Research trends on digital school leadership over time: Science mapping and content analysis

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Abstract

The purpose of this study is to map trends in literature about digital school leadership over the last decades. Combining bibliometric and automatic content analyses, we map and analyze a sample of 350 documents, retrieved in Web of Science (WoS), Scopus and Education Resources Information Center (ERIC) including titles and abstracts. The software VosViewer and Leximancer are used for analyses. Our sample is divided reflecting an early phase of digitalization in school (1992–2009), a phase of an increasing digitalization in school (2010–2020) and a phase of digitalization related to the Covid-19 pandemic (2021–2023). In general, the research literature on digital school leadership can be characterized as an emerging, fragmented, and inter-disciplinary field. Most literature is published after 2010 with an increase in publications after 2019, resulting in a peak in 2021. The literature is characterized by some influential highly connected authors revealing some changing thematic patterns over time. Further, findings highlight that when research on digital school leadership draws from various disciplines, this also indicates a need for a holistic and multifaceted approach. Scholars from different disciplines contribute to an updated understanding of digital school leadership. This interdisciplinary collaboration thus enriches the discourse, as it demonstrates how various perspectives may add new insights into the conceptualization of digital school leadership.

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1 Introduction

Schools are increasingly infused with digital technologies – for managerial, administrative, educational, and communicative purposes (e.g., Blau & Shamir-Inbal, 2017; Hatlevik, 2017). They make use of a wide range of digital resources, and digital practices are continuously changing (Vargo et al., 2021). This calls for new skills and competences for teachers and school leaders of which the latter is at the focus of this paper. Issues such as leadership and management, providing adequate digital infrastructure including hardware and software, fostering professional development for teachers, along with issues related to privacy and information security have emerged as crucial areas of responsibilities and competences for school leaders (e.g., Dexter & Richardson, 2020).

However, compared to the literature on the role of teachers in a digitalized environment (e.g., Harper & Milman, 2016) the literature addressing the school leader's role in digitalized school contexts seems to be rather fragmented and limited to geography (Korkmaz et al., 2022). It covers several disciplines, such as pedagogics, school management and technology studies, and to our knowledge, an updated and exhaustive review of the international literature is missing. Korkmaz et al. (2022) systematically reviewed the literature on trends in "technology leadership" research in education, a review limited to literature published in the Turkish language and including exclusively master theses and a doctoral thesis. The authors found an increase of studies over time, but they concluded that data from doctoral studies are not sufficient to generalize on the body of research literature in total. In a currently published systematic review of literature in English and German language over the last 20 years, Krein (2023) looked at the underlying understandings of the two concepts *school leadership* and *digitalization* in existing studies. He found few studies explicitly addressing both concepts, school leadership *and* digitalization, and thus, not the compound concept digital school leadership, the topic of our study. He highlights that most of the literature published during 2011 and 2021 covered rather superficial implications for school leaders associated with digitalization, and with different focuses or target groups. The review reveals that digitalization mainly appears to be discussed as a synonym for the use or the integration of digital devices or social networks and thus, limited to a techno-deterministic view. Socio-cultural dimensions, however, seem to be missing in the discussion of digitalization, even though they are increasingly important for school leadership. Further, the term school leadership seems to be unspecific and ambiguous, and its use in the literature appears to vary between (implicit) assumptions and the restriction to person(s) or concepts (technology) leadership. Finally, the included studies seem to focus on one task or dimension of school leadership and do not intake a broader perspective, such as digital transformation in schools. (Krein, 2023).

Moreover, while there are several understandings and research approaches towards school leadership, including instructional leadership, situational leadership, transformational leadership, distributed leadership, and leadership for learning (Daniëls et al., 2019), most focus on either instructional leadership, which

emphasizes teaching and learning, or transformational leadership, which aims to motivate staff towards school goals (Leithwood et al., 2020; Daniëls et al., 2019). Additionally, distributed leadership involves shared leadership among a team of leaders (Daniëls et al., 2019). As will be further elaborated here, the multiple areas of responsibility that school leaders are facing in schools with 1:1 coverage of digital devices, the school leader role may call for distributed leadership (Leithwood et al., 2020).

As schools in many Western countries are increasingly equipped with 1:1 coverage of digital devices for teachers and students (e.g., Harper & Milman, 2016), issues such as "platformization", interactive, online services for teachers, students, school leaders and parents (e.g., Cone, 2023, Kerssens & van Dijck, 2021), artificial intelligence (e.g., Gray, 2020) and privacy and ethical issues (e.g., Novella-García & Cloquell-Lozano, 2021) emerge. This complexity in the digital transformation of schools (e.g., Siljebo, 2020) also calls for updated leadership competences for school leaders, involving various types of digital literacies (Lindqvist & Pettersson, 2019; Reis-Andersson, 2023).

To get a systematized overview over the research literature on digital school leadership and its social and cognitive structure, we apply an approach using bibliometric methods such as network analysis, science mapping and automatic content analysis (see also: Arici et al., 2019). We take a bird's eye perspective, aiming to identify, map, systematize and describe a larger amount of literature. This is in contrast to Krein (2023), who in his systematic review narratively interpreted the literature according to understandings of school leadership and digitalization separately, to provide a broader starting point for discourse.

For years, researchers have studied teachers' self-efficacy, pedagogical beliefs, and practices towards integrating digital technology into teaching (e.g., Tondeur et al., 2012; Fernández-Batanero et al., 2020; Tømte et al., 2023). A key message from these findings is the need to involve school leaders in the implementation of new digital technology and for facilitating teachers' professional development towards digital competence (Islam & Grönlund, 2016). Moreover, it is suggested that school leaders differ significantly in their views on digitalization (Lindqvist & Petterson, 2019; Dexter & Richardson, 2020). With the aim to map the literature of a fragmented, but dynamically increasing field, we address the following questions:

1. When and where is the research published (publication year, journal, country), who are the main researchers of the field and how are they connected to each other?
2. What are the main themes and concepts related to digital school leadership and how have these developed over time?

Guided by these research questions, our contribution will bring an updated overview of the literature that addresses how and where this body of research has developed over time, across different country contexts. Moreover, we provide new insights on which research communities have been involved in this work, and

which themes and concepts have evolved in the literature over time. As demonstrated, this type of mapping review is missing in the academic body of literature, which is why we believe that findings from our study will serve as an important contribution to researchers and as a point of departure for future studies on digital school leadership on a more detailed level.

2 Method

2.1 Mapping review with bibliometric methods

As a type of "review research" (Kunisch et al., 2023) mapping reviews address a broader field or broader question than traditional systematic reviews. Their main objective is to investigate a research field mainly from a bird's eye perspective. Further, they define and examine geographic and conceptual boundaries around a specific topic with the aim of identifying knowledge gaps to inform further research (Grant & Booth, 2009). Distinguishing between different purposes of review research, Kunisch et al. (2023:12 f.) define representation as one of the main purposes of mapping reviews with the aim to describe the components of a topic in the literature and the relationships between studies e.g., by citations and reference lists, making it possible for researchers to interact with complex fields. Addressing a broader scope and drawing on large datasets, mapping reviews often apply bibliometric analyses summarizing large amounts of meta-data to visualize and map the state of the intellectual structure and emerging trends of a topic or field of research (Donthu et al., 2021), such as the topic of digital school leadership.

Using a pre-defined protocol is a core feature of the systematic review methodology, including scoping and mapping reviews. A protocol was registered in Open Science Framework (OSF) (Wollscheid et al., 2023). Further, this review was further informed by the Preferred Reporting Items for Scoping Reviews (PRISMA-Sc) statement providing standards for reporting scoping reviews (Tricco et al., 2018).

2.2 Data collection

2.2.1 Information resources

We conducted systematic searches in the following three complementary indexed databases, which included bibliometric metadata. To increase coverage of relevant documents in the field we used two general databases (WoS, Scopus) and one specialized database (ERIC) to retrieve our sample.

The *Web of Science Core (WoS)* Collection (1975–present) comprises the world's leading scholarly journals, books, and proceedings in the sciences, social sciences, arts and humanities, and navigates the full citation network. In WoS, we were able to limit the literature according to publication type and language (English). *Scopus citation index* contains records going back to 1823, but it is only consistent in indexing from 1996 onwards. Both WoS and Scopus are considered high-quality sources

for bibliometric analyses (Singh et al., 2021). *Education Resources Information Center (ERIC)* provides coverage of journal articles and a range of other publication types published since 1966. We used an adapted version provided by the commercial service ProQuest covering a wide range of subjects.

While WoS and Scopus provide bibliometric data of high quality, their degree in coverage is lower for journal articles published in other national languages than English, for publications in the Social Sciences and Humanities, for book chapters and monographs (e.g., Aksnes & Sivertsen, 2019) and for publications on interdisciplinary themes, like those studied in this article. Further, both databases have shown to have a geographical bias against literature from non-Western countries (Tennant, 2020).

Thus, we carefully assess our findings considering these limitations in data collection: lower coverage in the Social Sciences and Humanities, interdisciplinary topics and literature in other languages than English and literature from the Global South that might be of thematic relevance. To address some of those limitations, we additionally retrieved ERIC, a specialized database in education. (see also Heck et al., 2023).

2.2.2 Eligibility criteria

Our review includes empirical studies and conceptual papers dealing with digital school leadership over time and across countries. We included research published in English since 1945 and forward. To identify relevant documents, our search strategy was informed by inclusion and exclusion criteria drawing on the Population-concept-context framework recommended by the Joanna Briggs Institute (JBI, 2015) for mapping and scoping reviews (Peters et al., 2015).

We included studies dealing mainly with digital school leadership, and therefore excluded articles that secondarily mentioned digital school leadership (e.g., in implications). We further excluded references with insufficient information (in the abstract). Documents missing an abstract were included during the first round if they were explicit on school leadership and technology in the title, but excluded if full-text article was difficult to retrieve. Further, we excluded studies dealing with future school leaders, i.e., students to become school leaders in a preparational program (Table 1).

2.2.3 Literature search

We evaluated a couple of searches with different combinations of key words. After consultation with the review team and the research librarian at the University of South-Eastern Norway, we ended up with one search string (piloted in WoS). The search string was further developed, and quality assessed by the fifth author of this article. The search in the databases WoS, Scopus and ERIC generated a total of 2308 hits. The following search string for WoS was used:

Table 1 Eligible criteria

	Inclusion criteria	Exclusion criteria
P-population (Who?)	School leaders/managers in primary and secondary education (school leaders)	Leaders of early education schools/pre-education institutions Leaders in tertiary education; higher education Future school leaders Management Information systems only
C-concept (What?)	Digital school leadership	Educational leadership in general or in times of crisis (Covid-19 pandemic)
C-context (With what qualifiers?)	School education	Other educational contexts, e.g., higher education System perspective: Learning management System Covid-19
Timespan	No time limit	-
Publication status	Peer-reviewed journal articles	Books Conference proceedings Reports Publications difficult to retrieve electronically.
Language	English	Languages other than English
Design	Theoretical and empirical articles	Non-research
Geography	All	-

TS=(("one-to-one" OR digital* OR "1–1" OR "e-learn*" OR "m-learn*" OR "Information technolog*" OR ICT OR tech*) AND ("school leader*" OR "school principal*" OR "school manag*" OR "school rector" OR headmaster OR "school organi*" OR "school governance")) and English (Languages) and Article OR Early Access OR Review Article (Document Types) (Date: 26.04.23, 936 hits)

2.2.4 Assessing the scope of the search

By systematically searching in three databases, we aimed for retrieving a comprehensive set of records for the time span 1945–2022 and for scientific articles in English language. For the Social Sciences and Humanities literature, coverage in Scopus is somewhat broader than that in WoS. However, given a large overlap in coverage, the two databases indicate the same patterns of flaws, which means a relatively low coverage of publications in the Social Science and Humanities, and of literature published in national languages other than English, which includes other publication types than scientific journal articles (Aksnes & Sivertsen, 2019). We therefore limited our sample to peer-reviewed journal articles published in English.

2.2.5 Screening of studies

For manual screening we imported all references from our searches in WoS, Scopus and ERIC into the Covidence software.[1] Duplicates were removed automatically by Covidence. The fifth author double checked the list of duplicates and removed two additional duplicates that had not been removed automatically. For validation purposes, a pilot sample including 25 references were screened by three researchers and in case of conflicts consent was reached by discussion between the first, second, and third author. Thereafter, the next 500 references were screened by the first and third author for further validation, then the remaining references were screened by the first author. Unsure cases were discussed between the first and third author until consent was reached. The eligibility criteria informed the screening process for titles and abstracts, which had been revised after the validation phase. We further revised research questions and eligible criteria in consequences of the first screening. Figure 1 shows the data selection process starting with identification of references in the three databases over screening to inclusion of studies. Of 3,128 references retrieved from the three databases, 820 duplicates were removed, and 2,308 references were screened, resulting in 379 references. Among these 29 were excluded after a new round of screening, resulting in 350 references (documents) for inclusion.

The original sample consisted of 350 documents stored in a spreadsheet. Further, meta-data of documents were used and retrieved in the VosViewer software for the science mapping and network analysis. However, not all meta-data of the 350 documents could be retrieved due to technical problems, missing identifiers for analyses by VosViewer (dois) etc.
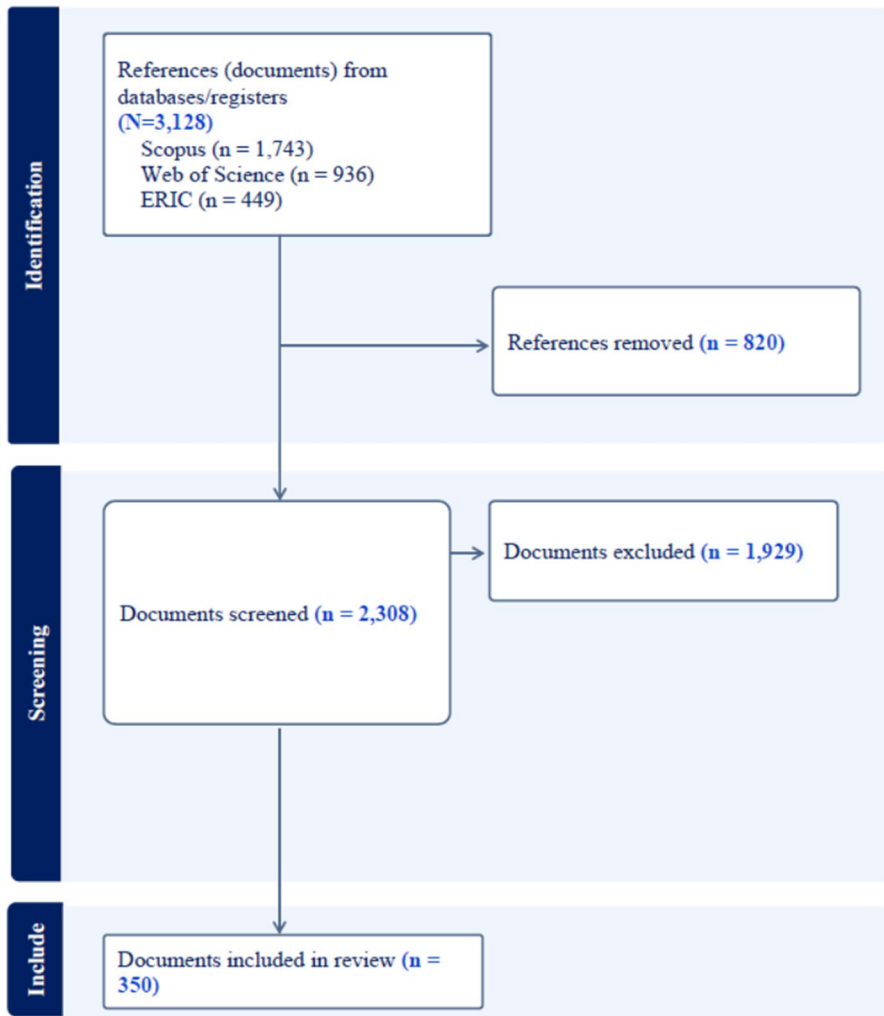
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[1] https://www.covidence.org/.

Fig. 1 PRISMA diagram: Data collection

2.2.6 Data analysis

Science mapping and network analysis Given the broad scope of this review, we use science mapping and network analysis techniques to describe the intellectual and social structure and emerging trends of the topic over time. We apply different techniques of science mapping such as co-citation analysis (Callahan et al., 2010), keyword co-occurrence analysis (Zhao et al., 2018) and bibliographic coupling (Donthu et al., 2021). For this, we use VosViewer, a tool for visualizing bibliometric networks consisting of nodes (e.g., publications, researchers) and edges showing relations between pairs of nodes (Van Eck & Waltman, 2014).

Citation analysis explores relationships between publications based on the assumption that citations reflect intellectual relations between publications formed when one publication cites the other (e.g., Donthu et al., 2021; Osareh, 1996). Citation analysis can be used to identify highly influential publications (Donthu et al., 2021) and the interdisciplinary character of a research field (Osareh, 1996). *Bibliographic coupling* draws on the assumption that two publications sharing common documents are also similar in terms of their content (e.g., Kessler, 1963, cit. in Weinberg, 1974). Bibliographic coupling investigates relationships among citing publications to identify common themes in a sample of literature (Donthu et al., 2021).

While citation analysis and bibliographic coupling focuses on documents or publications as the unit of analysis, that of co-word analysis are words, which means that it explores the content of the publications (Donthu et al., 2021). Keywords are retrieved from titles, abstracts, author keywords or from full texts. The analysis draws on the assumption that words that frequently appear together are also thematically related to each other (Zhao et al., 2018). Co-occurrence analyses of concepts means that the relatedness of concepts is determined depending on the number of documents in which they are linked together. Here, we used fractional counting, which means that the weight of a link is fractionalized according to the field and year context in which they appear.

Automatic content analysis in Leximancer For automatic content analysis and a cognitive analysis of the field, we use the text mining software Leximancer version 5.0 (Leximancer Pty Ltd.), providing a detailed overview of the data.[2] A complete data set of included documents ($N=350$) with title, abstracts, and meta-data (publication period), was analyzed. As a form of bibliometric software Leximancer extracts textual documents identifying core concepts, words and themes and presents them as concept maps of interrelated words together with their levels of relations (Crofts & Bisman, 2010). One of its strengths is to eliminate researcher bias in coding large amounts of texts, as the software automatically and objectively codes and analyses text sources and their parts (Smith & Humphreys, 2006). Leximancer produces a thesaurus of words and phrases (i.e., themes), which are then converted into concepts on the ground of contextual similarities according to groups of concepts (e.g., Lemon & Hayes, 2020). It conducts two stages of extraction from episodic co-occurrence information, named as semantic extraction, followed by a sequence of relational extraction (Smith & Humphreys, 2006). In other words, the algorithm of concept and theme mapping draws on the hierarchy of appearance and relational extraction taken from Bayesian decision theory (Stemler, 2015). The algorithm automatically detects co-occurring phrases and words and identifies significant semantic patterns and networks among concepts applying non-linear dynamics and machine learning (McDonald & Kelly, 2020).

Thereafter, a visual display, a concept map, is automatically created. The concept map graphically represents themes and conceptual relationships of any given text data, for example titles and abstracts (Cruz & Kim, 2023; Sotiriadou et al., 2014). The important features of the concept map comprise 1) colors, indicating the level

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[2] https://www.leximancer.com/science.

of importance of each theme (hot colors indicating the highest importance) and size of theme, revealing the level of clustering appearance of a concept with other concepts. This means that clusters of concepts are denoted "themes" that can vary from hot (red, orange) to cool colors (blue, green). The Leximancer program provides the statistical results of the text mining analysis, comprising *hit counts*, a frequency indicator of world-like concepts given in a dataset, *relevance* pointing to the co-occurrence of world-like concepts estimated as a percentile rate and *connectivity*, the sum of all the text co-occurrence counts of any given concept with every other concept on the concept map (Cruz & Kim, 2023). An advantage of this tool is to inform the researcher about the global context and significance of concepts, contributing to avoiding fixation on anecdotal evidence (Smith & Humphreys, 2006). Thus, the tool provides us with a bird's-eye perspective on the emerging literature and the development of core themes related to digital school leadership over several periods of time.

3 Findings

3.1 Science mapping and network analysis findings

1. When is the research published, where is the research published (institution, country), who are the main researchers of the field and how are they connected to each other?

The first research question addressed a bibliometric description of the published literature on digital school leadership. For publication period, most of the research is published after 2010. At the same time, there is an increase in publications after 2019, resulting in a peak in 2021 with 50 publications, which could be interpreted as an effect of the 2020–2022 Covid pandemic where schools in many countries resorted to online schooling. We thus divided the sample of publications into three groups according to the following time periods: 1992–2009, 2010–2020, 2021–2023. The first time-period (1992 − 2009) can be described by the infusion of technology, the establishment of high-speed internet connection and infrastructure and teacher training (OECD, 2002), while the second period (2010–2020) can be described by maturation of digital resources and teaching practices facilitated by the digital agenda for Europe (European & Commission, 2014), followed by the last period (2021–2023) influenced by the Covid-19 pandemic and the need for further digital transformation (Fig. 2).

The included 350 documents were published in 220 different scientific journals in total, which indicates a high fragmentation and distribution of the literature over different publication channels. A complete list of scientific journals can be found in Appendix 1. Figure 3 shows publications in journals with at least three studies included. The included studies are published in journals in the fields of education, administration and management and technology studies. Journals where most papers are published are the Journal of Educational Administration (12 publications), Educational Management Administration & Leadership (11 publications), International
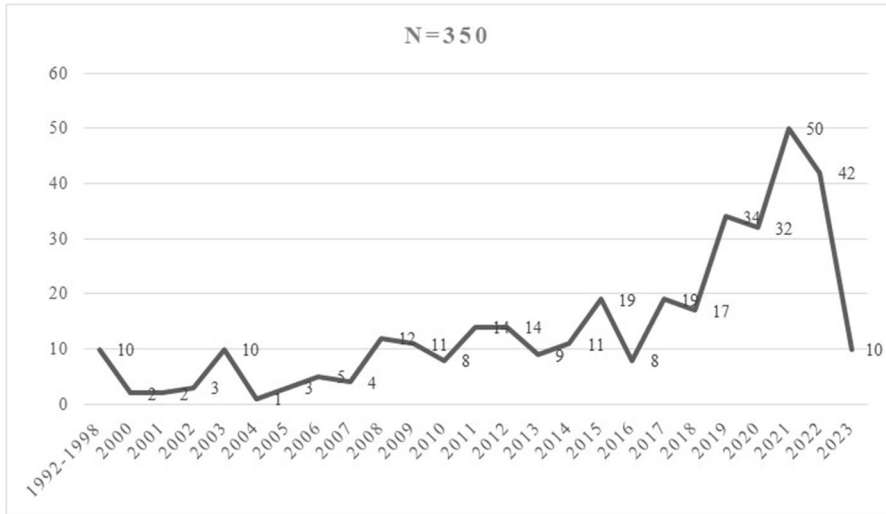
Fig. 2 Trends in publication: 1992–2023

Journal of Leadership in Education (9 publications) and Computers & Education (7 publications). Publications are widely spread across different journals. Only a few journals show a high concentration of publications, which might have an influence on citation behavior and the development of the field, assumed to be less intellectually stratified and more fragmented compared to more self-referential fields like economics (Kapeller et al., 2017).

In sum, the journal analysis shows a wide distribution of included studies, which means that only a few included studies are concentrated on certain journals. This might have an influence on authors' citation behavior and connections.

To identify the main researchers in the field, and connections between documents per country, we apply citation analysis and bibliographic coupling. Citation analysis study documents that are connected to each other by citation. In the following, we considered the geography of connected papers.

Figure 4 shows citations connections between author country affiliations in the sample. Larger nodes correspond to more highly cited papers on average. The sample shown is based on metadata of documents with at least 5 connections to other documents in the sample, which means that documents that are not cited by any of the included documents are left out. 17 items forming four clusters were included in the analyses below. Most connected papers by citation are published by authors located in the US (40.97 normalized citations). As a small country, Norway has a relatively high score, with 14.94 normalized citations, showing high similarity with Indonesia, Israel, and Hong Kong, countries forming one cluster of a set of closely related nodes: Publications from Sweden have a similarly high score (14.76 normalized citations) than Norway (14.94), and publications from authors located at Swedish institutions are closely related to publications from Belgium, the United Kingdom, and the Netherlands (Van Eck & Waltman, 2014).
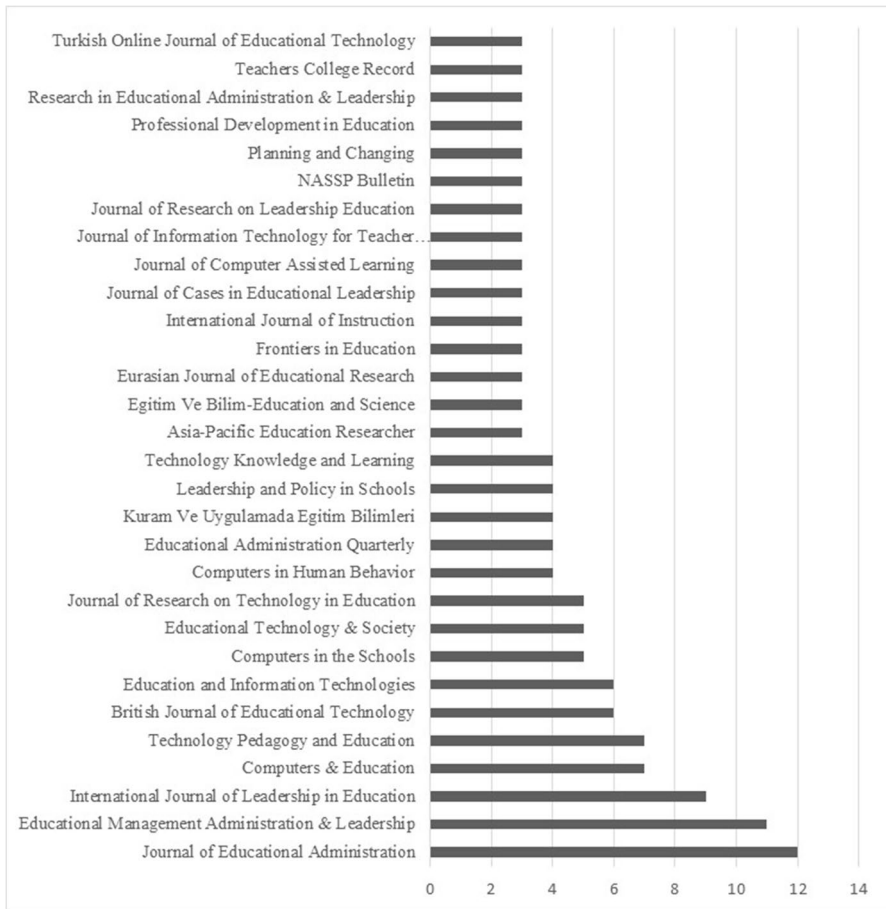
Fig. 3 Journals where most papers are published (with at least three publications)

Publications from authors located in Australia (28.70 normalized citations) are closely connected to those from authors located in Spain, Ireland, and Germany. (The complete overview over clusters, normalized citations per country, links, and their strengths can be made available on request).

To identify the main researchers in the field, we first identified first-authors, and number of (co-)authored papers. Figure 5 shows first-authors, who authored two or more papers. Only three authors in the sample have authored/co-authored five or more papers. Most authors have published one paper (not shown in Fig. 5) or two papers. Only three first-authors have (co-)authored five or more papers (Vanderlinde, R.; Blau, I.; Afshari, M.).

As a reminder, bibliographic coupling draws on the assumption that two publications with common documents are also similar in their content. Bibliographic coupling explores relationships among citing publications to identify common themes (Donthu et al., 2021). Figure 6 shows 7 clusters with at least 20 items connected by
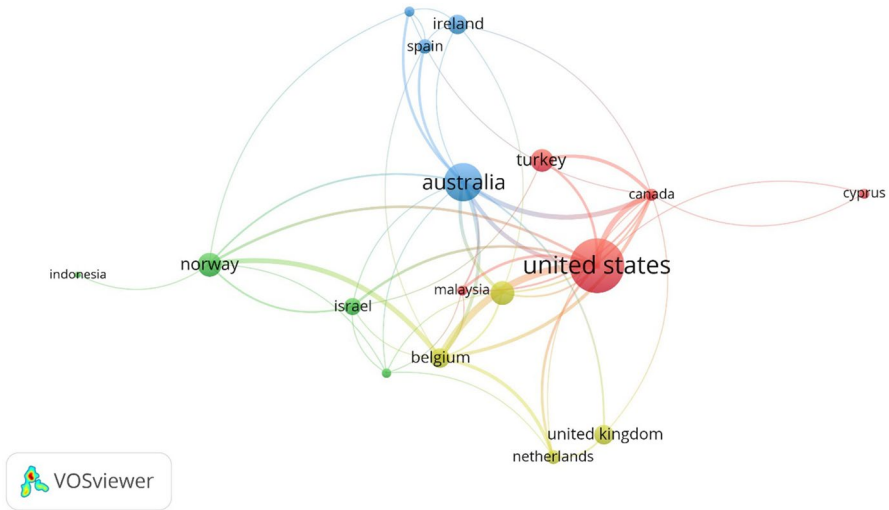
Fig. 4 Citation analysis – Unit of analysis: Geography of connected papers (*N*=17)

reference list, based on the relatively small sample of 35 items in total that remains after removing non-connected papers. The low connectivity illustrates a relatively high fragmentation of the field in terms of the literature by different publications references. The relatively small clusters of documents support our assumption of a rather heterogeneous and interdisciplinary literature. (The complete overview over clusters, normalized citations for all items, and links can be made available on request).

3.2 Content analyses findings and findings of the intellectual structure

As a reminder, content analysis is a research tool for determining the presence of words in samples of textual documents for breaking up the material into a countable number of categories and relationships to quantify and visualize text. It is required for building a reproducible and computable model of a very complex and intuitive information space (Smith & Humphreys, 2006). In our study, we conducted automatic content analyses based on a sample of documents including titles and abstracts.

3.2.1 Concept map covering literature over the period 1992–2023

Covering the whole time-period 1992–2023, the Leximancer concept map revealed three overarching themes or main concepts, each including several concepts, ranging according to their relevance from principal, school, to technology (Fig. 7). The three themes had hit counts ranging in their importance from 1518 (school: red), 1133 (teachers: green) to 1006 (technology: blue).
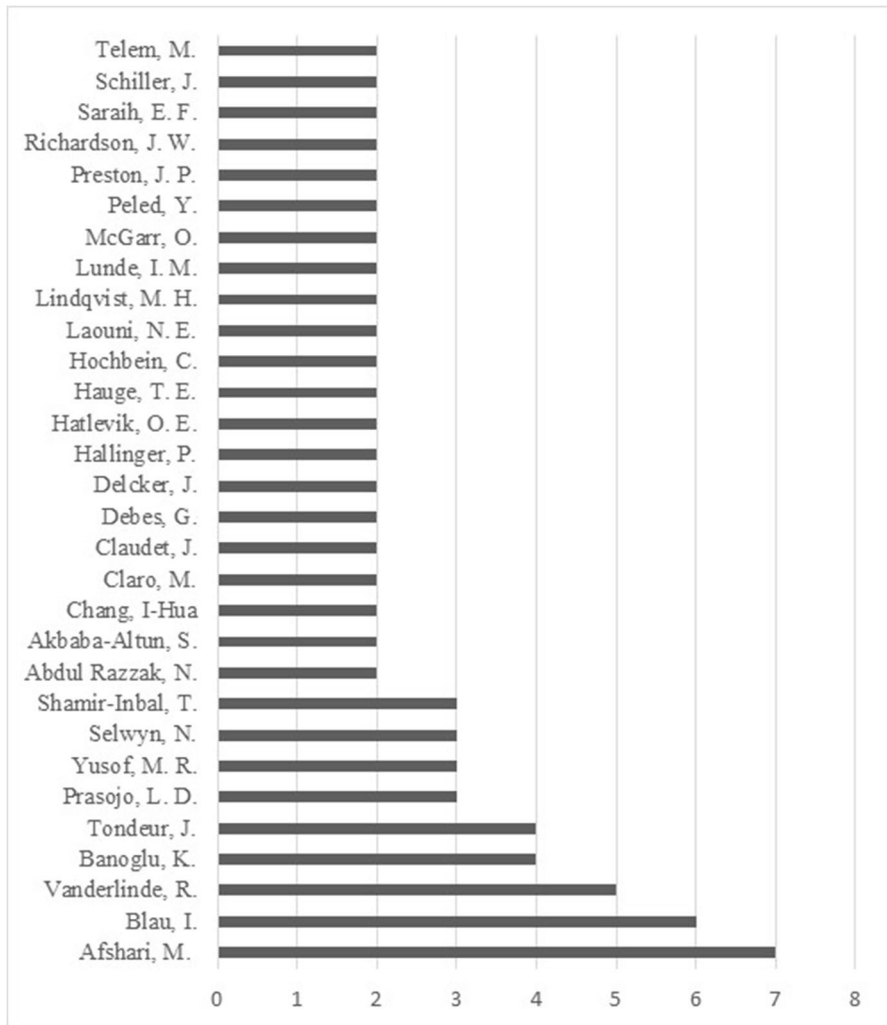
Fig. 5 Number of authored/co-authored publications by authors with at least 2 publications

Figure 8 shows concepts that reached 100 frequency hits and more. Principals (537), school (500) and technology (500) were concepts with the most frequent hits, followed by leadership (381), teachers (374) and leaders (288). Concepts not shown on Fig. 8, with least frequent hits, were e-leadership (4), virtual (8) and technical (10).

3.2.2 Changes in the intellectual structure over time

According to the assumption on three phases of digitalization, we divided our sample according to three time periods reflecting an early phase of digitalization in school (1992–2009), an increasing digitalization in school (2010–2020) and a digitalization in school during the pandemic (2021–2023).
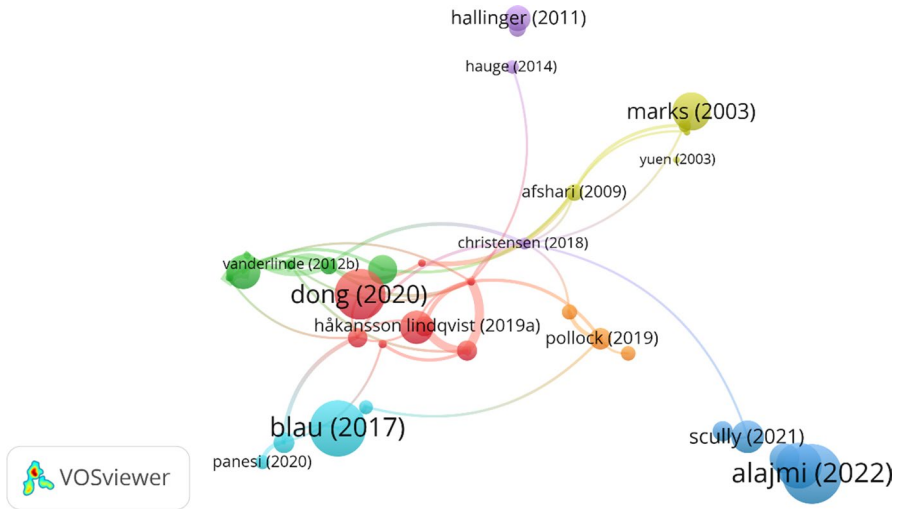
Fig. 6 Bibliographic coupling ($N=35$ items, 7 clusters, 139 links) – fractionalized counting

Figure 9 shows the development of the co-occurrence network over the three periods. The figure maps the complete network over the whole period, with the connections between nodes showing the network as it appears in each of the periods. The increasing density of the network corresponds to the larger publication output shown in Fig. 2. There are two main developments revealed by this picture: first, that the "core" fields of the digital school leader literature, i.e., pedagogy, sociology, philosophy of education and psychology, remain at the center of the co-occurrence network, and secondly, that there is a shift in the peripheral concerns of the field over time. Whereas the first period contains frequent mentions of psychiatry and leadership style, the middle period shows a growing concern with marketing, social media, and other economic concerns ("value" being a new well-connected node). The last period naturally contains many terms connected to the Covid-19 pandemic, but there also seems to be added focus on methodological issues in the literature (see "focus group" and "exploratory research"). The full node weight table can be made available on request.

3.2.3 Changes in themes over time

The concept map over themes for the three periods shows a change in connectivity of themes and a change in size and number of themes. As a reminder, connectivity is defined as the sum of all the text co-occurrence of any given concept with every other concept on the concept map (Cruz & Kim, 2023).

The analysis for the first period (early phase of digitalization) reveals five thematic clusters comprising the themes school (216 hits), technology (172 hits),

Description

Theme (hits)	Included Concepts
School (1518)	**school, principals**, education, educational, digital, students, management, secondary, secondary and school, pandemic, Covid, social, training, impact, survey, technical
Teachers (1133)	teachers, **leadership**, learning, leaders, development, practices, teaching, support, professional, challenges, online, resources, instructional, work, knowledge, digital and school and leadership, culture, skills, pedagogical, time, context, public, virtual
Technology (1006)	**technology**, ICT, information, integration, implementation, systems, communication, role, policy, administrators, process, change, technological, level, model, curriculum, e-leadership

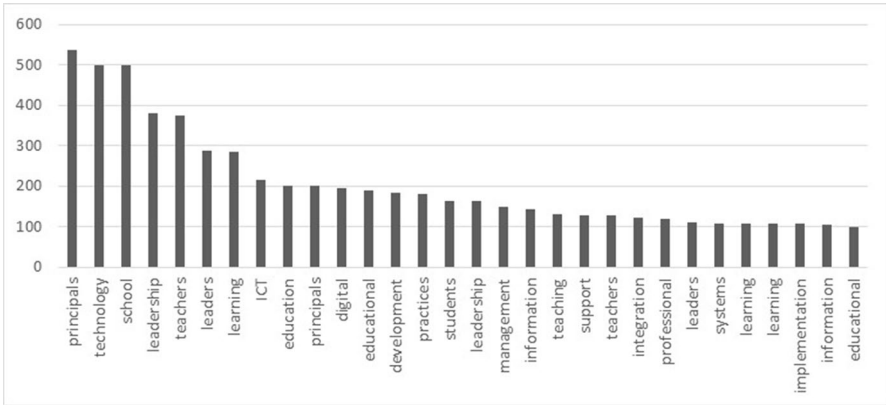**Fig. 7** Concept map of the literature published between 1992–2023 ($N=350$)

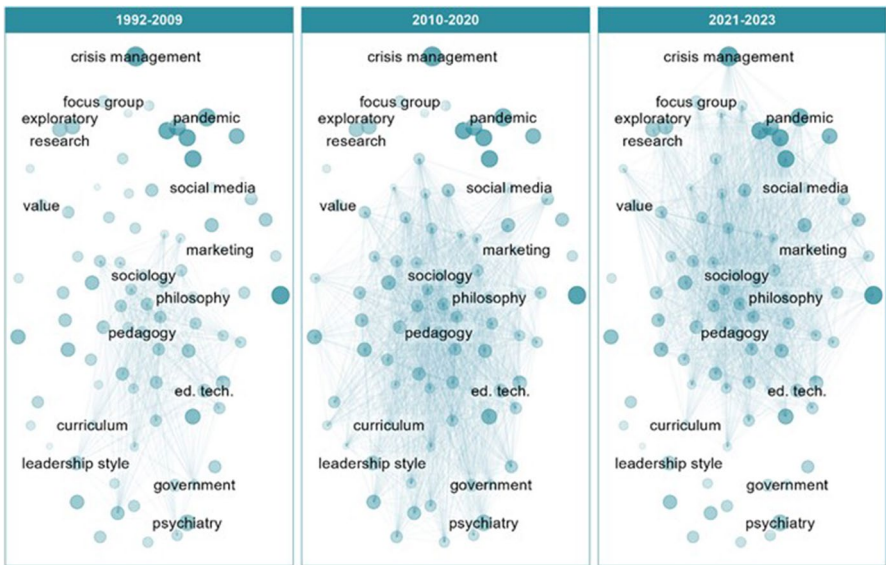**Fig. 8** Concepts with 100 frequency hits and more

Fig. 9 Co-occurrence: Field of study (min. 5 occurrences)

ICT (97 hits), education (62 hits) and students (11 hits), among them technology as the most important theme followed by school (Appendix Table 2).

For the second period (increasing digitalization), the analysis reveals a different picture, revealing five thematic clusters comprising school (789 hits), leadership (576 hits), ICT (387 hits), education (316 hits), distributed (30 hits). Among these, school turns out to be the most important thematic cluster showing the highest connectivity, followed by leadership and ICT. This pattern changes again in the third period (pandemic) (Appendix Table 3).
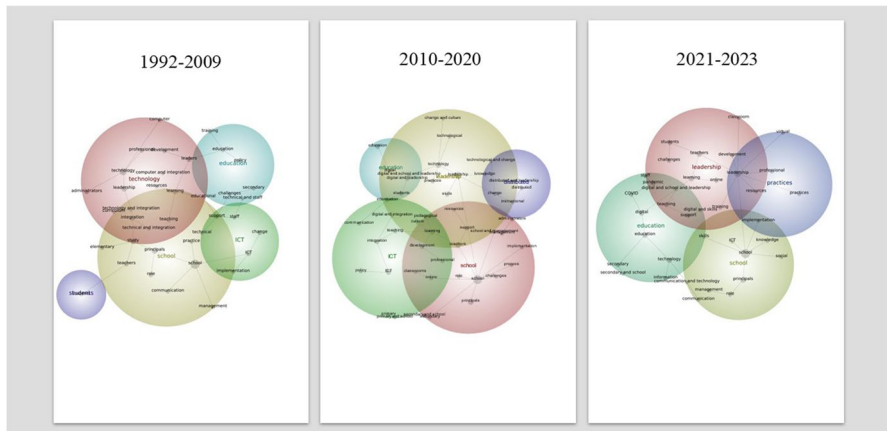
Fig. 10 Concepts maps for the three time periods

For 2021–2023 the concept map comprises four thematic clusters of relatively similar size comprising the themes school (503 hits), leadership (370 hits), education (347 hits) and practices (150 hits), among them leadership as the most important thematic cluster, followed by school, education and practices. The theme education comprises Covid and pandemic as related concepts, in addition to concepts like digital leadership, digital, technology, support and staff (Appendix Table 4).

Focusing on the most important theme, we observe a change in priorities in the literature from technology (red) in the first period over school (red) in the second period to leadership (red) in the third period, as the most important concepts. The theme school seems to be decreasing in importance during the pandemic, i.e., the third period, while leadership and practices seem to increase in importance that period, which is not surprisingly due to the necessity of home-schooling and alternative forms of teaching and education (see also Appendix 2).

Concept maps in Leximancer are primarily regarded as an explorative tool to visualize core findings and trends over time. To further quantify our results, we use the statistical results of the text mining analysis in Leximancer, comprising *hit counts*, a frequency indicator of concepts given in a dataset, *relevance* pointing to the co-occurrence of world-like concepts estimated as a percentile rate and *connectivity* (Fig. 10).

Figure 11 shows changes in the relevance score as computed by Leximancer over the three periods. Overall, the relevance scores remain fairly stable, there is for example just a slightly noted reduction in the relevance of "school". However, there is a significant reduction of the "technology" concept with 10% points, from 18.9 per cent (1992–2009) to 8.8 per cent (2021–2023), while the concepts of "leadership" and "teachers" increase in importance over time. The concept leadership, for example increases in relevance, from 10.4 per percent (1992–2009) to 15.9% (2021–2023).
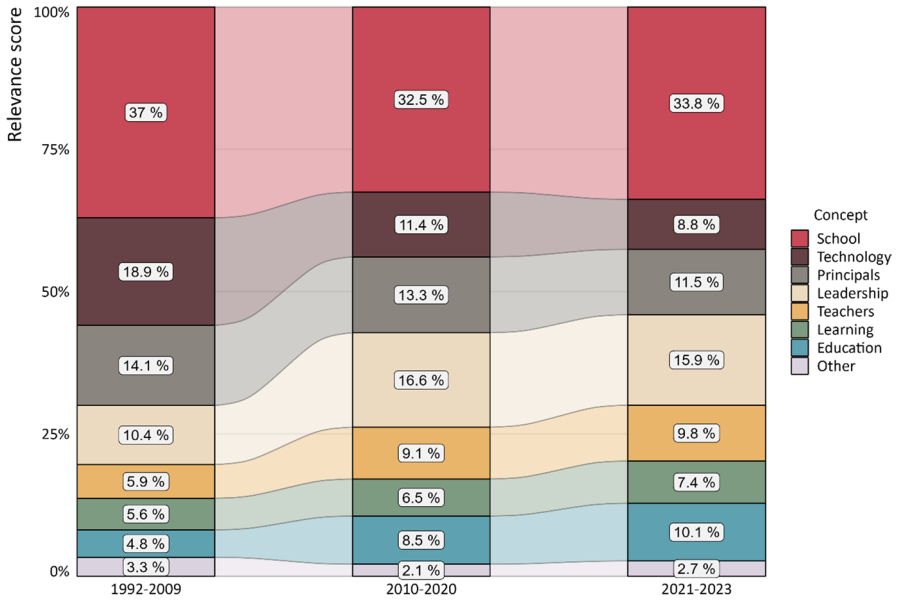
Fig. 11 Development of concept relevance over three time periods

This change in concept relevance can be read in conjunction with the changes in the co-occurrence network shown in Fig. 9 to indicate a move away from discussing specific technologies in the realm of digital school leadership and towards the socio-technical context of the technology – questions of value in digital school leadership or the effect of marketing and social media.

4 Discussion

Our systematic mapping review addressed the following research questions: When and where is the research published (institutions, country), who are the main researchers of the field and how are they connected to each other? What are the main themes and concepts related to digital school leadership and how have these developed over time?

In general, we found that research addressing digital school-leadership can be characterized as an emerging field of research, that originates from various disciplines. Our findings indicate that most of the research is published after 2010, with an increase in publications after 2019, resulting in a peak in 2021. We may interpret this development as a "pandemic effect", meaning that the Covid-19 pandemic forced/motivated increased use of digital technologies to maintain schooling during periods of lockdowns to enhance emergency remote teaching (Crompton et al., 2021), and that school leaders played a central role in these processes/this development. In addition, another interpretation of this finding may relate to the overall development of digitalization in schools from 2010 and onwards. There is reason to

believe that there is an increase of digitalization in schools, for example caused by the density of one-to-one coverage of digital devices (e.g., Munthe et al., 2022, Tømte et al., 2020), which again has attracted the attention of researchers to study the trend from a school leadership perspective.

The aims and objectives of the research on digital school leadership have also developed over time, and this development can be seen in relation to the timespan under study, as previously suggested. While the earliest research addressed issues on school leadership involving teachers and organizational dimensions, more current research has been concerned with various technological changes caused by the pandemic, such as emergency remote online teaching and the increased density of implementation of 1:1 coverage of digital devices for students and teachers (e.g., Krein, 2023; Timotheou et al., 2023; Siddiq et al., 2023).

While the research literature on digital school leadership in the earliest period had a certain eye on schools and schooling, our findings indicate that various topics related to digital technology have gained ground in the latest period. Moreover, our findings may indicate that in the most recent period under study, there has been less attention from the conventional literature on school leadership and management on issues targeting digitalization, but an increasing attention is observed in disciplines such as pedagogics and education research. This issue calls for attention as it may limit further development of digital school leadership. As suggested here, the complexity of digital school leadership calls for a diverse set of disciplines to fully understand its potential, and our findings may indicate weakening of attention from the management and school leadership research strand of which we would like to see strengthened to ensure a holistic approach.

The digitalization of societies, including the education system, and schools are likely to demand competent school leadership, calling for updated skills and expertise for school leaders on how to handle these new contexts. Nonetheless, while there is quite comprehensive body of research elaborating on teachers' professional digital competence (see for example Skantz-Åberg et al., 2022 ; Willemark et al., 2023), less is known on school leaders' professional competence (Pettersson et al., 2024). Moreover, there is reason to believe that school leaders would need other skills and competencies than their teachers when it comes to digitalization in schools, including implementation of technology, awareness of new technological trends, ensure privacy and ethical dimensions in the digital technologies in use, along with facilitating professional development for teachers, As noted, to meet this new situation, the research literature on school leadership suggests a trend towards distributed leadership, involving teams of leaders that may handle this new complex situation (Dexter & Richardson, 2020). Moreover, digital school leadership as an emerging field with interdisciplinary origins holds significant implications for the academic community, educational practitioners, and policymakers. This development underscores the evolving nature of educational leadership in the digital age, with several notable implications.

For example, our findings highlight that when research on digital school leadership draws from various disciplines, this also indicates a need for a holistic and multifaceted approach. Scholars from education, information technology, management,

and other related fields contribute to an updated understanding of digital leadership in schools. This interdisciplinary collaboration thus enriches the discourse, as it demonstrates how various perspectives may add new insights into the conceptualization of digital school leadership.

Moreover, digital school leadership as an emerging research field may indicate a dynamic and rapidly evolving educational landscape. Educational institutions are coping with the integration of digital technologies, necessitating leaders who can navigate this complex environment. Hence, there is a need for ongoing research to keep pace with the continuous developments in educational technology and how they impact school leaders. As noted, compared with the research literature targeting teachers' professional digital competencies, less is known about school leaders' professional digital competencies and how it may impact their leadership of the schools.

5 Concluding remarks

Applying an approach combining science mapping, network analysis and automatic content analyses, the aim of our review was to paint a broader picture of the fragmented and dynamically evolving literature on digital school leadership from a bird's-eye perspective.

5.1 Limitations

This science mapping approach addressing an open and broad question implies a limitation in analytical depth, focusing rather on a description of the literature and its intellectual structure based on meta-data instead of an analysis and synthesis of findings.

Another limitation might be the selection of three complementary databases that differ in disciplinary coverage and types of publication to achieve a broad coverage of the literature. We can, however, assume that parts of the relevant literature, in particular literature within specific fields in social sciences and humanities, are either not fully indexed in the bibliometric databases chosen or published in other national languages than English (Tennant, 2020; Sivertsen, 2019; Aksnes & Sivertsen, 2019), and thus not considered in our study.

Finally, our data can be characterized by a geographical bias against non-Western countries. According to Tennant (2020), the content of the two core databases WoS and Scopus used here is structurally biased against research conducted in non-Western countries, the Global South. We can assume that there exists literature on the topic of digital school leadership in countries in the Global South of a substantial size. As such, interpreting the claims in this article outside the context of the English-language literature in journals or publishers that are indexed in our sources carries with it the risk of overlooking potentially relevant contributions and perspectives.

5.2 Implications for further research and practice

To address these limitations in data collection and sources, further science mapping studies in these fields could focus on specific country contexts and combine international bibliometric databases with national databases (Sile, 2021) to account for heterogeneous publication patterns and multilingualism (Sivertsen, 2019).

Second, given limitations in geographical bias in favor of Western countries, we might replicate our study drawing on alterative data sources, such as OpenAlex, that are more inclusive in terms of literature in other languages than English and from non-Western countries, such as Asian countries, which might be of particular interest for our topic.

Third, while our study has had a broader scope in mapping literature on digital school leadership, our findings might inform further in-depth studies with a more specific scope. These studies could build on a smaller, more homogeneous, corpus of studies, for example limited to studies from "early adopting countries" (Rogers, 2010) such as Norway and Sweden, for qualitative thematic analysis and synthesis of findings of full-text articles. Here, we recommend supplementary searches, typical for the social sciences (Papaioannou et al., 2010), to identify additional documents in national languages of these countries such as Norwegian and Swedish to account for multilingualism. Thus, to obtain further insights and to further understand the concepts of digital school leadership, we encourage the research community to continue to explore this research topic from a more detailed perspective by utilizing qualitative text analysis methods to facilitate the systematic analysis of information-rich and key articles in a more organized way, with well-defined concepts and themes that are more logical and comprehensible to grasp. Further bibliometric analysis could help to identify highly cited/influential articles and research communities.

Finally, acquiring detailed and comprehensible concepts and ideas about digital school leadership, and their associated outcomes, can lead to better school leadership that is sustainable for pupils in the future.

There are also some implications for educational practitioners. For example, school leaders are to handle emerging issues caused by digitalization such as proving a solid digital infrastructure, ensure cybersecurity, and the effective use of technology for pedagogical purposes. Simultaneously, there are opportunities for transformative leadership that harness digital tools to enhance learning outcomes and organizational efficiency. Another implication might be their need for continuous professional development to handle these new leadership challenges caused by the digitalization processes in schools. Furthermore, policymakers are to recognize this interdisciplinary research approach, and further elaborate on the need to develop policy frameworks that promote collaboration between educators, technologists, and administrators to address the multifaceted challenges posed by digitalization.

Appendix 1

Journal	Sum
Journal of Educational Administration	12
Educational Management Administration & Leadership	11
International Journal of Leadership in Education	9
Computers & Education	7
Technology Pedagogy and Education	7
British Journal of Educational Technology	6
Education and Information Technologies	6
Computers in the Schools	5
Educational Technology & Society	5
Journal of Research on Technology in Education	5
Computers in Human Behavior	4
Educational Administration Quarterly	4
Kuram Ve Uygulamada Egitim Bilimleri	4
Leadership and Policy in Schools	4
Technology Knowledge and Learning	4
Asia-Pacific Education Researcher	3
Egitim Ve Bilim – Education and Science	3
Eurasian Journal of Educational Research	3
Frontiers in Education	3
International Journal of Instruction	3
Journal of Cases in Educational Leadership	3
Journal of Computer Assisted Learning	3
Journal of Information Technology for Teacher Education	3
Journal of Research on Leadership Education	3
NASSP Bulletin	3
Planning and Changing	3
Professional Development in Education	3
Research in Educational Administration & Leadership	3
Teachers College Record	3
Turkish Online Journal of Educational Technology	3
Academic Leadership	2
Alberta Journal of Educational Research	2
Amazonia Investiga	2
ARPN Journal of Engineering and Applied Sciences	2
Australian Educational Researcher	2
British Educational Research Journal	2
Cakrawala Pendidikan	2
Cambridge Journal of Education	2
Educational Considerations	2
Educational Studies	2

Journal	Sum
Educational Technology and Society	2
EURASIA Journal of Mathematics, Science & Technology Education	2
European Educational Research Journal	2
Heliyon	2
Information Technologies and Learning Tools	2
Innovate: Journal of Online Education	2
International Education Studies	2
International Journal of Advanced Computer Science and Applications	2
International Journal of Educational Management	2
International Journal of Emerging Technologies in Learning	2
International Journal of Evaluation and Research in Education	2
International Journal of Information and Learning Technology	2
International Journal of Learning	2
Journal of Educational Administration and History	2
Journal of Information Technology Education-Research	2
Journal of International Education Research	2
Journal of Management Development	2
Journal of School Leadership	2
Learning Environments Research	2
Mediterranean Journal of Social Sciences	2
Nordic Journal of Digital Literacy	2
Sage Open	2
Scandinavian Journal of Educational Research	2
School Leadership & Management	2
School Leadership and Management	2
Sustainability	2
Technology, Pedagogy and Education	2
Turkish Online Journal of Distance Education	2
Turkish Online Journal of Educational Technology – TOJET	2
Universal Journal of Educational Research	2
Advances in Educational Administration	1
Asia Pacific Journal of Education	1
Australasian Journal of Educational Technology	1
Australian Journal of Education	1
Australian Primary Mathematics Classroom	1
British Journal of Educational Studies	1
Canadian Journal of Educational Administration and Policy	1
Computer Science Education	1
Computers and Education	1
Contemporary Educational Technology	1
Croatian Journal of Education – Hrvatski Casopis Za Odgoj I Obrazovanje	1
Cypriot Journal of Educational Sciences	1
Data in Brief	1

Journal	Sum
Drustvena Istrazivanja	1
Educatio Siglo Xxi	1
Education	1
Education and Urban Society	1
Education in the Knowledge Society	1
Education Policy Analysis Archives	1
Education Sciences	1
Educational Action Research	1
Educational Administration: Theory and Practice	1
Educational Management Administration & Leadership	1
Educational Media International	1
Educational Research and Reviews	1
Educational Research Quarterly	1
Educational Researcher	1
Educational Review	1
Educational Sciences: Theory and Practice	1
Electronic Journal of E-Learning	1
Electronic Journal of Information Systems in Developing Countries	1
Electronics	1
Environmental Education Research	1
Ethnography and Education	1
Etr&D – Educational Technology Research and Development	1
Eurasia Journal of Mathematics Science and Technology Education	1
European Journal of Social Sciences	1
Frontiers in Psychology	1
Gestao e Producao	1
Health Promotion Journal of Australia	1
Human Resource Management International Digest	1
Ieee Revista Iberoamericana De Tecnologias Del Aprendizaje-Ieee Rita	1
Ifip Transactions A: Computer Science and Technology	1
Improving Schools	1
Information	1
Information and Learning Sciences	1
Innovations in Education and Training International	1
Interactive Learning Environments	1
Interchange	1
International and Multidisciplinary Journal of Social Sciences – RIMCIS	1
International Electronic Journal for Leadership in Learning	1
International Information and Library Review	1
International Journal for Lesson and Learning Studies	1
International Journal for the Advancement of Counselling	1
International Journal of Education and Development using Information and Communication Technology	1
International Journal of Education and Information Technologies	1

Journal	Sum
International Journal of Education and Practice	1
International Journal of Educational Development	1
International Journal of Educational Leadership and Management	1
International Journal of Educational Organization and Leadership	1
International Journal of Educational Reform	1
International Journal of Educational Research	1
International Journal of Environmental Research and Public Health	1
International Journal of ePortfolio	1
International Journal of Higher Education	1
International Journal of Information and Communication Technology Education	1
International Journal of Innovative Technology and Exploring Engineering	1
International Journal of Interactive Mobile Technologies	1
International Journal of Management in Education	1
International Journal of Mobile and Blended Learning	1
International Journal of Recent Technology and Engineering	1
International Journal of Supply Chain Management	1
International Journal of Technology, Knowledge and Society	1
International Journal on E-Learning	1
Irish Educational Studies	1
Jmir Formative Research	1
Journal of Applied Learning and Teaching	1
Journal of Asynchronous Learning Network	1
Journal of Education	1
Journal of Education and Practice	1
Journal of Education and Training Studies	1
Journal of Education Policy	1
Journal of Educational Change	1
Journal of Educational Computing Research	1
Journal of Education	1
Journal of Electrical and Computer Engineering	1
Journal of Further and Higher Education	1
Journal of Industrial Teacher Education	1
Journal of Information & Optimization Sciences	1
Journal of Information Technology Education: Innovations in Practice	1
Journal of Information Technology Education: Research	1
Journal of Information Technology Education: Research	1
Journal of Interactive Learning Research	1
Journal of Leadership, Equity, and Research	1
Journal of Media Literacy Education	1
Journal of Personnel Evaluation in Education	1
Journal of Research on Computing in Education	1
Journal of Science Education and Technology	1
Journal of Special Education	1

Journal	Sum
Journal of Theoretical and Applied Information Technology	1
Journal of Turkish Science Education	1
Journal of Workplace Learning	1
Large-Scale Assessments in Education	1
Life Science Journal – Acta Zhengzhou University Overseas Edition	1
Malaysian Journal of Learning & Instruction	1
Malaysian Online Journal of Educational Technology	1
Management in Education	1
Milli Egitim	1
New Educational Review	1
New Zealand Journal of Educational Studies	1
Obra Digital-Revista De Comunicacion	1
On the Horizon	1
Participatory Educational Research	1
Peabody Journal of Education	1
Pegem Egitim Ve Ogretim Dergisi	1
Pertanika Journal of Social Science and Humanities	1
Ponte	1
Procedia – Social and Behavioral Sciences	1
Qualitative Report	1
Research and Practice in Technology Enhanced Learning	1
Revista Inclusiones	1
Scholar-Practitioner Quarterly	1
School Effectiveness and School Improvement	1
School Leadership Review	1
School Organisation	1
Sodobna Pedagogika – Journal of Contemporary Educational Studies	1
South African Journal of Education	1
Studies in Educational Evaluation	1
Techtrends	1
Turkiye Iletisim Arastirmalari Dergisi – Turkish Review of Communication Studies	1
Voprosy Obrazovaniya/Educational Studies Moscow	1
World Journal on Educational Technology: Current Issues	1
Grand Total	350

Appendix 2

Table 2 Themes and included concepts: 1992–2009

Theme (hits)	Included Concepts
School (216)	school, principals, study, teachers, role, teaching, communication, elementary, practice, management, technical and integration
Technology (172)	technology, leadership, leaders, learning, integration, educational, technology and integration, development, administrators, professional, computer, curriculum, resources, computer and integration
ICT (97)	ICT, change, support, implementation, technical, staff
Education (62)	education, policy, secondary, challenges, training, technical and staff
Students (11)	students

Table 3 Themes and included concepts: 2009–2020

Theme (hits) according to importance	Included Concepts
School (789)	school, principals, teachers, learning, professional, support, management, school and management, implementation, secondary, secondary and school, role, online, administrators, challenges, process
Leadership (576)	leadership, technology, practices, students, skills, change, resources, technological, instructional, knowledge, pedagogical, change and culture
ICT (387)	ICT, development, teaching, integration, communication, policy, primary, primary and school, culture, classrooms, digital and integration
Education (316)	education, digital, information, digital and leadership, digital and school and leadership
Distributed (30)	distributed, distributed and leadership, technological and change

Table 4 Themes and included concepts: 2021–2023

Theme (hits) according to importance	Included Concepts
School (503)	school, principals, management, ICT, role, communication, social, communication and technology, knowledge, skills
Leadership (370)	leadership, teachers, learning, digital and school and leadership, students, development, challenges, online, training, classroom, digital and skills
Education (347)	education, technology, digital, pandemic, COVID, support, teaching, secondary, secondary and school, information, staff
Practices (150)	practices, professional, implementation, virtual, resources

Declarations

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