now, these social aspects of digitalisation have been undervalued in legislation; thus, it is fundamental for governments to conduct further research from multidisciplinary perspectives to analyse all possible issues. Policymakers must also consider issues such as insufficient teacher training in digitalisation, the inadequacy of currently available infrastructure and tools, as well as cybersecurity and privacy issues (Vieira *et al.*, 2023). The potential risk is that humans could become overdependent on ICT and lose control over the continuous development of digitalisation, potentially leading to social degradation. For this reason, regulatory acts must be

undertaken in order to allow society and higher education to benefit from these advanced technologies, using them to improve the quality of people's lives (Tavares et al., 2022).

6. Conclusion

In conclusion, this study has mapped the state-of-the-art of the University 5.0 concept, addressing its main characteristics, potential impacts, and implementation challenges through a comprehensive literature review. The findings highlight that U5.0 represents a significant paradigm shift for HEIs, transforming them into hubs of social and digital innovation with a strong emphasis on creating supportive structures, integrating interdisciplinary approaches, and promoting cross-sector collaboration. This evolution is crucial for HEIs to adapt to rapid societal transformations and prepare graduates for the demands of the fourth and fifth industrial revolutions.

Ultimately, the successful transition to U5.0 requires HEIs to embrace a holistic and strategic approach, fostering a culture of sustainability, prioritising student-centred learning, leveraging digital technologies effectively, ensuring robust cybersecurity, and promoting collaboration within the broader innovation ecosystem. This necessitates a balanced approach to technological integration and a commitment to sustainability and collaborative innovation in HEIs.

The study is limited by the databases referenced and by the consideration of articles written only in English. Therefore, further studies are also necessary to analyse the practical implementation of a U5.0 approach and verify the realistic impacts that emerge. Future research should focus on how the role of professors as mentors and educators impacts the transformation of HEIs into fifth-generation universities. Another possible avenue for future research could be that of investigating the growing importance of the STEAM approach and how it contributes to integrating student knowledge and providing them with Industry 5.0 skills. This study provides valuable insights for university practitioners, managers, and policymakers seeking to comprehend and incorporate the U5.0 paradigm into their strategic goals, thereby contributing to a more innovative, sustainable, and socially responsible future for higher education.

Declaration of Interest Statement

No potential conflict of interest was reported by the author(s).

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