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Article

Higher Education in the Era of Industry 5.0 and Society 5.0

José Góis

University of Coimbra, Association for the Development of Industrial Aerodynamics, Department of Mechanical Engineering, Coimbra, Portugal

***** Correspondence: jose.gois@dem.uc.pt

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Abstract: Education models are strongly influenced by the evolution of society, adapting to its needs and technological developments. Given the importance of advanced education, higher education is becoming more relevant in the context of Industry 5.0, and Society 5.0. This article analyses the changes needed in higher education institutions to meet the complex and interdisciplinary challenges that characterise both scenarios, discussing structural aspects of school management, training and assessment models, student profiles and interaction with society. The integration of technologies like artificial intelligence, cloud computing, and big data enhances operational efficiency, reduces costs, and promotes sustainability. However, this shift also places pressure on institutions to maintain rankings, develop flexible e-learning strategies, and balance technological growth with environmental responsibility. Higher educational institutions (HEI) must address these challenges by adopting sustainable practices like electronic waste management and virtualization. At the same time, research centers play a crucial role in developing green technologies and designing future industrial systems that seamlessly integrate human factors, driving sustainable innovation and resilience. While public HEI's may benefit from state support, private institutions can thrive by targeting niche markets with agile, sustainability-driven strategies. The rise of automation may polarize the job market, but HEI's can mitigate this by promoting flexible, interdisciplinary education, fostering collaboration with industry and government, and enabling continuous skill development. Ultimately, the future of higher education lies in creating adaptable, globally connected learners ready to tackle the complex challenges of Society 5.0.

Keywords: higher education institutions, industry 5.0, society 5.0, digital transformation, artificial intelligence, sustainability

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1. Introduction

Since the 1990s, the global economy has undergone a rapid process of globalization due to the advancement of information and communication technologies, especially with the emergence of mobile phones and the internet, which turned innovation into a driving force for economic growth [1,2]. Over the past 10 years, a variety of digital technologies have emerged and significantly transformed the way people live and work [3,4]. As a result, companies and industries have been compelled to adopt these new technologies in their operations, requiring modifications to business functions and directly impacting essential operations, processes, products, and services. This rapid technological evolution has become a major challenge for businesses and society, due to the emergence of new technologies, digital platforms, and infrastructures, as well as the impact of these innovations on the way people work and live [5].

While Industry 4.0 (I4.0) prioritizes a technology-centered approach, focusing on digitalization and artificial intelligence (AI)-based technologies to enhance production efficiency and flexibility — often at the expense of the original principles of social justice and sustainability — Industry 5.0 (I5.0) incorporates resilience, sustainability, and human-centricity as key elements of technology-driven value creation systems [6]. The era of I5.0 will be marked by a new wave of work based on human-machine symbiosis.

The innovative I5.0 perspective has significant repercussions for the competitiveness of the higher education sector [7,8]. Higher education institutions (HEIs) are often compared to society's immune system, essential for the knowledge base. The higher education sector plays a central role in producing new knowledge, fostering new technologies, and developing agile methods for driving social innovation processes [9,10].

The concept of Society 5.0 (S5.0) emerged around 2016 in this context, to anticipate technological developments [11]. S5.0 primarily leverages artificial intelligence, the Internet of Things (IoT), automation, and big data. The transition from Society 4.0 to Society 5.0 demands high-level skills, integrating critical thinking, social creativity, the ability to solve complex problems, and effective communication [11,12].

Although research on the changes and challenges facing HEIs due to industrial evolution has been growing, it was only in the last decade — driven by economic and social globalization and the COVID-19 pandemic — that the number of publications on the subject surged, especially in developed economies like the United States, Japan, China, South Korea, and some European countries.

Understanding the impact of I5.0 on higher education, through the analysis of organizational theories and models and the extent of their application, were the criteria adopted for this research, aiming to identify and analyze opportunities and threats for higher education institutions, with a special focus on education in Portugal.

2. Methodology

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The literature review focused on the most relevant articles published in scientific journals or conferences since 2019, using the keywords Industry 5.0, higher education, and Society 5.0, with the objective of examining various theories and the impacts of technology and digital transformation policies on higher education institutions (HEIs) and society.

A comprehensive analysis of the main theoretical perspectives and empirical studies presented by various authors is conducted, accompanied by a critical reflection, with a focus on higher education in Portugal. In the discussion and synthesis, areas of convergence, divergence, and intersections are highlighted, identifying knowledge gaps with the aim of recommending future research.

3. Impact of industry 5.0 on higher education institutions and society

Industry 5.0 (I5.0) has emerged as a driving force of change and impact in the education sector [13]. This impact has placed significant pressure and challenges on the business models and operations of higher education institutions (HEIs). Consequently, the central focus of higher education offerings has shifted towards the development of projects aimed at sustainability and innovation. In recent years, HEIs have transitioned from being purely research and teaching institutions to knowledge hubs tailored to meet the educational demands of emerging industries, as they shift from Industry 4.0 to Industry 5.0. Innovation centers within universities and polytechnics have the potential to produce and share specialized knowledge, generate innovations, and promote new and unique ideas to support society, helping to address the challenges of ever-changing economies and societies. The impact of Industry 5.0 on HEIs has led institutions to pay closer attention to rankings, while research centers have developed strategies to achieve excellence qualifications. HEIs have been developing a set of policies to regulate e-learning strategies, aligned with societal and planetary well-being, aiming to foster greater resilience and sustainability. The use of Artificial Intelligence (AI), cloud computing, big data, and the Internet of Things has played a crucial role in facilitating information exchange and communication during the Industry 4.0 era. The adoption and flexibility of information technologies have had financial impacts by reducing service costs and generated environmental benefits, particularly by minimizing paper-based information transmission [14].

3.1. Economic impact

Leveraging collaboration between robots and humans through brain-machine interfaces can increase productivity while promoting collaborative engagement [9]. From competition to collaboration in human-robot interaction, an economic impact is expected. To meet each student's desired expectations in a lifelong learning program tailored to adapt to Industry 5.0 and Society 5.0, higher education institutions (HEIs) will develop autonomous educational systems capable of managing student expectations based on their individual profiles.

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Intelligent autonomous educational systems are expected to bring two distinct benefits: (a) the creation of a platform that enables economies of scale, by accommodating a larger number of students and supporting a wider range of tasks, and (b) a reduction in training costs for students through the recognition and valorization of skills acquired through experience. This shift could enhance the institution's operational and functional efficiency while exponentially shortening learning cycles.

3.2. Ecological impact

Digital transformation generates over 50 million metric tons of electronic waste annually, with only 20% of that total being recycled. It is estimated that this amount of waste will increase to approximately 120 million tons by 2050 [15]. Given this scenario, higher education institutions should integrate recycling mechanisms to manage electronic waste and seek sustainable solutions. This requires the implementation of an effective electronic waste management system. In this context, cloud computing and the use of virtual systems can play a key role in reducing operational load and energy consumption in higher education institutions. Virtualization allows the full capacity of a physical machine to be used by distributing its resources across multiple users or environments, minimizing the number of computers and servers needed. Meanwhile, cloud computing significantly contributes to reducing fixed costs associated with building and maintenance of information technologies.

3.3. Energetic impact

Progress in the sustainable digital transformation of higher education institutions requires the integration of state-of-the-art software applications and hardware infrastructure to offer both online and offline courses without limitations. In-house or outsourced data centres are needed to effectively operationalise the educational offer. To ensure the functionality of these systems, there are critical aspects that need to be ensured: information processing, data exchange, information storage, execution of web and multimedia services, and data management. It is important to note that information and communication technologies (ICT) already consume between 5% and 9% of total global electricity, and this trend is expected to increase by 20% by 2030 [16]. With the growth of digital resources in schools expected, this will lead to an increase in electricity consumption.

3.4. Technologic impact

It is essential that research centres linked to higher education institutions develop new green technologies - known as ‘green IoT’ [17], which respond to the challenges of I5.0 and the demands of S5.0. In order to increase what is known as ‘intelligent production’, it is

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necessary to design industrial systems and work processes that make it possible to integrate and incorporate human factors into what will be the factories of the future.

3.5. Socio-cultural and ethical impacts

The European Union has encouraged research into methodologies that base the design of technology on values that include socio-cultural and ethical considerations [18]. Despite the tendency to frame technologies as neutral objects, they inevitably reflect the values of both their designers and users. Industry 5.0 is causing computer researchers, designers, industrial engineers, philosophers and jurists to prioritise human values in the way the technologies of industrial 5.0 systems can be designed [19]. Given the impact that manufacturing systems have on workers and society and considering that the paradigm of human-centred cyber-physical systems is still in its infancy, it is essential to investigate the role of human values and ethics in the design of convergent technologies that make Operator 4.0 possible. Operator 4.0 is characterised by the mastery of technical, emotional and behavioural skills needed to face the challenges of technological innovation in companies. This professional must be able to use the intelligent systems of Industry 4.0 creatively, analytically, productively and strategically.

3.6. Impact on the type of education institutions

It is expected that public educational institutions will find it easier to develop their competitiveness, especially due to state support. Private educational institutions, on the other hand, could gain an advantage if they are able to focus on certain market niches. Institutions that manage to integrate ‘green IoT’ strategies into educational, social and sustainability value chains, combining technological impetus with ethics and developing innovation to promote agility and the preservation of the planet will be more competitive. This process requires innovation ecosystem policies geared towards sustainability, which will create resilience. Although in recent years higher education has seen a growing flexibility of the offer and diversity of training proposals, with an emphasis on models developed in partnership with regional entities, industry and the government, the fact that public institutions generally have a rather aged teaching/research staff [20] is a difficulty in embracing disruptive changes capable of promoting the development of effective strategies. Another factor that can hinder the decision to initiate change is the prevalence of academic inbreeding in HEIs in Portugal [21], as opposed to other European countries such as Germany and Switzerland or the United States of America. State funding issues and the status of the teaching career may have contributed to this situation. Hiring an internal lecturer to fill a vacancy is less costly than hiring an external person. One of the consequences of faculty endogamy is the formation of homogeneous think tanks that lack intellectual independence. This makes it difficult to use the critical capacity of everyone. Ideas are confined to a limited circle of possibilities, especially when the professors in a department have a similar academic

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background. These conditions lead to a waste of individual talent and a loss of the opportunity to create synergies through diversity. As a result, the innovation system is severely compromised.

3.7. Impact on employment

Advances in digital technologies could lead to significant increases in machine-driven productivity, but also to unemployment as more and more workers are replaced or displaced by automation [22]. With the emergence of driverless cars, pilotless drones and various automated retail systems, computers are redefining the boundaries of tasks and occupations that were previously thought unlikely or difficult to displace by technology [23]. The phenomenon of technological unemployment has been discussed in terms of the impact of ICT on structural change, digitalisation and routinisation. New technologies such as robotics, artificial intelligence and 3D printing will eliminate existing jobs. The large-scale computerisation of routine tasks in low-skilled occupations could lead to a decline in wages for low-skilled workers performing routine tasks, while high-skilled workers will continue to be valued in terms of wages. Occupations will tend to become highly polarised by skill level and routine tasks [24]. As automation spreads, self-employment will become the new normal and the knowledge worker will be at the centre of the emerging knowledge economy [25]. These workers will be mobile assets with the flexibility to organise the way they produce results and objectives in organisations, and with the autonomy to offer services to others without compromising their own knowledge.

4. Future of higher education in society 5.0

In the future, higher education will be much more than imparting knowledge. Driven by advanced technology, artificial intelligence and the demand for specialised skills, schools will need to prepare individuals for the complex, interdisciplinary challenges that characterise Society 5.0. Education will need to be more flexible and accessible, with the widespread adoption of online and b-learning models. This will allow students to personalise their own learning pathways, combining traditional courses with practical projects, internships and real-world work experience. Higher education should also be highly collaborative and interdisciplinary. Universities should work closely with businesses, regional and national governments and civil society organisations to develop innovative solutions to issues such as climate change, energy efficiency, the circular economy, social inequality and technological advances. This should include the training and retraining of staff in government organisations to further reduce bureaucracy and make communication more effective. Challenges for higher education institutions include the need to ensure the security and privacy of student data, to avoid digital exclusion and to ensure that everyone has equal access to educational opportunities to integrate and benefit from Industry and Society 5.0.

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Lifelong learning and professional development are key to preparing the workforce for a society 5.0. Higher education institutions must promote this culture, enabling students to adapt to rapid and continuous changes in the labour market, in a globalised and diverse environment, promoting international and intercultural experiences. All this should be prepared in such a way as to enable students to progress and obtain qualifications more quickly and in a more targeted way. The assessment of knowledge in higher education also needs to be adapted to the different teaching modalities to be effective and efficient.

5. Conclusion

Higher education will benefit from the influence of I5.0 if it understands the potential impact and can embrace disruptive change and use it for effective strategic development. Sustainable adaptation is the key to better managing the ongoing influence of I5.0 on the operation and delivery of higher education around the world. The education of the future will focus more on the development of human skills that are less likely to be perfectly replicated by autonomous systems. Schools will need to develop programmes to increase the resilience of teachers and students, and to increase the social capital of teachers and students by:

- Developing self-confidence by creating AI-based educational projects and preparing teachers for the Industrial Revolution 5.0,
- Increasing participation in social networks, establishing partnerships with industry and directing programmes towards the use of AI,
- Strengthen social relations, respect differences and avoid discrimination,
- valuing social values and norms among community members.

Students should use higher education to develop leadership skills, digital literacy, communication skills, emotional intelligence (tolerance and ethics), entrepreneurship and global citizenship. They should also develop high levels of reasoning to solve complex problems, critical thinking, creativity and the ability to respond in a healthy and productive way to adversity or trauma, i.e. to foster resilience. With the increasing integration of advanced technologies into the educational environment, there is a risk that students will become overly dependent on these technologies to complete simple tasks or obtain basic information. This can lead to a loss of basic and critical thinking skills and difficulties in verbal communication. In an environment characterised by the rapid dissemination of information and a culture of immediacy, students may be at risk of acquiring superficial and fragmented knowledge.

Conflicts of Interest: The author declares no conflict of interest.

References

[1] Fukuda, K. Science, technology and innovation ecosystem transformation toward Society 5.0. *Int. Journal Production Economics* 220, **2019**, pp. 1–14.

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[2] Rocha, A.; Ferreira, F.; Milici, A.; Banaitien, N.; Banaitis, A. Enhancing innovation culture: the case of multinational advertising agency VMLY&R Lisboa. *Technoogical and Economic Development of Economy* 28 (5), **2022**, pp. 1476–1501.

[3] Jafari-Sadeghi, V.; Garcia-Perez, A.; Candelo, E.; Couturier, J. Exploring the impact of digital transformation on technology entrepreneurship and technological market expansion: the role of technology readiness, exploration and exploitation. *J. Bus. Res*. 124, **2021**, pp. 100–111.

[4] Vieira, F.; Ferreira, F.; Govindan, K.; Ferreira, N.; Banaitis, A. Measuring urban digitalization using cognitive mapping and the best worst method (BWM). *Technol. Soc*. 71, **2022**, pp. 1–12.

[5] Çipi, A.; Fernandes, A.; Ferreira, F.; Ferreira, N.; Meidute-Kavaliauskie, I. Decting and developing new business opportunities in society 5.0 contexts: A socio technical approach. *Technology in Society* 73, **2023**, 102243.

[6] Ivanov, D. The Industry 5.0 framework: viability-based integration of the resilience, sustainability, and human-centricity perspectives. *International Journal of Production Research* 61 (5), **2022**, pp. 1683–1695.

[7] Gürdür Broo, B.; Kaynak, O.; Sait, S. Rethinking engineering education at the age of I5.0. *Journal of Industrial Information Integration*, 25, **2022**, Article 100311, https://doi.org/10.1016/j.jii.2021.100311.

[8] Togo, M.; Gandidzanwa, C. The role of Education 5.0 in accelerating the implementation of SDGs and challenges encountered at the University of Zimbabwe. *Internation Journal of Sustainability in Higher Education*, 22 (7), **2021**, pp. 1520 – 1535, https://doi.org/10.1108/IJSHE-05-2020-0158.

[9] Carayananis, E.; Morawska, J. The future of Europe: Society 5.0 and I5.0 as driving forces of future universities. *Journal of the Knowledge Economy*, **2022**, https://doi.org/10.1007/s13132-021-00854-2.

[10] Mohamed, M.; Tlemsani, I.; Matthews, R.; Mason-Jones, R.; Ndrecaj, V. Emergent strategy in higher education: Postmodern digital and the future? *Administrative Sciences*, 12 (4), 196, **2022**, https://doi.org/10.3390/admsci12040196.

[11] Mytra, P.; Wardawaty; Akmal; Kusnadi; Rahmatukkah. Society 5.0 in Education: Higer Order Thinking Skills. Proceedings of the BIS-HSS 2020, Indonesia, November 2021, DOI 10.4108/eai.18-11-2020.2311812

[12] Doyle-Kent, M.; Shanahan, B. The development of a novel education model to sucessfully upskill technical workers for Industry 5.0: Ireland a case study. *IFAC-PapersOnLine* 55 (39), **2022**, pp. 425-430, https://creativecommons.org/licences/by-nc-nd/4.0/.

[13] Ivanov, D. The I5.0 framework: Visiability-based integration of the resilence, sustainability, and human-centralicity perspectives. *International Journal of Production Research*, 1 – 3, **2022**, https://doi.org/10.1080/00207543.2022.2118892.

© 2025 ITMA. All rights reserved.

[14] Guerrero, M.; Haeton, S.; Urbano, D. Building universities' intrapreneurial capabilities in digital era: The role and impacs of Massive Open Online Courses, Technovation 99, 2021, https://doi.org/10.1016/j.technovation.2020.102139.

[15] Platform for accelerating the circular economy (PACE). A new circular vision for electronics: Time for a global reboot. 2019. Available online: https://www3.weforum.org/docs/WEF_A_New_Circular_Vision_for_Electronics.pdf (accessed on 10 January 2025).

[16] European Circular Economy Research Alliance (ECERA). Digital circular economy: A cornestone of a sustainable European industry transformation. 2020. Available online: https://www.era-min.eu/sites/default/files/publications/201023_ecera_white_paper_on_digital_circular_economy.pdf (accessed on 8 Januray 2025).

[17] Longo, F.; Padovano, A.; Umbrello, S. Value-oriented and ethical technology engineering in industry 5.0: A human-centric perspective for the design of the fatory of the future. *Applied Sciences* 10 (12), **2020**, MDPI, https://doi.org/10.3390/app10124182.

[18] United Nations. The age of digital interdependence. Report of the UN Secretay-General's High-level Panel on Digital Cooperation, 2019. Available online:https://www.un.org/en/pdfs/DigitalCooperation-report-for%20web.pdf (accessed on 6 January 2025).

[19] Friedman, B.; Hendry, D. *Value sensitive design: Sahping technology with moral imagination*. MIT Press: Cambridge, MA, USA, 2019.

[20] Fonseca, A. ; Sá, C.; Viana, C.; Araújo, E.; Sousa, H.; Almeida, L.; Fernandes, L.C.; Vasconcelos R. Teaching staff at the Unversity of Minho: demographic characterisation and rejuvenation strategies. (original title in Portuguese: Corpo docente da Universidade do Minho: caracterização demográfica e estratégias de rejuvenescimento), University of Minho, Braga, 2020. Available online: https://repositorium.sdum.uminho.pt/bitstream/1822/73865/1/DOCENTESUM_final.pdf (accessed on 7 January 2025).

[21] Direção-Geral de Estatísticas da Educação e Ciência (DGEEC). Education statistics 2022/2023. (original title in Portuguese: Estatísticas da Educação 2022/2023). Available online: https://www.dgeec.medu.pt/artpub/65520ab1455255473193d29b#artigo-670e2bb57ef0cadc601a5ea6 (accessed on 9 January 2025).

[22] Peters, M. Beyond technological unemployment: the future of work. *Educational Philosophy and Theory* 52 (5), **2020**, pp. 485 – 491, Available online: https://doi.org/10.1080/00131857.2019.1608625.

[23] Focacci, C. Technological unemployment, robotisation, and green deal: A story of unstable spillovers in China and South Korea (2008.2018). *Technology in Society* 64, **2021**, 101504.

[24] Hunt, J.; Nunn, R. Has U.S. employment really polarized? A critical reappraisal. *Labour Economics* 75, **2022**, 102117.

© 2025 ITMA. All rights reserved.

[25] Ferreira, J.; Fernandes, C.; Guo, Y.; Rammal, H. Knowledge worker mobility and knowledge management in MNEs: a biblometric analyis and research agenda. *Journal of Business Research* 142, **2022**, pp. 464 – 475.

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