

Bibliometric Analysis of Digital Leadership Studies *

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Abstract

The purpose of this study is to provide a comprehensive and holistic perspective on the field of digital leadership by conducting a bibliometric analysis of publications in this field. Web of Science (WoS) Core Collection database was utilized to gather bibliometric data. Keywords such as "digital leadership", "e-leadership", "virtual leadership", "leadership 4.0" was used in the research. A total of 141 articles published between 2000 and 2022 were examined by means of the bibliometric analysis method. In the section of analysis, performance analyzes and bibliometric analyzes called co-occurrence and co-citation were performed. According to findings, the annual growth rate in the field of digital leadership is 15.09%, while the average number of citations per article is 21.48 in the performance analysis. Some of the prominent themes in the co-occurrence analysis include "Digital Leadership and Performance Management," "Knowledge and Student Experience in Digital Education," "Transformation and Innovation in Digital Leadership" etc. Some of the cluster names obtained as a result of co-citation analysis are "Digital Leadership and Virtual Team Management," "Coordination and Consensus in Multi-Agent Systems," "Digital Leadership Skills and Psychological Well-Being," which represent prominent and intensively studied themes in the field of digital leadership.

As a conclusion, the number and importance of studies in the field of digital leadership are gradually increasing. The obtained data help us understand the thematic evolution of digital leadership research and shifts of interest in the research community. Digital leadership is a leadership model that is focused on innovation and performance which require effective communication and information management competencies. Several recommendations are proposed for researchers, practitioners and policymakers to further develop and implement effective digital leadership strategies. Expanding theoretical frameworks, conducting longitudinal studies, implementing leadership development programs, fostering a digital culture, supporting digital transformation, establishing standards and guidelines, promoting digital literacy are amongst them.

Keywords: *Digital Leadership, Bibliometric Analysis, E-leadership, Digital Transformation, Co-occurrence Analysis, Co-citation Analysis.*

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1. INTRODUCTION

In today's world, where digitalization deeply affects business life, businesses are becoming more and more digital. In this respect, businesses that have missed the digital transformation process are expected to be slower, less flexible, and less competitive in the future (Zeike et al., 2019). Since digitalization leads to wide-ranging changes at all levels of the economy and society, it leads to both new challenges and opportunities, fundamentally altering the way people communicate and interact with each other and the activities of businesses in the market (Hensellek, 2020).

Leadership is a key success factor that enhances organizational success for digital transformation. At present, most businesses need a leader with sufficient knowledge and skills to execute their digitalization transformation process (Promsri, 2019). Digital leaders are defined as people, who have innovative ideas on the digital platform, motivate their employees in the digital environment, are able to communicate sustainably with their employees even in the digital environment, and have the capability to develop digital strategies (Sağbaşı and Erdoğan 2022). Digital leaders are critical in creating the digital culture for a new organization (Antonopoulou et al., 2021).

Digital leaders also recognize that technological developments are the major elements contributing to significant changes in every company (de Araujo et al., 2021). In the digital age, digital leaders are expected to have different mindsets and qualities compared to the traditional leadership styles. Existing leaders should be able to combine both traditional and new digital skills so that they could effectively lead their organizations (Kane et al., 2019). According to the report issued by Manpower Group, today's leaders need to use 80 percent of traditional leadership qualities as well as 20 percent of new digital leadership qualities in order to successfully drive digital transformation in organizations (Gray, 2018).

Bibliometric analysis method was used in this research. A bibliometric study is a quantitative approach for studying the bibliographic material and mapping the research field without subjective bias (Zupic and Cater, 2015). It brings into light the most influential works and authors, the evolution of the most used keywords, the most associated topics, and the dominant outcomes, among other pieces of evidence (Tigre et al., 2023). Bibliometric analysis makes it much easier to understand the relevant field as it provides the opportunity to synthesize studies in a research field (Durmaz et al., 2023: 710). In this study, which was conducted to carry out a bibliometric analysis of research in the field of digital leadership, variables such as author, citation, affiliation, and country were used. Web of Science Core Collection database was used for the research and digital leadership articles and book chapters in this database were included in the research as well. The importance and impact of digitalization have increased, thus digital leadership has also become an important issue that needs to be addressed. The purpose of the research: is to provide a comprehensive and holistic perspective on the field of digital leadership by conducting a bibliometric analysis of studies conducted in this field. Herewith, it is aimed to fill the gap in the field by providing researchers and practitioners with information about the

development of the field of digital leadership. The research questions are formulated as follows in line with the purposes of the research:

- What is the performance analysis (number of publications and citations by year, top publishing country, institution, journal and authors, top cited articles) of publications on Digital Leadership?
- What is the conceptual structure (co-occurrence) of publications on Digital Leadership?
- What is the intellectual structure (co-citation) of publications on Digital Leadership?

In parallel with digitalization, the number and importance of digital leadership studies are progressively increasing. The present study discusses whether the field of digital leadership can serve as a new leadership model that can enable the digital transformation of businesses. It is thought that the findings obtained from the research will make a significant contribution to the digital leadership literature.

2. LITERATURE REVIEW

Although leadership has been defined in different ways by many researchers, the most focus is on directing followers to achieve the desired goals (Antonopoulou et al., 2021). In the historical process, technological transformation has shaped different types of leadership and the leadership has evolved in different ways based on different patterns such as hierarchy, power and authoritarian personality. Digitalization, on the other hand, changes leadership styles and skills to a considerable extent in today's dominant digital economy (de Araujo et al., 2021).

The concept of digital leadership emerged in the 1990s, when the internet began to grow rapidly and many organizations turned to digital technologies to accelerate their operations and increase their productivity, but it became more important with the rapid advancement of information and communication technology in the 2000s (Nuryadin et al., 2023).

Digital businesses require top-to-bottom organizational transformation. Digital transformation is about competitiveness, new challenges and innovation, and how to create value from becoming digital without creating new ways of communicating and collaborating. Therefore, it is very important for business leaders to adopt an influential leadership style and to bear the right skills to inspire their employees to innovate and maintain the innovation in the digital age (Karippur and Balaramachandran, 2022).

Zhu et al. (2022) recognize the digital leadership as a rapid, inter-hierarchical, team-oriented and collaborative leadership style that focuses strongly on the innovation of an organization. Mihardjo et al. (2019), on the other hand, perceive digital leadership as another version of transformational leadership, describing it as "It is the combination of digital competence and digital culture, evaluating the opportunities presented by digital technologies and directing change". According to Larjovuori et

al. (2016), digital leadership is the capability of leaders to create a clear and purposeful vision for the digitalization process and to execute strategies to achieve it. As a result of their study conducted to define digital leadership, Ordu and Nayır (2021) described digital leadership as “Creating a culture of sustainable change in the organization by using technology to create an innovative vision”. According to Peng (2022), the concept of digital leadership is reshaping the business world by focusing on digital technology, and digital leadership is the ability of individuals or organizations to lead followers, teams, or entire organizations to fully incorporate thinking digital by benefiting digital insight, digital implementation, digital decision-making and digital guidance that they should have in the age of digital technology. Mihardjo and Rukmana (2018), believe that the digital leader has an important role in directing the rapid decision-making process and advancing change.

Digital leadership studies are based on Hambrick and Mason’s (1984) *upper echelons theory*. The main argument of upper echelons theory is that leaders’ experiences, values, and personalities influence their choices, and in return, these choices affect the organizational performance. This theory claims that the characteristics and experiences of leaders shape their perceptions, choices, and actions in a way that ultimately influences various organizational outcomes. Possessing a digital leadership style provides leaders with characteristics and performance that affect the behavior and decisions of the leader; thus the digital leader has an influence on variables at the business level (Wang, et al., 2022).

Promsri (2019) remarked that digitalization creates large leadership gaps in organizations around the world, which requires today’s leaders to have different skills. According to Hensellek (2020), a purposeful digital vision is a prerequisite for good digital leadership. Wang et al. (2022) believe that digital leadership emphasizes five key skills for leaders: creativity, thinking and questioning, curiosity, vast knowledge, and global vision and collaboration. Zhu et al. (2022) have the opinion that digital leaders have creative thinking, foresight and insight. Digital leadership embodies distinctive features such as creativity, in-depth knowledge, strong network and cooperation and vision. In the study conducted by Wang et al. (2022), it was revealed that digital leadership has a significant influence on corporate innovation, culture development and orientation creation.

It is seen that some bibliometric analysis studies were carried out in the field of digital leadership (Karakose et al. 2022; Tigre et al., 2023; Erer et al., 2023; Espina-Romero et al., 2023). In the study conducted by Karakose et al. (2022), it is understood that especially the performance analysis part is far from satisfactory. While many performance parameters can be examined, this part was analyzed with very few parameters. In addition, co-citation, citation, and bibliometric coupling analyzes performed classically depending on the selected software (SciMAT) were not included in this study. Another bibliometric analysis study on digital leadership was conducted by Tigre et al. (2023). In this study, bibliometric and network analysis of research on digital leadership was conducted. However, they detected very few clusters and nodes in the analysis results. In this study, nearly 50 nodes and more clusters were obtained as a result of each analysis. Erer et al. (2023) also performed a bibliometric

analysis of digital leadership according to the visual mapping technique. However, in this study, especially the clusters obtained with the analysis were not called themes and only the comments regarding the size and placement of the nodes seen in the image were deemed adequate without taking advantage of the data pool obtained as a result of the search strategy for the relationship of each cluster with the digital leadership field. This means that deep examination and theme titles were not determined in the study. In the study conducted by Espina-Romero et al. (2023), a bibliometric analysis of the trends and challenges of digital leadership in the ever-changing world was conducted. In this study, especially co-citation analysis was not performed, thus, the intellectual structure of the digital leadership field was neglected. This study is needed for the reasons stated.

3. MATERIALS & METHODS

The data used in the research were accessed using the WoS Core Collection database. While searching, keywords related to leadership were selected in the article title. These words include; “digital leadership”, “e-leadership”, “virtual leadership”, “leadership 4.0”, “digital leadership traits”, “digital leadership skills”, “digital leadership competencies”, “digitalization and leadership”, “e-leader”, “digital leader”, “virtual leader”, “leader 4.0”, “digital leader traits”, “digital leader skills”, “digital leader competencies”, “digitalization and leader”, “leader and technology”, “leader and innovation”, “leadership and digital transformation”. Keywords used in the research were searched using “OR” conjunction. Thus, it was aimed to reach all of the studies involving the field of digital leadership. Since Avolio, Kahai and Dodge’s article titled “E-Leadership: Implications for theory, research, and practice” published in 2000 was considered as an important base for digital leadership studies, we included the studies conducted between 2000 and 2022 in the analysis.

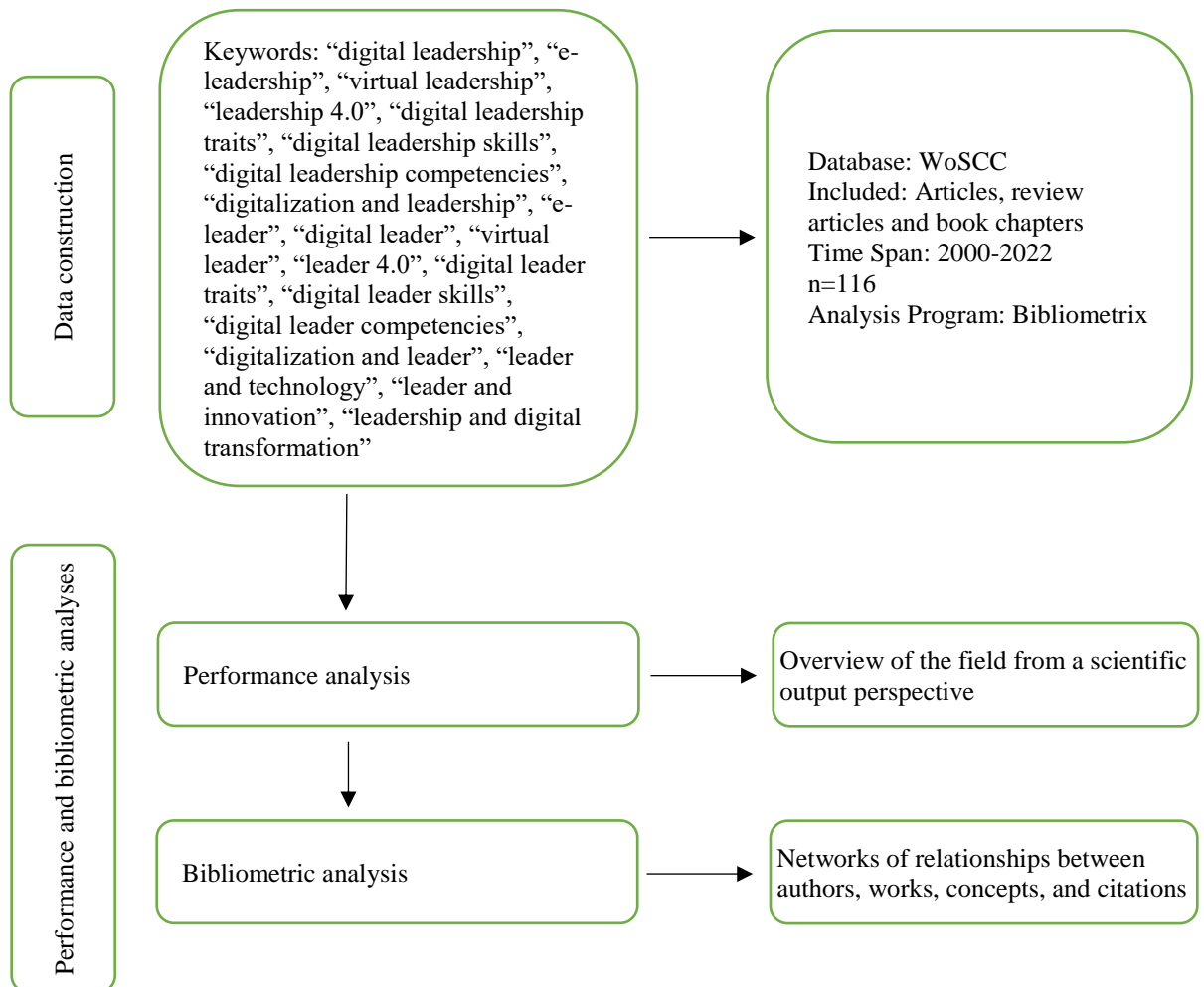
In line with the search strategy, 116 articles were reached and in Figure 1, the process of obtaining the data set and analysis is visualized.

The data set of the articles downloaded within the scope of bibliometric analysis was analyzed in terms of titles such as sources, authors and documents. Bibliometric analysis of this article was performed through “biblioshiny for bibliometrix” application which is a R 4.0.3 software tool. R programming language is a tool whose foundation was laid by John Chambers et al. in the 1960’s and used in statistical calculations (European Environment Agency, 2020; Prajapati, 2013).

Some of the reasons why bibliometrix application is preferred can be briefly stated as follows: First of all, there are many more modules available under the title of performance analysis compared to other analysis programs. For example, trend topic analyzes, impact analyzes (analysis of h, g, m indexes), multiple corresponding analyzes and dendrogram analyzes are modules that are not included in other bibliometric analysis programs. In addition, in terms of co-citation and co-occurrence analyzes, cluster can be determined with at least 50 words and at least 50 authors. Therefore, more clusters can be detected depending on the number of words obtained, and more common citation clusters can be

detected. For the reasons stated, bibliometrix application is favored among other analysis programs. Biblioshiny, a web interface for the Bibliometrix R package, was used for the analysis. It allows users to perform bibliometric analyses without any coding knowledge.

Figure 1. Data Construction, Performance Analyses and Bibliometric Analysis



The Web of Science (WoS) database stands out as an ideal resource for bibliometric analysis studies. WoS provides a comprehensive collection of scientific publications, allowing researchers to evaluate academic performance and trace literature trends (Man, et. al. 2023). Thanks to its wide coverage and inclusion of high-quality and peer-reviewed journals, WoS provides a strong basis for bibliometric analyzes such as impact factors of scientific studies, citation analysis and examination of collaborative networks (Bağış et. al. 2023). In addition, the advanced search and filtering tools offered by WoS help researchers conduct in-depth analyzes in specific areas (Öget et. al. 2024). Due to these features, WoS becomes a favored database for bibliometric analyses.

Bibliometric analyses were performed using the Bibliometrix software. Within the scope of the analysis, cooccurrence and co-citation analyzes were conducted to determine the cooperation networks and research trends of authors, keywords and publications. These methods have been used to reveal the

general trends of studies in the fields of creative design and innovative production, important researchers, common themes and research networks. In the design and presentation of the findings of this article, the article template published by Tengilimoğlu et al. (2024) was taken as an example.

4. FINDINGS

The findings section is shaped on two main axes. In the performance analyzes, the main information, the number of publications and citations by years, the rankings of the most published journals, authors, countries, and institutions and the 10 most cited articles were examined. In addition, trend topical thematic evaluation and multiple correspondence analysis were carried out under this sub-section. Under the title of the second sub-section, the results of two main bibliometric analyzes (co-occurrence and co-citation) are given.

4.1. Performance Analysis

Basic information about the articles is shown in Figure 2. When this Figure is examined, there were 141 publications (journals, early access and review) from 2000 to 2022. 119 of these publications were published as articles. It is observed that the annual growth rate of the field is 15.09% and the average citation per document is 21.48. It is seen that the publications were made by 382 authors, 24 publications were authored by single person, the co-author per publication was 3.04 and the international co-authoring rate was quite high with 24.11%. The high rate of international co-authoring shows that the field is very favorable in terms of generating international studies.

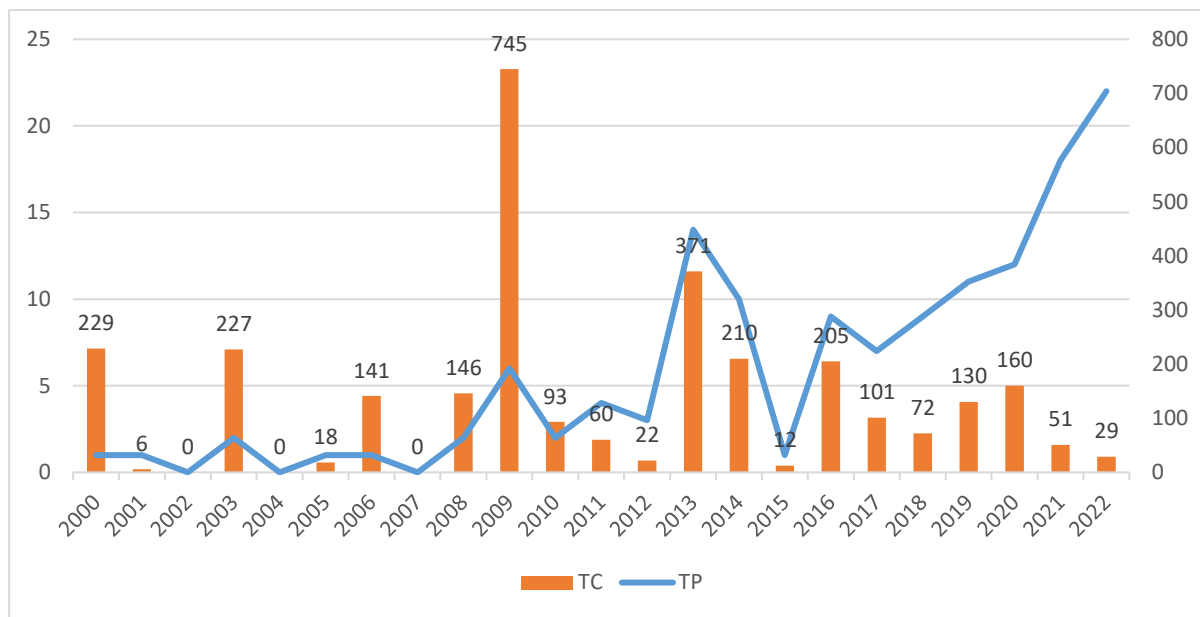
Figure 2. Main Information About Data



Number of Publications and Citations by Years: The distribution of the studies published on "Bibliometric Analysis of Digital Leadership Studies" by years and the number of citations are important to be understood the evolution and impact of research in the field of digital leadership. As seen in Graph 1, the high number of citations received between 2000 and 2003, despite the low number of publications (for example, 1 publication in 2000 and 229 citations), shows that the studies conducted during this period had a significant impact on the field. 2009 stands out, the highest number of citations (745) was reached with 6 publications this year. This indicates that there was an increasing interest in digital leadership at that time and that these studies created a wide area of influence.

Since 2013, there has been a significant increase in the number of publications, especially in 2013, with a remarkable increase of 14 publications and 371 citations compared to the previous years. This trend continues until 2022 and peaks with 22 publications in 2022. However, the low number of citations in 2021 and 2022 (51 and 29, respectively) may indicate that the studies conducted during this period have not yet been widely accepted or adequately evaluated.

Graph 1. Number of Publications and Citations by Years

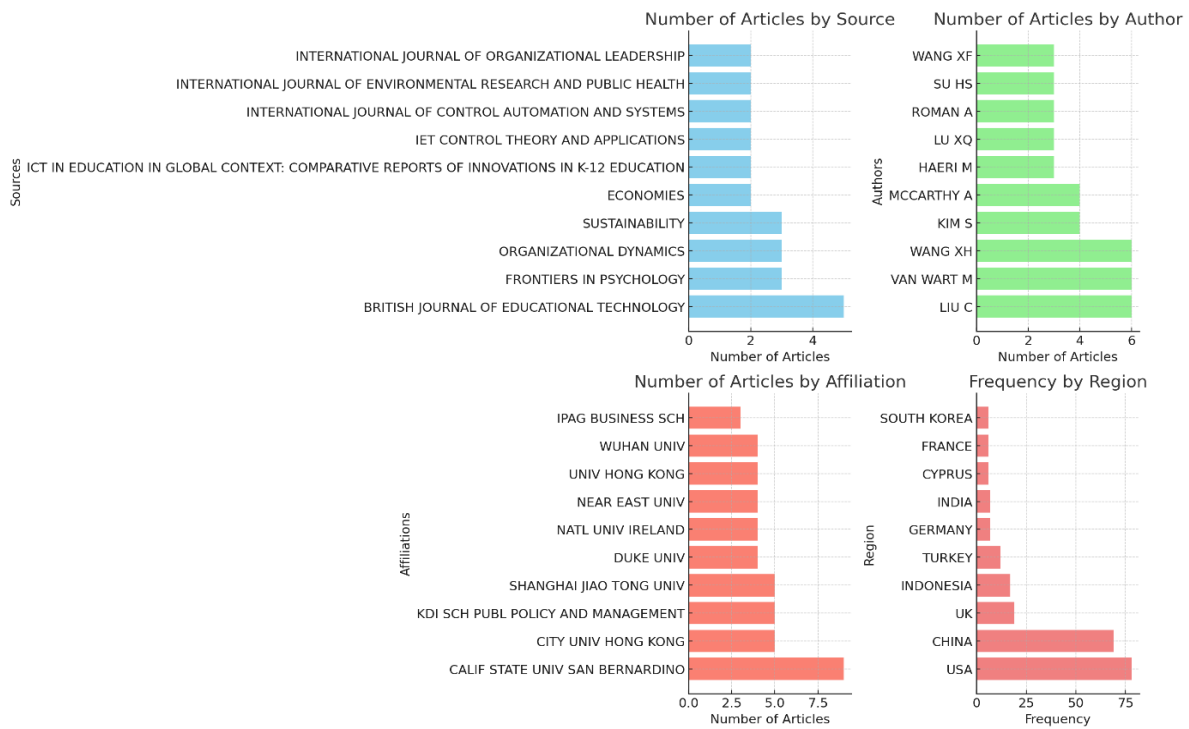


TC: Total Citation; TP: Total Production

Overall, the number of digital leadership studies has increased over time, but this increase has not always found a proportional reflection in citation numbers. This may signal the need for further analysis on the quality and impact of research in the field. These bibliometric data in the field of digital leadership help us better understand the general trends of the field and changes of interest in the research community.

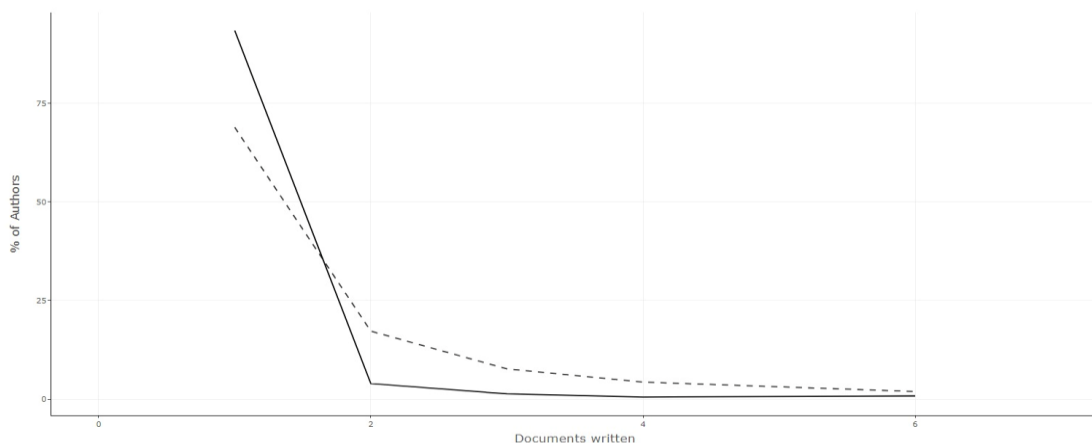
The most cited journals, institutions, countries and authors: The sources, authors, institutions and regional distribution of publications in the field of digital leadership are shown in the Graph 2. The British Journal of Educational Technology is the most widely published journal, with other notable journals including Frontiers in Psychology and Organizational Dynamics. Liu C, Van Wart M and Wang XH are among the authors who have written the most articles, each with six articles. California State University San Bernardino is the institution that publishes the most articles. City University Hong Kong and KDI School of Public Policy and Management are other leading institutions that follow. The USA is the region with the highest contribution in digital leadership research, followed by China and the United Kingdom. These data help us understand the global distribution of digital leadership studies and the regions where academic contributions are concentrated.

Graph 2. The most cited journals, institutions, countries and authors



Lotka's law: Lotka's law is a rule that defines the productivity distribution of scientific publications. This law suggests that scientific productivity generally fits a particular model, with a small number of researchers publishing a large number of papers and a large majority publishing a small number (Lotka, 1926). The validity of Lotka's law can be seen in the given graph and data. Graph 3 shows that 93.5% wrote only one document and only 0.8% wrote six documents. This supports a small number of researchers publishing a large number of papers and a large majority publishing a small number of papers, as envisaged by Lotka's law.

Graph 3. Lotka's law

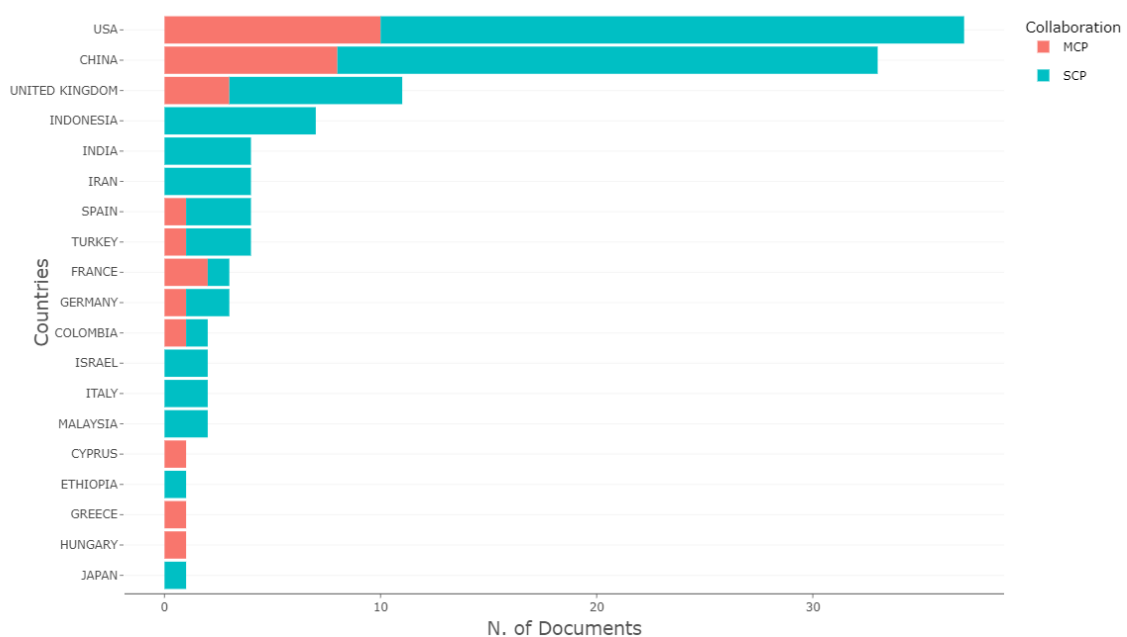


Corresponding Author's Countries Analysis: MCP (Multiple Country Publications) and SCP (Single Country Publications) are two important metrics that show international cooperation in scientific publications. While MCP refers to publications created with the cooperation of authors from more than

one country, SCP refers to publications made with the contributions of authors from a single country. These metrics are used to evaluate countries' participation in international research networks and scientific cooperation (Moshobane et. al. 2022).

Graph 4 shows the number of scientific publications on digital leadership in various countries and whether these publications are within the scope of international cooperation (MCP) or single-country cooperation (SCP). The United States (USA) and China are the countries that publish the most in the field of digital leadership. While the USA stands out with a high number of SCPs, the MCP rate is also noteworthy. This shows that research in the US are largely based on local collaborations, but international collaborations also have an important place. China has a more balanced distribution in the MCP and SCP, indicating that China attaches great importance to both local and international cooperation. The United Kingdom exhibits a profile in which MCP is more prominent. This shows that the UK is more focused on international cooperation in its research on digital leadership. These countries are mostly represented by the SCP, which shows that research are largely based on local collaborations. International cooperation rates are lower. Türkiye and Spain are among the countries that contribute to MCP, although SCP is predominant. This shows that these countries are participating in some international collaborations as well as local collaborations in digital leadership research. Countries such as France, Germany, Colombia, Israel and Italy are represented by both the SCP and the MCP, indicating that these countries are open to both local and international cooperation. Countries such as Malaysia, Cyprus, Ethiopia, Greece, Hungary and Japan have lower number of publications and higher rate of SCP. This shows that digital leadership research in these countries is often limited to local collaborations.

Graph 4. Corresponding Author's Country



These data provide important information about which countries cooperate more internationally in the field of digital leadership and which countries base their research more on local collaborations. Increasing international cooperation is of utmost importance in terms of sharing and developing scientific knowledge.

Tree Map and Word Cloud Analysis: The tree map and word cloud analysis given in Figure 3 and Figure 4 show the proportional distribution of different issues related to digital leadership and these issues in the total publication. Each frame reflects the relative size of a topic and how widespread it is in the field of research.

- Impact, model, technology, and performance: These four topics are among the most researched themes, each with a rate of 6%. This shows that the impact of digital leadership, models, use of technology and performance have a central place in research.
- Communication, information, and work: These topics, each with a rate of 5%, emphasize the importance of communication strategies, information management and business processes in digital leadership.
- Transformational leadership, systems, and face-to-face: These more specific topics account for 4% and there is still significant research interest in these areas.
- Other less common topics include trust, innovation, management, and teams. These issues reveal the importance of the human factor and teamwork within the scope of digital leadership.
- Themes such as algorithm, adoption, business, and education were represented with lower rates (2%), indicating the potential for further research in these areas.

Figure 3. Tree map



Overall, this tree map analysis shows that digital leadership research spans a diverse and comprehensive spectrum. The wide distribution of research topics emphasizes the multidisciplinary nature of this field and the need to combine different perspectives. While the bulk of the publications

focused on more technical and practical issues, human-oriented and theoretical issues attracted less research interest, which may signal the need for further work on these issues in the future.

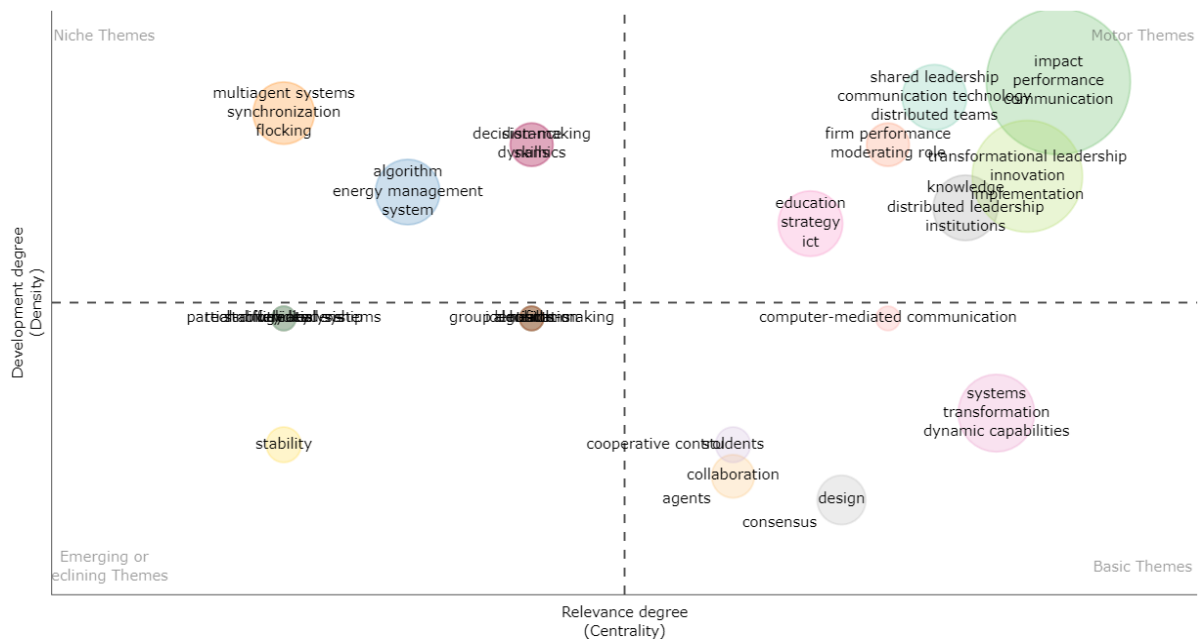
Figure 4. Word Cloud



Thematic Map Analysis: The thematic development of the area is shown in Graph 5. In thematic mapping analysis, overlap network clusters are shown as bubbles on the Graph in the context of centrality and intensity ranking developed by Callon et al. (1991). The number of repetitions of words in the cluster determines the size of the bubbles. The X axis represents the centrality of the network cluster, and the Y axis represents its density. Centrality is the measure of the degree to which a network cluster interacts with other graph clusters, in other words, the importance of a work theme. Density, on the other hand, is a metric that measures the intrinsic strength of a cluster network and theme development. Accordingly, motor themes are included in the upper right quadrant. These themes have high centrality and intensity; they are themes with a high level of development and a high level of importance in structuring a research topic. The niche themes in the upper left quadrant have high intensity and low centrality, indicating that they have limited relevance. The newly emerging or declining themes in the left lower quadrant are themes with low centrality and intensity; they are minimally developed and marginal themes. The main themes in the lower right quadrant are themes with high centrality but low density. Although these themes are important for the field, they have not developed sufficiently (Cahlik, 2000; Cobo et al., 2011, 2015).

Based on this, it is observed that both centrality and intensity are high, and the most important themes of the field are shared leadership, communication technology, distributed teams, firm performance, moderating role, transformational leadership, innovation, knowledge, implementation, distributed leadership, institutions, etc. The themes such as computer-mediated communication, systems, transformation, dynamic capabilities, design, consensus, agents, collaboration, etc. in the lower right quadrant of the graph have high centrality and low intensity, and as more publications are made, the potential to be motor themes is high (Cobo et al., 2011; Cobo et al., 2015). Niche themes of the study include decision-making, algorithms, systems, etc.

Graph 5. Thematic Map

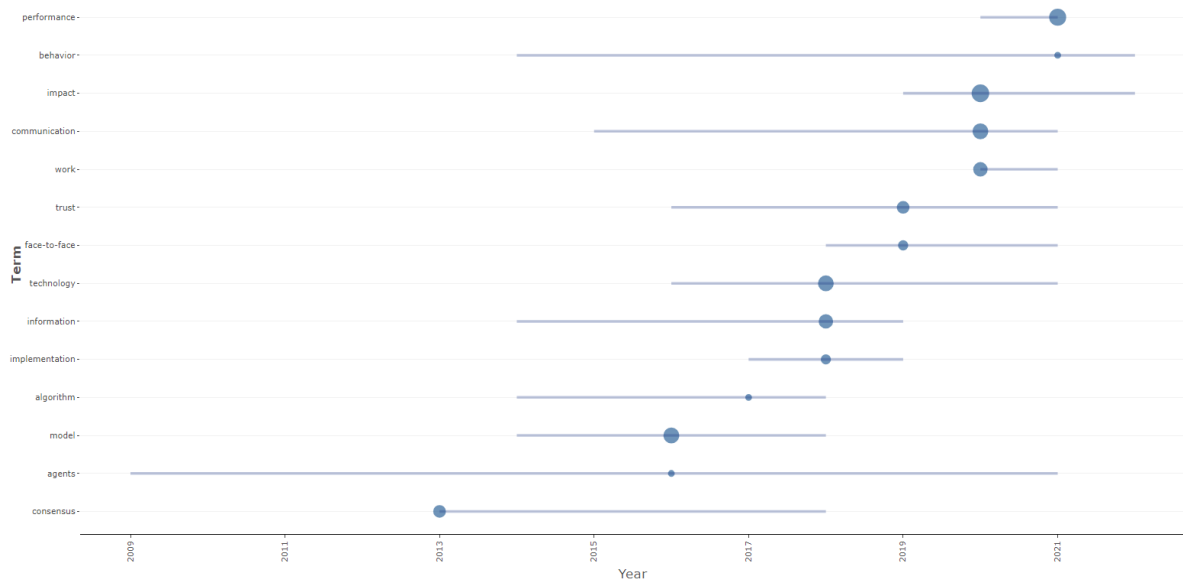


Trend Topic Analysis: The trend topic analysis shown in the Graph 6 shows how research trends in various themes related to digital leadership have changed over the years. This analysis allows us to understand when certain topics are popular and focus changes in the field of research.

- Performance and impact: These two themes have shown a noticeable increase since 2013 and attracted the most attention, especially between 2019 and 2021. This indicates that there is an increasing emphasis on business performance and overall effects of digital leadership.
- Communication and trust: Communication and trust found more place in research after 2015. These two themes are considered critical elements for the effective implementation of digital leadership.
- Technology and information: Technology has started to attract attention since 2013 and has reached an important peak especially in 2019. Information management, on the other hand, began to come to the fore after 2015. These two topics emphasize the important elements related to the management of technological tools and information flow in digital leadership.
- Model, algorithm and agents: The research interest in these technical issues has increased especially between 2019 and 2021, which indicates a concentration on the development of digital leadership models and algorithms.

These trends show that in addition to the basic concepts in the field of digital leadership, more technical studies for implementation are increasing. The change in research interest reveals that the field is constantly evolving and that leadership practices are transforming with technological advances. In particular, the rise of topics such as algorithm and model development are an indication that digital leadership is moving towards a more data-driven and analytical approach.

Graph 6. Trendy Topic Analysis



Thematic Evaluation: Graph 7 shows the thematic evolution of publications on digital leadership over three main periods: 2000-2010, 2011-2015 and 2016-2022. Each period reveals how specific themes have evolved and changed over time.

2000-2010 Period: In this period, the theme of "virtual leader" stands out as dominant. This shows that virtual leadership was an intense research topic in the early days and the foundations of the concept of virtual leadership were laid during this period.

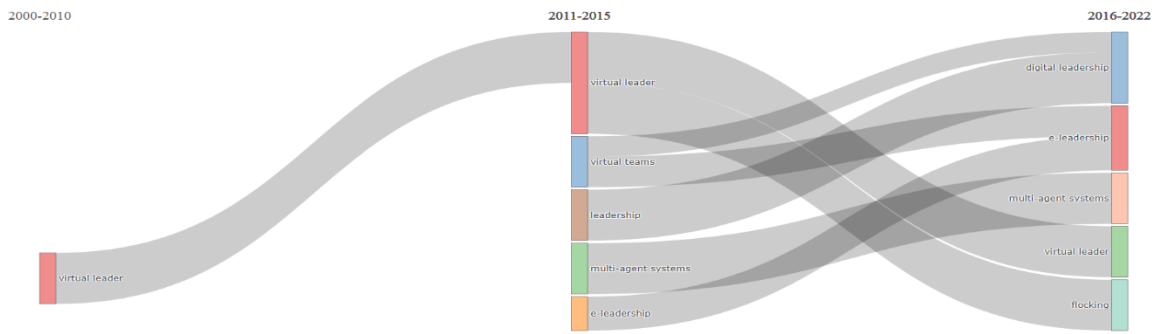
2011-2015 Period: The theme of "virtual leader" continues in this period, but new themes have emerged. Themes such as "virtual teams", "leadership", "multi-agent systems" and "e-leadership" show that research on virtual leadership has diversified and deepened. The theme "virtual teams" indicates a growing interest in the management of virtual teams. The "Leadership" theme indicates that the focus remains on general leadership issues. "Multi-agent systems" and "e-leadership" themes indicate that digital and technological leadership approaches have gained importance.

2016-2022 Period: Thematic diversity has increased further in this period. Themes such as "digital leadership" and "e-leadership" reflect the increasing interest in researching the effects of digital transformation on leadership.

"Multi-agent systems" and "virtual leader" themes remain important in this period, which shows that the concepts of multi-agent systems and virtual leadership have always found a place in research.

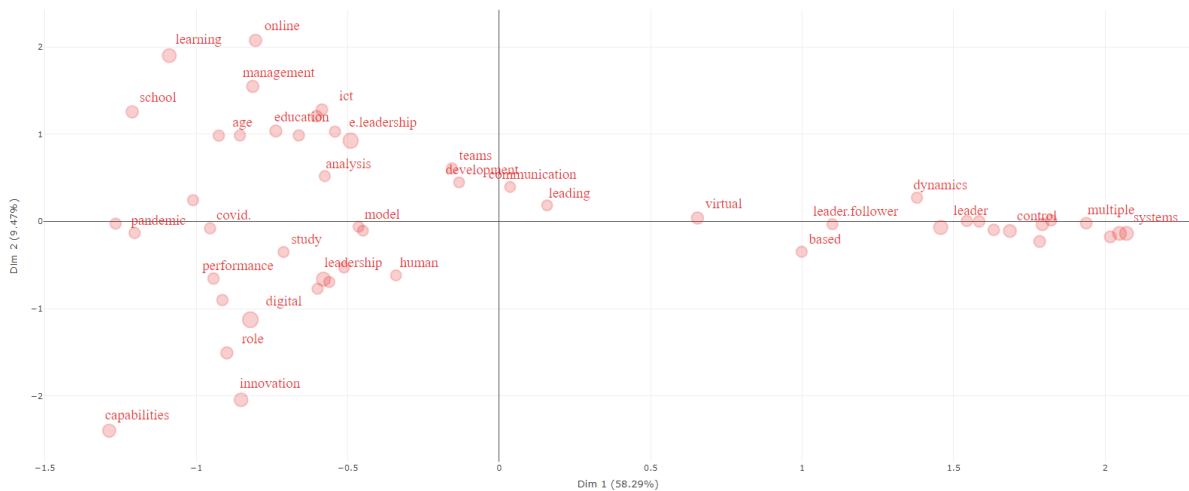
In general, Graph 7 clearly reveals how digital leadership research has evolved over time, which themes have come to the fore in different periods, and how research focuses have diversified. This thematic evolution shows that the topic of digital leadership has become an increasingly broad and deep field of research.

Graph 7. Thematic Evaluation



Multiple Correspondence Analysis (Title /Unigram): Multiple Correspondence Analysis (MCA) is a multidimensional statistical technique used to visualize and understand the relationships between categorical data. MCA analyzes how the variables and observations in the dataset are distributed across multiple dimensions, revealing patterns between these variables. MCA, which is frequently used especially in fields such as social sciences and marketing research, helps to simplify complex relationships in data (Greenacre, 1984). In the Graph 8, the studies on digital leadership were analyzed with Multiple Correspondence Analysis (MCA) at the level of single words (unigram). The axes in the graph show the percentage explanatory power of the dimensions: Dim 1 58.29% and Dim 2 9.47%. These two dimensions were used to understand the distribution of data and to visualize the relationships between words.

Garph 8. MCA analysis



Top Left Corner (Online Education and Management): This region is heavily involved in topics related to digital education and e-leadership. It is seen that online learning and e-leadership issues have gained importance especially during the COVID-19 pandemic. This highlights how digital leaders apply management skills in online education and the role of information and communication technologies

(ICT) in this process. The words that appear in this region are: "online," "learning," "management," "school," "education," "ict," "e-leadership."

Bottom Left Corner (Pandemic and Digital Transformation): This region represents studies that highlight the effects of the pandemic on digital leadership and performance. It is understood that digital transformation and innovation issues came to the fore during the pandemic. This refers to how digital leaders develop innovative solutions in times of crisis and their roles in this process. The words that appear in this region are: "pandemic," "covid," "performance," "digital," "role," "innovation."

Top Right Corner (Virtual Leadership and Communication): This region includes topics related to virtual leadership and communication. It is an area where studies on team management and communication skills of virtual leaders are concentrated. Leadership, effective communication and leadership strategies in the virtual environment are the main themes in this region. The words that appear in this region are: "virtual," "leader," "communication," "leading."

Bottom Right Corner (Leadership Dynamics and Control Systems): This region represents studies on leadership dynamics and control systems. Research focusing on multiple systems and leader-follower dynamics appears to be concentrated here. This shows how leaders manage organizational control and leadership dynamics. The words that appear in this region are: "leader," "control," "dynamics," "systems."

In general, Graph 8 shows how studies on digital leadership are concentrated in different thematic areas and the relationships between these areas. This type of analysis provides important clues for future research in the field of digital leadership and helps to provide a comprehensive understanding of the current literature.

4.2. Bibliometric Analysis

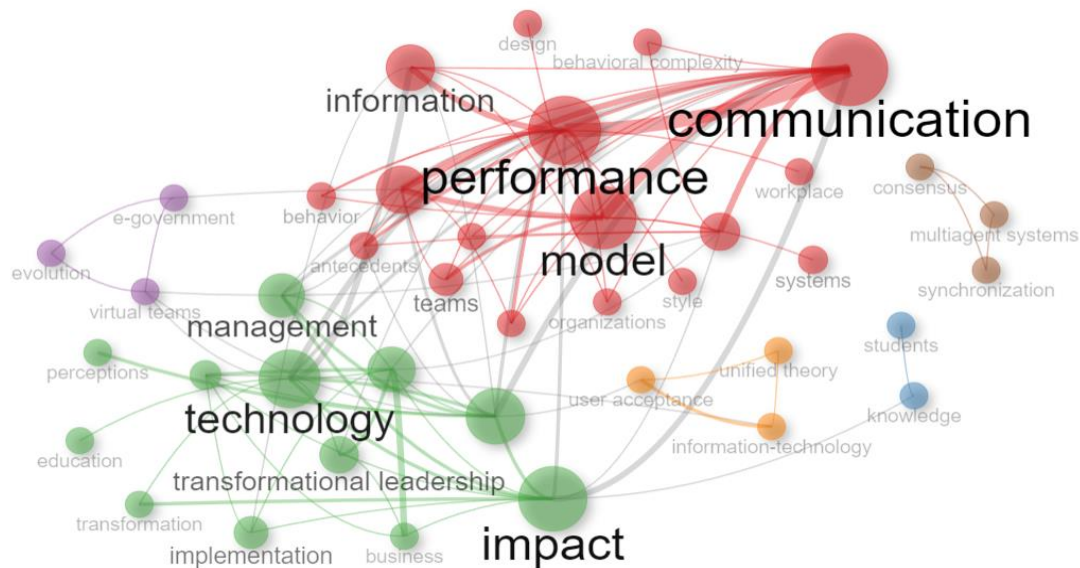
4.2.1. Co-Occurrence Network Analysis

Co-Occurrence Network Analysis given in Figure 5 was carried out for the Conceptual Structure map. Red Cluster ("Digital Leadership and Performance Management"): According to the results of the Co-occurrence analysis, the words under Cluster 1 draw attention as themes and concepts frequently discussed together in digital leadership research. A theme that can be created based on these words can be "Digital Leadership and Performance Management". The words under this theme highlight the impact of digital leadership on performance management and the important elements that need to be addressed in this context.

The concepts that contribute to the theme of Digital Leadership and Performance Management are; One of the ultimate goals of digital leadership is to increase the *performance* of individuals and organizations. Digital tools and strategies make performance evaluations and development plans more effective. Digital leadership plays a key role in the success of modern organizations, and various

elements need to be considered in order for this type of leadership to be implemented effectively. Effective *communication* is one of the cornerstones of digital leadership; clear and open communication ensures that teams are directed correctly, and organizational goals are achieved. While digital leadership models (*model*) determine which strategies leaders should use in the digital age and how they can be successful, information management (*information*) is critical for making the right decisions. Effective collection, analysis, and use of information directly affects leadership performance.

Figure 5. Co-Occurrence Network Analysis



While digital systems and technologies increase operational efficiency by supporting leadership processes, *team* management stands out as an important factor for successful digital leadership. Trust is a critical element for the success of digital leadership, and it is essential to adopt a reliable and transparent management style. The value of face-to-face communication should also be remembered; hybrid models should include both digital and face-to-face interactions.

Behaviors of leaders directly affect the motivation and performance of teams; therefore, digital leadership requires positive and motivating behaviors. Well-designed digital strategies and systems (*design*) make it easier for leaders to achieve their goals, while the *antecedents* of digital leadership help us understand how leaders prepare for digital transformation and what factors affect this process. Creativity plays an important role in developing digital solutions, and organizations determine the effectiveness of digital leadership. Shared leadership increases the distribution of powers and responsibilities and the participation of team members.

While digital leadership styles express the individual approaches and methods of leaders, digital *workplaces* enable leaders and teams to work efficiently using digital tools. *Behavioral complexity* refers

to the ability of digital leaders to adapt to various situations, and this requires digital leaders to be flexible and adaptive.

Digital leadership and performance management require effective management of a range of complex and interconnected elements. Each of these elements plays an important role in the success of digital leaders and should therefore be addressed in a holistic approach.

Blue Cluster (Knowledge and Student Experience in Digital Education): The words *knowledge* and *students* in Cluster 2 can be evaluated under the theme of knowledge transfer and student experience in digital education. This theme emphasizes the importance of knowledge management and student engagement in digital educational settings.

- *Knowledge*: In digital education, knowledge plays a critical role in both content and information management. Effective presentation of knowledge ensures students' active participation in the learning process and improves learning outcomes. Digital platforms make it possible to transfer information quickly and effectively to a wide audience. In addition, the digitalization of information access and information sharing processes ensures that learning materials are constantly updated, and students have access to the most up-to-date information. This improves quality in education and supports student success.
- *Students*: Students are at the heart of digital education processes. Digital education platforms support student-centered learning approaches and enrich the student experience. Students' interaction with digital tools allows them to participate more in the learning process. Furthermore, digital education offers students flexibility, allowing them to progress at their own pace of learning. This increases student motivation and responds better to individual learning needs.

Knowledge and student experience in digital education play an important role in increasing the quality of education and student success. Effective management of knowledge and student-centered approaches are key factors that determine the success of digital educational environments. This theme provides an important framework for academic research towards the development of innovative and effective methods in digital education.

Green Cluster (Transformation and Innovation in Digital Leadership): The theme that can be created based on the words in Cluster 3 can be "Transformation and Innovation in Digital Leadership". This theme addresses how digital leadership creates transformation and innovation in businesses and education.

Digital leadership has profound effects on organizations' performance, ways of doing business, and competitiveness. Effective management of digital transformation processes increases the efficiency and adaptation ability of businesses and educational institutions. Digital technologies enable leaders to make strategic decisions and develop innovative solutions. The effective use of these technologies plays a critical role in adapting to the digital age. By transforming work processes, digital leadership supports

modern ways of working, such as remote work and flexible work hours, which increases productivity and employee satisfaction in the workplace.

Digital transformation reshapes management understanding and leadership styles. Data-driven decision making, and innovative management techniques enable leaders to lead their organizations more effectively. Transformational leadership drives organizational change and encourages innovation by motivating employees. Innovation is one of the key elements of digital leadership and is critical to gaining a competitive advantage. Successful implementation of digital transformation strategies plays a vital role in achieving organizations' goals and requires planning, resource management, and performance monitoring.

In the business world, digital leadership is imperative to gain a competitive advantage and adapt quickly to market dynamics. Digital business models support sustainable growth. The factors that determine the success of digital leadership include the competencies of the leaders, organizational culture, and technological infrastructure. Digital leadership in education creates student-centered learning environments by transforming learning processes and pedagogical approaches and increases equality in education. Digital leadership influences the perceptions and attitudes of employees and stakeholders; positive perceptions and strong leadership facilitate the adoption of organizational change. Digital transformation radically changes ways of doing business, cultures, and strategies, and requires continuous improvement and adaptation.

This assessment comprehensively addresses how digital leadership makes an impact in the context of transformation and innovation, and what elements need to be considered in order to be successful.

Purple cluster (Evolution of E-Government and Virtual Teams in Digital Leadership): Cluster 4 addresses the effects of digital leadership on e-government practices, management of virtual teams, and evolution of these processes.

E-government refers to the provision of public services through digital platforms. Digital leadership plays a critical role in effectively implementing e-government practices and better serving citizens. Digital transformation increases efficiency in the public sector and facilitates citizens' interactions with the state.

Virtual teams stand out as an important element of digital leadership. Digital technologies enable geographically dispersed teams to work together effectively. Digital leaders optimize the coordination and collaboration of virtual teams, ensuring the successful execution of projects.

Digital leadership supports the continuous evolution of organizations and ways of doing business. In the digital age, leaders have to adapt quickly to innovations and adapt to changing conditions. This process of evolution makes it possible for organizations to remain competitive and achieve sustainable growth.

This theme comprehensively addresses the role of digital leadership in the management of e-government practices and virtual teams, and how these processes have evolved. Digital leaders make strategic decisions in these areas, make their organizations ready for digital transformation and support continuous development.

Orange Cluster (Information Technologies and User Acceptance): Cluster 5 focuses on information technology adoption and user acceptance.

Information technologies form the basis of digital leadership. The technological infrastructures of organizations determine the effectiveness and efficiency of digital transformation processes. User acceptance is a critical factor in the successful implementation of new technologies. Digital leaders develop strategies to increase the adoption of technologies by taking into account user needs and expectations. Unified Theory of Acceptance and Use of Technology (UTAUT) is a comprehensive model developed to explain the acceptance of information technologies. Digital leaders can better understand and manage the process of adopting technological innovations by using this theory.

This theme addresses the strategic approaches of digital leaders to ensure the effective use of information technologies and user acceptance. Taking these elements into account in digital transformation processes plays an important role in the success of organizations.

Brown Cluster (Multi-agent Systems and Synchronization): Cluster 6 deals with multi-agent systems in the context of digital leadership and the synchronization and reconciliation processes in these systems.

Reconciliation is the basis of decision-making processes in multi-mediated systems. Digital leaders increase the effectiveness and acceptability of decisions by ensuring consensus among various stakeholders. Multimediated systems involve the coordination of independent agents interacting with each other. These systems need a collective approach to solving complex problems. Digital leadership requires strategic coordination and management to ensure the efficient operation of such systems. Synchronization ensures that agents in multi-mediated systems work in harmony. Digital leaders optimize the overall performance of the system by ensuring this harmony and make it easier to achieve the goals.

This theme examines how digital leadership drives reconciliation and synchronization processes in multi-mediated systems and the effects of these processes on organizational success. Digital leaders manage these elements effectively, ensuring that complex systems work efficiently and harmoniously.

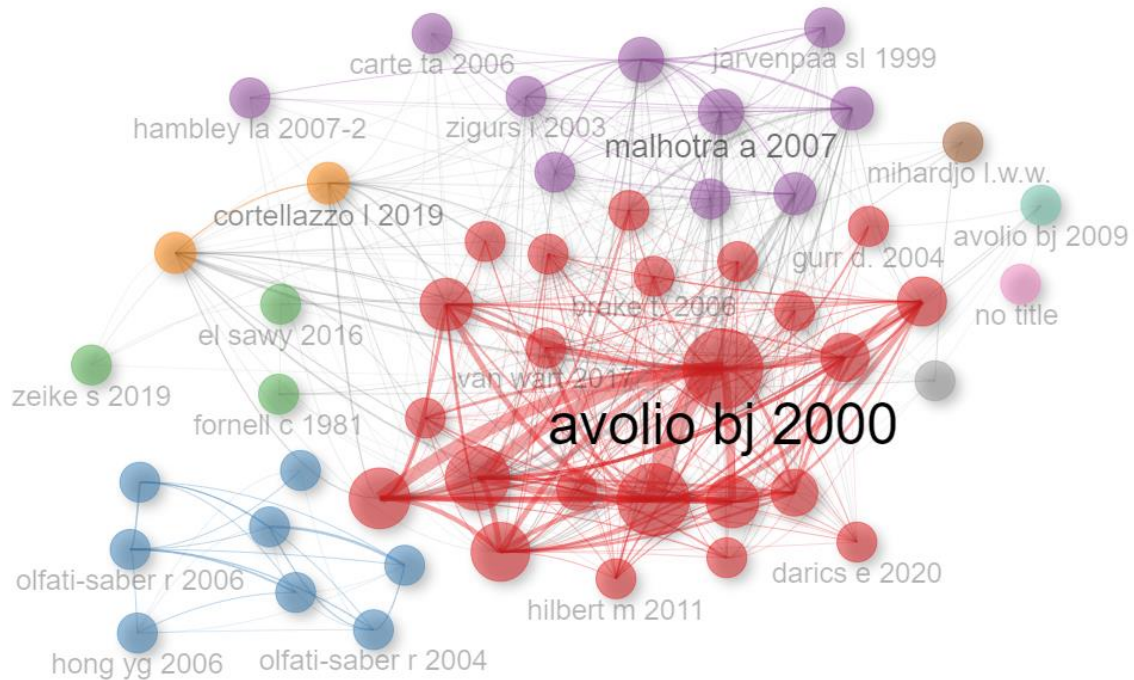
4.2.2. Co-Citation Analysis

Co-Citation Analysis was shown in Figure 6.

Red Cluster: Looking at the articles in Cluster 1, it is seen that e-leadership, virtual teams and digital transformation issues are mainly discussed. Therefore, the proposed theme for this cluster can be

"Digital Leadership and Virtual Team Management". Under this theme, the definition of e-leadership, the management of virtual teams, and the effects of digital transformation processes on organizations are examined in detail.

Figure 6. Co-citation Network Analysis



The articles in Cluster 1 cover digital leadership and virtual team management comprehensively. For instance, Avolio et al. (2000) discuss the effects of e-leadership on theory, research, and practice. This study examines the theoretical foundations of the concept of digital leadership and its applications in practice. Avolio et al. (2014), on the other hand, reconsider the transformations in the resource and transmission of leadership and explain how these transformations are shaped in the digital age. Purvanova and Bono (2009) analyze the context of transformational leadership in face-to-face and virtual teams, while highlighting the challenges faced in virtual leadership. Cascio and Shurygailo (2003) discuss how e-leadership and virtual teams affect organizational dynamics. This study examines the strategies used in the management of virtual teams and the effectiveness of these strategies. DeSanctis and Poole (1994), on the other hand, use adaptive structuring theory to capture the complexity of the use of advanced technology. This theory helps us understand the role of digital leadership in the use of technology. Van Wart et al. (2019) aim to operationalize the definition of e-leadership and identify e-leadership elements. This study discusses the components of e-leadership in detail and shows how this concept can be applied in practice. Hertel et al. (2005) review the current empirical research on the management of virtual teams. This study discusses the strategies required for the effective management of virtual teams and the applicability of these strategies.

While Avolio et al. (2003) examine the concept of digital leadership and how leadership styles change in virtual environments, Van Wart et al. (2017) emphasize the integration of information and communication technologies (ICT) into leadership theories and the technological infrastructure required for the effectiveness of e-leadership. Hunsaker and Hunsaker (2008) offer strategies for the effective management of virtual teams. While Dasgupta (2011) discusses how trust can be established in digital leadership and virtual team management, Lilian (2014) addresses the emerging opportunities and challenges for virtual team leaders. Brake (2006) focuses on the leadership of global virtual teams and how team members in different cultural regions can be managed. Daft and Huber (1986) describe the learning processes of organizations and how digital leaders can drive communication in virtual teams. Gurr (2004) examines the application of digital leadership in the education sector and effective strategies. While Schwarzmüller et al. (2018) discuss the effects of digital transformation on leadership, Venkatesh et al. (2003) examine how technology acceptance can be increased in digital leadership. Darics (2020) discusses the role of leadership and non-verbal communication in instant messaging, while Hertel et al. (2006) discuss competency assessment in virtual teams and the effects of these competencies on performance. Finally, Hilbert and López (2011) emphasize the effects of technological capacity worldwide and the importance of the technological infrastructure required for digital leadership.

These studies provide a comprehensive perspective on digital leadership and virtual team management, providing important information on how leaders can overcome these new challenges. Each of them provides an in-depth analysis of the dynamics and requirements of leadership in the digital age, while revealing the skills and strategies necessary for e-leaders to be successful.

The articles in Cluster 1 provide a broad perspective on digital leadership and virtual team management. These studies provide a wide range of information from theoretical foundations to practical applications of digital leadership. E-leadership and virtual team management are among the most important issues faced by organizations in the digital age. In this period when digital transformation processes are accelerating, leaders and managers need to have digital skills, manage virtual teams effectively and use digital technologies strategically. These articles emphasize the critical role of digital leadership and virtual team management on organizational success.

Blue Cluster: Looking at the articles in Cluster 2, it is seen that issues such as multi-agent dynamic systems, coordination and consensus problems, information flow and collaborative control are mainly discussed. Therefore, the proposed theme for this cluster can be "Coordination and Consensus in Multi-Agent Systems". Under this theme, the role of coordination mechanisms, consensus algorithms, and information flow in multi-agent systems are examined in detail.

The articles in Cluster 2 cover coordination and consensus in multi-agent dynamic systems comprehensively. For example, Olfati-Saber (2006) discusses herding algorithms and theory for multi-

agent dynamic systems. This study made significant contributions to the development of algorithms that enable agents to act together. Olfati-Saber and Murray (2004), on the other hand, address consensus problems with varying topology and time delays in agent networks. This study examines how agents can coordinate under different topology and latency conditions. Vicsek et al. (1995) examine a new type of phase transition in a system of self-moving particles. This study helps us understand the dynamics of self-organizing systems. Fax and Murray (2004) discuss information flow and collaborative control of tool formations. This study emphasizes the importance of information flow and collaborative control in multi-agent systems. Jadbabaie et al. (2003) examine how groups of mobile autonomous agents can be coordinated using the nearest neighbor rules. This study contributes to our understanding of how agents coordinate by interacting with each other and group dynamics.

The articles in Cluster 2 cover coordination and consensus in multi-agent systems from a broad perspective. These studies provide a wide range of information from theoretical foundations to practical applications of multi-agent systems. Multi-agent systems have important applications in various fields such as robotics, communications, biology, and social sciences. Therefore, the algorithms and methods developed to ensure the coordination and consensus of the agents are critical to the success of these systems. These articles make important contributions to the understanding of coordination and consensus processes in multi-agent systems.

Green Cluster: Looking at the articles in Cluster 3, it is seen that digital leadership skills and the relationship of these skills with organizational competencies and psychological well-being are discussed. Therefore, the proposed theme for this cluster can be "Digital Leadership Skills and Psychological Well-Being". Under this theme, the relationships between the development of digital leadership skills, the contribution of these skills to organizational success, and the psychological well-being of leaders are examined in detail.

The articles in Cluster 3 focus on digital leadership skills and the organizational and individual results of these skills. For example, El Sawy et al. (2016) discuss how LEGO builds the foundations and organizational competencies for digital leadership. This study provides important information on the development of digital leadership skills and the role of these skills in the digital transformation of the organization. Zeike et al. (2019) examine the relationships between digital leadership skills and psychological well-being. This study defines the skills that digital leaders should have and discusses the effects of these skills on the psychological health of leaders. It is stated that developing digital leadership skills can reduce leaders' stress levels in the workplace and increase their overall psychological well-being.

The articles in Cluster 3 draw attention to the importance of digital leadership skills at the organizational and individual level. Digital leadership skills are critical for organizations to be successful in their digital transformation processes. The development of these skills can help

organizations gain a competitive advantage by enabling them to use digital technologies effectively. In addition, the positive effects of digital leadership skills on leaders' psychological well-being can increase overall satisfaction and productivity in the workplace. These articles emphasize that digital leadership skills are important for both organizational success and individual health.

Purple cluster: Looking at the articles in Cluster 4, it is seen that issues such as the leadership of virtual teams, the importance of communication and trust, leadership styles in virtual teams and innovation are mainly discussed. Therefore, the proposed theme for this cluster can be "Leadership, Communication and Innovation in Virtual Teams". Under this theme, leadership strategies, communication methods, and trust-building processes in virtual teams, as well as the innovation dynamics in these teams, are examined in detail.

The articles in Cluster 4 cover leadership, communication and innovation in virtual teams comprehensively. For example, Kayworth et al. (2001) provide a theoretical rationale for IT infrastructure investments. This study emphasizes the importance of the technological infrastructure required for the effective functioning of virtual teams. Malhotra et al. (2007) discuss strategies for managing virtual teams. This study details the challenges faced by virtual team leaders and the strategies they can use to overcome these challenges. Bell and Kozlowski (2002) provide a typology for effective leadership of virtual teams. This study addresses leadership styles and approaches that can be used in the management of different types of virtual teams. Hambley et al. (2007) examine the effects of leadership style and communication environment on team interaction styles and outcomes. This study provides important findings on how leadership and communication should be managed in virtual teams.

Zigurs (2003) discusses whether leadership in virtual teams is an oxymoron or an opportunity. Jarvenpaa and Leidner (1999) examine the role of communication and trust in global virtual teams. This study emphasizes the importance of building and maintaining trust in virtual teams. Liao (2017) discusses the effects of leadership on different layers by considering leadership in virtual teams from a multi-level perspective. Carte et al. (2006) examine emerging leadership in self-directed virtual teams in a longitudinal study. This study analyzes concentrated and shared leadership behaviors in virtual teams. Gibson and Gibbs (2006), on the other hand, discuss the effects of geographical distribution, electronic dependence, dynamic structure and national diversity on team innovation by separating the concept of virtuality.

The articles in Cluster 4 cover leadership, communication and innovation in virtual teams from a wide perspective. These studies detail the leadership strategies, communication methods, and trust-building processes required for the effective management of virtual teams. In addition, the dynamics that drive innovation in virtual teams are addressed. For virtual teams to be successful, leaders need to communicate effectively, build trust, and create an innovative culture. While these articles emphasize

the importance of leadership and communication in virtual teams, they provide important information on how innovation can be promoted in these teams.

Orange Cluster: Looking at the articles in Cluster 5, it is seen that the role of leadership in a digitalized world and how e-leadership is defined through information and communication technologies (ICT) are discussed. Therefore, the proposed theme for this cluster can be "Leadership and E-Leadership Competencies in the Digitalized World". Under this theme, the effects of digitalization on leadership, digital leadership skills, and how leadership is defined through ICT are examined in detail.

The articles in Cluster 5 focus on how leadership evolves in the digitalizing world and how e-leadership competencies are defined. For example, Cortellazzo et al. (2019) provide a review addressing the role of leadership in a digitalized world. This study discusses the effects of digitalization on leadership and emphasizes the challenges and opportunities faced by digital leaders. In this context, the skills and competencies that digital leaders should have are discussed in detail.

Roman et al. (2019) define e-leadership as communication competence through ICT. This study evaluates the concept of e-leadership with an exploratory approach and discusses the role of ICT on leadership. Defining e-leadership competencies and how these competencies contribute to the performance of leaders is one of the main focuses of the study. The skills and strategies required to effectively lead through ICT are examined in detail in this study.

The articles in Cluster 5 cover the effects of digitalization on leadership and e-leadership competencies from a wide perspective. The challenges and opportunities faced by leaders in the digitalizing world are discussed in detail in these articles. Digital leadership means not only the effective use of digital technologies, but also the management of digital transformation processes and the consideration of the human factor in these processes. In this context, the competencies and skills of digital leaders are critical for organizations to succeed in their digital transformation processes. These articles make important contributions to the understanding of the concepts of digital leadership and e-leadership and to the development of competencies in these fields.

Brown Cluster (Cluster 6 Digital Transformation and Business Model Innovation): The study in Cluster 6 addresses how digital transformation affects business model innovation and the role of digital leadership in this process. This study conducted by Mihardjo and Sasmoko (2019) examines how existing companies in the telecommunications sector develop business model innovation with digital leadership and co-creation strategies. In this context, it is emphasized that digital leadership plays a stimulating role in business model innovation and this process becomes more effective with co-creation strategies.

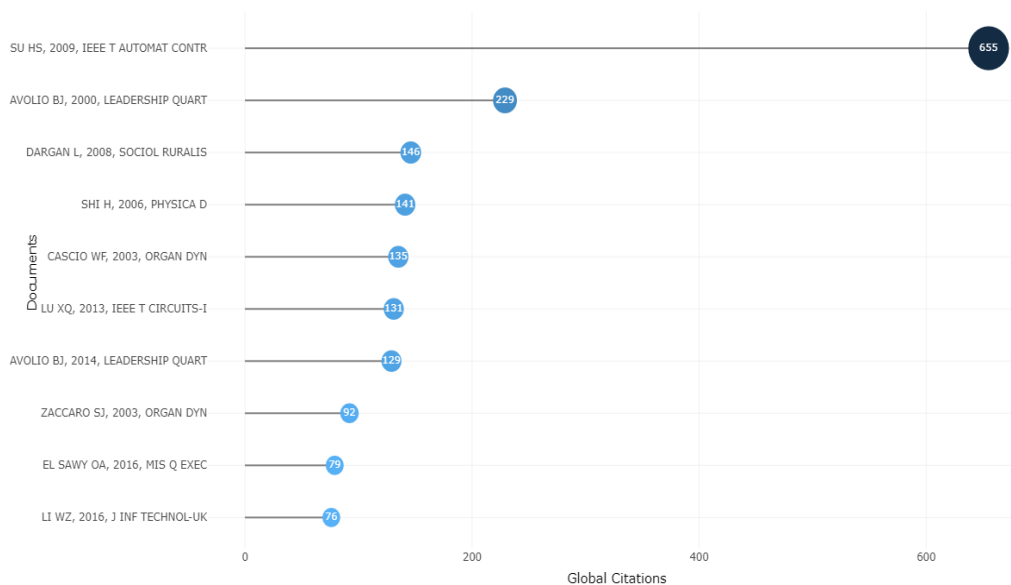
Gray Cluster (Cluster 7 Measurement Problems in Management and Leadership Research): The study in Cluster 8 discusses measurement problems in leadership research and the effects of these problems on management. Podsakoff et al. (2003) examine the reliability and validity of the

measurement tools used in leadership research and examine how these measurement problems are reflected in leadership research. The study highlights the importance of accurately measuring the concept of leadership and highlights the methodological challenges in this area.

Light Green Cluster (Cluster 8 Leadership Theories and Future Orientations): The study in Cluster 8 addresses current leadership theories, research trends and future orientations. This study conducted by Avolio et al. (2009) examines the current theoretical approaches in the field of leadership and the applications of these approaches in practice. The study also discusses emerging new trends in leadership research and the research that needs to be done in this area in the future.

The Most Global Cited Document: The most global cited articles are seen in Graph 9. According to this graph, Su Hs, 2009, IEE T Automat Contr ranks first with 655 citations. The article in question discussed the virtual leadership with agents (Su et al., 2009). Avolio BJ 2000, Leadership Quart ranks 2nd with 229 citations. The title of the article in question is “E-Leadership: Implications for Theory, Research, and Practice” (Avolio et al., 2000). The article analyzes how information technologies will affect leadership and organizations. Dargan L, 2008, Sociol Ruralis ranks third. This article, on the other hand, discusses leadership and innovation (Dargan and Shucksmith, 2008).

Graph 9. Most Global Cited Document



5. DISCUSSION

This section is examined under four separate headings. In the first heading, the performance analysis findings will be weighed. In the second heading, the findings of the most recent fifty articles in the data set obtained as a result of the search strategy were examined under the heading of "Evaluation in terms of Current Publications". In the third sub-heading, "Evaluation in terms of Co-Occurrence Analyses" and finally, in the fourth heading, "Evaluation in terms of Co-Citation Analyses" were evaluated separately.

Evaluation in terms of Performance Analyses: The results of bibliometric analysis in the field of digital leadership reveal that the field has shown significant growth and development over the years. 2000-2022, 141 publications show that this field has become the focus of academic attention. Especially since 2013, there has been a significant increase in the number of publications, and it reached its peak in 2022. However, this increase does not always find a proportional reflection in citation numbers, indicating the need for further analysis on the quality and impact of digital leadership research. In particular, the high rate of international cooperation (24.11%) reveals that the field attracts attention at a global level and that researchers from various countries conduct joint studies.

Bibliometric analysis also reveals the thematic evolution of digital leadership studies. While the focus was on virtual leadership in the 2000-2010 period, themes such as virtual teams, multi-agent systems and e-leadership came to the fore in the 2011-2015 period. In the 2016-2022 period, research on the effects of digital transformation on leadership has increased. Thematic mapping and trend analyses show that topics such as performance, communication, trust and technology management are critical in the field of digital leadership. These findings emphasize that research in the field of digital leadership has a versatile and dynamic structure, emphasizing the importance of further interdisciplinary work and international cooperation in the future. In this context, an in-depth examination of the theoretical and practical contributions of digital leadership research will allow the field to develop further.

Evaluation in terms of Current Publications: Digital leadership plays an important role in today's business world and refers to the interactions of leaders with digital technologies, their ability to manage digital transformation processes, and the adaptation of organizations to the digital age (Chatterjee et al., 2023). Digital leadership differs from traditional leadership with the intensive use of technology, the adoption of innovative approaches, and the prominence of digital skills (Yao, et al., 2024). Leaders are expected to have high digital literacy, strategic vision, and change management competencies (Behie et al., 2023).

Digital leaders make strategic decisions by directing digital transformation processes and determine the digitalization roadmap of the organization. For the success of these processes, leaders need to use technology effectively and adopt digital strategies (Shin et al., 2023; Mollah et al., 2023). In addition, digital leaders play a critical role in technology and innovation management, increasing the competitiveness of organizations and enabling them to produce continuous innovative solutions (Nieken, 2023; Zulu et al., 2023).

Digital leadership is a broad concept that covers the ways leaders interact with digital technologies, their roles in digital transformation processes, and their effects on organizational performance. This study aims to develop strategies and applications suitable for the requirements of the digital age by addressing various dimensions of digital leadership. These dimensions include technology

and innovation management, cultural change, digital skills, and employee relationships with competencies (Behie et al., 2023; Memon and Ooi, 2023; Tian et al., 2023).

Recent academic publications on digital leadership emphasize the importance of the role of leaders in digital transformation processes and how interaction with digital technologies shapes their leadership abilities. For example, the study of Sagbas et al. (2023) examined the effect of digital leadership on entrepreneurial intention and business performance through innovative behavior, while Xia et al. (2023) investigated how digital leadership affects digital entrepreneurship success through role models. These studies show the effects of digital leadership on organizational success and innovation.

While the research of Fatima and Masood (2024) evaluates the impact of digital leadership on open innovation and the serial mediation model in this effect, Luo et al. (2024) reveal the cultural diversity of this issue by addressing digital leadership models in the field of early childhood education in China. Al Dilby and Farmanesh (2023) examined the impact of digital leadership on job satisfaction and how this impact is shaped by work-life balance and trust in leaders.

Öngel et al. (2023) analyzed the effects of digital leadership on individual creativity and employee performance from an intergenerational perspective, while Zhang and Duan (2024) developed distributed non-fast formation follow-up control for UAVs within the framework of virtual leader-follower. These studies show the diversity and wide scope of digital leadership in terms of technological applications and innovation management.

In addition, Lin (2024) determined future research agendas by conducting a systematic literature review on digital leadership, while Wang and Dong (2024) examined the impact of telecommunication intensity on individual employee performance in China and the mediating and regulatory roles of job design and e-leadership in this impact.

As a result, digital leadership is a broad concept that reshapes leadership approaches in the modern business world, focusing on technological skills, strategic thinking, and innovative management. Academic studies in this field reveal various dynamics of digital leadership at organizational, technological, and individual levels and these studies shed light on the development of strategies and applications suitable for the requirements of the digital age.

Evaluation in terms of Co-occurrence Analyses: In co-occurrence analyzes, Cluster 1 covers the themes of digital leadership and performance management. Digital leadership plays a key role in the success of modern organizations, and various elements need to be considered in order for this type of leadership to be implemented effectively. Prominent keywords in this cluster include "performance," "communication," "model," "knowledge management," "systems," "team management," and "trust." For digital leaders to be successful, they need to improve their performance management processes by using effective communication, reliable management style, digital strategies and systems. Current publications

highlight the impact of digital leadership on performance management and explain how digital tools and strategies make these processes more effective (Shin et al., 2023).

The keywords in Cluster 2 are "knowledge" and "students" and can be evaluated under the theme of knowledge transfer and student experience in digital education. Knowledge management and student engagement in digital educational settings play a critical role in increasing the quality of education and student success. Effective presentation of knowledge ensures students' active participation in the learning process and improves learning outcomes. Digital platforms make it possible to transfer information quickly and effectively to a wide audience, while supporting student-centered learning approaches. Current publications emphasize the importance of knowledge management and student experience in digital education and show the potential of innovative methods in this field to increase the quality of education (Luo et al., 2024).

Cluster 3 addresses the themes of transformation and innovation in digital leadership. Digital leadership has profound effects on organizations' performance, ways of doing business, and competitiveness. Effective management of digital transformation processes increases the efficiency and adaptation ability of businesses and educational institutions. Prominent keywords in this cluster are "digital transformation," "innovation," "strategic decisions," and "productivity." Digital leaders adapt their organizations to the digital age by making strategic decisions and developing innovative solutions. Current publications emphasize that digital transformation and innovation are one of the basic elements of digital leadership and organizations need to develop digital leadership skills in order to be successful in these processes (Behie et al., 2023).

Cluster 4 addresses the effects of digital leadership on e-government practices and management of virtual teams. E-government refers to the provision of public services through digital platforms, and digital leadership plays a critical role in effectively implementing these practices. Virtual teams stand out as an important element of digital leadership, and digital technologies enable geographically dispersed teams to work together effectively. Prominent keywords in this cluster are "e-government," "virtual teams," "digital transformation," and "innovation." Digital leaders optimize the coordination and collaboration of virtual teams, ensuring the successful execution of projects. Current publications comprehensively address the role of digital leadership in the management of e-government practices and virtual teams, and how these processes have evolved (Mollah et al., 2023).

Cluster 5 focuses on information technology adoption and user acceptance. Information technologies form the basis of digital leadership, and the technological infrastructures of organizations determine the effectiveness and efficiency of digital transformation processes. User acceptance is a critical factor in the successful implementation of new technologies, and digital leaders develop strategies to increase the adoption of technologies by taking into account user needs and expectations. Prominent keywords in this cluster are "information technologies," "user acceptance," and "digital

leadership." Current publications address the strategic approaches of digital leaders to ensure the effective use of information technologies and user acceptance and emphasize that this process plays an important role in the success of organizations (Zulu et al., 2023).

Cluster 6 deals with multi-agent systems in the context of digital leadership and the synchronization and reconciliation processes in these systems. Reconciliation is the basis of decision-making processes in multi-mediated systems, and digital leaders increase the effectiveness and acceptability of decisions by ensuring consensus among various stakeholders. Prominent keywords in this cluster are "multi-mediated systems," "synchronization," and "consensus." Digital leaderships require strategic coordination and management to ensure the efficient operation of such systems. Current publications examine how digital leadership drives reconciliation and synchronization processes in multi-mediated systems and the effects of these processes on organizational success (Nieken, 2023).

Co-occurrence analyzes and comparative evaluation of current publications reveal that themes such as digital leadership and performance management, knowledge and student experience in digital education, transformation and innovation in digital leadership, the evolution of e-government and virtual teams, information technologies and user acceptance, multi-agent systems and synchronization have recently taken an important place in the academic literature. While these themes emphasize the critical role of digital leadership and technological transformation processes in the modern business world, they show that digital leaders' ability to make strategic decisions, produce innovative solutions, and develop digital skills are decisive for the success of organizations. Digital leadership creates positive effects both at the organizational and individual level by shedding light on the development of strategies and applications suitable for the requirements of the digital age.

Evaluation in terms of Co-Citation Analyses: In co-citation analyzes, it is seen that Cluster 1 is defined as "Digital Leadership and Virtual Team Management" and the articles in this cluster cover digital leadership, virtual team management and digital transformation comprehensively. For instance, Avolio et al. (2000) discuss the effects of e-leadership on theory, research, and practice, while Purvanova and Bono (2009) analyze the context of transformational leadership in face-to-face and virtual teams. Cascio and Shurygailo (2003) examine the strategies used in the management of virtual teams and the effectiveness of these strategies. These studies present the theoretical foundations of the concept of digital leadership and its applications in practice in detail. When valuated in terms of Current Publications, digital leadership plays an important role in today's business world and refers to the interactions of leaders with digital technologies, their ability to manage digital transformation processes, and the adaptation of organizations to the digital age (Chatterjee et al., 2023). Recent academic studies emphasize the effects of digital leadership on organizational success and innovation. For example, Sagbas et al. (2023) examined the effect of digital leadership on entrepreneurial intention and business performance through innovative behavior, while Xia et al. (2023) investigated how digital leadership affects digital entrepreneurship success through role models. In addition, while Fatima and Masood

(2024) evaluated the impact of digital leadership on open innovation and the serial mediation model in this effect, Luo et al. (2024) discussed digital leadership models in the field of early childhood education in China.

This evaluation shows that the themes of Cluster 1 have an important place in the current academic literature and that digital leadership and virtual team management issues are still valid. Digital leadership is of strategic importance in the modern business world, with dimensions such as technology and innovation management, cultural change, digital skills, and employee relationships with competencies. Accordingly, the critical role of digital leadership on organizational success and innovation is supported by current studies and sheds light on the development of strategies and applications suitable for the requirements of the digital age.

In Cluster 2, issues such as multi-agent dynamic systems, coordination and consensus problems, information flow and collaborative control are discussed. For example, Olfati-Saber (2006) discusses herding algorithms and theory for multi-agent dynamic systems. Olfati-Saber and Murray (2004), on the other hand, address consensus problems with varying topology and time delays in agent networks. The reflection of these themes in current publications is seen indirectly, especially in the context of digital leadership and digitalization. In the field of technology and innovation management, the focus is on how digital leaders ensure coordination between teams and systems and develop collaborative strategies. In this respect, the effective use of coordination and consensus mechanisms in the digitalization process is emphasized.

In Cluster 3, digital leadership skills and the relationship of these skills with organizational competencies and psychological well-being are discussed. For example, El Sawy et al. (2016) discuss how LEGO builds the foundations and organizational competencies for digital leadership. Zeike et al. (2019) examine the relationships between digital leadership skills and psychological well-being. In current publications, the importance of digital leadership and the effect of developing these leadership skills on organizational success are frequently emphasized. For example, Behie et al. (2023) state that digital leaders should have high digital literacy, strategic vision, and change management competencies. These studies show that digital leadership is critical for both organizational success and individual health.

In Cluster 4, issues such as the leadership of virtual teams, the importance of communication and trust, leadership styles in virtual teams and innovation are discussed. For example, Kayworth et al. (2001) provide a theoretical rationale for IT infrastructure investments. Malhotra et al. (2007) discuss strategies for managing virtual teams. In current publications, the relationship between virtual team management and digital leadership is frequently emphasized. It is stated that digital leaders need to manage virtual teams effectively and optimize their communication processes. For example, Shin et al.

(2023) emphasize that digital leaders should determine the digitalization roadmap of organizations by making strategic decisions in virtual teams.

Cluster 5 discusses the role of leadership in a digitalized world and how e-leadership is defined through information and communication technologies (ICT). For example, Cortellazzo et al. (2019) provide a review addressing the role of leadership in a digitalized world. Current publications discuss the challenges and opportunities faced by leaders in the digitalization process in detail. It is stated that digital leaders should make strategic decisions in their digital transformation processes and use technology effectively. For example, Zulu et al. (2023) emphasize that digital leadership plays a critical role in technology and innovation management.

In Cluster 6, how digital transformation affects business model innovation and the role of digital leadership in this process are discussed. Mihardjo and Sasmoko (2019) examine how the companies in the telecommunications sector develop business model innovation with digital leadership and co-creation strategies. Current publications emphasize the importance of business model innovation in digital transformation processes and the role of digital leadership in this process. It is stated that digital leaders need to develop new business models by managing the digitalization processes of organizations.

In Cluster 7, measurement problems in leadership research and the effects of these problems on management are discussed. Podsakoff et al. (2003) examine the reliability and validity of the measurement tools used in leadership research. Current publications focus on the validity and reliability of the methodologies used in digital leadership and e-leadership research. It is emphasized that appropriate methodological approaches should be developed to accurately measure the effects of digital leadership.

In Cluster 8, current leadership theories, research trends and future orientations are discussed. Avolio et al. (2009) examine the current theoretical approaches in the field of leadership and the applications of these approaches in practice. Current publications discuss the development of digital leadership theories and new research trends in this field. Future directions of digital leadership are addressed in the context of technology and innovation management. Accordingly, it is seen that studies on the theoretical foundations and practical applications of digital leadership continue to increase.

Co-citation analyzes and comparative evaluation of current publications show that themes such as digital leadership and virtual team management, coordination in multi-agent systems, digital leadership skills and psychological well-being, leadership in virtual teams, e-leadership competencies in the digitalizing world, digital transformation and business model innovation, measurement problems in leadership research and the future of leadership theories have recently taken an important place in the academic literature. While these themes emphasize the critical role of digital leadership and technological transformation processes in the modern business world, they put forward that digital leaders' ability to make strategic decisions, produce innovative solutions, and develop digital skills are

decisive for the success of organizations. Digital leadership creates positive effects both at the organizational and individual level by shedding light on the development of strategies and applications suitable for the requirements of the digital age.

This study emphasizes the power of bibliometric analyzes and citation analyzes in evaluating the scope and impact of the existing literature within the scope of digital leadership studies. However, these analyses do not provide information directly about the quality of the research, which is a significant limitation. As a matter of fact, these limitations have increased the interest in scientific metrics (Lim and Kumar 2023; Karayel et. al. 2022). It is important to note that only the WoS Core Collection database is used in this study and other databases are not taken into account. The search is limited to keywords and only English articles are included in the analysis among the publications found. Therefore, studies published in other languages with important findings may be excluded. Despite these limitations, the research findings have the potential to motivate future studies.

6. CONCLUSION

In today's digitalizing world, workplaces are taking on an uncertain, complex and variable structure. Therefore, a new leadership model is needed instead of the classical leadership approach. Digital leadership is an important leadership model that can meet the expectations of today's business world. Digital leadership is the combination of various leadership skills and characteristics that play a significant role in the firm's digital transformation (Malik et al., 2024). In leadership theory, digital leadership is described as the style of leadership that is a combination of transformational leadership style and the use of digital technology (Erhan et al., 2022: 1525). Also, digital leadership is used as an umbrella term that comprises leadership styles such as technology leadership, virtual leadership, e-leadership, and leadership 4.0., all of which share a similar meaning and are used interchangeably throughout the literature (Karakose et al., 2022: 3).

Digital leadership can be considered as an approach that enables the digitalization of businesses (Erhan et al., 2022: 1527). However, some studies in the literature have revealed that leaders do not need to be experts in digital technologies to achieve digital transformation. Basic technical knowledge and skills are sufficient, as it is more important for leaders to understand how these new technologies can influence the structures, processes, and operations of their organizations (Müller et al. 2024; Imran et al., 2020).

The study provides a comprehensive and holistic perspective on the field of digital leadership with using bibliometric analysis. Especially with the results obtained from the thematic analysis, an important gap in the field of digital leadership has been filled and a contribution has been made to the field.

As a result of the research, it is observed that research on the theoretical foundations and practical applications of digital leadership continues to increase, but Digital Leadership research is in

the growth phase and has not yet reached the maturity level. Tigre et al. (2023) also determined that in their research. Moreover, the concepts of virtual leadership and e-leadership were used before digital leadership and that research in the field of digital leadership has a versatile and dynamic structure, which demonstrates that digital leadership studies are suitable for studies from different disciplines and that international cooperation is important.

It is understood that topics such as performance, communication, trust and technology management are critical in the field of digital leadership. According to Imran et al. (2020), performance and development are key roles of leadership in ensuring the digital transformation of organizations. According to Sağbaşı and Erdoğan (2022), digital leaders are responsible for maintaining effective communication with employees, the executive team, and the information technology team inside the business as well as coordinating across these three groups to realize digitalization or digital applications. Also, for leaders, digital technologies mean new forms of communicating and organizing (El Sawy et al., 2020). Ziek and Smulowitz (2014) also determined in their study that one of the most used keywords in digital leadership studies is communication. Communication is a skill that helps leaders to influence their followers (Hambley et al., 2007). For this reason, strong communication is very important for digital leadership.

According to the results of the research, it is understood that themes such as the management of virtual teams, digital leadership skills and psychological well-being, e-leadership competencies in the digitalizing world, digital transformation and business model innovation, and the future of leadership theories have an important place in the academic literature on digital leadership.

Digital leadership focuses on technology, strategic thinking, and innovative approach while reshaping leadership approaches. Research in the field of digital leadership provides a better understanding of digital leadership in organizational, technological and individual terms and helps to develop strategies for these areas. According to Karippur and Balaramachandran (2022), it is crucial for business leaders to adopt an effective leadership style and have the right capabilities to inspire their employees to innovate and sustain in the digital age (Karippur and Balaramachandran, 2022). Many businesses are looking for leaders, who can keep up with technology and lead their organizations to adapt to change and innovation (Nuryadin et al., 2023).

In conclusion, digital leadership has strategic importance in today's business world, due to some important dimensions such as technology, innovation management, cultural change, digital skills, digital competencies, and employee relationships, and is critical to the success and innovation of organizations. Digital leaders contribute to the development of strategies and applications suitable for the needs of the digital age we live in. For this reason, digital leaders need to manage the digitalization processes of businesses and develop innovative business models.

Based on the findings and conclusions of this study on digital leadership, several recommendations are proposed to further develop and implement effective digital leadership strategies. First, it is essential to refine the theoretical foundations of digital leadership by incorporating interdisciplinary approaches that intersect with fields such as information technology, psychology, and organizational behavior. Longitudinal studies should be conducted to examine the long-term effects of digital leadership on organizational performance, innovation, and employee well-being, providing deeper insights into the sustainability and evolution of these practices. A combination of qualitative and quantitative research methods, should be utilized to explore the multifaceted nature of digital leadership.

Additionally, the role of emerging technologies such as artificial intelligence, blockchain, and the Internet of Things in shaping digital leadership must be investigated to understand their impact on leadership styles, decision-making processes, and organizational dynamics. Expanding research to diverse cultural and geographical contexts will help identify both universal and context-specific aspects of digital leadership. Implementing comprehensive leadership development programs focused on enhancing digital competencies, including strategic thinking, technological literacy, and innovation management, is also crucial.

Cultivating a digital culture within organizations that encourages continuous learning, experimentation, and adaptation to new technologies is vital. Leaders should model digital behaviors and support their teams in adopting digital tools and processes. Developing and utilizing digital communication and collaboration tools to facilitate seamless interactions among virtual teams, while emphasizing trust-building, maintaining open lines of communication, and fostering a sense of community despite physical distances, is recommended.

Prioritizing the psychological well-being of employees in digital environments by implementing support systems and policies that address digital fatigue, work-life balance, and mental health is critical. Leveraging data analytics to make informed decisions and drive performance improvements will require digital leaders to be proficient in using data to identify trends, measure outcomes, and optimize organizational processes. Providing incentives and support for organizations undergoing digital transformation, including facilitating access to digital technologies, funding for innovation projects, and training programs for digital skills development, is necessary.

Developing standards and guidelines for digital leadership practices will ensure consistency, transparency, and accountability, helping organizations benchmark their efforts and strive for continuous improvement. Investing in education and training programs that enhance digital literacy at all levels of society, including organizational leaders, employees, students, and the broader community, is essential. Encouraging collaboration between academia, industry, and government to drive research and innovation in digital leadership, and creating platforms for knowledge exchange and joint initiatives, will address the challenges and opportunities of digital leadership. By following these recommendations,

stakeholders can advance digital leadership, ensuring organizations are well-equipped to navigate the complexities of the digital age and achieve sustainable success.

The study does not necessitate Ethics Committee permission.

The study has been crafted in adherence to the principles of research and publication ethics.

The authors declare that there exists no financial conflict of interest involving any institution, organization, or individual(s) associated with the article. Furthermore, there are no conflicts of interest among the authors themselves.

All authors contributed to the entire process of the research.

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