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The Development and Evolution of Digital Leadership: A Bibliometric Mapping Approach-Based Study

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Abstract: The inevitable digitalization of workplaces in the present era, generally as a result of technological developments, has caused a paradigm shift, along with new innovative business models and business behaviors, which has required leaders to possess certain digital skills for sustainable corporate performance. Hence, studies on digital leadership have attracted the attention of academics and practitioners worldwide, with many studies having been conducted on the topic. However, a comprehensive analysis of the intellectual architecture, knowledge structure, and thematic evolution of the digital leadership field of research using science mapping tools has yet to be conducted. The current study, therefore, aimed at reviewing the intellectual structure and evolution of the digital leadership field through a bibliometric and science-mapping analysis. This study used digital leadership as an umbrella term comprising leadership styles such as *e-leadership*, *virtual leadership*, *technology leadership*, and *leadership 4.0*, which have similar meanings and can be used interchangeably. With this purpose, bibliometric performance and science mapping analysis was performed on articles related to the research field that were retrieved from the Scopus database using SciMAT software (version 1.1.04). The results of the study revealed that the scope of digital leadership research is gradually expanding and diversifying and that publication output is increasing steadily. In addition, period-based analysis showed that the *technology management* theme during the first period, the *virtual teams* and *technology* themes during the second period, and the *COVID-19*, *virtual reality*, and *digital technologies* themes during the third period emerged as the motor themes and formed the focus of research in this field. Thematic evolution analysis showed that *virtual leadership* during the first and second periods, *virtual teams* during the second period, *e-leadership* and *technology* during the second and third periods, and *digital leadership*, *COVID-19*, and *virtual reality* during the third period, along with *technology leadership* in all three periods were all noteworthy as well-developed research themes. These findings enable a better understanding of the research field of digital leadership and provide a reference for future research by revealing the conceptual structure and thematic evolution of the digital leadership knowledge base.

Keywords: digital leadership; technology leadership; e-leadership; virtual leadership; leadership 4.0; bibliometric analysis; science mapping; SciMAT



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1. Introduction

Developments in the digital age have encouraged digitalization in every field, triggering various changes across almost all sectors [1] and forcing organizations of different sizes and from various sectors to transform themselves into digital workspaces [2]. Even in institutions with lower levels of digitalization, employees now have generally prolonged contact with their workplaces via mobile devices and applications, with more and more

people working through virtual teams, and information is being shared via digital platforms [3]. Therefore, the digital age requires leaders in many organizations worldwide to combine traditional leadership skills with digital skills [1].

Digital leadership is a new leadership style associated with industry 4.0 [4]. The first three industrial revolutions consisted of mechanical production (mechanization), electricity, and information technologies, respectively. The fourth industrial revolution, which has seen new business models created, relates to the introduction of the internet of things into production, as well as human-to-device and device-to-device communication [5,6]. The development of industry 4.0, which is considered to be a technology-themed project and a new style of production, has not only led to the emergence of digital leadership [7–9], but has also become significant in the initiation of digitalization and digital transformation. Digitalization has changed the way many organizations operate; however, organizations never transform by themselves. The most important factor that enables such technological transformation or change within an organization is the vision of its leaders regarding digitalization [10].

Digital transformation emphasizes the economic and social effects of digitalization, while digitization refers to the conversion of analog data and processes into a format that is machine-readable [11]. Digital transformation is characterized by the integration of physical and digital systems through combining advanced technologies, as well as creating innovative business models and smart products/services [12]. Based on this perspective, digital transformation has become important for organizations across all sectors as it impacts stakeholder relations, work procedures, and even value creation processes. The main concern of stakeholders in this transformation is to define a vision and roadmap that reflects a viable way forward [13]. The aim of digital transformation is to provide continuous optimization to an organization's capability to detect and quickly respond to changes in the global world [14]. In the present era, it is believed that organizations that cannot catch up with the current digitalization trend will become slower, less flexible, and, therefore, less competitive than digitally pioneering organizations [15].

2. Literature Review

The world has always been in a state of change and transformation, but the most striking difference between the changes seen in the past and that of today is the sheer speed and extent of the changes taking place. Innovations in information technology, along with globalization, digitalization, and communication technologies, have caused many organizations to radically change their management processes. The use of information technology began in the 1970s with the first computer systems used in industry. However, since then, the use of information technologies and digitalization have been of crucial importance for industry, public administration, and society as a whole [16].

Digital technology is undoubtedly the trigger of the rapid changes we are experiencing in today's industrial and social world. Broadband internet access, mobile smart devices, artificial intelligence, virtual reality, and many other technology-based applications have taken place in all areas of modern-day life. In this regard, leaders who can effectively manage the digital world can also make a meaningful contribution to the digital transformation of their organizations [17]. Leaders are of critical importance to organizations with their role of selecting, equipping, training, and influencing personnel (employees) [18]. Therefore, it is important for leaders to support and motivate employees so as to improve their digital skills in the rapidly developing digital environment of the current age, in which radical transformation is brought about through digitalization [2]. Constantly changing and developing business environments, taken together with the human factor, have led to the emergence of different leadership styles. New digital tools that emerged with the development of internet technologies have become a vital element for leaders with the digitalization of workplaces [19,20]. In this context, both the industry 4.0 revolution and the developments seen in internet technologies have required leaders to possess certain digital competencies, which has paved the way for the emergence of digital leadership. In

addition, the need for digital leadership has increased more than ever before since today's organizations have transformed or are in the process of transforming from traditional to digital workplaces [21].

In the relevant current academic literature, digital leadership is defined as a leadership style that combines transformational leadership with the use of digital technologies [22,23]. Avolio et al. [24] used the term e-leadership, a term that combines leadership and technology. Within the scope of the current study, 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.

Digital leadership is described as a social influence process mediated by modern information technologies to support change and the improvement of behaviors and organizational performance across all stakeholder groups. From this perspective, digital leaders aim to consistently manage digital transformation processes by adopting multiple leadership approaches. Therefore, effective digital leadership requires an empathetic problem-solving perspective, fast, accurate, and participatory decision-making ability, as well as effective networking skills [24–26]. In addition, Promsri [27] underlined the different qualities of digital leadership such as digital literacy, vision, customer focus, agility, risk taking, and cooperation.

The results of a study by Karakose et al. [23] showed that the basic qualities of digital leaders include (i) the use of digital technology, (ii) support for digital transformation, (iii) support for technology-based professional development, (iv) support for a digital learning culture, and (v) digital leadership skills (technology use, managerial skills, and individual skills). In this sense, digital leadership is not about bringing computers together, running them, or being an expert programmer. Digital leaders are visionary people who have the ability to effectively lead an organization by using information and communication technologies in order to meet the demands of the digital age [28]. According to Miller [29], digital leaders can improve the life, well-being, and conditions of an organization and its employees by using a wide array of digital technologies.

In times of crisis, leaders may need to take on different roles in order to overcome certain challenges. On 11 March 2020, the World Health Organization declared COVID-19 as a pandemic [30] that resulted in a period of significant chaos and crisis for leaders, organizations, and employees worldwide. When considered in terms of educational management, it may be said that COVID-19 created a clear need for social distancing, which resulted in the almost overnight transformation of predominantly traditional learning systems into digital active areas [31]. The business world, on the other hand, also had to change its business models from the outset of the pandemic in order to adapt to new digital conditions that triggered a period of rapid change and development [32]. These challenging processes rendered the digital capabilities of leaders even more significant, and research interest in digital leadership was seen to increase during the pandemic [33,34].

In the digital age, the effective and sustainable success of organizations depends heavily on traditional leaders who can support their leadership with digital skills. In recent years, digital leadership has garnered significant research interest, and numerous studies have been carried out on digital leadership in different research fields, such as the social sciences [35], engineering [36], business and management [37], economics [38], and health [39]. However, to our knowledge, the literature lacks a conceptual analysis based on bibliometric methods and science mapping tools that comprehensively investigate the evolving field of digital leadership. Therefore, this research aims to reveal the intellectual structure and evolution of the digital leadership knowledge base using bibliometrics and science mapping methods. More specifically, our study addresses the following research questions:

- RQ 1.** What is the overall volume, growth trajectory, and distribution of published articles in the digital leadership knowledge base?
- RQ 2.** What are the most influential authors and journals in the digital leadership research field?
- RQ 3.** What is the intellectual structure and evolution of the digital leadership knowledge base?
- RQ 4.** What topical foci in digital leadership research have attracted the greatest attention from scholars?

3. Materials and Methods

3.1. Study Design

In this study, we combined bibliometric performance analysis and science mapping methods to determine the strategic themes, scientific evolution structure, and bibliometric performance of articles on digital leadership. We used SciMAT [40] software (version 1.1.04) to analyze the bibliometric performance, the conceptual structure, and the thematic evolution of 314 articles published on digital leadership. SciMAT combines science mapping and bibliometric performance analysis methods to examine the structural and dynamic aspects of a research field, to visualize its thematic evolution, and to determine its performance [41–43].

Comparing SciMAT with other bibliometric analysis tools, such as WOSviewer, Bibexcel CiteSpace II, CoPalRed, or the Science of Science Tool (Sci2), Cobo et al. [43] highlight the salient features of SciMAT as (i) incorporating modules to carry out all the steps of the science mapping, (ii) presenting a powerful deduplicating module, (iii) building a large variety of bibliometric networks, (iv) enabling the use of various visualization techniques, such as cluster or thematic evolution networks, (v) enriching the results with bibliometric measures based on citations, such as the sum, minimum, maximum, and average citations, or complex measures, such as the h-index, and as a result, allows for science mapping analysis under a longitudinal framework to analyze and discover the conceptual and intellectual evolution of a research field across consecutive time periods. Therefore, in light of our purpose, we preferred to use the SciMAT software in the present study.

3.2. Data Search and Identification

Digital databases, such as the Web of Science (WoS), Scopus, or Google Scholar, are often preferred for searching and extracting data in bibliometric studies. Mongeon and Paul-Hus [44] stated that Scopus covers more journals than WoS; however, almost all of the articles indexed in the WoS database are also indexed in Scopus. Therefore, the use of Scopus database helps to prevent data loss by reducing the risk of articles being missed from the analysis. Cañadas et al. [45], on the other hand, emphasized that Scopus is accepted as one of the optimum databases for bibliometrics. It also offers more complete bibliographic data than Google Scholar [46]. Therefore, we used the Scopus database to search and extract data. In this study, a three-step process of searching and defining data, extracting and cleaning data, and finally analyzing data [47] was followed. The procedure for data search and extraction was reported according to PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidance [48] (see Figure 1).

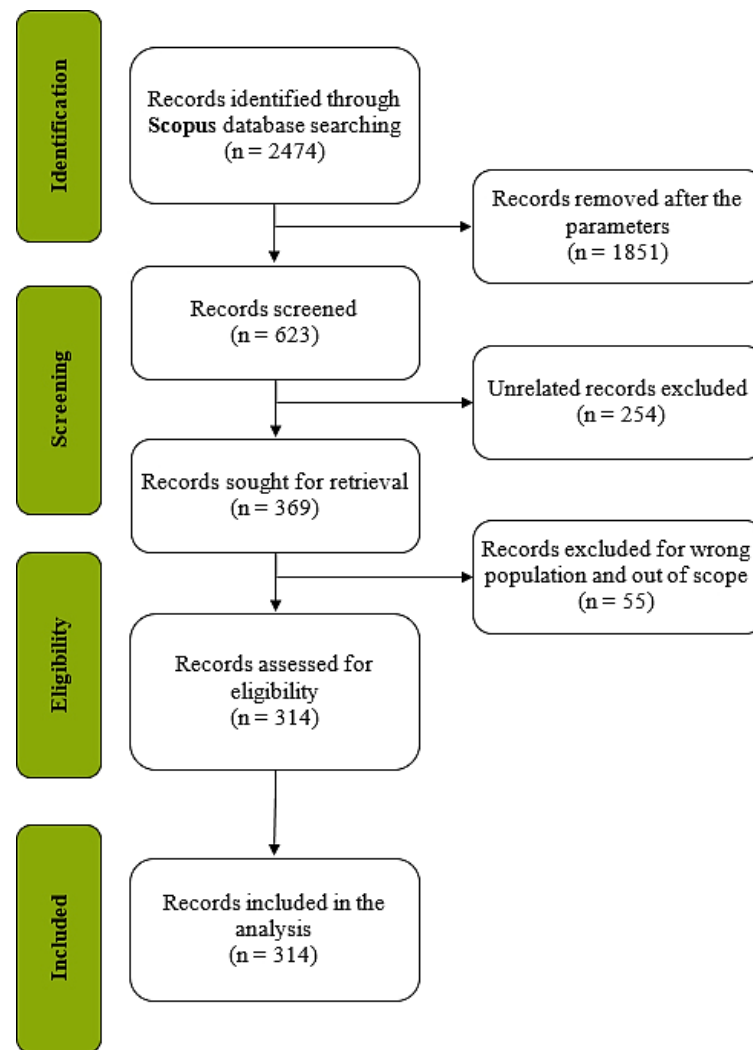


Figure 1. PRISMA flow diagram.

We first developed an inclusion/exclusion criteria list in light of the purpose of our study. The list included four main headings: *language*, *context*, *document type*, and *database*. In terms of language, we only included articles written in English due to the authors' ability to understand and analyze English-only content. With regard to context, our search was broad, so we included research in any context as long as it addressed digital leadership or one of its types. However, we included only journal articles while excluding conference proceedings, books, or book chapters. As detailed above, the search was performed using the Scopus database, as it covered a wide variety of journals from various research fields.

Next, we performed a keyword search against the Scopus database on 15 May 2022 using the following keyword string:

TITLE-ABS-KEY ("digital leader" OR "technology leader*" OR "virtual leader*" OR "e-leader*" OR "electronic leadership" OR "4.0 leadership" OR "leadership 4.0" OR "online leadership" OR "remote leadership" OR "cyber leadership")*.

Keywords were selected after an in-depth review of the relevant literature and with the approval of a group of field experts. This initial search yielded a total of 2474 documents. After excluding 1851 documents that did not meet the search criteria, 623 articles remained. Then, we examined the titles of these 623 items individually and excluded a further 254 since they were not directly related to the topic of digital leadership. We then read the abstracts of the remaining 369 documents in detail and excluded a further 55 documents

as they were not found to be directly focused on digital leadership. The final number of documents eligible for analysis was 314 published articles.

3.3. Data Extraction and Analysis

After performing a data search and identification against the Scopus database, we transferred the bibliographic data of the articles (article title, authors, keywords, abstract, citations, publication date, and journal name) to the SciMAT program for analysis. Next, we manually combined key terms with similar meanings, such as *leader* and *leaders*, *virtual leader* and *virtual leaders*, *e-leadership* and *electronic leadership*, etc., in order to increase the efficiency and quality of the thematic analysis. The details of the bibliometric analysis based on the h-index and cword analysis using the SciMAT software tool are as follows [42,43,49–52]:

- (a) Within the scope of the current study, we used the *equivalence index* to calculate the similarity of conceptual links between keywords. We used the clustering algorithm, which is a simple central algorithm that shows the relationship strength of clusters to detect themes. At this stage, we prepared to present the *digital leadership* research themes using two different tools, *strategic diagram* and *thematic network*, in a four-quadrant, two-dimensional strategic diagram based on centrality (x -axis) and density (y -axis) values. Here, centrality measures the degree of interaction of a cluster with other clusters or the strength of their relationship, which is formulated as $c = 10 \times \sum ekh$. Density, on the other hand, measures the internal strength of the link, that is, the strength of the relationship between the keywords within a theme, which is formulated as $d = 100(\sum eij/w)$.
- (b) However, for a conceptual analysis based on cword and h-index analysis, the research themes were divided into four categories, as shown in the *strategic diagram* in Figure 2a: (a) *Motor themes (Q1)*: high centrality and intensity (themes are well-developed and considered important to the research field); (b) *Basic and transversal themes (Q2)*: high centrality and low density (themes not well-developed due to a lack of appropriate density, but have potential to evolve into motor themes in the future due to high centrality); (c) *Emerging or declining themes (Q3)*: low centrality and density (themes not well-developed and represent the field's marginal topics); and (d) *Highly developed and isolated themes (Q4)*: low centrality and high density (themes with good density but poor centrality, representing topics that lack the appropriate background for the field).
- (c) *Thematic network structure*. Figure 2b shows how strategic themes emerge together with other subthemes related to the research field. The size of the circles in the thematic networks relates to the number of publications, whilst line thickness relates to the relationship strength. The *thematic evolution map* (see Figure 2c) helps to explore the original themes, as well as their evolution and interrelationships over time. Solid lines on the thematic map indicate that the same keywords are shared between themes, whilst the dashed lines indicate that common words are shared apart from the theme names. The line thickness relates to the degree of relationship, whilst the circle size relates to the number of publications.

In order to save the data from uniformity [43,53], we performed the analysis over consecutive periods. We first divided the articles on digital leadership into three distinct time periods: 1983–2007 as Period 1, 2008–2014 as Period 2, and 2015–2021 as Period 3. As the criterion for determining the periods, we took the production of the relevant literature (i.e., the number of publications) as a basis. However, since the current research was performed in 2022, we excluded articles published during 2022 from the science mapping analysis since the year was ongoing at the time.

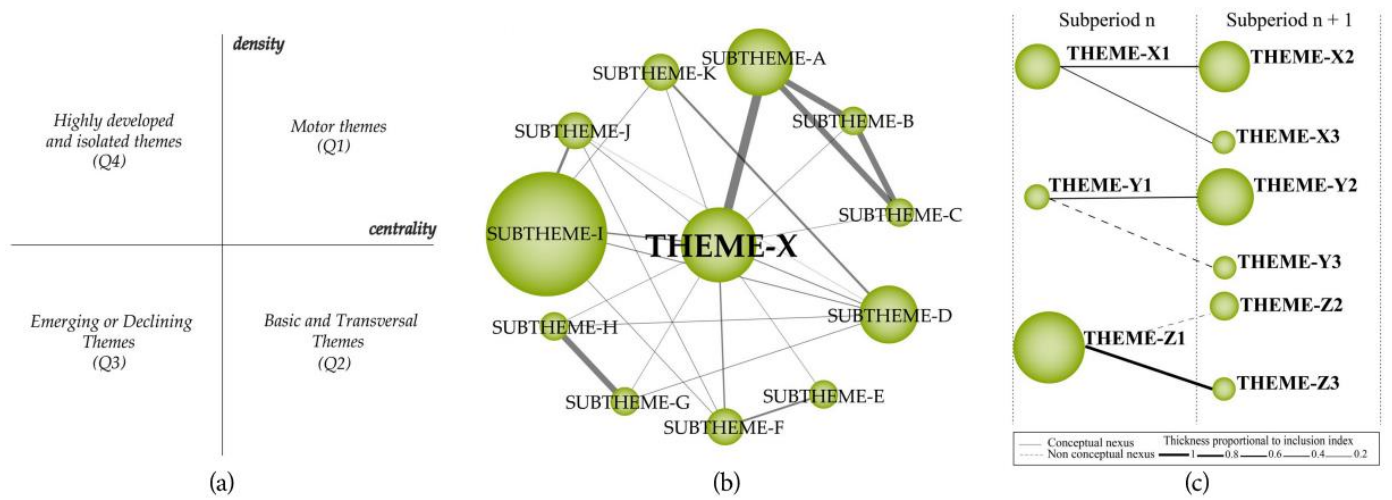


Figure 2. (a) Strategic diagram, (b) thematic network structure, (c) thematic evolution structure [43].

4. Results

4.1. Overall Bibliometric Analysis

In this section, we performed an analysis based on bibliometric indicators in order to evaluate the *digital leadership* research field in light of the quantitative data.

4.1.1. Publication Trends

Figure 3 shows the distribution of 314 digital leadership-focused articles by year of publication, the number of accumulated publications, and the graphical representation of the average citations per article [53]. The continuous red line in Figure 3 shows the yearly citation rates, whilst the continuous grey line shows the number of articles accumulated per year, and the green columns denote the distribution of articles by year of publication.

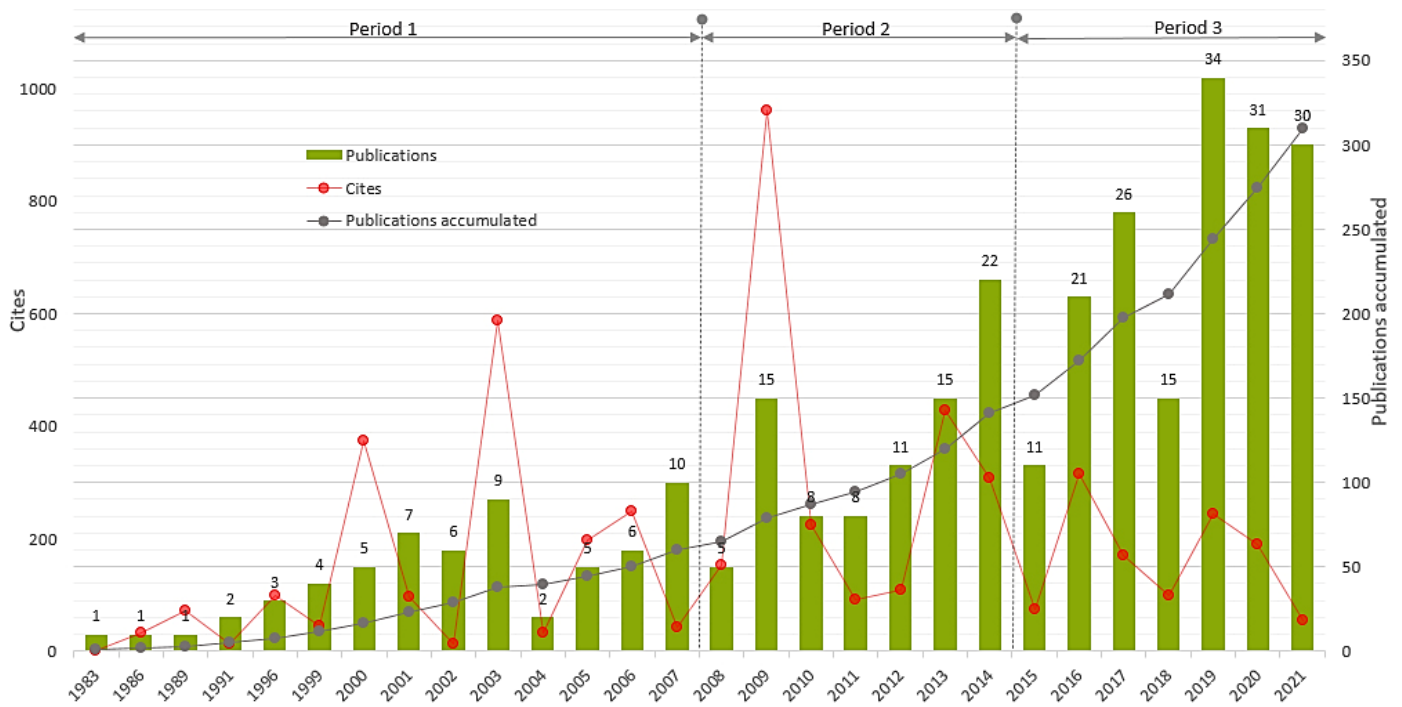


Figure 3. Chronological distribution of publications and citations (1983–2021).

Figure 3 illustrates that studies on digital leadership increased each year cumulatively, starting from 1983, although the annual increase in the number of publications fluctuated on a period-by-period basis. The highest citation year for articles on digital leadership was 2009. In Period 3 (2015–2021), the number of publications on digital leadership increased more extensively, which reveals that research interest in digital leadership reached a peak during the last period. In addition, despite the significant increase in the number of publications on digital leadership during the third period, the articles published during this time received fewer citations compared to publications in previous periods.

4.1.2. Most Influential Authors

The authors of 314 articles were analyzed, and the total number of contributors was determined as 629, although some authors were involved in more than one study. Table 1 presents the top 20 authors who contributed the most to the literature on digital leadership based on the total number of citations their articles received. The names of the authors, the number of cited articles, their h-index value, and the number of citations are presented, respectively, in Table 1.

Table 1. Most cited/productive authors.

Rank	Author	TC *	TP	h-Index
1	Wang, Xiaofan	1065	9	47
2	Su, Housheng	1016	4	45
3	Lin, Zongli	760	1	62
4	Avolio, Bruce J.	597	3	78
5	Dodge, George E.	307	1	4
6	Kahai, Surinder Singh	457	3	22
7	Chu, Tianguang	216	2	31
8	Shi, Hong	216	2	11
9	Wang, Long	216	2	81
10	Lu, Xiaoqing	209	3	22
11	Cascio, Wayne F.	186	1	34
12	Chen, Shihua	186	2	28
13	Shurygailo, Stan	186	1	2
14	Dexter, Sara	171	2	13
15	Anderson, Ronald E.	170	1	13
16	Baker, Bradford	140	1	3
17	Sosik, John J.	140	1	39
18	Lü, Jinhua	138	1	69
19	Lu, Renquan	138	1	57
20	Bader, Paige	136	1	1

* TC: total citations; TP: total publications. Data retrieved from Scopus on 15 May 2022.

According to the 314 analyzed articles, the most cited authors on digital leadership were found to be Wang, X. ($f = 1065$) and Su, H. ($f = 1016$), with Wang, X. having made the highest contribution to the field, with nine articles and an h-index value of 47.

4.1.3. Most Influential Journals

Between 1983 and 2021, a total of 314 articles were published on digital leadership in 245 different journals. The top 20 journals are listed in Table 2 based on the total number of published articles, with their respective Scimago Journal Rank (SJR) and Scopus Quartile value.

Table 2. Most productive/cited journals.

Rank	Journal Name	TP *	TC	SJR	Scopus Quartile
1	Research Technology Management	6	43	0.90	Q1
2	British Journal of Educational Technology	5	116	1.87	Q1
3	Organizational Dynamics	4	477	0.49	Q2
4	Egitim ve Bilim	4	38	0.24	Q3
5	Turkish Online Journal of Educational Technology	4	17	n/a	n/a
6	MIT Sloan Management Review	3	93	0.65	Q2
7	International Journal of Environmental Research and Public Health	3	30	0.81	Q1
8	Management Science Letters	3	29	n/a	n/a
9	TechTrends	3	13	0.74	Q1
10	International Journal of Learning, Teaching and Educational Research	3	11	0.23	Q3
11	ITNOW	3	2	0.12	Q4
12	Leadership Quarterly	2	447	4.91	Q1
13	Educational Administration Quarterly	2	185	1.95	Q1
14	Journal of Educational Administration	2	118	1.01	Q1
15	MIS Quarterly Executive	2	108	2.00	Q1
16	Journal of Information Technology For Teacher Education	2	49	n/a	n/a
17	Educational Technology and Society	2	47	1.31	Q1
18	Frontiers in Psychology	2	47	0.87	Q1
19	Computers and Education	2	39	3.68	Q1
20	Sustainability (Switzerland)	2	22	0.66	Q1

* TP: total publications; TC: total citations; SJR: Scientific Journal Ranking. Data retrieved from Scopus on 15 May 2022.

Table 2 shows that the journals with the highest number of articles published on digital leadership were *Research Technology Management* ($f = 6$), the *British Journal of Educational Technology* ($f = 5$), and *Organizational Dynamics* ($f = 4$), respectively. When the Scopus Quartile values of the journals are observed, it can be seen that 12 journals are included in the Q1 category, whilst two journals are included in the Q2 category, and these journals have a significant number of citations.

4.2. Science Mapping and Performance Analysis

In this section, the results of the science mapping analysis using the SciMAT software are reported as (i) thematic analysis, according to periods (strategic diagrams and thematic networks), (ii) overlapping graph analysis, and (iii) evolution map analysis. In addition, the performance analysis of the themes is presented separately in terms of the h-index value, the number of citations, and the centrality and intensity values.

4.2.1. Scientific Evolution Structure

Period 1 (1983–2007)

Seven themes emerged from the analysis of the 62 articles published during the first period. The performance values of the first period and the strategic diagram are presented in Figure 4.

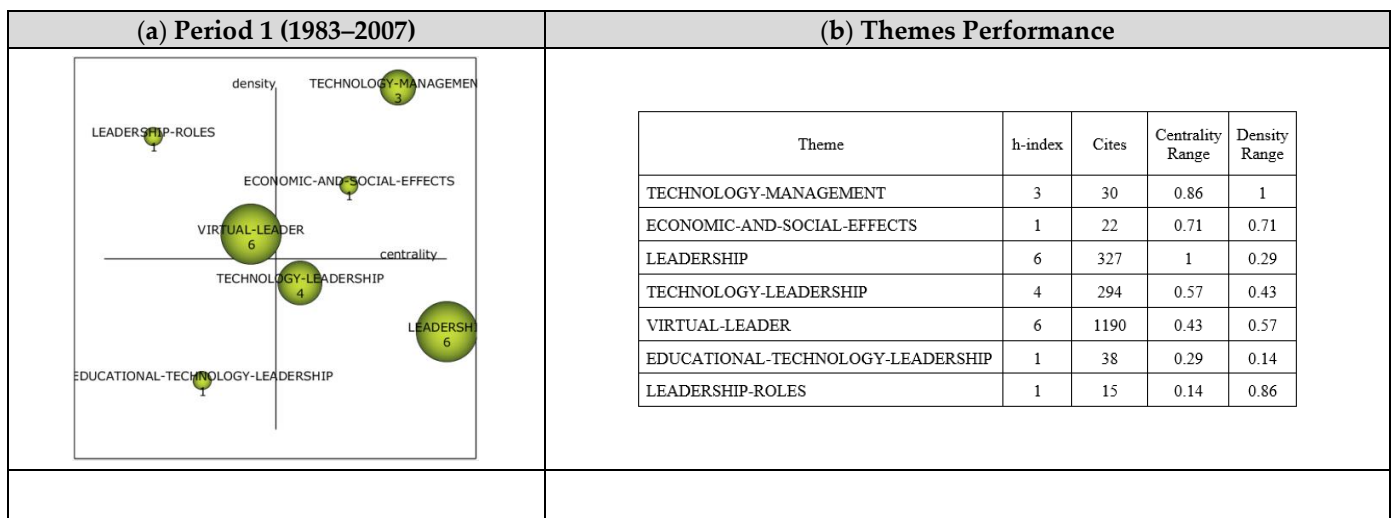


Figure 4. (a) Strategic diagram for Period 1 and (b) performance analysis for Period 1. Source: SciMAT.

During the first period (1983–2007), a total of seven main themes emerged. The *Technology-Management* and *Economic-And-Social-Effects* themes were found to be the motor themes that contributed the most to the development of the field. The *Leadership-Roles* and *Virtual-Leader* themes were found to be highly developed and isolated themes. The *Educational-Technology-Leadership* theme was an emerging and declining theme, which first emerged and then disappeared during the first period. The *Leadership* and *Technology-Leadership* themes were included in the basic and transversal themes, which shows that these themes, despite being related to the field, were not developed sufficiently during the first period. The theme with the highest importance during the first period was the *Virtual-Leader* theme, which is represented by eight articles.

The cluster networks (see Figure 5) were examined in order to determine the sub-themes related to the main themes that emerged during the first period (1983–2007). Accordingly, it was determined that the main theme of *Technology-Management* (0.86, 1) was associated with the *Strategic-Leadership*, *Leadership-Qualities*, *Industry*, *Management-Science*, *Manager*, *Industrial-Management*, *Teaching*, and *Product-Development* subthemes. Strong relationships were observed between these subthemes. Studies on *Industry* [54], *Leadership Qualities* [55], *Strategic Leadership* [56], *Manager* [57], *Product Development* [58], *Teaching* [59], and *Management Science* [60] support our results with regards to the *Technology-Management* cluster network.

The analysis also revealed that the main theme of *Economic-And-Social-Effects* (0.71, 0.71) had associations with the *Technology-Transfer*, *Labor-Market*, *Engineering*, *Marketing*, and *Computer-Science* subthemes. Studies on *Engineering* [61], *Computer-Science* [62], and *Market* [63] are offered as examples to support our results with regard to the *Economic-And-Social-Effects* cluster network.

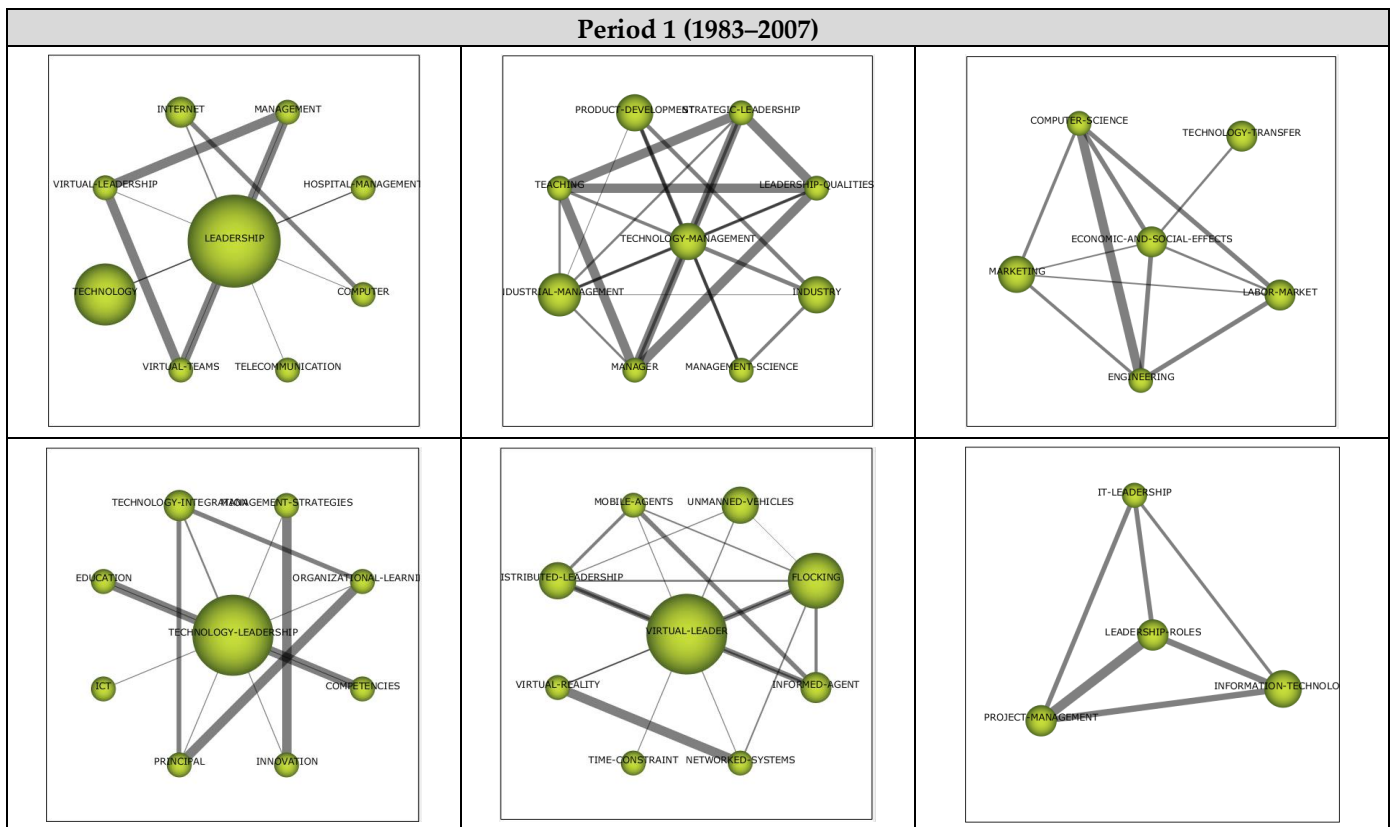


Figure 5. Thematic network structures (1983–2007).

Period 2 (2008–2014)

A total of seven themes emerged from the analysis of the 84 articles published during the second period. The performance values and strategic diagram of Period 2 are presented in Figure 6.

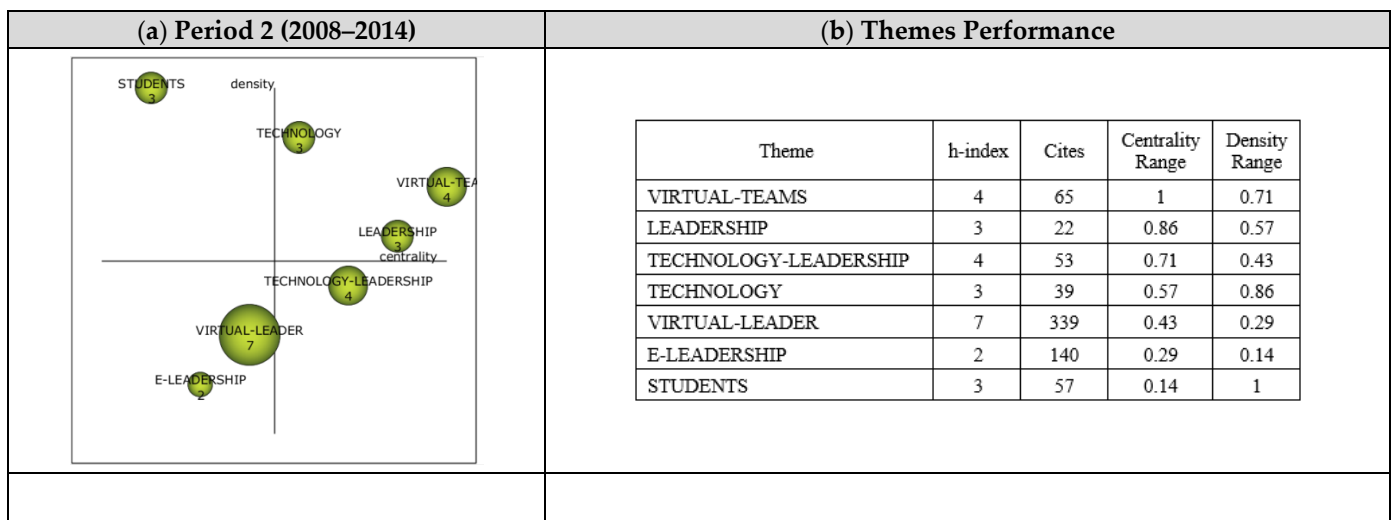


Figure 6. (a) Strategic diagram for Period 2 and (b) performance analysis for Period 2. Source: SciMAT.

The most significant theme that emerged during the second period (2008–2014) was found to be *Virtual-Leader*, represented by 12 articles. The *Virtual-Teams*, *Leadership*, and *Technology* themes emerged as the motor themes that contributed the most to the development

of the field, whilst the *Students* theme was found to be highly developed and isolated. The *Virtual-Leader* and *E-Leadership* themes were shown to be emerging and declining themes during the second period, whereas the *Technology-Leadership* theme, on the other hand, was found to be a basic and transversal theme, indicating that, despite being related to the field, it was underdeveloped during this period.

The cluster networks of the motor themes (see Figure 7) were examined in order to determine the subthemes related to the motor themes that emerged during the second period (2008–2014). Accordingly, the motor theme of *Virtual-Teams* (1, 0.71) was found to be associated with the subthemes of *Web-enabled Leadership*, *Video-Conferencing*, *Communication*, *Virtual-Reality*, *Management*, *Leadership-Roles*, *Emergent-Leadership*, and *Online-Communication*. Studies on *Web-enabled Leadership* [64], *Video Conferencing* [65], *Communication* [66], *Virtual Reality* [67], *Leadership Roles* [68], *Emergent Leadership* [69], and *Online Communication* [70] and are illustrative of the subthemes in the *Virtual-Teams* cluster network.

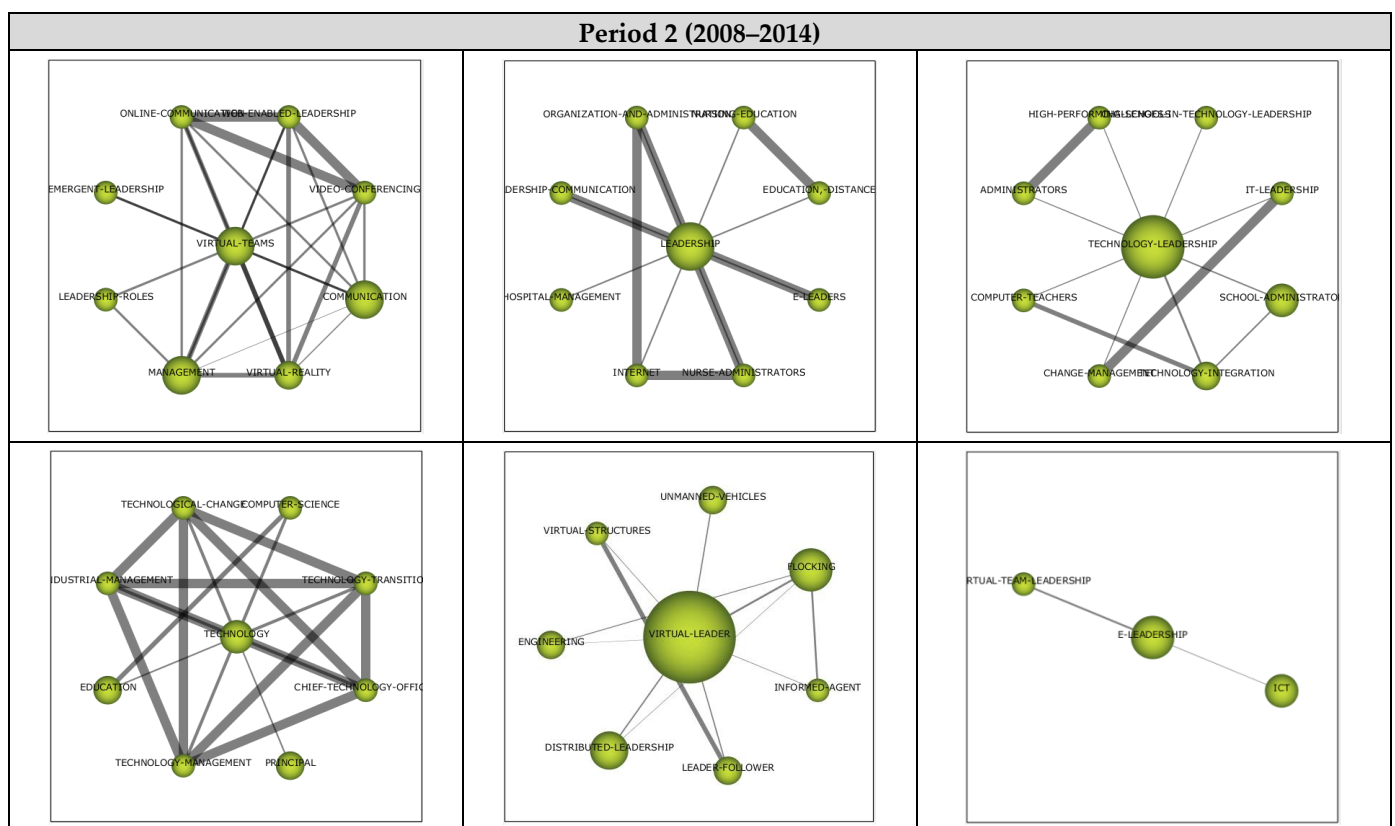


Figure 7. Thematic network structures (2008–2014).

The *Leadership* (0.86, 0.57) main theme was found to have strong associations with the subthemes of *Nursing-Education*, *Education-Distance*, *E-Leaders*, *Nurse-Administration*, *Hospital-Management*, *Leadership-Communication*, and *Organization-And-Administration*. Studies on *Nursing education* [71], *E-Leaders* [72], *Nurse Administrator* [73], *Hospital Management* [74], and *Leadership Communication* [70], which are examples supporting the subthemes revealed for the *Leadership* cluster network.

In addition, the main theme of *Technology* was found to be strongly associated with the subthemes of *Computer-Science*, *Technology-Transition*, *Chief-Technology-Officer*, *Principal*, *Technology-Management*, *Education*, *Industrial-Management*, and *Technological-Change*. Studies by van der Hoven et al. [75] on *Technology Transition* and *Chief Technology Officer*, Weng and Tang [76] on *Principal*, Aksal [77] on *Technology Management*, and Jameson [78] on *Education* are some of the studies that illustrate the subthemes of the *Technology* cluster network.

Period 3 (2015–2021)

A total of 19 themes emerged from the analysis of the 168 articles published during the third period. The performance values and strategic diagram of the themes in Period 3 are presented in Figure 8.

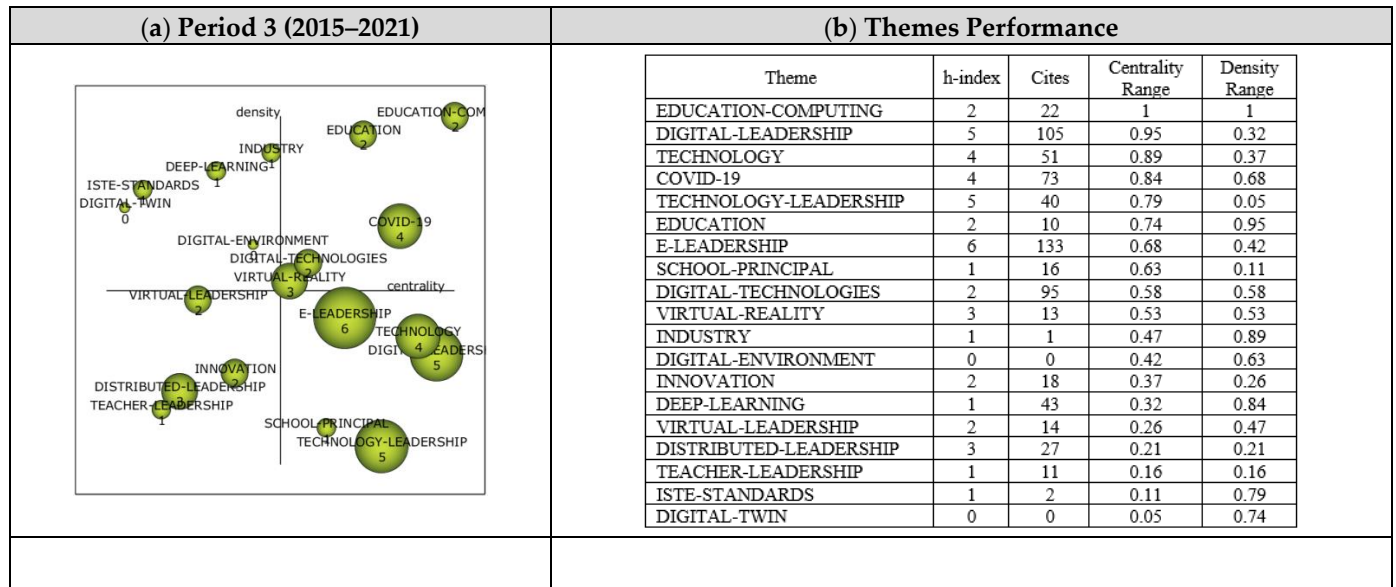


Figure 8. (a) Strategic diagram for Period 3 and (b) performance analysis for Period 3. Source: SciMAT.

During the third period, which comprised the years between 2015 and 2021, 19 main themes emerged. The *Digital-Leadership* theme emerged as the most significant theme, represented by 18 articles. The motor themes that contributed to the development of this research field during the third period were found to be *Education-Computing*, *COVID-19*, *Education*, *Digital-Technologies*, and *Virtual-Reality*, whilst the *Industry*, *Deep-Learning*, *ISTE-Standards*, *Digital-Twin*, and *Digital-Environment* themes emerged as highly developed and isolated themes with high interrelationships. The *Virtual-Leadership*, *Innovation*, *Distributed-Leadership*, and *Teacher-Leadership* themes were found to be emerging and declining during this third period, and the *E-Leadership*, *Digital-Leadership*, *Technology*, *Technology-Leadership*, and *School-Principal* themes were among those considered basic and transversal, which were not developed sufficiently during the third period despite being related to the field.

The cluster networks of the motor themes (see Figure 9) that emerged during the third period (2015–2021) were examined in order to determine the associated subthemes. The motor theme of *Education-Computing* (1, 1) was found to be strongly associated with the *Education-Reform*, *Organizational-Factors*, *Interactive-Learning-Environment*, *Learning-Communities*, *Teaching*, *Economic-And-Social-Effects*, *Leadership-Qualities*, and *Risk-Management* subthemes. The studies on *Education Reform* [79], *Organizational Factors* [80], *Interactive Learning Environment* [81], *Learning Communities* [82], *Teaching* [83], and *Leadership Qualities* [81] are representative of the findings with regard to the *Education-Computing* cluster network.

In addition, the motor theme of *Education* (0.74, 0.95) was found to have strong associations with the *Nursing-Management*, *M-Learning*, *Nurse-Administrators*, *Hospital-Management*, *Information-Processing*, *Organizational*, *Virtual*, and *Mentor* subthemes. Studies on *Nursing Management* [84] and *Mentor* [85] are offered as support for the results revealed with regards to the *Education* cluster network.

The motor theme of *COVID-19* (0.84, 0.68) was found to have strong associations with the *Work-From-Home*, *K-12-Education*, *Teleworking*, *Technology-Capabilities*, *Learning*, *Remote-Working*, *New-Normal*, and *Leadership-Efficacy* themes, whilst *Work-From-Home* and *Leadership-Efficacy* were found to be strongly associated with the themes of *K-12-*

Education, Technology-Capabilities, and Learning. The studies on Work from Home [34], Teleworking [86], Technology Capabilities [23], Remote Working [87], New Normal [88], and Leadership Efficacy [34] illustrate our results with regard to the COVID-19 cluster network.

The motor theme of Digital-Technology (0.58, 0.58) was found to have strong associations with Digital-Innovation, Digital-Technologies, Decision-Making, Leadership-Style, Strategic-Leadership, Digital-Teaching, Business-Organizations, Virtual-And-Augmented-Reality, and Organizational-Change. In addition, the Virtual-And-Augmented-Reality, Strategic-Leadership, and Business-Organizations themes had strong interrelationships. The studies on Digital-Innovation [89], Digital-Technologies [90], Decision-Making [91], Leadership-Style [92], Strategic-Leadership [93], Digital-Teaching [94], and Organizational-Change [95] are supportive of our results with regard to the Digital-Technology cluster network.

The motor theme of Virtual-Reality (0.53, 0.53) was found to be associated with the sub-themes of Unmanned-Vehicles, Flocking, Employee, Group-Process, Virtual-Leader, Workplace, Mobile-Agents, and Leadership-Behavior. In addition, the Leadership-Behavior and Group-Process, and Mobile-Agents and Flocking themes were found to have strong interrelationships. The studies on Flocking and Mobile Agents [96], Workplace [97], Leadership-Behavior [98], and Group-Process [99] are offered as support for the presented results with regard to the Virtual-Reality cluster network.

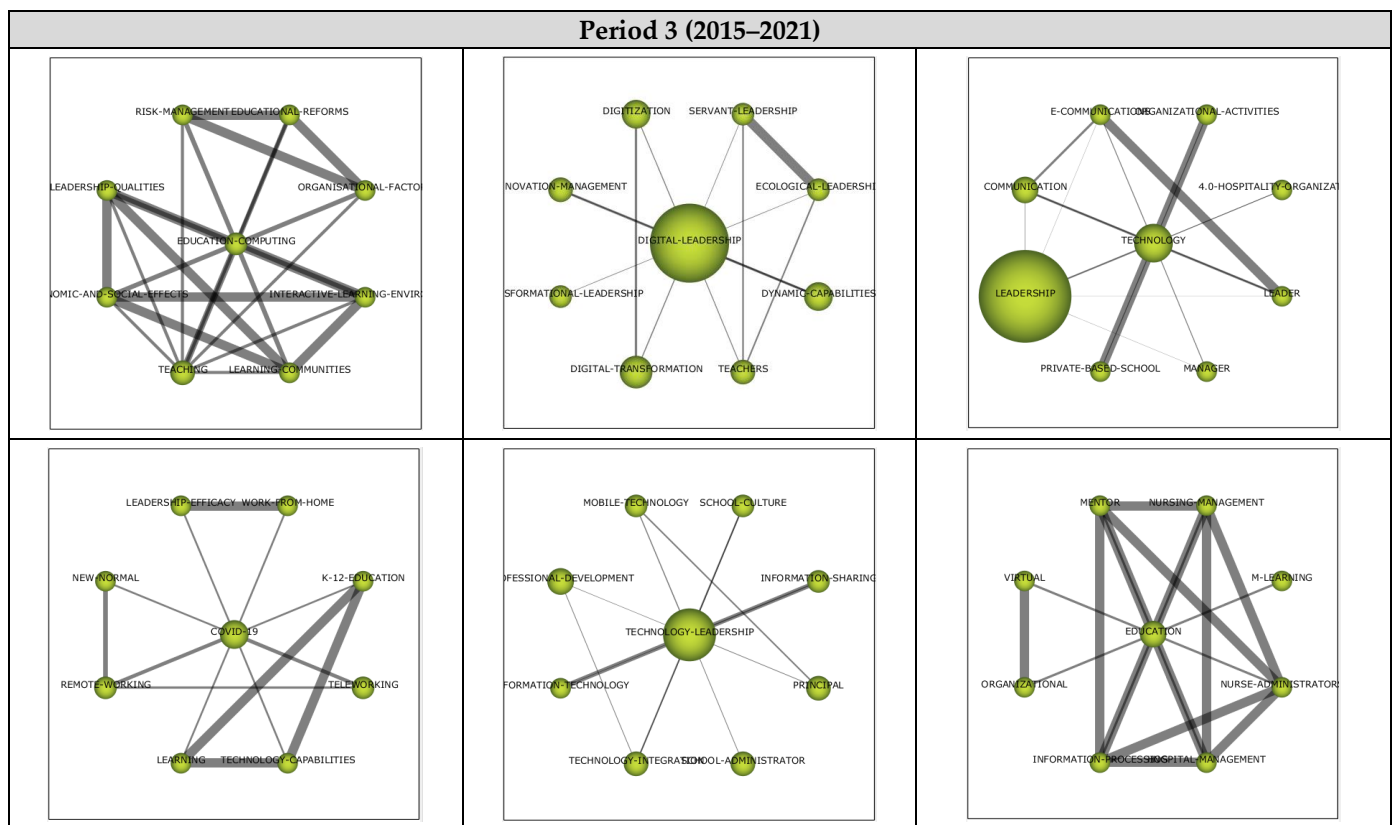


Figure 9. Cont.

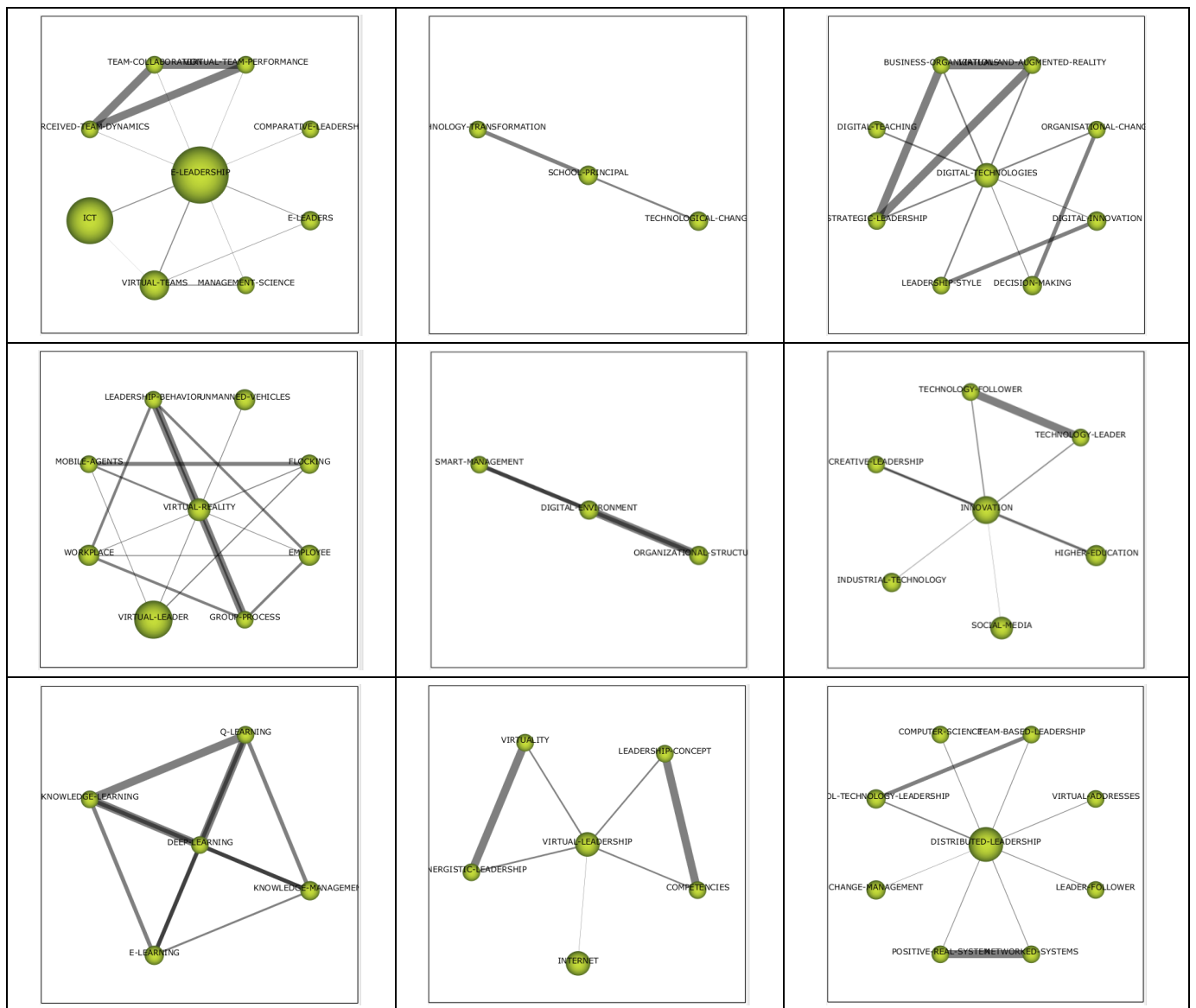


Figure 9. Thematic network structures (2015–2021).

4.2.2. Overlap Fractions

The *overlapping-items graph* shows the number of keywords in each period as well as the newly appeared, lost, and reused keywords in the subsequent period that follows [100]. The *overlapping map* in Figure 10a shows that there were 65 keywords in total used during the first period and that 32 of these keywords did not appear in the second period, whilst 33 of them did. On the other hand, there were 69 keywords used during the second period, of which 43 were used in the following third period, whilst 26 were not. The third period included a total of 172 keywords. While the number of keywords used for the first time during the second period was 36, this was found to be 129 during the third period. However, the similarity index was found to decrease between the periods (from 0.33 to 0.22). The *overlapping-items graph* revealed that the terminology related to digital leadership is getting stronger every year, and new terms have been introduced to the field. The keywords, from left to right, increased from 65 during the first period to 172 during the last period. This significant increase in the number of keywords revealed that those topics of research focusing on digital leadership have diversified and increased cumulatively. The increase in the number of keywords included in each period shows that the studies on

digital leadership have constantly been developing, and the disappearing keywords show that the terms have been constantly updated in this research field.

4.2.3. Thematic Evolution Structure

The *thematic evolution map* shown in Figure 10b illustrates the relationship between the patterns of development in the knowledge bases and the digital leadership-focused research themes over the analyzed periods. The size of the spheres shown on the map relates to the number of publications, whilst the thickness of the lines connecting the spheres relates to the correlation between the themes that emerged during each period [43,52]. The *thematic evolution map* shows that seven themes emerged during the first period (1983–2007), which constitutes 28.66% of all the articles included in the analysis. Six of these themes survived in other periods, and one disappeared without making any connection. The *Technology-Leadership* theme that emerged in the first period continued its existence across all three periods. In addition, the *Virtual-Leader* and *Leadership* themes from the first period continued to exist during the second period as well. While the theme of *Leadership-Roles* from the first period was exchanged with the themes of *Virtual-Teams* and *Technology-Leadership* during the second period, the *Technology-Management* theme from the first period was exchanged with the *Technology* and *Student* themes during the second period. The *Economic-And-Social-Effects* theme was exchanged with *Technology* and *Virtual-Leader* themes during the second period, whilst the *Educational-Technology-Leadership* theme from the first period disappeared in the other periods and made no connections with the themes that emerged in the subsequent periods.

Seven themes emerged during the second period (2008–2014), which constitutes 21.34% of the articles analyzed. While three of these themes were from the first period, four of them appeared for the first time in the second period. All the themes from this period were connected with those that emerged during the first or the third period. The *Virtual-Teams* theme was exchanged with the *Technology*, *Virtual-Reality*, and *E-Leadership* themes during the third period, whilst the *Leadership* theme was exchanged with *Education*, *Technology*, *E-Leadership*, and *Virtual-Leadership* themes during the third period. The *Technology* theme continued to exist in the third period and had connections with the *Education*, *Technology-Leadership*, *Distributed-Leadership*, and *School-Principal* themes during the second period. The *Education-Computing* theme evolved into the *Digital-Technologies*, *Digital-Leadership*, and *Deep-Learning* themes, whereas the *E-Leadership* theme, on the other hand, continued to exist during the third period.

The third period (2015–2021) represented 50% of the articles analyzed, and 19 themes emerged during this period. Three of these themes were transferred from the second period; however, 16 appeared for the first time during the third period. Among them, the themes of *Education-Computing*, *Industry*, *Education*, *Digital-Technologies*, *Virtual-Reality*, *Digital-Leadership*, *Distributed-Leadership*, *Virtual-Leadership*, and *Deep-Learning* were connected to those from the previous (second) period. In addition, the themes that appeared only in the third period were found to be *COVID-19*, *Innovation*, *Digital-Twin*, *ISTE-Standards*, *Digital-Environment*, and *Teacher-Leadership*.

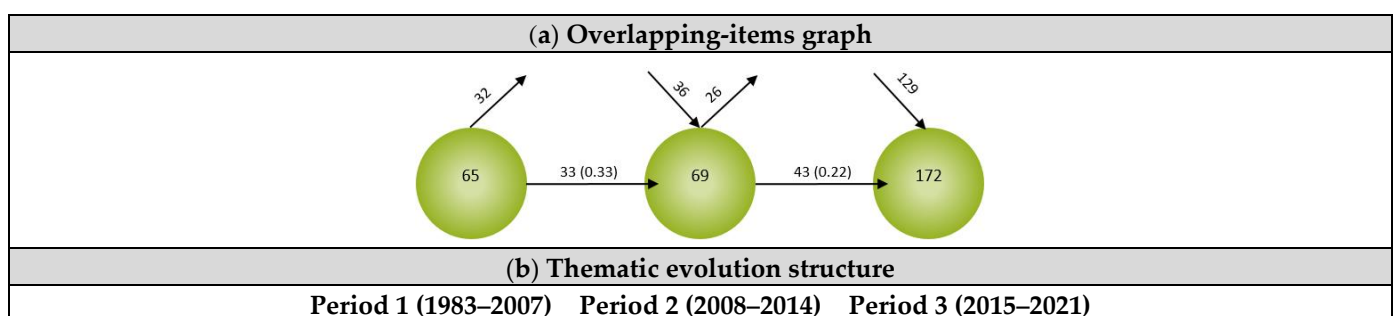


Figure 10. Cont.

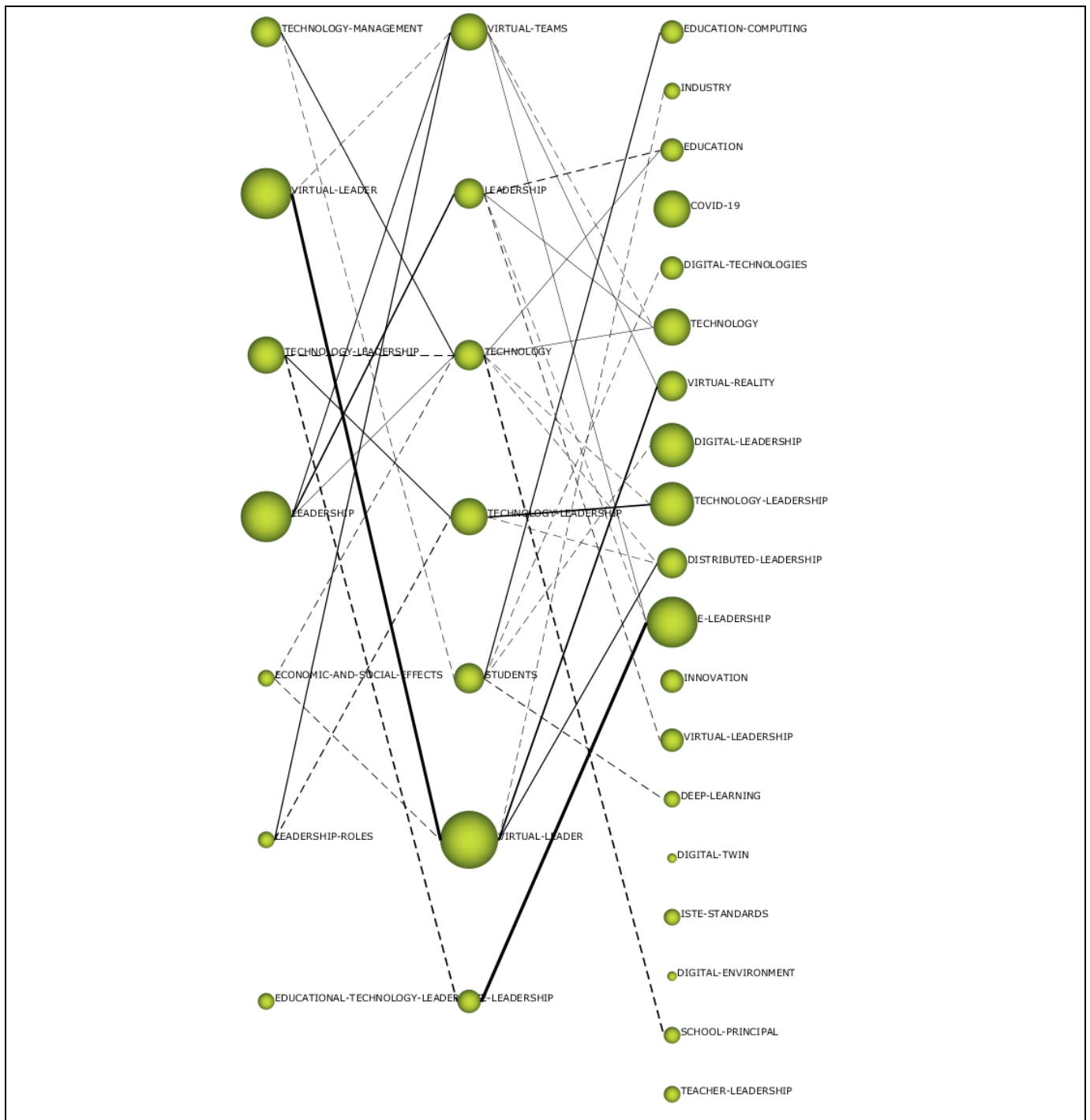


Figure 10. (a) Overlapping map and (b) thematic evolution map. Source: SciMAT.

5. Discussion

The current study comprehensively investigated the intellectual structure and evolution of digital leadership research by combining bibliometric and science mapping analysis. The results reveal that research interest in digital leadership has increased exponentially. When considering the number (density) of publications, three consecutive time periods were determined to delineate the scope of the digital leadership knowledge base, as well as the emerging research trends in this field of research.

During the first period, comprising the years between 1983 and 2007, the *Technology-Management* and *Economic-And-Social-Effects* themes were found to be the main focus of

study. This could be a concrete reflection of the increasing impact of globalization. It may be said that globalization, as an uninterruptedly continuing process from the past to the present, became even more influential after the 1980s. The economic and social impacts of today's digital world are felt intensely in every part of society. In this context, international activities have further clarified the importance of digital transformation and digital leadership and have led to the portrayal of digital leadership as an intercultural type of leadership [101]. The dynamic and complex nature of new technologies has revealed the necessity of developing the existing management competencies of institutions. This important change in the economic, social, and technological environment has further fueled the need for a new type of leadership equipped with high-tech skills. In such a context, digital leaders are expected to act fast and flexibly in new organizational structures while, at the same time, the need to manage the organization's digital transformation process has become prominent [25,102].

Under the influence of globalization and digitalization, artificial intelligence, the internet of things, the sharing economy, and blockchain concepts are likely to become more evident in all areas of socioeconomic life in the coming years. Besides their associations with economics and management, these concepts are very likely to become an integral part of effective business models and global business practices [102]. While the development of digital technologies pushes organizations into a more competitive environment, it has made access to global capital, talent, and other resources much easier [89,103]. Considering the positive/negative socioeconomic effects of digitalization, which have emerged with the influence of technological developments, technology management has become even more crucial. Nambisan et al. [104] emphasized that these developments require the progression of newer theories to better understand the management of these complex processes in the digital world.

In the current study, the *Virtual-Teams, Leadership, and Technology* themes were found to be among the main themes of digital leadership research during the second period (2008–2014). In connection with the concepts of *Virtual-Teams* and *virtual leadership*, the term *virtual working* has long become popular in the business world since the development of communication technologies [105,106]. The increasing popularity of *virtual teams* in contemporary organizations has been achieved by successfully structuring the work between teams, increasing the competition, and thus reducing costs [107]. However, some disadvantages of *Virtual Teams* are also noted. For example, less supervision and control in virtual environments, the difficulty of following the flow in the virtual environment, and the fluctuations in employees' commitment to the organization, which are characterized by more freedom, were mentioned among these difficulties [108,109]. In order to overcome these challenges, virtual leaders build trust by using communication technologies, valuing diversity, monitoring team progress using technology, and managing virtual meetings [110]. It has become easier for *virtual leaders* to lead virtual teams thanks to the developments in information technologies, and the use of the internet has become more widespread in business and social areas.

Along with the more general use of the internet towards the end of the 1990s, communication tools using internet infrastructure have also diversified [111]. Thus, teams that could not meet face-to-face due to their spatial distance now have the opportunity to meet within virtual environments. Thanks to the possibilities offered by advanced communication technologies, web-based applications for project management, video conferencing, and program management have been widely used by virtual teams [112]. These emerging technological developments have also had an impact on the academic field, and research on virtual teams and virtual leadership have accelerated. The difficulties caused by the separation of time and space in virtual teams have required leaders to acquire effective management skills in the virtual environment [113,114] because leadership plays an important role in overcoming the challenges faced by virtual teams and realizing the potential benefits. Gilson et al. [3] stated that scientists examining virtual leadership focus on "leader behaviors" and "leader characteristics," as seen in traditional leadership research. Thus,

the concept of virtual leadership has found more space both in the business world and in the academic literature.

In the current study, research on digital leadership was found to center around the themes of *COVID-19*, *Virtual-Reality*, *Education-Computing*, and *Digital-Technologies* during the third period (2015–2021). The third period of the study, which constituted the years between 2015 and 2021, can be considered an era characterized by the intense impact of technology in every field, as well as wider and easier access to the internet. In addition, towards the end of this period, the world faced the onset of COVID-19, which quickly turned into a global pandemic that triggered health, economic, and social crises. During this challenging process, leadership styles, such as *virtual leadership* or *e-leadership*, have also reshaped the duties and responsibilities faced by leaders at all levels within organizations. Furthermore, artificial intelligence, robotics, the internet of things, blockchain, virtual reality, augmented reality, machine learning, big data, and various forms of digital technology have forced the management and work processes of organizations into a swift move to digital transformation. In this new era known as “Industry 4.0”, managers have also been required to transform themselves to become *digital leaders* who can direct digital transformation and become *digital change agents* within their respective organizations [115]. One of the tools that may help to facilitate the digital transformation of digital leaders is *virtual reality* because in the virtual reality context, which is a three-dimensional interactive environment created using computers, users can create and realize different experiences [116].

Virtual reality is a concept with an interdisciplinary nature that combines human sciences with engineering and has a special position in the scientific scheme. The emergence of the virtual reality concept was not sudden but rather was born out of other concepts in previous eras. Today, the use of virtual reality is widespread and ranges from science and technology to human and natural sciences. As such, virtual reality, which is essentially a part of the *Science and Technology of Information and Communication* field, has become more frequently employed within a variety of disciplines, such as psychology, physiology, neurology, robotics, and design [117]. For example, while virtual reality is often used in the field of medical and military education, it may also be applied in limited cases in the field of general education [118], which is also reflected by the number of empirical studies revealed in the field of general education that have focused on virtual reality.

It has been discussed for a long time whether or not *virtual reality* has the potential to revolutionize the field of education. It has been frequently stated in these discussions that virtual reality reveals less harmful results in possible failures and that learners can practice and apply new skills with simulation-based training. Despite these expectations, apart from special training simulators for surgeons, pilots, and military personnel, virtual reality technologies have only been applied in general education and training since 2013, when affordable virtual reality equipment entered the market, making this new technology more accessible to the wider public for the purposes of research and education [119].

Hill [120] stated that virtual reality could be beneficial in gaining leadership experience. Accordingly, a manager can seek to gain experience by practicing within a simulated environment, interacting with a virtual human (an animated character) in a real-world type scenario before facing an interpersonal problem in the office. Thanks to these social simulators, beyond one-on-one interaction, managers can more confidently recognize the complex social environment of the organization. Virtual reality, which is continually developing with breakthroughs in technology, will help to reduce the costs resulting from human mistakes that may arise during on-the-job leadership training.

In the current study, the concept of virtual reality, which is one of the main themes that emerged during the third time period (2015–2021), was found to have associations with augmented reality, artificial intelligence, and machine learning. *Augmented reality* provides an interactive experience with both real and virtual content by adding virtual information to the user’s physical environment. Users can also use their own bodies during the augmented reality experience [121,122], as opposed to that of an animated screen-based character. Although there are some concerns about the use of augmented reality in education, the

spread of mobile technologies, such as tablet computers, desktop computers, and mobile smartphones, has also influenced the research on augmented reality in education [123,124]. With the spread of advanced augmented reality technologies in educational environments, the previously expensive and complex equipment that was generally unavailable is no longer needed to construct augmented reality experiences [125]. Accordingly, the number of studies focusing on augmented reality applications has increased significantly since 2013 [126], as well as the studies on virtual reality, which is a fact also supported by the findings of the current study. Following 2015, the current study revealed that the subject of augmented reality was more frequently seen in research in the area of digital leadership.

One of the significant findings of our study is that the COVID-19 theme, which emerged during the third time period and is independent of the other two periods, clearly makes the wider influence of the COVID-19 pandemic evident in this regard. The pandemic undoubtedly changed human habits and lifestyles, as well as necessitating the redefinition of modern business strategies. It has also played a significant role in accelerating digital transformation across numerous sectors, such as the economy, health, and also education [127,128]. The pandemic created a challenging work environment for both employees and leaders, and new responsibilities have been added to those of leaders as a result. Among these responsibilities are compelling tasks such as helping staff adapt to changes in their work and social environments [129,130], initiating/accelerating the digital transformation to ensure the survival of the organization [131], and developing overall digital competency [33]. In the new organizational context shaped by the dynamics of the COVID-19 pandemic, digital leaders need to communicate extensively with the other stakeholders of an organization using multiple technology-based tools, such as e-mail, intranet, internet, video conferencing platforms and applications, messaging applications, and various other related tools [132,133].

The COVID-19 pandemic quickly unleashed not only a global health crisis but also an international economic threat. During the pandemic, when active social life was interrupted, business and industrial shutdowns imposed and enforced worldwide to prevent the spread of the virus created unique challenges for managers, employers, and employees alike [134,135]. The effects of these changes that occurred during the pandemic are believed to have survived beyond the pandemic; for example, distance education and learning, the use of digital tools in education, and open universities, which became prominent during the pandemic, are now likely to maintain their ongoing popularity [136–138]. From this perspective, academic research interest in the development of digital leadership skills can be expected to continue, both in the field of education and also in business management.

Limitations

Even though the present study contributed significantly to the literature by identifying the intellectual structure and evolution of digital leadership research, it also bears some limitations, as with any study. The dataset is limited to journal articles focusing on digital leadership indexed on the Scopus database. Although the Scopus database includes a significant number of journals and articles and is considered to be the optimum database for bibliometric and science mapping analysis, the dataset may have inadvertently dismissed some articles published in the relevant research area. Yet, the dismissal of a few of the documents would not change the results significantly thanks to the coword analysis that helps reach a broader scope of related research work.

6. Conclusions

By using digital leadership as an overarching term to refer to any type of technology-focused leadership model, the present study conducted a broad investigation into the scientific evolution of the digital leadership research field and delineated the conceptual and intellectual evolution of its knowledge base since the first article was published in 1983. It is noteworthy that the scientific evolution of the field had parallels with both technological advancements and developments in leadership literature. As evidenced by

the periodical science mapping analysis, research started with a focus on the management of technology-integrated organizations as well as the economic and social effects of these new technologies and then moved through to the investigation of leadership practices, particularly with regard to enhancing the operations of virtual teams and, more recently, to leadership practice in coping with the impact of newer digital technologies, such as virtual or artificial reality.

The present study revealed that research interest in digital leadership increased and the themes addressed by researchers diversified significantly and steadily between 2008 and 2021. Despite this widening scope of research, the mind-blowing, revolutionary changes in the contemporary digital world warrant ongoing research to provide fresh insights into the development and practice of best leadership practices that could yield positive outcomes for modern businesses and organizations where constant change has substituted the stable norm. As Kotter [139] eloquently explains, by building new systems or transforming old ones, “only leadership can blast through the many sources of corporate inertia, . . . [and] motivate the actions needed to alter behavior in any significant way”, which makes digital leadership a significant model to investigate and practice in the contemporary world of digital breakthroughs. Similarly, the research underlines that leadership is a significant factor in supporting organizations’ sustainable working and behavior by increasing its consciousness of sustainability [140], and leaders act as key actors in enabling the successful implementation of organizational sustainability by developing adaptive systems in response to the complex demands from their broader environment [141]. In this regard, the findings of the present study offer significant insights into the future investigations of digital leadership by highlighting the changing research trends and exhibiting the well/under-researched or emerging perspectives.

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Informed Consent Statement: Not applicable.

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Conflicts of Interest: The authors declare no conflict of interest.

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