Quaderni di Comunità

Persone, Educazione e Welfare nella società 5.0

Community Notebook

People, Education, and Welfare in society 5.0

n. 3/2023

REINVENTING UNIVERSITY.

THE DIGITAL CHALLENGE IN HIGHER EDUCATION

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eurilink

University Press

Iscrizione presso il Registro Stampa del Tribunale di Roma
al n. 172/2021 del 20 ottobre 2021

Eurilink University Press Srl
Via Gregorio VII, 601 - 00165 Roma
www.eurilink.it - ufficiostampa@eurilink.it
ISBN: 979 12 80164 71 1
ISSN: 2785-7697 (Print)

Prima edizione, febbraio 2024
Progetto grafico di Eurilink

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1. DIGITAL INNOVATIONS AS THE BASIS FOR THE IMPLEMENTATION OF THE CONCEPT FOR THE DEVELOPMENT OF T-SHAPED SKILLS IN HIGHER EDUCATION[1]

by Halyna Mishenina[*], Ligita Šimanskienė[**], and Erika Župerkienė[***]

Abstract: *In the digital age, higher education is evolving to equip students with versatile T-shaped skills, combining deep expertise and broad knowledge. A research question was held: how do digital innovations play a pivotal role in nurturing T-shaped skills within higher education, considering the dynamic job market? The research methods used were an extensive literature review, best practice analysis, thematic studies, document analysis, data systematisation, generalisation, and modeling using the Mermaid tool. Findings emphasise the essential role of digital innovations in higher education, promoting T-shaped specialists. Key takeaways underscore the impact of digital learning, continuous assessment, and emerging technologies like the Metaverse. The article highlights the transformative potential of digital innovations in higher education, with a focus on strategic planning, resource allocation, and proactive measures. It provides comprehensive insights into digital innovation's role in shaping T-shaped skills and calls for future longitudinal and contextual research.*

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[1] Accepted June 2023 - Published December 2023.

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Keywords: Education, Digital innovation, T-shaped specialists, T-shaped skills.

Abstract: *Nell'era digitale, l'istruzione superiore si sta evolvendo per preparare gli studenti con competenze a forma di T, che combinano una conoscenza approfondita e una vasta gamma di conoscenze. Questo articolo esplora come le innovazioni digitali svolgano un ruolo centrale nella coltivazione delle competenze a forma di T nell'istruzione superiore, tenendo conto del dinamico mercato del lavoro. La ricerca coinvolge un'ampia revisione della letteratura, un'analisi delle migliori pratiche e studi tematici, offrendo una comprensione completa. Le conclusioni sottolineano il ruolo essenziale delle innovazioni digitali nell'istruzione superiore, promuovendo specialisti a forma di T. I punti chiave evidenziano l'impatto dell'apprendimento digitale, della valutazione continua e delle tecnologie emergenti come il Metaverso. L'articolo mette in luce il potenziale trasformativo delle innovazioni digitali nell'istruzione superiore, con un focus sulla pianificazione strategica, l'allocazione delle risorse e misure proattive, fornendo, infine approfondimenti utili a comprendere il ruolo dell'innovazione digitale nella formazione delle competenze a forma di T, invitando altresì a futuri studi longitudinali e contestuali.*

Parole chiave: Educazione, innovazione digitale, specialisti a T, competenze a T.

Introduction

In the digital age, there is a rethinking of the role of higher education. The focus is on preparing students with versatile skills that cover in-depth expertise and a broad range of knowledge. A central concept in this shift is the idea of "T-shaped skills." This model envisions that individuals should have deep knowledge in a specific area (depicted by the vertical part of the "T"), as well as the ability to collaborate across different fields (represented by the

horizontal bar of the "T"). This article explores how digital innovation plays a crucial role in fostering the development of these T-shaped skills within higher education. This is particularly relevant in today's rapidly changing job market. The article delves into the principles of effective learning and the cultivation of T-shaped skills in students adapting to the modern era's digital innovations.

The primary objective of the research is to investigate the impact and effectiveness of digital innovations in developing T-skills in higher education. Specifically, it aims to identify the strategies and best practices employed by higher education institutions in utilising digital platforms and tools to enhance students' multidimensional skills within the context of the evolving educational landscape driven by digital transformation.

Additionally, the study seeks to examine the potential and challenges associated with integrating these digital solutions into higher education practices and establish pathways for the further advancement of T-shaped skills in the era of digitalisation.

The research methodology adopted to achieve this objective was grounded in several methods. Notably, it featured a systematic and extensive review of the existing literature, encompassing scholarly articles, reports, and research studies related to digital innovations in higher education and the development of T-shaped skills. This literature review was pivotal in establishing the theoretical foundations and identifying key trends and concepts.

In addition, the research encompassed an analysis of best practices and thematic studies. By examining successful cases from higher education institutions, we gained a deeper understanding of the practical implementation of digital innovations and their impact on developing T-shaped skills.

The document analysis, which included examining official documents, policies, scholarly materials, and institutional

documents related to the integration of digital innovations in education, allowed us to understand the institutional approach and strategies for educational development in the dynamic context of digital transformation. It also facilitated the identification of future directions for integrating digital innovations in education for preparing T-shaped professionals.

This comprehensive approach enabled us to offer a holistic and well-rounded investigation of the subject, contributing to theoretical understanding and practical implications for higher education institutions striving to prepare T-shaped professionals in the digital era.

Data collection. A substantial amount of literature was analysed in this article, including journal articles, reports, and even documents and websites. Several electronic databases were used to conduct the document analysis and literature reviews.

Research results. The study's outcomes provide strong evidence for incorporating digital innovations into contemporary higher education. This is crucial for preparing T-shaped specialists and highlights the potential for further digitalisation of the higher education sector. These findings serve as a foundation for future theoretical and practical research focused on using digital innovations to educate higher education students comprehensively and effectively. By addressing these aspects, this research paper aims to provide a comprehensive understanding of the role of digital innovation in shaping the T-shaped development of skills in higher education, thus contributing to the discussion about the future of education in the digital age. Some key research points.

Digitally Enhanced Learning and Teaching (DELT) and Institutional Adaptation. Institutions are acknowledging the crucial role of DELT in modern education, with nearly 80% implementing strategies for its enhancement. Successfully implementing these

strategies depends on institutional adaptability, staff resources, and active participation from both staff and students.

Need for Continuous Evaluation and Improvement. As digital technologies continuously evolve, higher education institutions must consistently evaluate the efficacy and impact of these digital tools and solutions. Rigorous examination and feedback mechanisms can ensure the optimal application of digital innovations for developing T-shaped skills.

Emerging Technologies Facilitate the Development of T-Shaped Skills. Integrating digital innovations in higher education, such as virtual reality, artificial intelligence (AI), and machine learning (ML), provide interactive and immersive learning experiences. This facilitates a more engaging learning environment and aids in developing T-shaped skills, providing both breadth and depth in knowledge across various fields and specialised expertise in a particular domain, respectively.

The Metaverse as a New Frontier for T-Shaped Skills Acquisition. As evidenced by the increasing interest in the metaverse for educational applications, this immersive digital environment offers novel opportunities for experiential learning and developing T-shaped skills. However, challenges such as cost, data privacy, access disparity, and potential for bias must be addressed to maximise its benefits.

The uniqueness of this study lies in its focused examination of the intersection of digital innovation and T-shaped skill development. While other studies have separately examined digital transformation in education and the pursuit of T-shaped skills, an attempt has been made to synthesise these two lines of research. This provides insight into the strategies, challenges, and potential for developing T-shaped skills with digital reinforcement.

Digital transformation trends have profoundly impacted the quality of higher education, promoting accessibility,

personalisation, experiential learning, global connectivity, improved infrastructure, etc. As the world embraces digital technologies, this impact will continue, further challenging the higher education system and trials. But it will also give new horizons for development.

Educational practices, including face-to-face, online, or hybrid flexible models, are evolving to accommodate students' diverse learning preferences. Digital Innovation and Education Technology (EdTech) solutions drive this shift by improving student outcomes and aligning traditional pedagogy with modern student expectations.

Literature Review

The concept of T-shaped skills, denoting depth in a specific field (the vertical bar of the T) coupled with a broad range of ancillary skills (the horizontal bar), has gained increased recognition in higher education. The necessity of such skills is well-documented. Guest (1991) first introduced this concept, which was later popularised by Mikkel Thunestvedt Hansen and von Oetinger B. (2001) and Tim Brown (2005), CEO of IDEO. The study (Wall *et al.*, 2015) examines the transformation from I-shaped to T-shaped managers and the role of various stakeholders in this process. Some scholars (Pessi *et al.*, 2015) mention I-shaped skills when discussing the growth of T-shaped and π-shaped skills. Mikkel Thunestvedt Hansen and HE Sánchez Ibarra (2020) delve into the advantages of managers being equipped with both in-depth specialised expertise and wide-ranging generalist knowledge in their paper "The Best Managers Are Both Specialists and Generalists". Their findings underline the relevance of T-shaped

professionals, who embody a similar blend of deep and broad capabilities.

In a more recent study, Johan Ninan, Marcel Hertogh and Yan Liu (2022), without explicitly employing the terminology of "tree", "X", "M", or "L" shaped professionals, delve into analogous competencies and concepts in their work on project leadership. Five distinct professional categories are mentioned in the literature, including I-shaped, dash-shaped, H-shaped, comb-shaped, and T-shaped (Demirkan & Spohrer, 2015).

In the context of contemporary T-shaped professional development and digitalisation, the article "Shaping T-shaped Professionals to Master Digital Transformation" (Caputo, *et al.*, 2023) is particularly important. The article offers a perspective that views T-shaped skills and digitalisation differently. It emphasises that the multifaceted challenges of digital transformation require a departure from established approaches and management models. Drawing on systems thinking, the authors emphasise the need to shift to a new paradigm that accurately defines T-shaped professionals capable of managing digital transformation in evolving dynamic environments.

With the advancement of digital technologies, higher education institutions have started integrating digital solutions to promote T-shaped skills. Digital transformation has become a pivotal component of higher education, as observed in several studies.

The digital transformation in higher education has its roots in the advent of computing technology and its gradual integration into teaching and learning processes. In the earliest phase, mainframe computers and later personal computers became tools for administrative tasks, research, and rudimentary teaching applications (Bates, 2019). The internet and web technologies in the 1990s and early 2000s ushered in a new era, allowing for

asynchronous learning, distance education, and the development of Learning Management Systems (LMS) that managed course content and facilitated interaction (Hazemi, Hailes, & Wilbur, 2012). The increasing role of digital technologies in higher education has been the subject of numerous academic studies, each examining different aspects of this large-scale and complex process. This literature review attempts to synthesise relevant research findings in the field, creating a comprehensive account of digital innovation in higher education.

Neil Selwyn (2016), for example, offers a valuable starting point with a critical examination of the impact of technology on education. Contrary to the general view that technology is an inherent good for learning, the author presents a more accentuated perspective. His work highlights the importance of a socially oriented approach to digital technologies in education, questioning the perceived benefits and identifying the need for further research.

Some scholars (Hess *et al.*, 2016) take a broader view of digital transformation, looking at different strategic options organisations can pursue during the transition. Although irrelevant to higher education, their work provides important insights for this sector, helping formulate effective digital transformation strategies.

Against these theoretical and strategic debates, Christopher Brooks and Mark McCormack (2020) shed light on the practical reality of digital transformation. The paper argues that the digital revolution in higher education has already occurred and that online learning platforms have a transformative impact. Their work provides an updated perspective on digital transformation, highlighting the significant changes already occurring.

At the policy level, Adrian Curaj, Ligia Deca, and Remus Pricopie (2018) assess the impact of past and prospective policies

on the European Higher Education Area. This paper considers digital innovation as an integral part of policy-making, hinting at future directions for the digital transformation of higher education in the European context.

Some studies (Castro *et al.*, 2020) present a systematic review of 19 research studies on digital transformation (DT) in higher education from 2016 to 2019. These scholars present three points of view on this process - technological, organisational, and social. The authors also emphasise that technological interventions primarily affect teaching, infrastructure, curriculum, and administration, and, to a lesser extent, affect research, business processes, human resources, or digital transformation management. Meanwhile, Guillermo Rodriguez-Abitia and Graciela Bribiesca-Correa in their paper (2021), provide a holistic view of the paradigm shift brought about by the digital transformation in higher education. Their study describes the current state and future trajectories of digital transformation, focusing on the challenges and opportunities inherent in this transformation.

The eLinC report (Cortès, 2022) provides an in-depth study to understand the background, current situation, and opportunities as this technological innovation in education is applied.

Looking into the future of digital innovation in higher education, Aidan Michael McCarthy (2023) explore the gap between leadership and technology. The authors highlight the critical need for proactive, responsive leadership that can effectively bridge the gap between institutional goals and technological implementation. Their work provides important insights into future leadership strategies and practices in digitally transformed institutions.

Innovative digital technologies, including the Experience Internet, the Metaverse, and Digital Twins, are transforming higher

education methodologies by facilitating immersive learning experiences (Maksimović, Davidović, Nikola, 2022). The Metaverse, a hotly debated digital innovation, signifies a new virtual universe that offers untapped educational opportunities (Zhang *et al.*, 2022). It enables the modelling of realistic learning scenarios via various technologies, enhancing the efficiency of blended learning. These groundbreaking digital advancements offer a fusion of traditional and online learning, creating an immersive, engaging learning environment (Cortès, 2022; Marr, 2022). Thus, the literature review establishes a theoretical foundation for understanding the trajectories of T-shaped skills development in the context of the ongoing digital transformation within higher education. It also serves as a basis for comprehending the evolution from using mainframes and personal computers to the emergence of the internet and web technologies, leading to asynchronous learning, distance education, and Learning Management Systems. The analysis of contemporary thematic reports, academic research, and reviews confirms the growing role of digital technologies in higher education, facilitating an understanding of the landscape of digital transformation in higher education. To provide a comprehensive view of this evolving landscape, we have also touched upon the technological, organisational, social, and policy aspects of digital innovations in higher education. Additionally, we have sought to underscore the transformative potential of innovative digital technologies, such as the Experience Internet, Metaverse, and Digital Twins, shaping higher education methodologies and immersive learning experiences. However, more research is necessary to comprehend and exploit these emerging technologies in education fully.

1. *Shaping the Future: A Conceptual Exploration of T-shaped Skills in Modern Higher Education*

According to the World Economic Forum's Future of Jobs report, by 2025, half of all employees will need to reskill as technology adoption grows.

Modern trends in the labour market and the HR sector today expect a specialist to have broad horizontal erudition (both general and professional), which provides him with an increase in adaptability to new knowledge and the ability to retrain, acquire new skills in demand, and rebuild following the new challenges of the time.

Table 1 Indicators characterising labour market and HR sector trends reflect the main aspects of the Future of Jobs Report 2023, regarding skills disruption, growth, and decline in the importance of skills, training needs, and the relationship between skills and corporate skills development strategies.

Table 1: Indicators characterising labour market and HR sector trends

Key focus area	*Detailed Insights*
1. Skill disruption	44% of workers' skills will be disrupted in the next five years
2. Growing importance skills	1. Cognitive skills (complex problem-solving) 2. Creative thinking 3. Technology literacy 4. Self-efficacy skills 5. Socio-emotional attitudes (curiosity, lifelong learning, resilience, flexibility, agility, motivation, self-awareness) 6. Systems thinking, A.I. and big data, talent management, service orientation and customer service
3. Declining importance skills	Reading, writing and mathematics; global citizenship; sensory-processing abilities; manual dexterity, endurance and precision

4. Training needs	Six in 10 workers will require training before 2027. Only half of the workers currently have access to adequate training opportunities
5. Upskilling priorities 2023-2027	1. Analytical thinking (10% of training initiatives) 2. Creative thinking (8% of upskilling initiatives) 3. AI and big data (42% of companies) 4. Leadership and social influence (40% of companies) 5. Resilience, flexibility and agility (32% of companies) 6. Curiosity and lifelong learning (30% of companies)
6. Skills and corporate upskilling strategies	Skills such as AI and big data, leadership and social influence are prioritised more than their current importance in the workforce. also emphasised are design and user experience, environmental stewardship, marketing and media, and networks and cybersecurity
7. Fastest-growing roles	1. AI and machine learning specialists 2. sustainability specialists 3. business intelligence analysts 4. information security analysts 5. renewable energy engineers 6. solar energy installation and system engineers
8. Fastest-declining roles	1. bank tellers and related clerks 2. postal service clerks 3. cashiers and ticket clerks 4. data entry clerks
9. Job growth areas	1. education (10% growth, 3 million additional jobs for vocational education teachers and university and higher education teachers) 2. agriculture (30% growth, 3 million additional jobs for agricultural equipment operators) 3. digital commerce and trade (4 million digitally-enabled roles like e-commerce specialists, digital transformation specialists, and digital marketing and strategy specialists)
10. Job decline areas	Administrative roles and traditional security, factory, and commerce roles (26 million fewer jobs in record-keeping and administrative roles, cashiers and ticket clerks, data entry, accounting, bookkeeping and pay

Source: systematised by the authors on the basis of Future of Jobs Report, 2023

Within technology adoption, big data, cloud computing and AI feature highly on the likelihood of adoption. More than 75% of

companies are looking to adopt these technologies in the next five years.

Based on the Future of Jobs Report, 2023, it can be argued that the Concept of T-shaped Skills is coming to the forefront in preparing students for the future, in particular for career opportunities, as having one vertical of expertise is not enough in an environment of constantly updating professional knowledge. In the future, this trend will only intensify, as current research and projections confirm (Boehm *et al.*, 2019; Babatope *et al.*, 2020). Therefore, when training a competent professional in higher education, among the most important arguments in favour of reforming the educational process is the strong potential to train T-Shaped professionals.

T-Shaped People are specialists who balance a broad outlook with in-depth expertise in one of the areas in which they specialise. This composition makes them unique and useful leaders in today's world. The T-shaped specialist is contrasted with the I-specialist (an expert in only one area) and the generalist - the person who is superficially knowledgeable in everything but has no expertise in any area (Uhlenbrook *et al.*, 2012).

The concept of T-shaped skills first emerged in the consulting field, thanks to David Guest 1991 after the classic I-shaped approach (Smith, 2014; Wall *et al.*, 2015), where development was focused exclusively within a single specialisation.

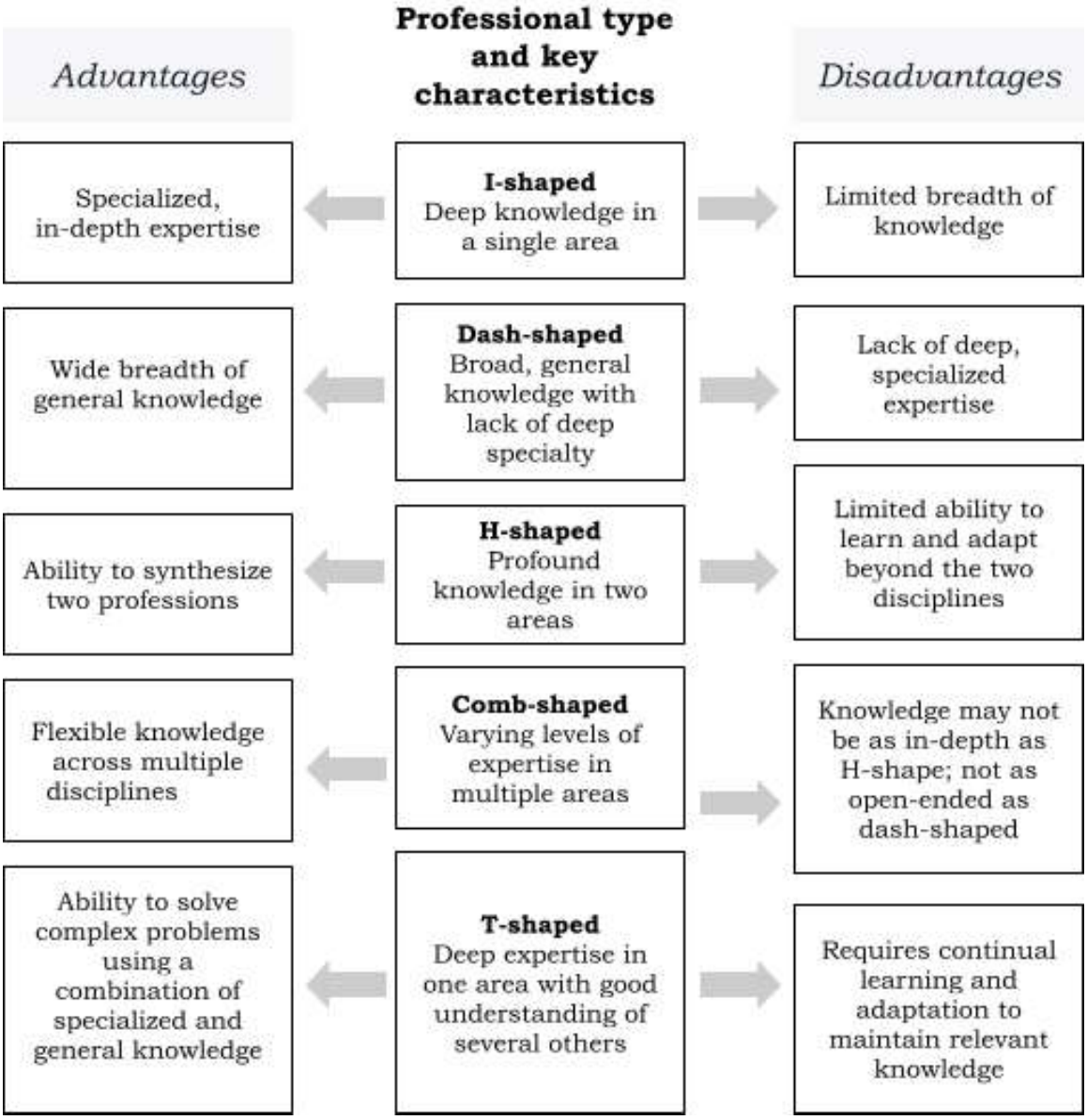
Originally, the term "T-shaped person" referred to people with business experience and skills in IT. But today, when we talk about T-shaped people, we mean people who are both experts in a particular professional area and knowledgeable in related ones. They may have various useful skills among them that allow them to work comfortably in related professions (or not necessarily related ones). Sometimes this type is confused with "generalists" -

generalists, but there is an important difference between them: generalists do not have deep expertise in a particular field.

Five distinct professional categories are mentioned in the literature including I-shaped, dash-shaped, H-shaped, comb-shaped, and T-shaped (Demirkan & Spohrer, 2015). Briefly, these categories can be characterised as follows: I-shaped professionals are experts in one area (Bierema, 2019), while dash-shaped professionals, considered universalists, lack in-depth specialist knowledge (Uhlenbrook & Jong, 2012). H-shaped professionals, who combine two areas of knowledge, are also distinguished (Tranquillo, 2017), and comb-shaped professionals, who have knowledge in many areas, albeit to varying degrees (Uhlenbrook & Jong, 2012).

Figure 1 - Characteristics of professional profiles illustrate the depth and breadth of competencies for these 5 categories, as well as their advantages and disadvantages.

Figure 1: Characteristics of professional profiles



Source: Systematised by the authors based on (Babatope, 2020; Tranquillo, 2017; Bierema, 2019; Demirkan et al.*, 2018; Uhlenbrook* et al.*, 2012)*

These professional profiles highlight the continuing demand for T-shaped professionals who can work interdisciplinarily or transdisciplinary. For example. Professionals working on

infrastructure projects fill several roles, such as management, leadership, communication, monitoring, extension, entrepreneur, troubleshooter, resource allocator, and negotiator. Filling these roles requires a combination of technical and managerial competencies (Ninan *et al.*, 2022)

The competence concept of T-shaped professionals proposed by David Guest was further developed. His followers identified types such as Tree-Shaped People (with a branched structure of knowledge and skills), X-shaped People (leaders with transversal competencies across one or two vertical specialisations), M-Shaped and L-Shaped (Sakamoto *et al.*, 2009; Hansen, 2020).

Today, one of these models can be found in various discussions across disciplines. They are often used in the literature on HR and business strategies to describe the desired qualities of employees. Based on general industry trends and analysis of recent labour market fluctuations (Future of Jobs Report, 2023) in Table 2 - T-shaped specialisations currently and in Table 3 - Future T-shaped specialisations we have tried to systematise some of the current and future highly valued T-shaped specialisations.

Table 2: T-shaped specializations currently

T-shaped specializations	*Deep Knowledge (Vertical Bar of T)*	*Broad Understanding (Horizontal Bar of T)*
Data Science	Interpreting and analyzing data, using machine learning tools, building predictive models, communicating findings	Understanding business, technology, and statistics
Digital Marketing	SEO, social media marketing, content creation, analytics	Understanding wider marketing field, business strategy, consumer behavior, basic design principles

Software Development	Specialization in one or more programming languages or development frameworks	Understanding software architecture, user experience, project management, business needs
Cybersecurity	Expertise in network security, information security, or cyber forensics	Understanding IT, legal issues, management, human factors in security

Source: created by the authors

Table 3 Future T-Shaped Specializations

T-shaped specializations	*Deep Knowledge (Vertical Bar of T)*	*Broad Understanding (Horizontal Bar of T)*
Artificial Intelligence (AI) Machine Learning (ML)	Developing AI/ML models	Understanding ethical considerations, business applications, data privacy
Quantum Computing	Understanding quantum principles and algorithms	Broad knowledge of computer science and programming
Climate Science and Sustainability	Expertise in climate science or sustainable practices	Understanding policy, business strategy, technology

Source: created by the authors

T-shaped skills allow you to transcend narrow specialisation and survive in an era of digital turbulence. T-shaped people with in-depth knowledge in at least one field and extensive knowledge in others (e.g. related fields) are in high demand in the labour market due to the increasing complexity and interdisciplinary nature of modern work (as the Future of Jobs Report, 2023 shows). Understanding this reality poses challenges for the higher education system (and education in general) (European University Association, 2019).

In our view, the development of T-skills today can only be effectively achieved through the use of several overlapping hybrid and physical, and of course digital, learning spaces.

Innovative digital spaces allow learners to move seamlessly from resource-based learning to interactive discussion groups and industry-specific webinars while developing broad knowledge and specialist expertise. Involving external individuals in teaching and learning facilitates this development, providing learners with real-world applications and diverse perspectives (Jackson, 2019; Hazemi *et al.*, 2012; Ellis, 2016).

Digital transformation and innovation in this field are fundamentally changing the way we teach and learn in higher education. This transition increases the availability of different learning resources and platforms, providing students with the opportunity to acquire specialised knowledge (vertical "T") from a wide range of sources. At the same time, the use of digital tools for collaboration and communication enables students to work across disciplines to acquire broader knowledge and skills (horizontal 'T'). These aspects are explored in more detail in the following sections.

2. *Transformation of higher education in the context of digital development*

Higher education institutions that want to remain relevant today and for the foreseeable future have no choice but to turn to digital innovation. Above all, to improve teaching, learning, student management, and faculty effectiveness.

Digital transformation is significantly changing the quality of higher education by changing paradigms in teaching and learning processes. This is primarily due to two things: firstly, the ubiquitous access to the Internet and smartphones; secondly, the possibility to

enter the education industry in different ways (which the COVID-19 pandemic has further facilitated by boosting online education) (Here's What Higher Education, 2023).

Today's ever-evolving global education system is increasingly driven by processes of digital transformation. Competition between universities to provide better services remains key to the further development of the entire education system. There is therefore an urgent need to use digital innovation to improve the quality of education and the student experience (Bygstad *et al.*, 2022; Brasa *et al.*, 2022; European Commission, 2021). The transformational benefits of the digitalisation of universities are an undeniable fact (the transformation of education in Singapore is a prime example). The rapid development of digital technologies and the actively changing demands of the labour market make it necessary to develop strategic actions for an effective digital ecosystem in local and global universities (Mohamed Hashim *et al.*, 2022, Gaebel *et al.*, 2022).

The rapid transition to digitisation, virtualisation, and the use of virtual tools has radically changed university operations and service delivery models, forcing universities to adapt quickly to these changes and explore and create digital transformation strategies (Puckett al., 2022; Mohamed Hashim *et al.*, 2022). To offer relevant knowledge and skills and to attract and retain students.

And here's why. According to a study by The New Consumer (New Trend, 2021), 45% of Generation Z participants reported feeling most at home in an online environment. This online preference varies by generation: 43% of Millennials, 22% of Generation X, and 7% of baby boomers express similar feelings. In addition, Wunderman Thompson Intelligence (New Trend, 2021) found that 76% of respondents depend on technology in their daily lives and activities. Meanwhile, dependence on technology in various

aspects of life ranged from 64% in social life to 50% in well-being. And the trend as we can observe is only getting stronger.

For its part, according to research by the European Commission (EC), in 2019, 80% of higher education institutions in Europe reported using digital tools and platforms for teaching and learning. However, only 23% of institutions reported offering fully online degree programs. The European University Association (EUA) survey in 2020 showed that 72% of higher education institutions in Europe had a digital strategy and 53% had a dedicated department or unit for digital education (Gaebel *et al.*, 2022).

In turn, according to research by the European Commission (EC), 80% of higher education institutions in Europe reported using digital tools and platforms for teaching and learning in 2019. However, only 23% of institutions reported offering fully online degree programs. The European University Association (EUA) 2020 survey found that 72% of higher education institutions in Europe had a digital strategy and 53% had a dedicated department or unit for digital education (Gaebel *et al.*, 2022).

Overall, digital innovation is expected to continue to change the landscape of higher education. Thus, the Digital Education Action Plan (2021-2027) adopted by the European Commission (EC) sets two strategic priorities:

1. developing a high-performance digital education ecosystem;
2. enhancing digital skills and competencies for digital transformation.

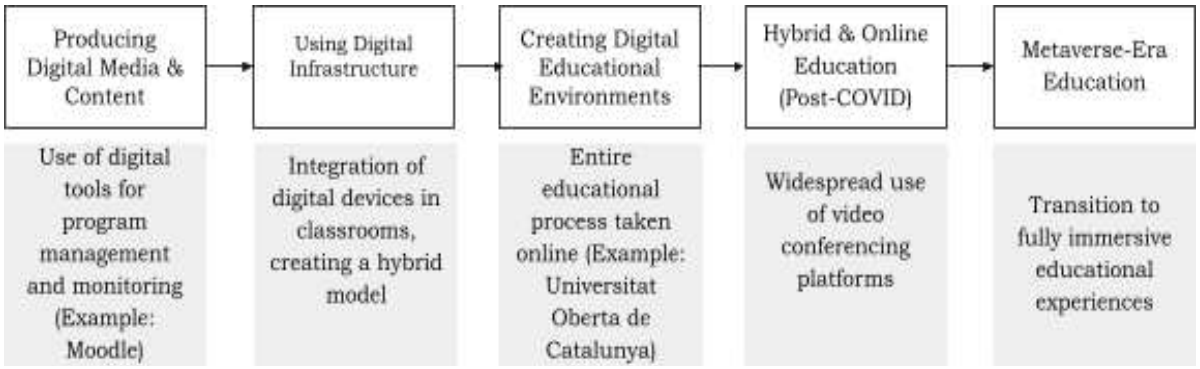
The plan sets out a common vision for high-quality, inclusive, and accessible digital education in Europe and aims to support the adaptation of education and learning. The plan notes that digital education should foster more personalised, flexible, and student-centred learning (Action Plan).

We can also see a rapid momentum toward growth in educational digital technologies. Edtech start-ups have attracted

record amounts of venture capital in 2020 and 2021 (Brasa *et al.*, 2022) According to the Brighteye European Edtech Funding Report, investment in educational technology has tripled since 2020 to $20 billion in 2021 (The European Edtech Funding Report, 2022). Several major companies have developed principles for the digital transformation of higher education. The models presented by KPMG, Microsoft, and Google offer different perspectives on digital transformation. These frameworks are necessary for a theoretically sound and empirically tested model of digital transformation in educational institutions, taking into account their core functions such as teaching and learning, research, and community service. More details on the companies' proposals in (Alenezi, 2021). It is worth noting that the transition from traditional to digital education began with the introduction of digital tools for program management and supervision (such as Moodle). Digital devices began to be integrated into classrooms: computers, tablets, smart boards, and mobile phones (today this is not just the norm but a necessity). This has led to a hybrid model of education. Some higher education institutions have gone further by moving the entire educational process online. However, it was the beginning of the COVID-19 pandemic that forced the move to hybrid and online education almost everywhere, and video conferencing platforms became a common tool.

Figure 2 - Stages of educational transition and key features show the transformation of higher education in a digital environment.

Figure 2: Stages of educational transition and key features



Source: created by the authors based on (Brasca et al.*, 2022; Mohamed* et al.*, 2022; Alenezi, 2021; Al-Maroof* et al.*, 2021; UNESCO Strategy on Technological Innovation in Education, 2021)*

Trends such as cloud computing, open educational resources, and massive open online courses are shaping the current level of digital education. Open educational courses, based on the open-access model, offer access to the latest learning materials that can be used anywhere and anytime. In turn, massive open online courses are considered affordable and universal tools for retraining and advanced training.

The digital transformation has significantly changed the quality of higher education, and in general, can now be characterised by such aspects (Leontiades, 2018; Mohamed *et al.*, 2022):

Enhanced accessibility. Technological advances, such as text-to-speech software or transcription software, have made it easier for students (including those with disabilities) to learn. Geographical barriers are greatly reduced by online learning, allowing students to access quality education regardless of their location.

Cloud-based learning. This technology has facilitated access to educational resources, allowing teachers and students to

continue their educational activities during the pandemic by providing a platform for interactive online classes, sending assignments, collaborative projects and even digital exams.

Digital security. With the digitalization of higher education, the security of students' confidential data has become a major concern. Effective security protocols are essential to protect this data and ensure the authenticity of digitally submitted assignments and assessments.

Digital citizenship. Digital citizenship training is becoming increasingly important to ensure that students communicate online in a civilised manner. This important skill prepares students for the digital professional world by facilitating collaborative behaviour online.

Big data. The use of big data in education has enabled educational institutions to better understand the patterns, challenges, and successes of students. It allows educational institutions to break down data silos, helping them to better shape their programs and resources to improve student outcomes.

In addition, personalised learning can rightly be considered one of the main achievements of the digital transformation of education. This leads to better engagement and learning, encouraging students to progress in their educational trajectory.

It is worth noting that today, the integration of artificial intelligence technologies into education extends to the promotion of creativity, thereby adding another dimension to the learning environment. There is also speculation that the meta-universe will make a new leap from face-to-face or online education to a fully immersive educational experience, thereby completely changing the educational paradigm (Metaversities, 2022; McCarthy 2023 *et al.*, 2023).

Based on research on digital transformation in higher education (Khotari *et al.*, 2019; Røe, 2022; Brasa *et al.*, 2022;

McCarthy *et al.*, 2023), it can generally be concluded that digitalisation of institutions should occur systematically, based on four key factors:

People who, as key actors in the educational process, should be committed to promoting cultural change and a new organisational model in their educational institutions, as well as being trained in digital skills.

Technology as a means of facilitating and improving educational and management processes, the collection, analysis, and use of data generated by students' actions, and the implementation of digital innovations applicable to education.

Management and academic processes in which students are first and foremost considered and decisions are made by and for them, while constantly thinking about how to optimize operations to improve internal and external services.

Comprehensive communications management as the ability to respond quickly to resistance to change, maintaining flexible, clear and agile communications within and outside the university, and being present in different channels for this purpose.

As a result, higher education institutions that strive for so-called "digital maturity" and invest in digital innovation can achieve better results in the following areas: a) student success in enrolment, retention, and employability; b) operational efficiency; c) innovation in teaching; d) innovation in research.

Overall, to summarise the above, competition between universities to provide better education and develop relevant skills for students remains key to their future development, and the digital transformation of universities and the education system as a whole is an imperative of our times. The challenges and opportunities associated with this process require careful planning and strategic execution, as digital transformation involves a cultural, human, and technological shift, and the variety of digital tools affects and

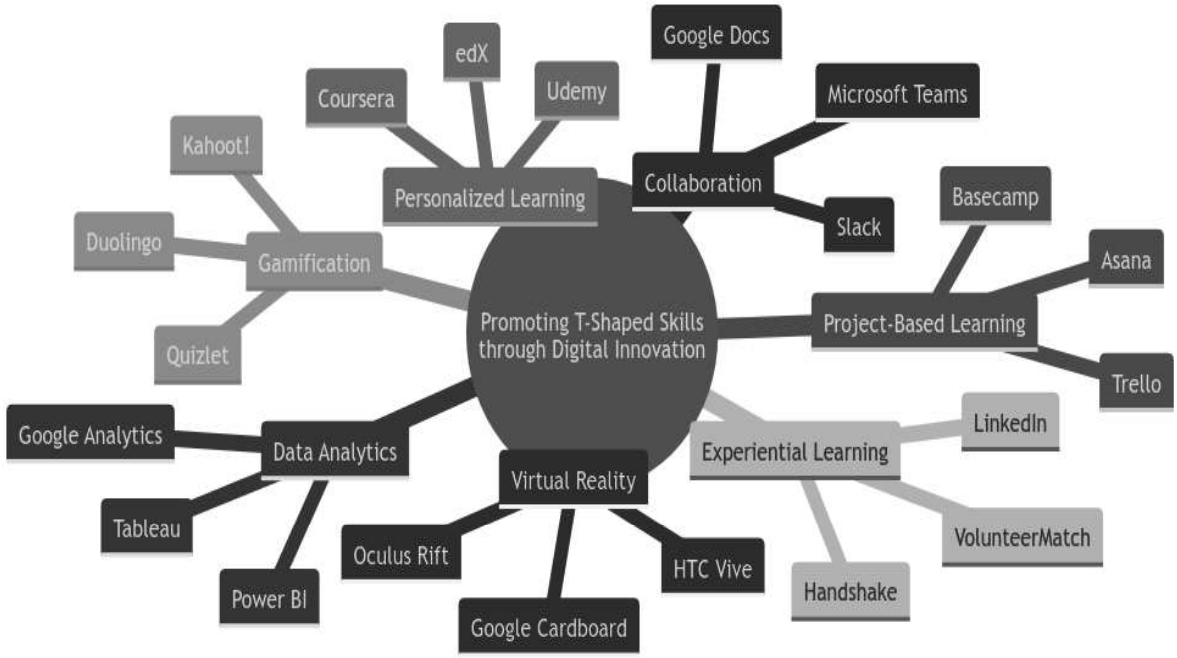
changes almost everything. Nevertheless, the potential benefits - improved quality of education, better training of students and increased global competitiveness - make this path not only necessary but also promising, including and especially in the training of T-shaped professionals.

3. Digital Innovations and T-Shaped Skills Development

Digital innovations play an important role in T-shaped skills development by providing platforms and tools that facilitate both specialised and interdisciplinary learning. For example, Virtual Reality (VR), which until recently was considered more of an entertainment technology, has now become an important tool in experiential learning and allows students to 'experience' learning material, thereby enriching their understanding and increasing their readiness for real-world application (Maksimović *et al.*, 2022; Khotari *et al.*, 2019; Røe, 2022).

Today, the practice of developing T-shaped skills through digital innovation can be illustrated as follows (Figure 3).

Figure 3: Best practices for promoting T-shaped skills through digital innovations



Source: created by the authors with Mermaid - tool (Gardner & Estry, 2017; Demirkan & Spohrer, 2018; Rodrigues et al.*, 2021; Olesen* et al.*, 2021; Cheng* et al.*, 2022; UNESCO Strategy on Technological Innovation in Education, 2021; Caputo* et al.*, 2023)*

For example, in the realm of fostering collaboration skills, the use of platforms such as Google Docs, Microsoft Teams, and Slack can significantly enhance students' communication and teamwork abilities. Similarly, platforms like LinkedIn, Handshake, and Volunteer Match can play a pivotal role in providing internships, co-op programs, and service-learning initiatives.

The utilization of gamification, employing tools like Kahoot!, Quizlet, and Duolingo, transforms ordinary lessons into interactive and enjoyable experiences, thereby greatly improving retention and understanding.

Additional examples of digital innovations and their impact on the development of T-shaped skills are presented in Table 4.

Table 4: Examples of digital innovations in education for the Development of T-Shaped Skills

Digital innovation examples in education	*Development of T-Shaped Skills*
1. AI and ML-based tools (Carnegie Learning, Quizlet, MATHia)	Deepens specialised knowledge through the personalisation of learning and the provision of resources tailored to individual needs.
2. Data analytics platforms (BrightBytes, Watermark, Panorama Education)	Enhance decision-making and critical thinking skills, fostering both depth and breadth of knowledge.
3. Online learning platforms (Coursera, edX, FutureLearn)	Allows for the pursuit of specialised courses while simultaneously offering exposure to a range of disciplines, aiding interdisciplinary understanding.
4. Collaboration tools (Google Workspace for Education, Microsoft Teams for Education, Slack for Education)	Facilitates interdisciplinary collaboration and communication, stimulating the development of a broad range of skills and knowledge.
5. VR and AR tools (Google Expeditions, zSpace, Labster)	Provides immersive learning experiences, deepening specialised knowledge and widening interdisciplinary understanding through real-world simulations.
6. Digital assessment (Turnitin, ExamSoft, GradeScope)	Assists in tracking and assessing the depth of specialised knowledge and breadth of interdisciplinary understanding, facilitating balanced development of T-Shaped skills.
7. Digital twin technology (Simcenter, Akselos, ANSYS)	Enables practical, hands-on learning in a virtual environment, enhancing specialised skills while promoting a broader understanding of the interconnections and complexities within a system.

Source: New trend report, 2021; UNESCO Strategy on Technological Innovation in Education, 2021; Marr, 2022; Cheng et al.*, 2022.*

There is no doubt that innovative digital technologies will continue to have a crucial role to play in the educational process. Already today, the Internet of Impressions, the use of Metaverse, and Digital Twins are changing approaches to learning in higher

education by providing immersive learning. For example, the Digital Twin (DT), one of the most promising new technologies at the moment, can provide engineering students with learning opportunities beyond the classroom (Maksimović *et al.*, 2022).

The Metaverse is one of the most hotly debated aspects in the digital world today. The opportunities that this digital innovation brings to education are being actively discussed and tested.

Metaverse is a compound word combined with "meta-" (beyond; transcending) and "verse" (the root of "universe," cosmos; the whole world), which denotes a new virtual universe created beyond the real world. The origin, definition, and features of the Metaverse are explored in detail by (Zhang *et al.*, 2022)

In the Metaverse, various realistic learning scenes can be simulated and created using technologies such as digital doubles, virtual reality, augmented reality, XR, etc.

This technology can significantly improve blended learning, by combining traditional face-to-face and online learning, providing a more immersive and engaging learning environment (Cortès, 2022; Marr, 2022):

Firstly, immersive experiences in the Metaverse provided by virtual reality headsets can solve problems associated with screen-based learning (e.g. video conferencing fatigue, lack of motivation and depersonalisation).

Second, by allowing learners, irrespective of their physical location, to participate in an educational environment and engage in various learning activities, the meta-universe facilitates both synchronous and asynchronous learning. Participants can positively interact with real or virtual teachers and peers, creating a sense of being together in the same space.

Thirdly, this approach not only increases interest and engagement in learning but also offers practical solutions to problems inherent in current videoconferencing learning. Thus, the

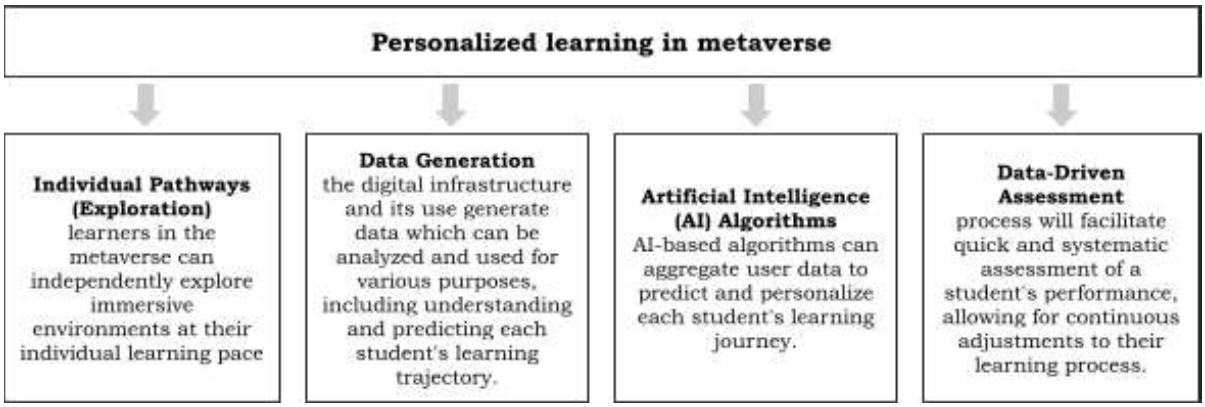
metaverse represents a promising direction for the development of new blended learning paradigms, facilitating the expansion of learning experience and involvement, which is an effective tool in the development of T-shaped skills in students. As part of our study, for example, it is also of interest that the metaverse is not just an innovation for VR or AR, but a set of new technologies such as 5G, AI, blockchain, digital twins, holography or IoT (Internet of Things) with through which a technology base can be built for specific areas, and its components and functions can vary depending on the needs (Zhang *et al.*, 2022; Kye *et al.*, 2021; Park *et al.*, 2022; Shin, 2022; Cortès, 2022).

The Metaverse is a fusion of virtual augmented reality and physically persisting virtual space. It includes both rendered and augmented elements from the real world and creations created in the virtual world. For example, a courtroom, a manufacturing plant, an operating room, etc. can be modelled. The gap between the virtual and physical worlds in the metaverse will be narrowed or even eliminated, making the student's experience more immersive, multi-sensory, and close to authentic.

Thus, this technology in education provides three-dimensional visual learning, more realistic interactivity, and easier access for remote students. Which naturally positively influences the process and quality of training for specialists with different skills (Cortès, 2022). As already noted, digital education should contribute to more personalised, flexible and student-centred learning. It promotes the development of personalised approaches to learning, adapting to individual learning styles and taking into account the specific strengths and weaknesses of students.

Figure 4 - Metaverse Enhancements in Personalized Learning presents four ways in which the Metaverse is improving personalised learning.

Figure 4: Metaverse enhancements in personalised learning



Source: created by the authors based on (Cortès, 2022; Kye et al.*, 2022)*

Thus, metaverse technology can more effectively help develop T-shaped skills by providing students with the opportunity to gain in-depth knowledge in their chosen field, as well as exposing them to a wide range of related disciplines and skills. There are five areas where the metaverse can develop T-shaped skills in students:

1. *Blended learning.* The Metaverse can be used to create a blended learning environment that combines traditional classroom learning with online learning to provide students with a more personalised and engaging learning experience.
2. *Language learning.* The Metaverse can provide an immersive language learning experience where students can practice speaking and listening skills in a realistic virtual environment.
3. *Learning based on competencies.* The Metaverse can be used to create virtual simulations and scenarios in which students can practice and demonstrate their skills and competencies.
4. *Inclusive education.* The Metaverse can provide an accessible and inclusive learning environment for students with disabilities or special needs.

5. *Collaborative learning.* The Metaverse can facilitate collaborative learning by providing virtual spaces where students can work together on projects and assignments.

These are just a few examples of how this technology can be used to train T-shaped specialists. The potential has not yet been fully exploited. However, there may be some areas of higher education where the use of these technologies is more limited. For example, areas that require hands-on training or hands-on experience may not be able to take full advantage of these technologies. It is also worth noting that with all the promising potential of the metaverse in the digital transformation of education, there are a number of problems that may limit the use of this technology. The main problems are presented in *Table 4 - Overview of problems associated with the metaverse.*

Table 4 - Overview of problems associated with the metaverse

Problems	Description of the problem
1. Significant costs and time	The Metaverse requires significant spending on licensing VR content, building digital campuses, purchasing VR headsets, and more. Universities need to invest significant time and resources in training teachers to deliver Metaverse courses and develop new digital materials.
2. Data privacy, security and safety	The business models of the Metaverse companies are based on the collection of detailed personal data of users. These platforms may collect sensitive data and there is a risk that this information may be accessed or misused. Cyber attacks in the metaverse can cause physical harm or expose students to inappropriate content.
3. Lack of access to developed infrastructure in rural areas	Many applications in the metaverse require high-speed data networks to function optimally. However, users in rural areas often lack the infrastructure needed to support the streaming of high-quality Metaverse content.

4. Adaptation of tasks to the new environment	The introduction of metaverse technology requires significant changes in approaches to teaching and learning. Traditional assessment methods may not be suitable for the unstructured and individual learning offered by the metaverse.
5. Reinforcing bias	The biases present in traditional educational content may be reinforced in the metaverse due to the immersive nature of the content. These biases can affect students' understanding of certain topics and events, potentially hindering the achievement of fairness and equality.

Source: (Metaversities, 2022; Shin, 2022; Cortès, 2022)

The digital innovations described in this section can be and are already partially used in many areas of higher education, including STEM fields, business, humanities and social sciences, and so on. They can provide students with an immersive and interactive learning experience that will help them develop both technical knowledge and transferable skills, such as critical thinking, problem-solving, communication and collaboration, which are fundamental in preparing modern professionals in demand in a changing job market. However, given these issues, it is important to carefully assess the potential benefits and limitations of introducing these technologies in different areas of higher education to determine where they can be used most effectively.

Conclusion

The need to introduce digital innovations in higher education to train T-shaped specialists is difficult to overestimate. It is truly a transformative process that has the potential to lead to more effective, inclusive and personalised learning. However, it also comes with a unique set of challenges and risks.

First, a significant obstacle is the issue of equal access to technological infrastructure. For the successful implementation of these digital tools, it is necessary that each participant in the educational process (student and teacher) has continuous access to the Internet, appropriate equipment and software. Any shortage of these resources could exacerbate the digital divide, affecting students and teachers disproportionately (for example, in rural or economically disadvantaged areas).

Second, the cost implications of such innovations must be considered. Purchasing software licenses, maintaining equipment, and investing in ongoing training for staff and students can be a significant part of the cost. Such costs can represent an insurmountable barrier to digital transformation for institutions with budget constraints.

Third, the area of privacy and security presents its own set of challenges. As the digital realm becomes an integral part of education, the amount of personal data collected, stored, and processed is increasing exponentially.

Thus, the introduction of digital innovations in higher education to prepare T-shaped specialists promises a number of benefits, and the associated problems and risks require thoughtful attention. Strategic planning, resource allocation and proactive action are the keys to a successful and inclusive digital transformation.

Considering the above aspects, this research paper aims to provide a comprehensive understanding of the role of digital innovation in shaping the T-shaped development of skills in higher education in today's realities, thereby contributing to the discussion about the future of education in the digital age and others.

This study is essentially a snapshot of the current situation. In the future, Longitudinal Studies will be useful - when

the same variables are observed over a long period of time. This could provide a more detailed insight into how digital innovation affects T-shaped skill development.

While the study explores the adoption and integration of digital innovations, going forward, it may be necessary to develop sophisticated models or metrics to measure the impact of these technologies on student learning outcomes and their development of T-shaped skills. Also, the authors of this study believe that in the future it is worth studying a wider range of institutional contexts, including various types of higher education institutions (for example, public, and private), and various geographical regions. This will provide a finer understanding of how context influences the integration and impact of digital innovation.

It is also logical to assume that an examination of the political environment, both at the level of individual institutions and in broader education policy, can provide insight into systemic factors and barriers to digital innovation for T-skills development.

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