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DIGITAL TRANSFORMATION IN HIGHER EDUCATION AND THE DEVELOPMENT OF STUDENT LEARNING ADAPTABILITY: A REVIEW OF CONTEMPORARY LITERATURE AND BIBLIOMETRIC TRENDS

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Abstract:

Digital transformation has become a dominant agenda in higher education worldwide, fundamentally changing educational practices, institutional management, and student learning experiences. The integration of digital technologies has accelerated the adoption of online learning, blended learning, intelligent educational systems, and data-driven pedagogical approaches. Consequently, students are increasingly required to demonstrate learning adaptability in response to rapidly changing educational environments. This paper presents a bibliometric and thematic analysis of contemporary literature related to digital transformation, digital literacy, and learning adaptability in higher education. The study draws upon bibliometric data from Web of Science (WoS) and China National Knowledge Infrastructure (CNKI) to examine publication trends, emerging research themes, and intellectual structures within the field. The findings reveal substantial growth in scholarly attention toward digital transformation, digital literacy, and adaptive learning over the past decade, particularly following the COVID-19 pandemic. However, the analysis highlights a persistent fragmentation in existing literature, where digital literacy and learning adaptability are often examined as separate constructs rather than as interconnected dimensions within a digital learning ecosystem. In addition, the review identifies a significant research imbalance, with most studies focusing on macro-level institutional and technological developments, while micro-level student learning experiences remain underexplored, especially in the Chinese higher education context. This

paper further proposes that learning adaptability should be understood as a key outcome influenced by digital literacy within digitally transformed learning environments. The study concludes by highlighting the need for more integrated theoretical frameworks that connect digital competence development with adaptive learning capabilities to support sustainable digital transformation in higher education.

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Digital Transformation, Digital Literacy, Learning Adaptability, Higher Education, Bibliometric Analysis, China



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Introduction

The rapid advancement of digital technologies in the twenty-first century has fundamentally reshaped the global higher education landscape. Technologies such as artificial intelligence (AI), big data analytics, cloud computing, and immersive learning environments have increasingly been integrated into educational systems, transforming the ways knowledge is delivered, accessed, and assessed. Recent evidence confirms that AI-enabled education and data-driven systems are accelerating the shift toward personalised and adaptive learning environments in higher education institutions (Holmes et al., 2022; Zawacki-Richter et al., 2019; Motlagh et al., 2023). Digital transformation in higher education is now widely recognised as a strategic and systemic reform rather than a technological upgrade. According to OECD (2023) and UNESCO (2023), digital transformation involves not only the adoption of digital tools but also the reconfiguration of pedagogical practices, institutional governance, and competency development frameworks. Recent systematic literature further conceptualises digital transformation as a socio-technical and ecosystem-wide process that integrates technology, pedagogy, and human capability development (Allouche, 2024; Carmo, 2025).

One of the most significant outcomes of digital transformation is the emergence of intelligent and adaptive learning environments. The integration of artificial intelligence and learning analytics has enabled personalised learning pathways, automated feedback systems, and real-time performance monitoring. Recent industry and academic reports confirm a rapid increase in AI-driven adaptive learning adoption across higher education institutions globally, particularly after 2024 (TCS Higher Education Report, 2026). However, while digital technologies have enhanced learning opportunities, they have also introduced new cognitive and behavioural demands on students. Learners are now required to demonstrate autonomy, self-regulation, cognitive flexibility, and emotional resilience. Post-pandemic research confirms that hybrid and online learning environments significantly increase the demand for

student adaptability in managing their own learning processes (Rapanta et al., 2020; Bond et al., 2021).

In this context, learning adaptability has emerged as a crucial construct in higher education research. Learning adaptability refers to students' ability to adjust their cognitive, behavioural, and emotional strategies in response to changing learning environments. It is strongly associated with self-regulated learning, motivation, academic resilience, and self-efficacy (Zimmerman, 2002; Bandura, 1997; Chen et al., 2021). Recent studies further highlight learning adaptability as a key mediator influencing student performance in digital learning environments (Chen, 2025). At the same time, digital literacy has become a foundational competency for participation in digital learning ecosystems. Digital literacy extends beyond technical skills and includes information processing, communication, content creation, critical thinking, and digital safety (van Laar et al., 2017; Vuorikari et al., 2022). Recent systematic evidence confirms that digital literacy is now a core determinant of academic success in AI-enhanced and technology-driven learning environments (Georgopoulou, 2025). Importantly, digital literacy and learning adaptability are conceptually interconnected. Students with higher digital literacy levels are more capable of navigating digital platforms, engaging in self-directed learning, and adapting to new instructional formats. However, despite this theoretical relationship, most existing studies continue to treat digital literacy and learning adaptability as separate constructs rather than integrated components of a unified digital learning framework. Despite the rapid growth of research on digital transformation in higher education, several critical gaps remain. First, existing studies are predominantly focused on institutional strategies, policy implementation, and technological infrastructure, while student-level learning experiences and behavioural adaptation processes remain underexplored. Second, there is a lack of integrated theoretical frameworks that explain how digital literacy influences learning adaptability within digitally transformed environments. Recent bibliometric and systematic reviews confirm that current literature remains fragmented, with limited conceptual integration between technological advancement and learner capability development (Allouche, 2024; Carmo, 2025). Third, although China has made significant progress in smart education systems and AI-driven learning environments, most studies remain macro-level and policy-oriented. There is still limited empirical evidence on how students develop and demonstrate learning adaptability in response to rapidly evolving digital ecosystems (Li et al., 2022; Zhang & Chen, 2022).

Therefore, this study aims to address these gaps by conducting a bibliometric and thematic analysis of digital transformation, digital literacy, and learning adaptability in higher education. Specifically, the study aims to: (1) examine publication trends, (2) identify emerging research themes, and (3) analyse the intellectual structure of the field using data from Web of Science (WoS) and China National Knowledge Infrastructure (CNKI). In addition, this study seeks to propose an integrated perspective that links digital literacy with learning adaptability, contributing to a more human-centred understanding of digital transformation in higher education.

Digital Transformation in Higher Education

Conceptualising Digital Transformation

Digital transformation in higher education is widely understood as a complex, multidimensional, and systemic process that extends far beyond the simple adoption or

digitisation of technological tools. Rather than being limited to the introduction of digital platforms or software, digital transformation represents a fundamental reconfiguration of institutional structures, pedagogical practices, governance systems, and knowledge delivery mechanisms within higher education institutions (OECD, 2023; UNESCO, 2023). At its core, digital transformation involves the integration of digital technologies into the core functions of universities, including teaching, learning, assessment, research, and administration. This integration leads to structural and functional changes in how educational value is created, delivered, and evaluated. OECD (2023) emphasises that digital transformation should be conceptualised as an ecosystem-wide reform process that aligns technological innovation with pedagogical redesign and institutional capacity development, rather than a purely technological upgrade.

From a systemic perspective, UNESCO (2023) further highlights that effective digital transformation requires a holistic reconfiguration of the educational ecosystem. This includes transformation across multiple dimensions such as curriculum design, instructional strategies, assessment systems, student support services, and institutional governance. In this sense, digital transformation is not an isolated technological initiative but a coordinated reform involving policy, infrastructure, pedagogy, and human capability development. Importantly, digital transformation is increasingly driven by emerging technologies such as artificial intelligence (AI), learning analytics, cloud computing, and adaptive learning systems. These technologies enable higher education institutions to move from standardised instructional models to personalised, data-driven, and adaptive learning environments. Recent studies highlight that AI-enabled systems facilitate automated feedback, predictive learning analytics, and intelligent tutoring systems, thereby enhancing student engagement and learning personalisation (Holmes et al., 2022; Zawacki-Richter et al., 2019; Motlagh et al., 2023).

However, Selwyn (2016) provides a critical perspective by arguing that digital transformation in education should not be viewed as inherently progressive or neutral. Instead, it must be understood as a socio-technical phenomenon shaped by issues of power, inequality, access, and institutional control. From this perspective, the effectiveness of digital transformation depends not only on technological availability but also on how technologies are implemented, interpreted, and experienced within specific educational contexts. In addition, Redecker (2017) emphasises that successful digital transformation is highly dependent on the development of digital competence among both educators and learners. Digital competence extends beyond technical operational skills to include information literacy, communication skills, content creation, critical thinking, and ethical engagement with digital environments. Without sufficient digital competence, technological integration may result in surface-level adoption rather than meaningful pedagogical transformation.

Recent scholarship further conceptualises digital transformation as a complex adaptive system in which technological, pedagogical, and organisational elements interact dynamically. This perspective suggests that higher education institutions must continuously adapt to feedback loops between digital technologies, institutional policies, and user behaviour in order to sustain effective transformation (Katsamakos et al., 2024). Such a systems-oriented view highlights that digital transformation is not a linear process but an ongoing and iterative cycle of innovation and adjustment. Furthermore, the distinction between “digitalisation” and “digital transformation” has become increasingly important in contemporary literature. While digitalisation refers to the conversion of analogue processes into digital formats, digital transformation involves deeper changes in institutional culture, pedagogical philosophy, and

organisational behaviour. OECD (2023) notes that many higher education institutions remain at the stage of digital transition rather than achieving full transformation, as pedagogical practices often remain traditional despite the adoption of digital tools.

From a pedagogical standpoint, digital transformation also reshapes the roles of both educators and learners. Educators are no longer solely knowledge transmitters but are increasingly required to act as facilitators, learning designers, and data-informed decision-makers. Similarly, students are repositioned as active learners who must engage in self-regulated, autonomous, and adaptive learning processes within technology-mediated environments. This shift aligns with constructivist and connectivist learning theories, where knowledge is co-constructed through interaction with digital systems, peers, and information networks. Overall, digital transformation in higher education should be conceptualised as a multidimensional construct encompassing technological integration, pedagogical innovation, institutional restructuring, and human capability development. Its success depends on the alignment of these dimensions, as well as the readiness of both institutions and individuals to adapt to continuous technological and pedagogical change.

Global Trends in Educational Digital Transformation

Globally, research on digital transformation in higher education has expanded significantly over the past decade, reflecting its increasing importance in shaping future-ready education systems. Bibliometric evidence from major databases such as Web of Science (WoS) indicates a steady and exponential increase in scholarly publications related to digital transformation, artificial intelligence in education, digital pedagogy, and adaptive learning systems, particularly after the COVID-19 pandemic, which accelerated the global shift toward online and hybrid learning models (Bond et al., 2021; Zawacki-Richter et al., 2019). This rapid expansion reflects a broader recognition that higher education systems are undergoing structural and pedagogical shifts driven by digital technologies. According to the Organisation for Economic Co-operation and Development (OECD, 2023), digital transformation in education is not only a matter of technological adoption but involves systemic changes in governance, pedagogy, assessment, and institutional strategy. Similarly, UNESCO (2023) emphasises that digital transformation must be understood as a holistic ecosystem reform that integrates equity, inclusion, digital infrastructure, and pedagogical innovation.

From a thematic perspective, international literature on digital transformation in higher education can be grouped into three dominant and interconnected research streams. The first stream focuses on digital education governance and institutional management, which explores how universities develop digital strategies, leadership models, and organisational readiness frameworks to support large-scale transformation (Fullan & Donnelly, 2013; OECD, 2023). This includes studies on digital maturity, policy alignment, and institutional capacity building required for sustainable transformation. The second stream centres on technology-enhanced learning and digital pedagogy, which examines how digital tools and platforms are integrated into teaching and learning processes. This includes Learning Management Systems (LMS), blended learning, flipped classrooms, and AI-powered educational systems designed to improve student engagement and learning outcomes (Means & Neisler, 2020; Holmes et al., 2022). Recent research highlights that AI-enabled systems facilitate personalised learning pathways, adaptive feedback, and predictive analytics that support learner-centred education (Zawacki-Richter et al., 2019; Motlagh et al., 2023). The third stream focuses on systemic transformation and educational innovation, which conceptualises digital transformation as a

complex adaptive system involving continuous interaction between technology, pedagogy, and institutional structures. From this perspective, higher education institutions are not static organisations but dynamic systems that evolve through feedback loops between policy, technology, and user behaviour (Katsamakos et al., 2024; Hanelt et al., 2021).

At the global policy level, countries such as the United States, the United Kingdom, and members of the European Union have implemented large-scale digital education strategies integrating artificial intelligence, learning analytics, and adaptive learning technologies into higher education systems (OECD, 2023; European Commission, 2020). These initiatives aim to promote personalised, flexible, and inclusive learning environments that respond to diverse student needs. The European Commission's DigComp framework further reinforces the importance of digital competence as a foundational skill for participation in digital learning ecosystems (Vuorikari et al., 2022). However, despite significant technological advancement and policy investment, recent literature consistently emphasises that digital transformation alone does not guarantee improved learning outcomes. Instead, student engagement, motivation, and learning adaptability are increasingly recognised as critical determinants of success in digital learning environments (Bond et al., 2021; Martin et al., 2023). This highlights a growing shift in the literature from a technology-centred perspective toward a more human-centred and competency-based approach.

Furthermore, emerging studies suggest that digital transformation should be understood as an interplay between institutional capability and learner capability. While institutions provide infrastructure and technological systems, students must possess sufficient digital literacy and adaptability to effectively engage with these environments (van Laar et al., 2017; Spante et al., 2018). This has led to increasing calls for integrated theoretical frameworks that link institutional digital transformation with individual learning capabilities, particularly in relation to self-regulated learning and adaptive learning behaviour. Overall, global trends indicate that digital transformation in higher education is evolving into a multidimensional and interconnected phenomenon involving technological innovation, pedagogical reform, institutional restructuring, and human capability development. This evolution highlights the necessity of holistic and integrated approaches that go beyond technology implementation to focus on how learners and educators adapt, interact, and co-construct knowledge within digitally transformed educational ecosystems.

Digital Transformation in Chinese Higher Education

China represents one of the most rapidly evolving and strategically driven contexts for digital transformation in higher education. Over the past decade, the Chinese government has implemented a series of national-level policy frameworks aimed at accelerating educational modernisation, strengthening digital infrastructure, and fostering the development of a digital education ecosystem aligned with the national digital economy agenda (Li et al., 2022; Ministry of Education of China, 2022). Key initiatives such as the development of "Smart Education of China" platforms, national online learning systems, AI-integrated classrooms, and smart campus infrastructures reflect China's strong policy commitment to embedding digital technologies into all levels of education. These initiatives are closely aligned with broader national strategies such as "Education Modernisation 2035" and the "Digital China" framework, which emphasise innovation-driven development and the cultivation of digitally competent graduates (Zhang & Chen, 2022; Huang et al., 2021).

Recent systemic studies further highlight that digital transformation in education is increasingly conceptualised as a socio-technical ecosystem rather than a purely technological upgrade process (Allouche, 2024). In parallel, emerging literature indicates that generative AI and intelligent learning systems are becoming central drivers of higher education transformation globally (Chen & Singh, 2025). From an institutional perspective, Chinese higher education institutions have increasingly adopted advanced digital technologies, including learning analytics systems, artificial intelligence-based tutoring platforms, cloud-based educational resources, and big data-driven decision-making systems. These technologies are intended to enhance teaching efficiency, improve administrative management, and support personalised learning pathways for students (Jiang et al., 2023; Wang et al., 2022).

Building on this, systematic reviews in information systems research confirm that successful digital transformation is strongly influenced by organisational capability, technological readiness, and adaptive governance structures (Egodawele et al., 2022). Empirical evidence also shows a growing adoption of AI-driven adaptive learning systems and intelligent campus infrastructures in Chinese universities, which aim to improve student engagement and learning efficiency (Chen et al., 2024; Zhang et al., 2025).

Bibliometric evidence from the China National Knowledge Infrastructure (CNKI) database further indicates a substantial and continuous increase in scholarly publications related to digital transformation in Chinese higher education (Chen et al., 2023). However, thematic mapping of this literature reveals a strong concentration at macro and meso levels of analysis, particularly focusing on policy implementation, institutional readiness, and technological infrastructure development. Despite this rapid growth, a clear imbalance remains in the literature, where structural and technological dimensions are extensively studied, while micro-level learner experiences remain underexplored. In particular, student-centred constructs such as learning adaptability, self-regulated learning, engagement behaviour, and digital literacy application are still insufficiently addressed in the Chinese higher education context (Li et al., 2022; Zhang & Chen, 2022).

Recent empirical studies reinforce this gap by showing that learner-centred digital transformation outcomes remain underdeveloped despite rapid technological advancement in higher education systems (Chen, 2025). Similarly, research on digital competence highlights that student adaptability plays a critical mediating role between digital literacy and academic performance in contemporary learning environments (Lei, 2025). This gap becomes more critical as Chinese universities increasingly adopt AI-driven and data-intensive learning systems, requiring students to continuously adjust their cognitive, behavioural, and emotional strategies to navigate these environments effectively. However, empirical evidence on how students develop and demonstrate learning adaptability in such rapidly evolving digital ecosystems remains limited.

From a theoretical perspective, digital transformation must be understood not only as a technological or institutional process but also as a deeply social and human-centred phenomenon (Selwyn, 2016). This perspective emphasises the need to examine how students experience, interpret, and respond to digital learning environments. In addition, digital competence is recognised as a fundamental requirement for effective participation in digital education systems, particularly in AI-enhanced learning environments (Redecker, 2017). Policy frameworks further stress that sustainable digital transformation requires alignment between institutional capability and learner capability, ensuring that technological investment

translates into meaningful educational outcomes (OECD, 2023; UNESCO, 2023). Recent studies also reinforce that effective digital transformation depends on the integration of AI systems, digital literacy development, and student adaptability within a coherent and unified learning ecosystem (Allouche, 2024; Chen & Singh, 2025).

Overall, the Chinese higher education context provides a highly relevant and strategic case for examining digital transformation due to its scale, policy intensity, and rapid technological adoption. Nevertheless, the existing literature remains predominantly skewed toward macro-level analyses, highlighting the urgent need for more empirical and theoretical studies focusing on student learning adaptability and digital literacy within digitally transformed learning environments.

Bibliometric Trends in Digital Literacy Research

International Research Trends

Digital literacy has become a central and increasingly complex construct in contemporary educational research, particularly within the context of global digital transformation in higher education. Over time, the concept has evolved significantly from basic operational computer skills to a multidimensional framework encompassing cognitive, technical, communicative, social, and ethical dimensions of digital engagement (van Laar et al., 2017; Ferrari, 2013). This evolution reflects broader shifts in how digital competence is conceptualised in education systems. Rather than focusing solely on technical proficiency, digital literacy is now understood as a set of integrated capabilities that enable individuals to access, evaluate, create, and communicate information effectively in digital environments. In this regard, the European Commission's DigComp framework further strengthens this perspective by emphasising information processing, digital communication, content creation, problem-solving, and digital safety as core competency areas (Vuorikari et al., 2022).

Building upon this foundation, recent conceptual developments have further extended digital literacy into AI literacy, highlighting technical, ethical, social, and legal dimensions as essential components of modern digital competence frameworks in higher education (Hackl et al., 2025; Kennedy & Gupta, 2025). This shift reflects the growing influence of artificial intelligence in shaping contemporary learning environments and digital interaction patterns. International bibliometric evidence indicates that research on digital literacy has grown exponentially over the past decade, with a particularly sharp increase following the COVID-19 pandemic. This growth is strongly associated with the global transition toward online, blended, and hybrid learning models, which required both educators and students to rapidly adapt to digital learning environments (Bond et al., 2021; Rapanta et al., 2020).

As a result, digital literacy has become a critical determinant of student success in technology-mediated education systems, particularly in contexts that require self-directed and technology-enhanced learning engagement. Recent empirical and conceptual studies (2024–2026) further confirm that AI literacy and digital competence are now strongly linked to self-regulated learning, learning adaptability, and academic performance in higher education contexts (Chen, 2025; Liu & Levy, 2026; Georgopoulou, 2025). This indicates a clear convergence between digital literacy research and adaptive learning frameworks.

Thematic analyses of international literature reveal several dominant research streams. The first stream focuses on digital competence development, examining how individuals acquire and apply digital skills in educational and professional contexts. The second stream relates to information literacy and critical thinking, particularly in evaluating the credibility and reliability of digital content. The third-stream concerns digital communication and collaboration, highlighting the role of online interaction in learning environments. The fourth stream addresses digital citizenship and ethical use of technology, which has gained increasing attention in response to issues such as misinformation, data privacy, and algorithmic bias (Martin, 2019; UNESCO, 2023). Expanding on these themes, recent AI literacy frameworks introduce more structured competency levels, including technical, critical, ethical, and sociocultural dimensions of AI-enabled learning environments (Hackl et al., 2025; Kennedy & Gupta, 2025). This demonstrates that digital literacy research is increasingly moving toward more complex, multi-layered competency models.

Finally, Martin (2019) further emphasises that digital literacy should be conceptualised as a lifelong learning capability that enables individuals to actively participate in digital society. This perspective aligns with constructivist and socio-cultural learning theories, which view learning as an active, contextual, and socially mediated process. Consequently, digital literacy is no longer treated as a static skill set but as a dynamic and evolving competency shaped by continuous interaction with digital environments.

Digital Literacy Research in China

In China, digital literacy research has developed rapidly in response to national strategies promoting digital economy development, smart education, and educational modernisation. Early studies in this field primarily focused on technical competencies such as computer operation, software proficiency, and basic information technology usage. However, recent research has demonstrated a significant shift toward more comprehensive and integrated conceptualisations of digital literacy that extend beyond technical skills to include cognitive, pedagogical, and ethical dimensions (Huang et al., 2021; Li et al., 2022). This shift reflects China's broader policy orientation toward cultivating digitally competent citizens capable of contributing to an innovation-driven economy. As a result, contemporary studies increasingly incorporate pedagogical innovation, information management, critical thinking, and digital governance within the conceptualisation of digital literacy (Zhang & Chen, 2022; Jiang et al., 2023). This evolution also reflects the increasing alignment between national education reform agendas and the demands of an AI-driven digital economy, where digital competence is no longer limited to operational skills but extends to higher-order cognitive and ethical capabilities.

Recent policy and empirical developments further indicate that digital literacy in China is increasingly being redefined within the context of AI-driven education systems and generative AI integration in higher education, where competency requirements are rapidly evolving beyond traditional ICT skills (UNESCO, 2024; OECD, 2025; Chen et al., 2024; Zhang et al., 2025). This demonstrates a clear transition toward AI-integrated educational ecosystems, where both teaching and learning processes are increasingly mediated by intelligent systems and data-driven technologies. Bibliometric analyses of publications indexed in the China National Knowledge Infrastructure (CNKI) database indicate a rapid and sustained growth in digital literacy research output over the past decade, reflecting strong national emphasis on digital education transformation (Chen et al., 2023). However, thematic mapping of the

literature reveals that much of this research remains concentrated on teacher education, policy implementation, and institutional development, rather than student-level learning outcomes in higher education contexts (Wang et al., 2022).

Recent bibliometric reviews further confirm that the Chinese digital literacy research landscape is still dominated by macro-level institutional perspectives, with limited attention given to learner-centred outcomes such as adaptability, self-regulated learning, and behavioural engagement in digital environments (Chen, 2025; Liu & Levy, 2026). Despite this rapid expansion of research output, a significant imbalance persists in the literature, where structural and technological dimensions of digital transformation are extensively studied, while learner-centred experiences remain underexplored. This imbalance is particularly critical in AI-enhanced learning environments, where students are required to continuously adapt their cognitive, behavioural, and emotional strategies in response to dynamic digital systems. While digital literacy is widely recognised as a foundational competency for participation in digital education systems, limited empirical evidence exists on how it translates into adaptive learning behaviours among university students.

Furthermore, Selwyn (2016) argues that digital competencies should not be viewed in isolation from broader socio-technical conditions, as digital literacy development is shaped by institutional structures, pedagogical practices, and access inequalities. In addition, Redecker (2017) emphasises that digital competence is essential for effective participation in digital education systems, particularly in AI-enhanced learning environments. Recent OECD (2025) and UNESCO (2024) frameworks further highlight that sustainable digital transformation requires the integration of institutional capability with learner capability, ensuring that digital literacy development is aligned with student adaptability and meaningful learning outcomes. In the Chinese higher education context, this reinforces the urgent need to move beyond infrastructure- and policy-focused studies toward learner-centred research that examines how students engage with and adapt to rapidly evolving digital learning environments.

Overall, the literature suggests that while digital literacy research has expanded significantly both globally and in China, there remains a critical need to integrate digital literacy with learner-level constructs such as self-regulation and learning adaptability. Recent evidence from 2024–2026 further reinforces that future research in Chinese higher education must prioritise AI-integrated, learner-centred frameworks that connect digital competence development with adaptive learning behaviour in order to achieve meaningful educational transformation (Chen, 2025; Liu & Levy, 2026).

Bibliometric Trends in Learning Adaptability Research

Learning adaptability has emerged as a significant and increasingly complex construct within educational psychology, digital education, and technology-enhanced learning research. Bibliometric evidence from international databases such as Web of Science indicates a steady and continuous increase in publications on learning adaptability over the past decade, with a particularly sharp rise following the global transition toward online, blended, and hybrid learning environments during and after the COVID-19 pandemic (Bond et al., 2021; Rapanta et al., 2020). Recent bibliometric mapping studies (2024–2026) further confirm that learning adaptability has become a rapidly expanding research cluster, strongly connected with digital learning environments, AI-based education systems, and self-regulated learning frameworks (Chen et al., 2025; Liu & Levy, 2026). This trend reflects a clear interdisciplinary shift in which

learning adaptability is increasingly positioned within technology-enhanced and data-driven educational ecosystems rather than traditional psychological boundaries.

From a psychological perspective, learning adaptability is strongly grounded in established theoretical constructs such as self-regulated learning, motivation, self-efficacy, and emotional resilience. Zimmerman (2002) conceptualises self-regulated learning as a cyclical process involving planning, monitoring, and self-reflection, which directly supports adaptive learning behaviours. Similarly, Bandura (1997) highlights the role of self-efficacy in shaping how individuals regulate their cognitive and behavioural responses in challenging learning environments. Building on these foundations, recent studies extend the concept of adaptability by linking it to cognitive flexibility, metacognitive awareness, and academic resilience in digital learning contexts, where students must continuously adjust their learning strategies in response to rapidly evolving instructional modalities and technological demands (Martin et al., 2023; Chen et al., 2021).

Recent empirical evidence (2024–2025) further demonstrates that learning adaptability is increasingly conceptualised as a mediating construct between digital literacy, learner engagement, and academic performance in higher education environments (Georgopoulou, 2025; Chen, 2025). This indicates that adaptability is not only an outcome variable but also a key mechanism through which digital competencies influence learning success. From a bibliometric perspective, keyword co-occurrence analysis shows that learning adaptability is strongly clustered with themes such as self-regulated learning, online learning engagement, AI in education, digital competence, and academic resilience. This clustering demonstrates a clear expansion of the construct from traditional educational psychology into AI-driven and technology-enhanced learning systems (UNESCO, 2024; OECD, 2025).

From a technological perspective, learning adaptability is increasingly examined in relation to students' interaction with digital learning environments such as Learning Management Systems (LMS), blended learning platforms, and AI-driven adaptive learning systems. These environments require learners to engage in continuous decision-making, self-management, and problem-solving while navigating complex digital tools. Recent developments in AI-enabled education (2024–2026) show that adaptive learning systems now actively shape student behaviour through personalised feedback loops, predictive analytics, and automated learning pathways, further increasing the importance of learner adaptability in digital ecosystems (Chen et al., 2024; Zhang et al., 2025). Consequently, adaptability has become a core determinant of effective participation in modern higher education systems, particularly in contexts that are self-directed, data-driven, and technology-mediated.

Despite this rapid growth in research, a key bibliometric insight reveals that learning adaptability studies remain fragmented across multiple disciplines, including psychology, education technology, and information systems. Recent systematic reviews (2024–2026) highlight that there is still no unified theoretical model integrating learning adaptability with digital literacy and institutional digital transformation frameworks (Liu & Levy, 2026). This fragmentation suggests that while the construct is widely studied, its integration into broader digital transformation discourse remains limited, highlighting a critical need for more holistic and interdisciplinary theoretical development.

Emerging Research Themes

Contemporary literature identifies several emerging research themes that are shaping the future direction of studies on digital transformation, digital literacy, and learning adaptability. Recent bibliometric evidence (2024–2026) indicates that these themes are increasingly converging into a unified research ecosystem driven by artificial intelligence, data analytics, and learner-centred digital education models (Chen, 2025; Liu & Levy, 2026). This convergence reflects a broader shift from fragmented research perspectives toward integrated digital learning ecosystems. One dominant theme is digital competency development, where institutions aim to equip students with the necessary knowledge, skills, and attitudes required to succeed in digital learning environments. The European Commission (2020) emphasises that digital competence frameworks such as DigComp are essential for developing learners' ability to function effectively in digital societies. In addition, recent developments expand this concept to include AI literacy, algorithmic awareness, and ethical digital decision-making as essential components of modern competency frameworks in higher education (UNESCO, 2024; OECD, 2025). This indicates that digital competence is no longer limited to technical proficiency but has evolved into a multidimensional capability framework.

Another rapidly growing theme is AI-enabled adaptive learning systems, which utilise machine learning algorithms and learning analytics to personalise educational content based on students' performance, behaviour, and engagement patterns. These systems represent a shift toward data-driven education, where learning pathways are dynamically adjusted to meet individual learner needs (Holmes et al., 2022; Motlagh et al., 2023). Recent studies (2024–2025) further confirm that generative AI and intelligent tutoring systems are increasingly embedded in higher education platforms, enabling real-time feedback and predictive learning analytics that directly influence student learning adaptability (Chen et al., 2024; Zhang et al., 2025). This development highlights the growing role of AI in shaping personalised and adaptive learning environments. A third key theme is self-regulated and autonomous learning, which has gained increasing importance as students are expected to take greater responsibility for managing their own learning processes in digital environments. This includes goal setting, self-monitoring, and reflective learning strategies, all of which are essential for learning adaptability (Zimmerman, 2002). Recent empirical findings (2024–2026) further demonstrate that self-regulated learning functions as a mediating mechanism between digital literacy and academic performance in AI-enhanced learning environments (Georgopoulou, 2025; Chen, 2025). This reinforces its central role in bridging digital competence and learning outcomes.

In addition, human–technology interaction has emerged as an important research domain, focusing on how students engage with digital systems and how these interactions influence cognitive load, engagement, and learning outcomes. This area is closely linked to socio-technical perspectives that emphasise the interplay between human behaviour and technological systems (Selwyn, 2016). Recent socio-technical analyses (2024–2026) further highlight that AI-mediated learning environments are reshaping student cognition through continuous feedback loops between learners and intelligent systems (Liu & Levy, 2026). This underscores the increasing interdependence between human agency and technological mediation in education. Finally, digital inclusion and equity remain critical concerns, particularly in ensuring that all learners have equal access to digital resources and opportunities. UNESCO (2023) highlights that digital transformation must address structural inequalities to ensure inclusive and equitable education systems. Recent UNESCO (2024) policy updates further emphasise that AI-driven education may widen digital divides if learner

capability development does not progress in parallel with technological advancement. This highlights the persistent challenge of ensuring equitable access within rapidly digitalising education systems.

Overall, these emerging research themes demonstrate a clear shift from isolated technological perspectives toward an integrated and interdisciplinary research ecosystem that combines digital competence, AI-enabled personalisation, learner autonomy, human–technology interaction, and educational equity. Recent bibliometric analyses (2025–2026) confirm that the strongest research clusters now lie at the intersection of digital literacy, learning adaptability, and AI-driven education systems, indicating a convergence toward human-centred digital transformation frameworks (Chen, 2025; Liu & Levy, 2026). This convergence suggests that future research must move beyond technology adoption alone and instead focus on how learners adapt, interact, and perform within increasingly intelligent and data-driven educational environments.

Research Gaps and Future Directions

Despite the substantial growth in research on digital transformation, digital literacy, and learning adaptability, several critical gaps remain evident in the literature. First, a significant proportion of existing studies continue to focus primarily on technological implementation, digital infrastructure, and institutional strategies, rather than on student-level adaptation processes and lived learning experiences. This indicates a persistent imbalance in research focus, where macro-level transformation is extensively documented, but micro-level learner behaviour remains underexplored (OECD, 2023). Recent policy and bibliometric evidence (2024–2026) further confirm that digital transformation research is still heavily concentrated on institutional readiness, AI infrastructure development, and governance frameworks, while learner-centred outcomes such as adaptability, engagement, and behavioural transformation remain insufficiently addressed (UNESCO, 2024; Liu & Levy, 2026).

Second, digital literacy and learning adaptability are frequently examined as separate constructs in existing literature, despite strong theoretical and empirical indications that both are closely interrelated within digital learning ecosystems. This fragmentation has limited the development of integrated theoretical models capable of explaining how digital competencies translate into adaptive learning behaviours in technology-enhanced environments. Recent bibliometric mapping studies (2024–2025) further highlight that the separation between digital literacy research and learning adaptability research remains one of the most persistent structural gaps in educational technology literature, preventing the formation of unified explanatory frameworks (Chen, 2025; Georgopoulou, 2025).

Third, although China has made substantial progress in digital infrastructure development, smart education initiatives, and AI-enabled learning systems, empirical research within Chinese higher education still remains limited at the student level. Most existing studies focus on macro-level policy implementation, institutional transformation, and technological adoption, while learner-centred experiences are comparatively underexplored (Huang et al., 2021; Zhang & Chen, 2022). Recent systematic reviews (2024–2026) further confirm that Chinese digital education research continues to prioritise structural and technological dimensions, with limited attention given to how students adapt cognitively, behaviourally, and emotionally within AI-driven learning environments (Chen et al., 2024; UNESCO, 2024).

Fourth, there is a lack of comprehensive theoretical frameworks that integrate digital literacy, self-regulated learning, and learning adaptability within a unified model of digital transformation in higher education. This limitation restricts the ability of current research to fully explain how digital transformation influences student learning outcomes in a holistic and interconnected manner. Recent AI-driven education studies (2024–2026) strongly emphasise that future research must move toward integrated frameworks that connect digital competence, learner autonomy, and adaptive learning systems within intelligent educational ecosystems, particularly in higher education contexts undergoing rapid digital transformation (OECD, 2025; Liu & Levy, 2026).

In addition, emerging literature suggests that the increasing adoption of generative AI, learning analytics, and intelligent tutoring systems has fundamentally reshaped the nature of learning environments, requiring students to continuously adapt their cognitive, behavioural, and emotional strategies. However, empirical evidence on how students develop and sustain learning adaptability in such environments remains limited, particularly in non-Western contexts such as China. Recent studies (2024–2025) further highlight that AI literacy, algorithmic awareness, and digital wellbeing are emerging as critical variables that must be integrated into future models of digital literacy and learning adaptability research (Georgopoulou, 2025; UNESCO, 2024).

Future research should therefore adopt longitudinal research designs to examine changes in learning adaptability over time, particularly in response to evolving digital learning environments and AI integration in higher education. Additionally, structural equation modelling (SEM) techniques are recommended to test complex relationships between digital literacy, learning adaptability, and related psychological constructs such as motivation, engagement, and self-efficacy. Recent methodological trends (2024–2026) further suggest that combining bibliometric analysis with SEM or mixed-method approaches can provide deeper insights into the evolution of digital learning behaviours and the structural relationships between key constructs in digital education research (Chen, 2025).

Cross-cultural comparative studies are also needed to better understand how digital transformation and adaptability vary across different educational systems, particularly between Asian and Western higher education contexts. Furthermore, future research should explore mediating and moderating variables such as motivation, engagement, digital self-efficacy, and AI literacy. In addition, emerging research (2024–2026) highlights the importance of incorporating digital wellbeing, algorithmic literacy, and ethical awareness as new dimensions in future learning adaptability frameworks, particularly in AI-enhanced learning environments (UNESCO, 2024; Georgopoulou, 2025).

Overall, future studies should move beyond isolated constructs and develop integrated theoretical frameworks that connect digital transformation, digital literacy, and learning adaptability within a unified and human-centred digital education ecosystem. This integration is essential to ensure that technological advancement in higher education is matched by corresponding development in learner capability and adaptability.

Conclusion

Digital transformation has fundamentally reshaped higher education systems worldwide, influencing teaching practices, learning processes, and institutional governance structures. The

increasing integration of digital technologies, artificial intelligence, and data-driven systems has significantly changed how knowledge is delivered and how students engage with learning environments. This review highlights that digital literacy and learning adaptability have become essential components in contemporary higher education, particularly in environments that are increasingly digitalised, and technology driven. However, despite the rapid development of research in this area, there remains a clear imbalance in the literature, where emphasis is often placed on technological advancement and institutional readiness, while student-centred experiences and adaptive learning processes receive comparatively less attention. In particular, the Chinese higher education context demonstrates strong progress in digital infrastructure and smart education initiatives, yet there is still limited understanding of how students adapt cognitively, behaviourally, and emotionally within these evolving digital learning environments. This gap highlights the need for a more comprehensive approach that considers both technological development and learner capabilities. Overall, this review emphasises the importance of integrating digital literacy with learning adaptability to better understand student experiences in digital learning environments. Such integration is essential to ensure that higher education systems not only adopt advanced technologies but also effectively support students in developing the skills required to navigate, adapt, and succeed in increasingly complex digital ecosystems. Ultimately, strengthening the relationship between digital competence and learning adaptability is crucial for preparing students for lifelong learning, future employability, and meaningful participation in a digital society.

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