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Leadership and digital transformation: insights from bibliometric research

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Liderança e transformação digital: insights da pesquisa bibliométrica

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Liderazgo y transformación digital: perspectivas de la investigación bibliométrica

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Abstract: *This study presents a bibliometric review of scientific literature on leadership and digital transformation, based on publications indexed in Scopus (January 2020–December 2024), following the PRISMA protocol. The results indicate four thematic clusters that structure the literature: digital leadership and organizational outcomes; technology strategy and implementation; management and challenges in the digital era; and the competencies and specific contexts required to lead transformation. Three interrelated conceptual dimensions were identified: strategic and organizational; socio-human and educational; and technological and operational. The analysis reveals that the success of digital transformation depends on a strategic vision that integrates organizational culture, agility, digital literacy, and human skills and goes beyond technology adoption. Emerging themes include digital leadership competencies, sustainability, pandemic-driven digital acceleration, and hybrid models of work and education. The study shows the need to adapt leadership models to new technological, cultural, and organizational realities. As a contribution, this study provides insights into leadership and organizational management, technology management, human resource management, and the educational context.*

Keywords: *Digital competences. Digital Leadership. Digital literacy. Digital Strategy. Hybrid models of work and education.*

Resumo: Este estudo apresenta uma revisão bibliométrica da literatura científica sobre liderança e transformação digital, com base em publicações indexadas na Scopus (janeiro de 2020 a dezembro de 2024), seguindo o protocolo PRISMA. Os resultados indicam quatro grupos temáticos que estruturam a literatura: liderança digital e resultados organizacionais; estratégia e implementação tecnológica; gestão e desafios na era digital; e as competências e contextos específicos necessários para liderar a transformação. Foram identificadas três dimensões conceituais inter-relacionadas: estratégica e organizacional; sócio humana e educacional; e tecnológica e operacional. A análise revela que o sucesso da transformação digital depende de uma visão estratégica que integre cultura organizacional, agilidade, literacia digital e competências humanas, indo além da adoção da tecnologia. Os temas emergentes incluem competências de liderança digital, sustentabilidade, aceleração digital impulsionada pela pandemia e modelos híbridos de trabalho e educação. O estudo evidencia a necessidade de adaptar os modelos de liderança às novas realidades tecnológicas, culturais e organizacionais. Como contribuição, este estudo fornece insights sobre liderança e gestão organizacional, gestão de tecnologia, gestão de recursos humanos e o contexto educacional.

Palavras-chave: Competências digitais. Estratégia digital. Liderança digital. Literacia digital. Modelos híbridos de trabalho e educação.

Resumen: *Este estudio presenta una revisión bibliométrica de la literatura científica sobre liderazgo y transformación digital, basada en publicaciones indexadas en Scopus (enero de 2020-diciembre de 2024), siguiendo el protocolo PRISMA.*

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Los resultados indican cuatro grupos temáticos que estructuran la literatura: liderazgo digital y resultados organizativos; estrategia tecnológica e implementación; gestión y retos en la era digital; y las competencias y contextos específicos necesarios para liderar la transformación. Se identificaron tres dimensiones conceptuales interrelacionadas: estratégica y organizativa; sociohumana y educativa; y tecnológica y operativa. El análisis revela que el éxito de la transformación digital depende de una visión estratégica que integre la cultura organizativa, la agilidad, la alfabetización digital y las habilidades humanas, y que vaya más allá de la adopción de la tecnología. Entre los temas emergentes se incluyen las competencias de liderazgo digital, la sostenibilidad, la aceleración digital impulsada por la pandemia y los modelos híbridos de trabajo y educación. El estudio muestra la necesidad de adaptar los modelos de liderazgo a las nuevas realidades tecnológicas, culturales y organizativas. Como contribución, este estudio ofrece información sobre el liderazgo y la gestión organizativa, la gestión tecnológica, la gestión de recursos humanos y el contexto educativo.

Palabras clave: *Alfabetización digital. Competencias digitales. Estrategia digital. Liderazgo digital. Modelos híbridos de trabajo y educación.*

INTRODUCTION

Digital transformation (DT) is not a recent phenomenon. However, it underwent a profound change in the early 2020s, driven by factors such as the COVID-19 pandemic, which intensified digitization and adaptation to new realities. Technologies such as Artificial Intelligence (AI), big data, cloud computing, and the Internet of Things (IoT) (Ononiwu *et al.*, 2024) have contributed to improved operational efficiency and innovation in business models (Patwari *et al.*, 2024). For a successful digital transition, leadership is a pivotal component in guiding strategies and fostering a change-oriented culture that is necessary (Abbu *et al.*, 2022; AlNuaimi *et al.*, 2022). Effective leadership in DT requires inspiring and engaging teams towards organizational innovation and agility, transcending the simple adoption of technology (Lousã; Lousã, 2018; Cortellazzo *et al.*, 2019). Studies have suggested that transformational leadership stands out as a crucial approach, as it enables the mobilization of human and technological resources to achieve the strategic objectives of digitalization (Philip, 2021). During crises, leadership is relevant, contributing to organizational resilience and continuity, as shown in the COVID-19 pandemic (Bartsch *et al.*, 2020). While many studies have examined leadership or DT (DT) independently, there is a scarcity of research that integrates both areas. Given the rapidly evolving landscape and the variety of methodologies, there is a need for up-to-date bibliometric reviews to uncover emerging trends in the interplay of leadership and DT (e.g., Elmatsani, 2024). This research aims to address this void by focusing on leadership within the framework of DT and providing a comprehensive overview of the topic's evolution over the past five years. The analysis is intended to enrich the current understanding, pinpoint new trends and challenges, and bolster both theoretical and practical applications in organizations. To accomplish this, the article suggests a bibliometric analysis to investigate the trajectory, patterns, and thematic developments of leadership in DT. Accordingly, the study seeks to answer the following three research questions: RQ1: What are the main themes (clusters) identified in the literature on leadership and digital transformation? RQ2: How are these themes positioned in the research field in terms of strategic relevance and scientific maturity? RQ3: What are the underlying conceptual dimensions that structure research in this domain, and which emerging topics delineate the frontier of knowledge?

The following section outlines the concepts of DT and leadership. Next, the adopted bibliometric methodology, including the research strategy. The results are then presented and discussed. The paper concludes with key findings, acknowledges limitations, and suggests future research directions.

CONCEPTS

2.1 LEADERSHIP

The concept of leadership has evolved significantly, moving from a focus on individual

paths to being understood as a complex and emergent phenomenon shaped by various contextual factors (Yukl, 2013; Lousã; Mónico, 2017). This development reflects the needs and challenges of change faced by societies and organizations over time. As a result, a multiplicity of approaches to the study of leadership has emerged.

Transformational leadership arose as a response to the need for leaders capable of inspiring and managing change during turbulent times (Bass; Riggio, 2005). This leadership model has proven effective in driving digitalization within organizations, as it emphasizes creating an inspiring vision, encouraging innovation, and developing an organizational culture that is open to change (Philip, 2021). It is directly linked to organizational agility, a critical factor for adapting to new digital demands (AlNuaimi *et al.*, 2022).

Digital leadership has become essential in today's business environment, influenced by rapid technological advancements and the need for organizations to innovate. This approach entails strategic thinking, collaboration, and the capacity to manage uncertainty, crucial for implementing DT initiatives (Canbolat, 2023). It involves the competencies and strategies leaders use to guide teams in a digital landscape, emphasizing the adaptation to new technologies and fostering a culture focused on continuous innovation (Eberl; Drews, 2021). Skills necessary for digital leaders include emotional intelligence and data-driven decision-making (Abbu *et al.*, 2022).

2.2 DIGITAL TRANSFORMATION

The concept of DT has gathered particular interest at both academic and practical levels over the past decade. DT is a multidimensional phenomenon that goes beyond the mere adoption of new technologies, requiring an integrated approach that encompasses technological, social, and organizational aspects. From a technological standpoint, DT is based on the incorporation of emerging technologies such as AI, IoT, and automation to enhance efficiency and drive innovation in businesses (Brock; von Wangenheim, 2019; Ononiwu *et al.*, 2024). Still, the success of this transformation hinges not only on technology but also on human interactions with these innovations. From a social perspective, it can reshape human relationships, leadership styles, and organizational culture. Moreover, employee resistance and the necessity for developing digital skills create substantial challenges that affect the process's effectiveness (Abbu *et al.*, 2022). At the organizational level, DT can lead to a profound restructuring of business models and corporate strategies (Hess, 2016), necessitating leadership that promotes agility and manages cultural changes (AlNuaimi *et al.*, 2022).

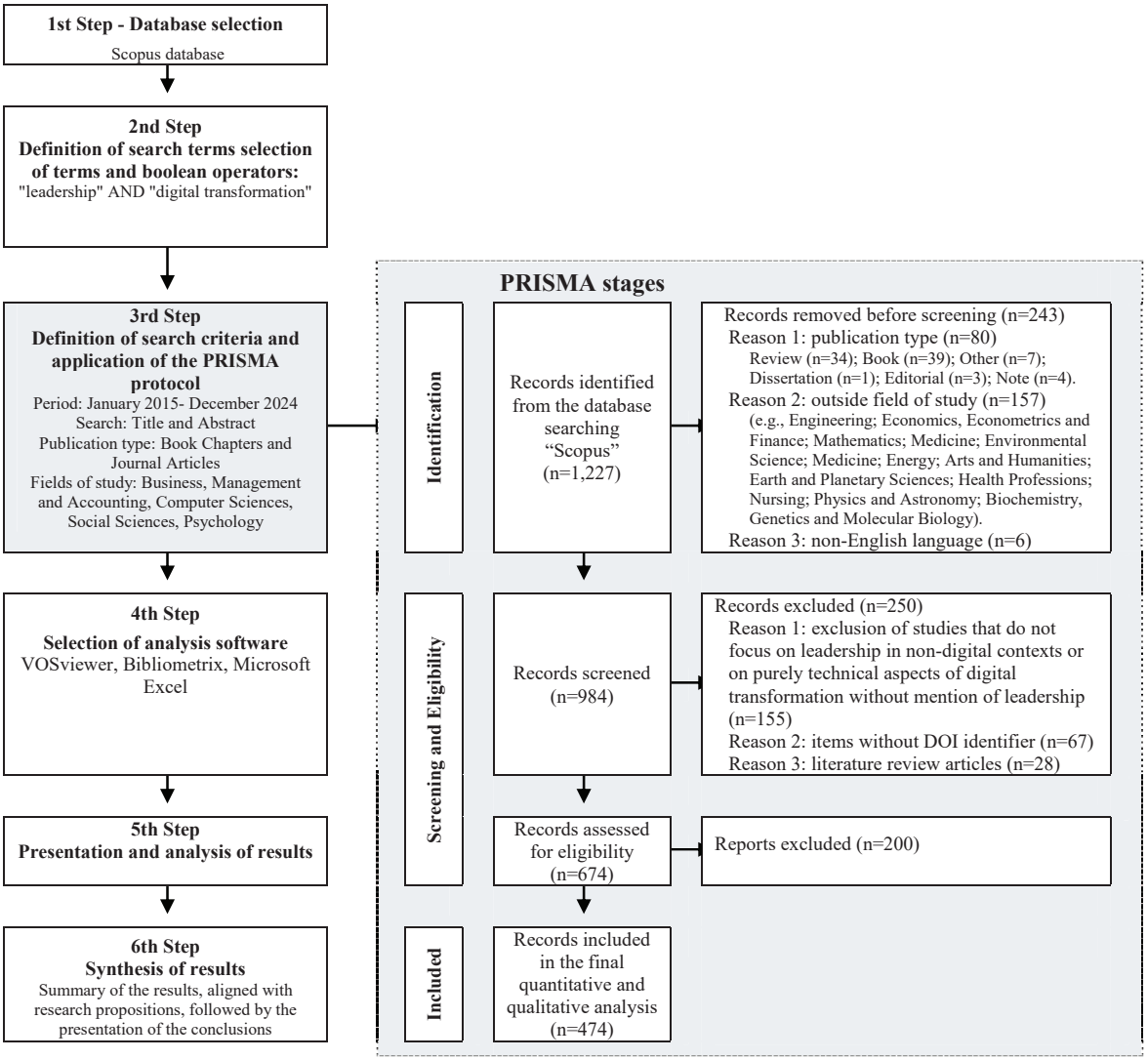
METHODOLOGY

Bibliometric analysis assesses research trends and priorities through statistical methods, identifying key focus areas, emerging themes, and publication relationships across disciplines (Aria; Cuccurullo, 2017). The study utilized a bibliometric methodology following six structured stages in alignment with the PRISMA protocol (Figure 1) to ensure transparency, reproducibility, and rigor in data selection and analysis. The stages included (i) selecting a reliable database across scientific domains; (ii) defining search terms with Boolean operators to locate studies at the intersection of two core topics; (iii) establishing eligibility criteria per the PRISMA protocol; (iv) selecting analysis tools such as VOSviewer, Bibliometrix (R), and Microsoft Excel for statistical processing and graphical visualization; (v) identifying predominant themes; and (vi) synthesizing and discussing the results in light of the study's theoretical propositions, leading to the main conclusions. This study employed the Scopus database, which is widely recognized for its comprehensive multidisciplinary coverage, rigorous indexing, and detailed citation metrics that facilitate the analysis of scientific impact and the identification of research trends (Donthu *et al.*, 2021). The search focused on the co-occurrence of the terms "Leadership" and "Digital Transformation" in the metadata (title, abstract, and keywords). The search was

restricted to the terms "Leadership" AND "Digital Transformation" to ensure focus on the direct intersection between the two concepts, avoiding thematic dispersion. This choice is justified by the need to specifically map the role of leadership in DT processes, excluding adjacent phenomena (e.g., leadership in general innovation). Recognizing the multidisciplinary nature of the field, 984 publications were analyzed, focusing on specific areas such as "Business, Management, and Accounting" (n=505), "Computer Science" (n=391), "Social Sciences" (n=378), and "Psychology" (n=40). The sample consisted exclusively of articles, chapters, reviews, and conference papers published in English between January 2020 and December 2024, ensuring a comprehensive bibliographic database to analyze trends during a period of significant DT. The breakdown included 588 journal articles, 223 conference papers and reviews, and 173 book chapters. Two independent investigators conducted an initial screening of relevant studies based on titles, abstracts, and keywords aligned with predefined eligibility criteria. Inclusion criteria targeted studies explicitly mentioning concepts of leadership, such as "leadership" or "management," and terms associated with "digital transformation" or "digital change" in their titles or abstracts, indicating a potential relationship between leadership and DT. Exclusion criteria encompassed thematic restrictions, such as studies on leadership in non-digital contexts or those focused solely on technology without a leadership analysis. Additionally, documents lacking a Digital Object Identifier (DOI) were omitted to maintain the integrity and traceability of bibliometric data (Donthu *et al.*, 2021). Excluding literature review articles aimed to avoid distortions in results due to their high citation accumulation and broad topic coverage, which could skew thematic analyses and citation indicators (Zupic; Čater, 2015). The reviewers-maintained consistency throughout this process, resolving any disagreements through consensus. The review process analyzed 674 articles, applying exclusion criteria that eliminated studies lacking substantial analysis on leadership and DT, those focusing solely on technology, and single non-generalizable case studies. This resulted in 200 exclusions, leaving 474 articles for synthesis. The records were exported in BibTeX and CSV format, containing the title, authors, keywords, and references. Duplicates were removed, and keywords were standardized.

The keyword co-occurrence network was constructed using VOSviewer version 1.6.19 (Van Eck; Waltman, 2010) and Bibliometrix (R) (Aria; Cuccurullo, 2017) software, considering only terms with a minimum number of occurrences equal to 20. Before the analysis, Zipf's law of word occurrence was applied to identify the most representative terms and reduce the impact of low-frequency words. Thematic clusters were identified by the Louvain modularity algorithm. Next, the thematic map was developed in Bibliometrix, which classified the themes into four categories: driving, basic, specialized, and emerging/declining themes, based on their centrality and density. Finally, a Multiple Correspondence Analysis (MCA) was performed to explore the factorial structure of the keywords and highlight the proximity between themes. The results were interpreted in an integrated manner, allowing the identification of consolidated trends and gaps in literature.

Figure 1 – MethodologySource: Own elaboration (2025).



Source: Own elaboration (2025).

RESULTS

4.1 THEMATIC STRUCTURE OF LITERATURE (RQ1)

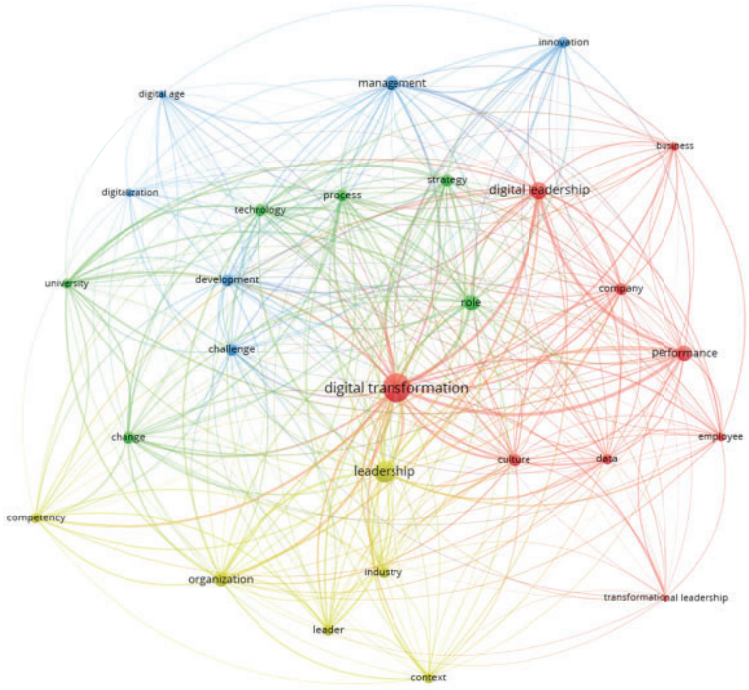
The analysis of keywords in the realm of Leadership and DT revealed a structured conceptual framework through the identification of 27 keywords with a minimum of 20 occurrences. These keywords were categorized into four distinct clusters, as presented in Table 1 and Figure 2, which demonstrate varied thematic approaches. In assessing the co-occurrence of keywords, particularly from titles and abstracts following Bornmann *et al.* (2018), Zipf's Law indicated a significant concentration around key terms such as "digital transformation", "leadership", and "digital leadership". This suggests a strong thematic core that links leadership with DT in organizational contexts. The red cluster emerges as the most dominant, featuring seven keywords with "digital transformation" at the forefront. The green cluster contains six keywords, primarily focused on "role". The blue cluster, comprising five keywords, is centered around "management", while the yellow cluster highlights "leadership" with two keywords.

Table 1- Cluster of co-occurrences of keywords

Cluster	Items	Number of occurrences	Relevance
Red	digital transformation	387	0.47
	digital leadership	132	0.96
	performance	105	4.35
	culture	70	0.41
	company	67	0.50
	data	50	0.13
	employee	38	0.35
	business	37	0.82
	transformational leadership	24	0.97
Green	role	104	0.21
	technology	80	0.34
	strategy	69	0.38
	change	63	0.84
	process	58	0.55
	university	42	0.53
Blue	management	94	0.34
	challenge	69	1.03
	development	65	0.03
	innovation	60	0.60
	digitalization	30	1.26
	digital age	29	0.67
Yellow	leadership	214	0.47
	organization	101	0.35
	competency	61	1.73
	leader	60	1.15
	industry	54	0.88
	context	52	0.64

Source: Prepared by the authors (2025).

Figure 2- Keyword Co-occurrence Network



Source: VOSviewer (2025).

The **Red Cluster** identifies the link between "digital leadership and organizational outcomes", asserting the importance of leadership in DT. This process encompasses more than technology adoption; it involves significant shifts in business models, culture, and employee attitudes (Hanelt *et al.*, 2021). A systemic and strategic approach is essential, with "digital leadership" reflecting the increasing recognition of leaders' roles in facilitating digital change by aligning technology with organizational aims and promoting innovation

(Abbu *et al.*, 2022). It contrasts with traditional leadership by focusing on agile methodologies, data-driven decisions, and collaborative practices (Eberl; Drews, 2021). Transformational leadership, though less emphasized, is also critical for driving digital change, inspiring and stimulating employees, especially in unpredictable environments (Philip, 2021). This leadership style aids in cultivating adaptive digital cultures aligned with innovative goals. Moreover, "performance" is highlighted as a crucial component, underscoring that effective digital leadership yields improved performance via strategic agility, innovation, and enhanced resilience (AlNuaimi *et al.*, 2022). The interplay between leadership and performance reinforces the idea that DT is a means to achieve sustainable value, not just an endpoint. Human and cultural factors such as "culture", "employee", and "business" are also prominent, emphasizing that leaders must cultivate a culture focused on innovation and continuous learning for successful transformation (Weber *et al.*, 2022). Employee engagement plays a pivotal role in the success of transformation initiatives. Interestingly, while "data" is important in the tech domain, it has low relevance in this context (0.13), indicating a gap in linking digital leadership to data management. Brock and von Wangenheim (2019) emphasize the need for leaders to approach AI strategically and ethically, highlighting the leadership role in integrating these technologies appropriately. In conclusion, this cluster highlights the foundational relationship between DT, digital leadership, and performance within organizational change, indicating that traditional leadership models remain relevant in the digital landscape.

Green Cluster, categorized as "Strategy and Technology Implementation", emphasizes the critical role of leadership in organizational strategies aimed at addressing digitalization challenges, incorporating concepts such as role, technology, strategy, change, process, and university. Despite the term "role" being the most frequently mentioned (104 occurrences), its bibliometric relevance is low (0.21), indicating a superficial treatment in the literature. Digital leadership requires a flexible approach to accommodate various leadership styles and roles (Cortellazzo *et al.*, 2019). The significant mention of "technology" (80 occurrences; relevance of 0.34) underscores the necessity for digital leaders to align technology with strategic goals, with Brock and von Wangenheim (2019) asserting that effective leadership should manage realistic expectations about emerging technologies like AI, integrating them into business models. Strategic leadership emerges as crucial, evident from the term "strategy" (69 occurrences; relevance of 0.38), indicating that DT is primarily strategic rather than solely technological. AlNuaimi *et al.* (2022) assert that successful transformation relies on aligning leadership with digital strategy, while Matt *et al.* (2015) stress the importance of proactive digital strategies that position organizations as change leaders. Although "change" appears less frequently (63 occurrences), its thematic relevance (0.84) highlights that digital leadership fundamentally embodies leadership of change. Bartsch *et al.* (2020) identify communication, managing resistance, and instilling urgency as vital for effective leadership during digital transitions. Weber *et al.* (2022) point out that successful leaders balance inspirational behaviors with strategic direction, adjusting to different transformation stages. The need to reconfigure internal "processes" (58 occurrences; 0.55 relevance) is also discussed, with literature suggesting that DT necessitates a comprehensive redesign of operational flows and mental models. As Imran *et al.* (2021) argue, effective DT requires integrating technological and cultural changes, with leadership acting as a bridge between these demands and human adaptability. Lastly, "university" (42 occurrences; 0.53 relevance) highlights the significant role of higher education as both a beneficiary and a key driver of technological innovation. Rodríguez-Abitia and Bribiesca-Correa (2021) discuss the responsibilities of universities in both developing and implementing DT strategies, a sentiment echoed by Laufer *et al.* (2021), who emphasize the challenge academic leaders face in balancing pedagogical qual-

ity with digital agility during the pandemic. In summary, the cluster captures the essence of the transformation process, where Technology serves as a tool, Strategy is the master plan, Change is the essential action, and the Role of stakeholders is pivotal. The involvement of universities emphasizes their role in competency development for navigating this process.

Blue Cluster, "Management, Development and Challenges of the Digital Age", explores the interplay among management, innovation, organizational development, and the challenges posed by the digital era. The term "management" appears most frequently (94 occurrences; 0.34 relevance), indicating its significance, while "digitalization" has the highest thematic relevance (1.26) and reflects a focus on how management addresses DT challenges. Effective digital management necessitates a coordinated approach with leaders facilitating technological, cultural, and structural shifts (Verhoef *et al.*, 2021) and translating digital strategies into actionable steps (Hanelt *et al.*, 2021). The term "challenge" (69 occurrences; relevance 1.03) serves as a central theme, highlighting obstacles in DT, such as resistance to change, skill gaps, and organizational rigidity. Crises like the COVID-19 pandemic have amplified the demands for adaptive digital leadership (Bartsch *et al.*, 2020), resilient organizational models, and leaders capable of navigating uncertainty (Obrenovic *et al.*, 2020). "Development" has a moderate frequency (65 occurrences) but low relevance (0.03), suggesting that discussions around it are broad and non-specific. However, it remains crucial for DT, especially regarding team empowerment and skills development. Philip (2021) points out the importance of leadership development to promote transformational leadership conducive to learning and agility. "Innovation" (60 occurrences; 0.6 relevance) is identified as a key element for success in DT, emphasizing leaders' roles in creating environments that foster experimentation while maintaining accountability (Gierlich-Joas *et al.*, 2020). Leaders need transformational competencies to leverage digital innovations effectively (Schiuma *et al.*, 2022). Although "digitalization" is mentioned less often (30 occurrences), its relevance (1.26) indicates its critical role in restructuring business models, necessitating visionary leadership (Vial, 2019). Digital leaders act as bridges between technology and business strategies, ensuring alignment of innovation with organizational value (Zulu and Khosrowshahi, 2021). The term "digital age" (29 occurrences; 0.67 relevance) encapsulates an era of rapid transformation that demands new relational, digital, and strategic skills from leaders, emphasizing that leadership in this context must foster a new organizational culture and adaptive mindset (Cortellazzo *et al.*, 2019). Ultimately, this cluster underscores practical aspects and challenges of transformation, with keywords Management, Challenge, and Innovation highlighting the essential need for evolved management practices to foster innovation and address the trials of Digitalization and the Digital Age, while the lesser emphasis on Development suggests it is not a central concern in the discourse.

In **Yellow Cluster's** "Skills and Organizational Context", the central theme revolves around the role of leadership and the competencies essential for leaders amid the DT landscape. The term "leadership" is the most prevalent, appearing 214 times, indicating its critical importance in driving digital innovation. This is supported by its relevance score of 0.47, which signifies leadership as a foundational concept within the discourse (Cortellazzo *et al.*, 2019). Abbu *et al.* (2022) argue that effective digital leaders act not just as technology managers but as catalysts for organizational and strategic change. The term "organization", noted with 101 occurrences and a relevance of 0.35, signifies the environment where leadership evolves and influences transformations, reflecting the need for adaptive leadership that can navigate the complexities of digitalization (Hanelt *et al.*, 2021). Jackson and Dunn-Jensen (2021) highlight the necessity for leadership development focusing on innovation, agility, and strategic competencies. The term "competency", despite appearing 61 times, holds the highest relevance at 1.73, underscoring the increasing focus on the specific skills required for leadership success in a digital context. Schiuma *et al.*

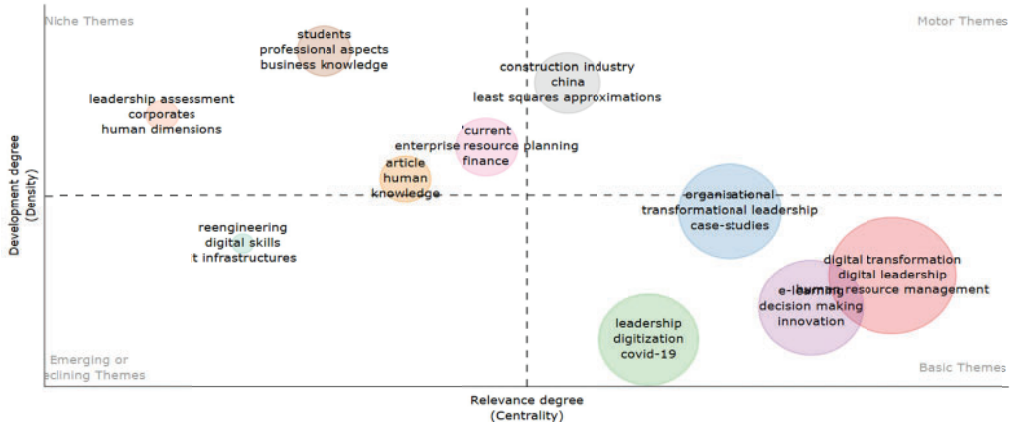
(2022) outline six pivotal competencies for digital transformational leadership, such as systemic vision and emotional intelligence. The Digital Leadership Scale by Abbu *et al.* (2022) further contributes to understanding leaders' readiness by highlighting traits like self-awareness and technological fluency. The frequency of "leader" (60 occurrences; 1.15 relevance) emphasizes the multifaceted roles of leaders—strategists, mentors, and integrators—important for aligning DT with organizational goals, as noted by Weber *et al.* (2022). Transformational leadership is particularly highlighted by Philip (2021) for its ability to inspire innovation and experimentation. The term "industry", with 54 occurrences and a relevance of 0.88, reflects the heightened scrutiny of digital leadership within industrial contexts, especially considering the unique challenges presented by industry 4.0. DT is shown to vary by sector and the digital maturity of industries (Imran *et al.*, 2021; Zulu; Khosrowshahi, 2021), necessitating leaders who adapt strategies to the specifics of their fields. Furthermore, the term "context" (52 occurrences; 0.64 relevance) acknowledges that the efficacy of digital leadership is significantly influenced by its contextual environment, as discussed by Hinings *et al.* (2018). Overall, this cluster highlights the critical interrelations between Leadership, Organization, Industry, and the necessary Competencies for leaders to excel in the current technological landscape.

4.2 STRATEGIC POSITIONING OF THE THEMES (RQ2)

The thematic analysis using centrality and density parameters revealed the maturity and strategic roles of key themes in the literature on leadership and DT (Figure 3). The Motor Themes encompass "transformational leadership", "organizational", and "case studies", highlighting transformational leadership as a key element in DT. This perspective aligns with prior research by Cortellazzo *et al.* (2019) and Philip (2021), emphasizing its role in driving innovation and enhancing digital capabilities. Schiuma *et al.* (2022) specify the competencies required for transformational leaders in disruptive digital environments, while Hinings *et al.* (2018) stress that DT transcends technological upgrades, necessitating institutional and organizational innovation and redefining leaders' roles in managing complexity. The Basic Themes, namely "digital transformation", "digital leadership", "e-learning", "human resource management", "decision making", and "innovation", demonstrate high relevance but are still in the process of theoretical and empirical development. Authors such as AlNuaimi *et al.* (2022) highlight digital leadership as an emerging construct, linking traditional leadership competencies with new demands tied to managing digital technologies, fostering organizational agility, and ensuring strategic alignment. The dimensions of "e-learning", "decision making", and "innovation", alongside "leadership" and "digitalization", have been especially reinforced in the context of the COVID-19 pandemic, as evidenced by the studies of Bartsch *et al.* (2020) and Laufer *et al.* (2021), which demonstrated that digital adaptation capacity was essential to ensure the continuity of operations and organizational learning. The link between innovation and decision-making is highlighted by Hanelt *et al.* (2021), who argue that DT requires leaders capable of integrating new technologies into strategic business decisions in an agile and resilient manner. The Niche Themes reveal topics such as "students", "professional aspects", and "business knowledge", which, although well-developed, exhibit lower centrality. These findings suggest more specialized research areas, such as the development of digital competencies among students and professionals, as demonstrated by Jackson and Dunn-Jensen (2021) and Rodríguez-Abitia and Bribiesca-Correa (2021). Within this domain, the study by Karakose *et al.* (2021) also stands out, addressing the role of school leaders in promoting digital literacy during the pandemic, thereby reinforcing the importance of leadership in developing technological competencies across different sectors. The Emerging or Declining Themes, namely "reengineering", "digital skills", and "IT infrastructures", may indicate a declining

relevance, as research shifts from a purely technical focus (infrastructure and basic skills) toward more strategic and human-centered approaches to DT. A solid technological foundation remains an essential prerequisite for DT (Matt *et al.*, 2015), although the current focus is increasingly directed toward leadership strategies and organizational culture. The thematic mapping shows that leadership, particularly transformational and digital leadership, is central to the success of DT processes. Digital leaders must possess specific competencies (Abbu *et al.* 2022) to drive the necessary changes and accelerate technology adoption. The development of organizational resilience in volatile contexts (e.g., pandemic) has further reinforced the need for adaptive and strategic leadership (Obrenovic *et al.*, 2020).

Figure 3- Thematic Map



Source: Bibliometrix (2025).

4.3 CONCEPTUAL DIMENSIONS AND FRONTIER OF KNOWLEDGE (RQ3)

The analysis of the factor map (Figure 4) shows that research in Leadership and DT is structured in three interconnected conceptual dimensions, reflecting different forms of knowledge organization in the domain:

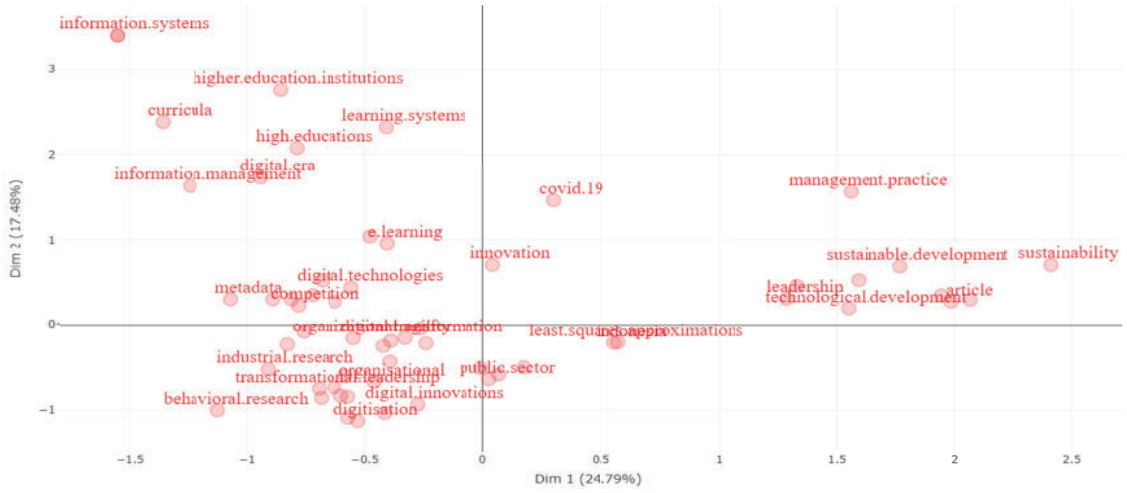
- Educational and institutional digital dimensions. The terms such as “higher education institutions”, “curricula”, “learning systems”, and “digital era”, “higher education institutions”, “learning systems”, and “e learning” highlight the role of educational institutions in the DT. This dimension highlights the relevance of DT in teaching and training leaders (Laufer *et al.,* 2021; Rodríguez-Abitia and Bribiesca-Correa 2021). The pandemic accelerated the transition to digital environments in the education sector, highlighting the importance of digital skills, hybrid pedagogical models, and new forms of academic leadership.

- Technological and operational dimensions. The terms such as “digital technologies”, “digitization”, “digital innovation”, and “information management”, reflecting the convergence between emerging technologies, their organizational application and management practices (Hinings *et al.*, 2018).

- Strategic and organizational dimensions. Integrates terms such as “leadership”, “technological development”, “sustainability”, and “management practice”, indicating the growing concern about the role of leadership in organizational sustainability and innovation (Schiuma *et al.*, 2022; Zulu and Khosrowshahi, 2021). The focus is on the ability of leaders to align strategic vision, organizational culture, and technological adoption, highlighting DT as an intentional and value-oriented process.

The term “covid-19” appears relatively isolated, pointing out that the pandemic brought specific challenges that catalyzed the need for adaptive leadership in DT processes (Bartsch *et al.*, 2020).

Figure 4- Factorial Analysis – Word Map



Source: Bibliometrix (2025).

DISCUSSION

This bibliometric study investigated the evolution of scientific literature on leadership and DT in the last five years. The results demonstrate a significant advance in the field, consolidating itself as an interdisciplinary domain that articulates technology, human behavior, and organizational strategy. The findings indicate a maturation of topics related to leadership and DT, with the rise of digital leadership emerging as a concept that prompts a reevaluation of leadership roles in response to current technological challenges (Abbu *et al.*, 2022). Additionally, there is growing recognition of the potential of transformational leadership to drive digital change in a context of accelerated and unpredictable change (Philip, 2021). This evolution is tied to the essential need for digital skills and organizational agility in a context characterized by constant innovation and complexity (AlNuaimi *et al.*, 2022). The research emphasizes the convergence of digital and transformational leadership, the importance of organizational results, and the value placed on internal culture and employee engagement, advocating for a comprehensive approach to implementing change. The consolidation of a strategic and technological dimension reflects a systemic view of leadership, where the leader's role extends beyond technology management, incorporating strategic, cultural, procedural, and educational factors. Recent literature emphasizes that the effectiveness of leadership lies in its ability to simultaneously act as a strategist, change agent, technology manager, and facilitator of organizational learning (AlNuaimi *et al.*, 2022; Weber *et al.*, 2022). Moreover, leadership is a key strategic driver of organizational transformation toward innovation and sustainability (Schiuma *et al.*, 2022; Zulu; Khosrowshahi, 2021). Additionally, management faces multiple challenges in the digital age, including resistance to change, skill deficits, and inflexible organizational structures, highlighting that DT is closely linked to human and relational dynamics rather than just technical challenges (e.g., Zulu; Khosrowshahi, 2021). Emerging approaches encompass topics such as digital competencies, organizational agility, and digital education, which reflect new theoretical and practical concerns in addressing the challenges of DT (Rodríguez-Abitia; Bribiesca-Correa, 2021). Simultaneously, specialized areas such as professionalization, student competency development, and business knowledge constitute formative resources that are still consolidating. Although relevant for preparing digital leaders and developing business-related competencies, these dimensions remain poorly integrated into work practices and, consequently, have a limited impact in the field. Their consolidation requires interdisciplinary approaches and

stronger alignment with the core pillars of DT and leadership (Laufer *et al.*, 2021).

Theoretical implications

The results of this study contribute to the advancement of theory by showing that leadership and DT constitute a scientific field in consolidation, supported by three main conceptual dimensions: strategic and organizational, socio-human and educational, and technological and operational. This three-dimensional model reinforces the need to overcome fragmented approaches, proposing an integrative perspective that articulates transformational leadership, digital skills, organizational culture and information systems. In addition, the centrality of digital leadership as a systemic phenomenon and not just an individual one is confirmed, positioning it as a conceptual axis between technology, people and strategy. These results offer a basis for the development of more robust theoretical frameworks that integrate leadership, innovation, organizational learning, and digital ethics.

Practical implications

The study shows the need to adapt leadership models to new technological, cultural, and organizational realities. At the management level, it is important to develop strategies that integrate technology and people, as is the need for leaders to develop specific digital skills. DT requires leaders able to manage complexity, drive change, and align strategic objectives with the sustainable adoption of emerging technologies. Organizations need to foster agile cultures and environments conducive to innovation, in which leaders act as facilitators of transformation. At the human resources management level, HR departments must act as facilitators of DT, highlighting the need for continuous training strategies in digital skills and soft skills and the protection of workers' mental health in digital environments. In addition to the business context, the trends observed reveal challenges with an impact on society. For example, digitalization can exacerbate inequalities if minimum digital skills are not guaranteed across different sectors and age groups. Digital leadership in public and educational contexts (e.g., e-governance, e-learning) has implications for inclusion, transparency, and efficiency of services. In the context of higher education, there is a growing need to develop training programs in e-leadership and digital learning, accompanied by curricula that prioritize digital competencies and transversal soft skills. At the level of public policy, it becomes essential to strengthen national strategies for digital capacity building, ensure sustained investment in technological infrastructure, and promote a sustainable and ethically responsible DT.

CONCLUSIONS

This study presented a bibliometric analysis of scientific production on leadership in the context of DT, covering the last five years. The thematic analysis showed that DT is understood not only as a technological challenge but also as an organizational and human phenomenon, which requires relational, strategic, and communicational skills on the part of leaders. In addition, the increasing focus on specific contexts (e.g., public sector or digital education) suggests new theoretical frontiers that require contextually sensitive and methodologically diverse approaches. In summary, the field of leadership and DT is in a process of conceptual maturation and empirical expansion, characterized by strong interdisciplinarity and challenges of theoretical integration and scientific collaboration.

Despite the scope of the present bibliometric data, this analysis has some limitations. The exclusive use of the Scopus database may have restricted the sample, potentially excluding relevant publications indexed in other platforms. Also, the selection criteria adopted, including keyword choices and the exclusion of certain document types, may have also influenced the results. Additionally, relevant studies published in local databases or in non-English languages may have been excluded.

The literature on leadership and DT pres-

ents promising areas for future research. Longitudinal studies that analyze the sustained impact of digital leadership on DT processes are needed. The application of mixed methods, combining quantitative and qualitative analyses. Comparative investigations across different sectors and case studies can help elucidate the specificities of digital leadership in diverse organizational contexts. E-leadership requires further investigation. Empirical studies focusing on how digital tools and technologies are used to lead and manage teams effectively and on specific competencies required of e-leaders, including technical, communication, and strategic skills. Future research should also explore the integration of leadership with emerging domains like AI, sustainability, and digital education. Additionally, the impact of digital leadership and DT on employee well-being, particularly in remote and hybrid work contexts, is also important.

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