VISUALIZING RESEARCH IN EDUCATIONAL TECHNOLOGY LEADERSHIP USING CITESPACE

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ABSTRACT

Bibliometric review on educational technology leadership could help educators better understand the availability, timeliness, and reproducibility of literature in this field. This paper provides insights into academic publications on educational technology leadership from a visualizing bibliometric perspective, aiming at examining research focuses and trends. 339 articles were analyzed published between 2010 and 2020 using science mapping and presented in co-citation networks. Findings indicated that the research focuses of education technology leadership during this period were the influence of technology leadership on teaching and learning, technology integration, educational technology leadership strategies, and professional development training about technology. The results also revealed a consistent increase in academic interest regarding research trends of educational technology leadership. Although education technology leadership gained growing global attention due to the rapid development of educational technology, there is a gap in the amount of research from academic institutions between developed and developing countries. The authors proposed a research network of education technology leadership that connects technology leadership to several high-frequency relevant research factors. This article is beneficial for scholars to keep their knowledge of educational technology leadership up to date, which could give an overview of basic knowledge for further studies in this field.

Keywords: Education technology leadership, Visualizing analysis, Research trend

INTRODUCTION

With the rapid rise in the use of Information Communication Technology (ICT) in education in the digital era, educational technology leadership has been conceptualized and studied since the 1990s (Flanagan & Jacobsen, 2003), and it is becoming increasingly vital. When all education stakeholders rely more on ICT, leaders undertake the task of changing their roles as technology leaders, be technologically competent, and lead staff members to follow the development of educational technologies (Chua & Chua, 2017). Accordingly, technology leadership plays a critical role in guiding and promoting school effectiveness and the development of educational informatization (Chua & Chua, 2017; Flanagan & Jacobsen, 2003; Tan, 2010). However, educational technology leaders face various challenges, such as inadequate use of online platforms, leaders' unwillingness to change, and followers' low technological ability (Wong & Daud, 2017).

Thus, understanding the current situation and possible barriers of technology leadership is beneficial for technological innovations of schools or colleges that attempt to promote ICT integration and effectiveness within their organizations (Ayad & Ajrami, 2017; Wong & Daud, 2017). An increasing number of academic

publications has contributed to this field, among which review research on educational leadership for technology integration is gradually gaining momentum (Daugherty, Mentzer, Lybrook, & Little-Wiles, 2013; Tan, 2010; Uysal & Madenoğlu, 2015). However, the problem is that some existing claims apparently were concluded based on personal experience or secondary sources due to the lack of holistic cognition on the basic knowledge (Li & He, 2017). More specifically, no review studies have been found that applied the visual analytic approach to seek the research focuses and research trends.

To address the problem, the authors aim to provide a knowledge mapping of technology leadership visually and identify research focuses and research trends in this area. Thus, the research questions are: What are the research focuses of education technology leadership? What are the research trends of education technology leadership regarding publications, institutions, and countries? There are several advantages of bibliometric analysis for research in educational leadership and management (Najam & Mustamil, 2020; Zhu, Song, Zhu, & Johnson, 2019). The analysis based on co-occurrence relationship can support the understanding of the research focuses and frontiers in this field; by analyzing regarding the research organizations and countries, researchers could identify the core forces to promote research from the organizational or regional level, which also helps the researchers to understand the research trend (Zhu et al., 2019). The authors aim to provide a scientometrics overview and valuable data by conducting the review using CiteSpace. CiteSpace is a science mapping tool that presents information in visualizing networks, which has been used for examining research focuses, research trends, the current situation, and the essential changes in a wide range of fields (Chen, 2006).

LITERATURE REVIEW

Educational technology leadership has drawn much attention in relation to leaders' increasing influence, responsibility, and additional technical knowledge and skills in the past decades. Accordingly, several descriptions of technology leadership have been proposed concerning the standards, goals, abilities, and characteristics of leaders' technology usage in an organization (Anderson & Dexter, 2005; Daugherty et al., 2013). Anderson and Dexter (2005) regarded technology leadership as an indispensable part of school characteristics concerning the leaders' abilities for decision-making ability, policy implementation, and technology use within the school. From a philosophical view, Daugherty et al. (2013) defined technology leaders as those who have the capacity to effectively and adequately understand, access, use, and manage technologies for work and make reasonable decisions to guide technological development. Generally, educational technology leadership could be the interaction between technology and leadership that refers to mastering ICT use in the classroom and utilizing ICT for management at the organizational level, which involves technical ICT skills and practical leadership skills (Chua & Chua, 2017).

Many studies have explored the functional role of technology leadership, as well as the relationships between technology leadership and other factors in education (Tan, 2010; Yee, 2000). Yee (2000) investigated the role of school technology leaders by conducting a case study involving seven schools in the United States, New Zealand, and Canada. The results identified eight characteristics of technology leaders: provision and rational distribution of resources like hardware and software, provision of a learning-centered environment, the openness of teaching or working with technologies, patience with adapting to technology, enhancement of shared

leadership, constant monitoring of school progress, networking with stakeholders, and motivating innovations (Yee, 2000). Further, Tan (2010) reviewed twelve empirical studies on this issue and argued that technology leaders could bring about four types of changes for the school, namely technology infrastructure construction, optimization of organization structure and technology policy, integration of ICT into teaching and learning, and creation of school culture regarding ICT use. Tan (2010)'s conclusion indicated that technology leadership has a positive effect and predictive function on the level of ICT usage in schools; meanwhile, the school culture and organizational characteristics have effects on the level of computer usage in the curriculum.

As educational organizations growingly use technology, schools and colleges should propose new standards for leaders and teachers related to ICT knowledge and skills, integrate technology into leadership and management, and sustain the e-teaching and e-learning platforms. In terms of the evaluation standard of educational technology leadership, National Educational Technology Standards for Administrators (NETS-A) (2009) is a generally accepted guide for education leaders to recognize their role as technology leaders to achieve technology integration in education, which gained wide recognition from numerous educational institutions worldwide (Sincar, 2013). Then, NETS-A was developed into a set of International Society for Technology in Education (ISTE) standards: ISTE Standards for Teachers (ISTE, 2008), ISTE Standards for Administrators (ISTE, 2009), and ISTE Standards for Education Leaders (ISTE, 2018), which were used as instruments to evaluate technology leadership in various empirical studies (Ayad & Ajrami, 2017; Yan, 2020). This empirical evidence indicated that integrating technology leadership into education can be challenged because of multiple leadership cultures and structures demanding different levels of professional development and specific training (Chua & Chua, 2017).

Scholars have addressed various aspects of educational technology leadership, such as the grounded model for technology leadership (Chua & Chua, 2017), integration of technology into leadership theory (Van Wart, Roman, Wang, & Liu, 2017), skills and roles of the technology leaders (García, 2015), global and innovative educational technology (Bowen et al., 2013; Huang & Sharif, 2016), technology leadership styles (Gençer & Samur, 2016), technology leadership challenges (Sincar, 2013; Yee, 2000), and technology leadership in teaching and learning (Saad & Sankaran, 2018). Together, these studies have shown that education technology leadership research is necessary and varied. Most of those studies concentrated on the initial stage, including the conceptualization, evolution, and interactive factors of technology leadership. Besides, the search for related research found only a limited number of review studies on technology leadership. Few of them inquired into the research focuses and trends in-depth in visualized form.

METHODOLOGY

This article utilized a bibliometric approach through intuitive visualizing analysis. The bibliometric approach originated from the library and information sciences research field, which can be used to frame representative findings in previous literature by classifying bibliographic data or content (Broadus, 1987). The science mapping tool CiteSpace can take a set of inputs from a valuable bibliographic data resource and construct a structure of the necessary information and knowledge of the selected topic, which has been receiving increasing attention since the 2000s (Chen & Song, 2019). The authors used the updated version of the visualization software CiteSpace

due to its comprehensive setting and accurate calculation.

a) Identification of Data
The data source for bibliometric analysis in this study was collected from the online database Scopus, which is one of the most authoritative and widely used databases for a broad review of high-quality social scientific studies in many research fields. The search keywords were ("technology leadership" OR "technology leader") in the initial search phase, and the retrieval date was 15th June 2021. A total of 923 articles in Scopus were preliminarily identified in this stage of the review process.

b) Screening of Data
In the next stage, a set of inclusion and exclusion criteria were specified in table 1 for the screening of data. The author screened 923 articles based on these criteria by reading through and the title, abstract, and journal type of each initial retrieval article. Noticeable, academic publications from the research field of social science—mainly from the education field, were chosen to ensure the relevance of retrieved articles to this research topic. All literature types in the database were included for inclusive and comprehensive perceptions. Besides, the author skimmed the full texts of several studies that cannot be evaluated through the abstract. Following the above steps, a total of 584 publications were excluded, while 339 articles were included as the input data for the analysis.

Table 1: *The inclusion and exclusion criteria*

The Inclusion Criteria	**The Exclusion Criteria**
studies from 2010 to 2020	studies before 2010, after 2020
studies in the field of education	studies not in the field of education
in English language	in other languages

c) Data Analysis
In order to conduct bibliometric analysis, the authors collected the data with cited references for 339 studies, exported these data in Scopus through the extraction of a RIS file, imported to CiteSpace, cleaned the data with a duplicate remover, and conducted the visual presentation with this software. The authors adjusted the parameters like threshold, font size, and color to perform the best display. The analysis terms involved in the output of networks in the data analysis are listed in table 2.

Table 2: *The main analysis terms of CiteSpace (Chen, 2016)*

The Term	**The Explanation**
Node	Interconnected entity or vertex
Cluster	The panoramic network was divided into groups
Network (N)	Each of the snapshot or structure with a set of interconnected nodes through visual encodings
Node Type	It can be set in network configuration for different types of networks, such as author, institution, country, keywords, cited

	reference, citation frequency, etc.
Modularity (MQ)	The extent to which a network can be decomposed to multiple components. MQ>0.3 means that the cluster structure is significant. The closer MQ value to 1.00, the more distinct classification of groups within the network.
Mean Silhouette (MS)	The quality of a clustering configuration. MS>0.5 means that the cluster structure is reasonable.
Burstness	The rate of change. The burstness frequency refers to a particular duration in which a sudden change takes place.

RESULTS AND DISCUSSION

Analysis Based on the Keywords Co-occurrence

The keywords co-occurrence analysis is helpful for researchers to discover the knowledge relationships among research contents, understand the core knowledge by displaying the knowledge network in a certain research field, which is commonly used to examine research focuses. Selecting “Keyword” as “Node type” and using the Log-likelihood Rate (LLR) clustering algorithm, a total of 1318 keywords were obtained in the timeline view in this study (Figure 1). Running the filtering out small clusters function, it calculated 11 high-frequency keywords, with the occurrence frequency equal to or more than 25 times, namely: pedagogy, technology integration, motivation for instructional use, distributed leadership, higher education, professional development, TPACK, education policy, academic affairs, transformational leadership, computer use in education, teaching and collaborative learning.

Significantly, the output of the cluster (#2) technology integration shows a rational structure with a high value of Mean Silhouette (MS=0.803), labeled with 57 sub-clusters such as professional development; computer science; technology leadership strategies; empirical study; faculty adaptation; integrating laptop computer; school administration; sustaining pedagogical change; active learning method; learning community; enhanced teaching; effective teaching, emerging qualities; organizational culture; administrative practice; school innovation; ICT development, TPACK and so on. As shown in Figure 1, the research focuses shifted from technology usage at the beginning of the 2010s with co-occurrence sub-clusters like “education technology” and “computer use”, to teaching-oriented activity like “pedagogy” in 2015, and to learning-oriented activities like “learning systems” and “blended learning” in 2020. The technology leadership studies in the school context with sub-clusters “school administration” and “school innovation” emerged in 2010, while the studies in higher education settings appeared in 2013.

According to the output data, “technology integration” is a significant research focus, gaining growing attention worldwide in the technology leadership research area. The process of technology integration into management, teaching, and learning brings corresponding responsibilities to leaders, headteachers, administrators, and teachers, who should have the capacity to use ICT at both the curriculum level and the organization level and to promote learning performance and school effectiveness (Weng & Tang, 2014). Among these research focuses, the sub-clusters “enhanced teaching”, “effective teaching”, and “sustaining pedagogical change” are

notable. Many selected publications explored the relationship between technology leadership and teaching, its impact on pedagogy, its effect on teaching outcomes, and the training courses for teachers, since much evidence showed the use of ICT to support teaching had become one main task for schools or colleges (Saad & Sankaran, 2018).

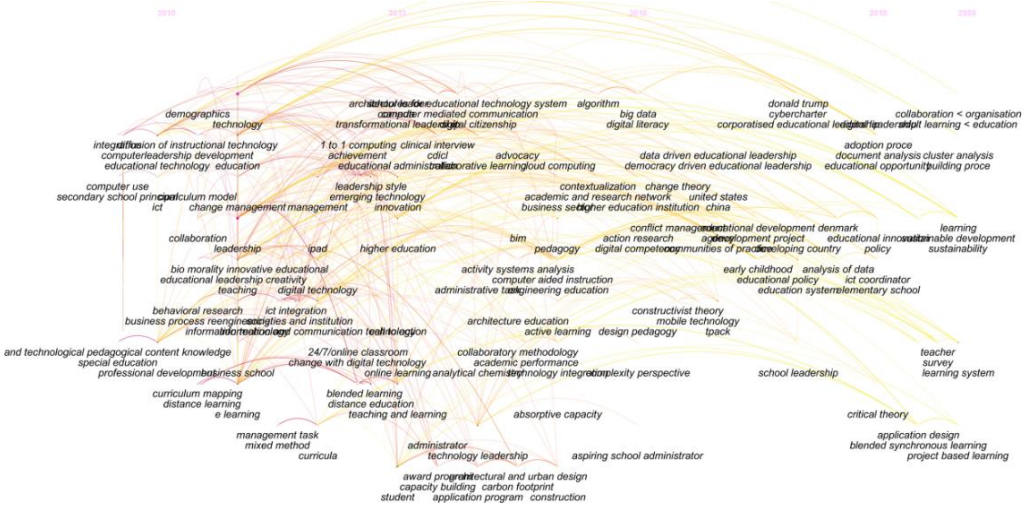

Figure 1: Timeline visualization based on keywords of educational technology leadership

Also, “Technology Pedagogy and Content Knowledge (TPACK)”, referring to the connections and interactions among content, pedagogy, and technology for developing effective teaching, extensive participation, and active innovation, was a widely used theoretical model for the studies on educational technology leadership (Khan, 2014). “Professional development” focuses on both leaders’ and staff members’ professional development training related to ICT use under the background of informatization (Brown & Jacobsen, 2016).

Another interesting finding refers to sub-clusters of “transformational leadership” and “distributed leadership”. Some studies found similar characteristics of transformational leaders or distributed leaders with technology leaders, indicating that technology leaders can be connected to other leadership styles. Technology leaders can motivate followers to design creative solutions to complex problems, inspire them to make the greatest efforts to achieve technology integration, encourage them to create a culture of innovation, and form a shared vision to transform and integrate technology (Kahai, Jestire, & Huang, 2013). Distributed leadership is not only a leader’s behavior but also an organizational behavior, which assigns leaders’ responsibilities to principals, vice-principals, department heads, ICT coordinators, teachers, etc., who are frequently mentioned in technology context to ensure effective communication and cooperation among all stakeholders (Harris, Jones, & Baba, 2013). Technology leaders should master both the abilities and ICT skills mentioned previously, and technology leadership is evolving together with different areas of leadership (Chin, 2010). Furthermore, even though there were numerous studies on technology leadership in the school environment or K12 context, such as in the sub-clusters “school administration” and “school innovation” (Weng & Tang, 2014; Wong & Daud, 2017), the proportion of studies regarding the higher education context has increased based on the co-citation analysis (Ayad &

Ajrami, 2017).

To have a clear overview of the research focuses in the field of educational technology leadership, the author applied the function of Filter out Small Clusters and Log-likelihood Rate (LLR) to display the cluster labels (Figure 2). The results show that there are 945 groups of co-citation relationships from 2010 to 2020, consisting of 14 clusters. The co-cited clustering nodes spread outward with clustering codes #0 technology, #1 community, #2 technology integration, #3 school subject matter, #4 video analysis, #5 information technology, #6 academic development, #7 academic affairs, #8 common measurement system, #9 school level factors (Nodes Labelled = 1.0%, Density = 0.023, Modularity (MQ) = 0.784, Mean Silhouette (MS) = 0.519). Among these indexes, MQ and MS are two important indicators that present the characteristics of the co-citation network structure. MQ value>0.3 means a significant cluster structure. The higher the score, the deeper a network can be decomposed into multiple dimensions. MS value is an indicator to measure the homogeneity of the network (MS>0.5 means reasonable structure), and the closer it is to 1, the higher the homogeneity and rationality of the output data in the network (Chen, 2016). In this study, the score of MQ is 0.784, and the score of MS is 0.519. Thus, the co-citation structure has a tight and rational center structure with high network homogeneity and strong connectivity, while the surrounding sub-clusters are relatively loose.

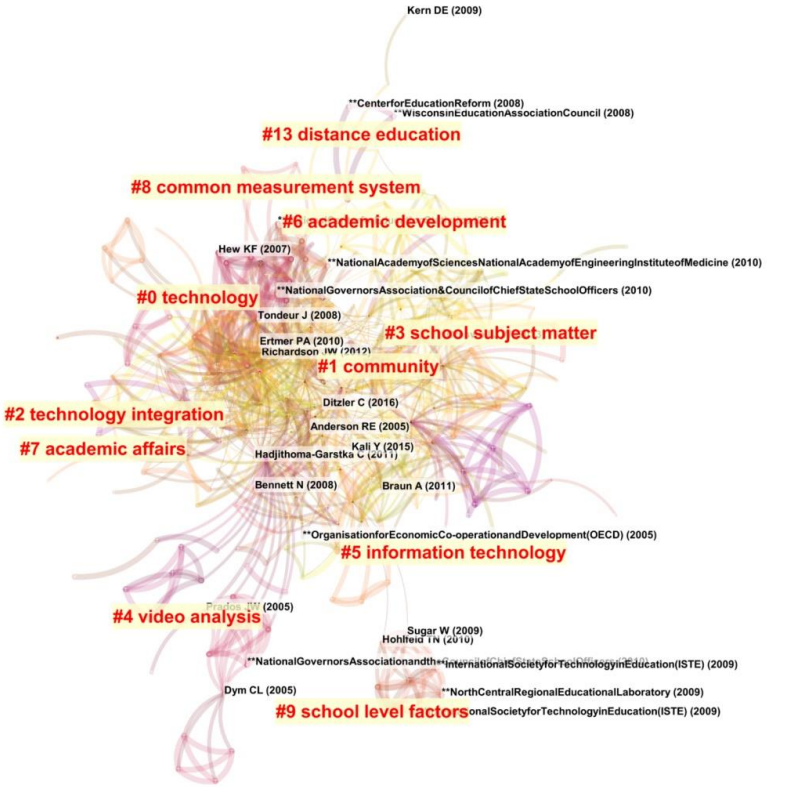

Figure 2: The co-citation network with cluster labels on educational technology leadership

Analysis Based on Publications and Authors

Figure 3 presents the distribution of the number of published articles on the topic of educational technology leadership, which shows changes in recent years and possible developments. There were moderately fewer publications between 2010

and 2015 than between 2016 and 2020, and the number of papers peaked in 2019. Despite the slight fluctuation in 2020, the number of publications remains relatively high. Thus, educational technology leadership has increasingly obtained attention in academia, which can be predicted to rise steadily.

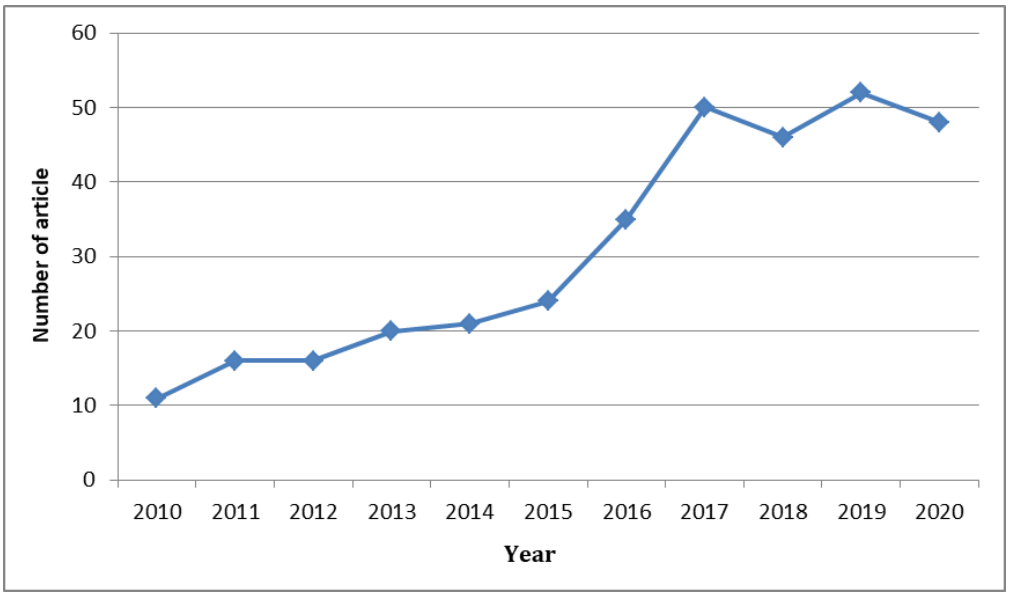

Figure 3: The number of publications in each year

The literature citation frequency is also an important indicator to analyze research focuses. As presented in table 3, the contents of these articles focused on the leaders' roles in technology, the impact of technology leadership on learning outcomes, the relation between technology leadership and school effectiveness, technology leadership strategies, and the importance of technology leadership training in education.

Table 3: *Times of cited list based on this review scope*

Author	Title	Times Cited
Tondeur et al. (2012)	Preparing pre-service teachers to integrate technology in education: A synthesis of qualitative evidence	279
Voogt, Knezek, Cox, Knezek, & ten Brummelhuis (2013)	Under which conditions does ICT have a positive effect on teaching and learning? A call to action	90
Spector (2013)	Emerging educational technologies and research directions	38
Davies (2010)	On school educational technology leadership	32
Chang (2012)	The effect of principals' technological leadership on teachers' technological literacy and teaching effectiveness in Taiwanese elementary schools	30

Thomas, Herring, Redmond, & Smaldino (2013)	Leading Change and Innovation in Teacher Preparation: A Blueprint for Developing TPACK Ready Teacher Candidates	24
Richardson, Bathon, Flora, & Lewis (2012)	NETS. A scholarship: A review of published literature	21
Weng & Tang (2014)	The relationship between technology leadership strategies and effectiveness of school administration: An empirical study	19
Cakir (2012)	Technology integration and technology leadership in schools as learning organizations	17

In addition, the author used "Author" as node type (Top N=50) and selected "Minimum Spanning Tree" to optimize the co-occurrence network. The results (Nodes = 241, Links = 72, Density=0.002) showed that there were 241 authors in the field of educational technology leadership, with a total of 72 collaborations among them between 2010-2020. Based on Price's Law (de Solla Price, 1965), $M \approx 0.749 \times$ Nmax (M = the number of papers, Nmax = the number of papers from the authors with the most published papers). If the number of articles published by an author is more than M, the author is one of the main authors. When the total number of papers published by main authors reaches 50%, it indicates that a core group of authors had been formed in this field. Calculated based on Nmax (47) in this study, the authors who have published more than 7 articles belong to the high publishing ability group in the field. From 2000 to 2020, 17 scholars published over 7 papers (n=125), accounting for 36.87% of the selected literature (n=339), indicating that the core author group of educational technology leadership research had not been formed.

Together, the research focuses on educational technology leadership can be categorized into four aspects, namely impact of technology leadership on teaching and learning, ICT integration, effective strategies for educational technology leadership, and professional development training for educational technology leadership, because these clusters significantly appear with higher frequency and internal homogeneity.

Analysis Based on Countries and Institutions

To identify major countries and academic organizations that contribute to educational technology leadership, and analyze research trends in this field, the authors considered various factors, including the institutions, counties, and timeline. Selecting the "Node type" as "Country", the cluster network contains 55 nodes and 73 links as shown in the countries' network visualization (Figure 4), which showed that the research on technology leadership was centered in the USA, Australia, England, and Canada, whereas relatively few studies in other countries in the past decade. Studies were conducted in 55 countries in total; thus, the trend could be that the primary research force remains in developed countries with higher technology integration levels, and the research area is gradually gaining more global attention.

Figure 4: The clustering structure based on the countries

Table 4 lists the top 10 countries and the index of centrality, which is an indicator for measuring a property of a node in networks that is affected by connectivity patterns. The cluster's launching area was expanding, suggesting that many related studies were being conducted in various countries during this period. Besides, when the "node type" was selected as "institution" with the same setting as the rest of the parameters, the top five authors' institutions were the University of Virginia, Ghent University, Nanyang Technological University, Deakin University, and the University of Hong Kong. In terms of the density, the value of the country-based algorithm is 0.046, and the institution-based algorithm is 0.004, which means that fewer research concentrations either based on the classification of countries or institutions. Based on the calculation method in Price's Law, academic institutions that have published more than 8 papers are the core research institution group in this field. It was found that 19 institutions have published more than 8 papers with a total of 174 papers, accounting for 56.49%. There were only 21 institutions conducting research in 2010 and 176 institutions during this period. It can be seen that the core research institution group of educational technology leadership has appeared in recent years. Also, the authors regarded that more research institutions and universities will continue to contribute to this area with the development and use of technology in education in the future.

The above institutions and countries were the major research strength in technology leadership. The results found that institutions with more studies were mainly distributed in western developed countries. Although academic communications existed, the relatively scattered network structure at the institutional and national levels showed that the degree of research cooperation in this field among these institutions and countries was low. The evidence provides an insight into the needs

of collaborative research contexts and more open resources for further research institutions.

Table 4: *Top 10 countries based on the visualizing analysis*

Counts	Countries	Centrality
166	USA	0.95
29	Australia	0.23
28	England	0.14
22	Canada	0.10
19	China	0.11
14	Turkey	0.01
14	Spain	0.10
13	Belgium	0.03
12	Netherlands	0.12
11	Malaysia	0.05

Analysis Based on Burst Terms

Through the keywords co-occurrence analysis across the time span and burst terms analysis, the research trend of educational technology leadership presents a comprehensive process from ideology to action. The data showed increasing attention on leaders' and teachers' beliefs in technology and innovation in 2011, while scholars have focused more on technology competence and technology integration since 2013. There is an apparent change in the focus from teacher-centered to student-centered learning environment support by technology in 2014. Significantly, a large number of studies on pedagogy and TPACK appeared since 2016. More recently, numerous studies examined technology leadership's impact on students' learning achievement and members' engagement. The results revealed a clear trend in technology leadership, which should be more practical for both individual and organizational effectiveness. Thus, more research on technology leadership strategy for effective innovation, management, and teaching has been carried out over time, in concert with the additional measures and changed practice related to the use of ICT to achieve the organizational goals. A reasonable explanation for this increase may be that technology development has brought new opportunities for education innovation. Technology is constantly advancing, which calls for effective leadership strategies to promote effective technology integration.

Keywords with the strongest citation bursts indicate words with a sudden increase in citation frequency, which can be used to reflect the research trend in a certain period. Thus, to better understand the development trend of the research on educational technology leadership, the parameter setting "Burst terms" was set to identify the suddenly emerging research trends during certain periods. As shown in figure 5, the burst term from 2011 to 2015 is "integration", the burst term between 2013 and 2016 is "innovation", and the burst term in 2015 and 2016 is "higher education". The burst term "student" emerged in 2018 and till persists, indicating

the student-centered research enthusiasm, such as the impact of educational technology leadership on students' outcomes and performance.

Keywords	Year	Strength	Begin	End	2010 - 2020
integration	2010	2.7631	**2011**	2015	
innovation	2010	3.2599	**2013**	2016	
higher education	2010	4.7093	**2015**	2016	
student	2010	5.6321	**2018**	2020	

Figure 5: Keywords with the strongest citation bursts on educational technology leadership

Based on the above analysis, the authors proposed the research network of educational technology leadership (Figure 6). Combined with these indexes, including co-citation, reference, keywords, institution, and countries network visualization, it showed that four major clusters are in the center of this network, namely learning, professional development, technology integration, and education leadership. Therefore, this paper concluded four major trends of educational technology leadership research: (i) the ICT policy and planning in education technology gains more interest, because it supports clear technology leadership standards and strategies and ensures the effectiveness and sustainability of management and leadership in school or college; (ii) research on students-centered teaching and learning process regarding using technological tools is going to be explored more, because most practical goals are related to the improvement of students' learning outcomes and participation in the learning process; (iii) the coming research on educational technology leadership could be meaningful of facing the changes and challenges come with new educational technologies; (iv) studies concerning professional development training programs for capable e-abilities and e-skills are needed all the time.

Therefore, the results indicated the following three implications: First, further research on technology leadership must focus on the models of technology integration, impact of technology leadership on technology integration, and influential factors of technology leadership. Second, the factors that affect technology integration are the principal objects that ought to be more empirically studied. Third, improving teachers' knowledge and skills based on the TPACK model, innovative teaching ability, and STEM in teaching should be the research focuses, which connected technology leadership to teachers' professional development. Thus, leaders should pay attention to practice and training. Training activities should be designed as demand-oriented, which can overcome the gap between theory and practice. Fourth, technology leadership is closely related to the education environment, organizational culture, and educational policy. Educators need to explore the technology-enabled environment from a comprehensive perspective involving factors in the social, cultural, historical, and technological aspects.

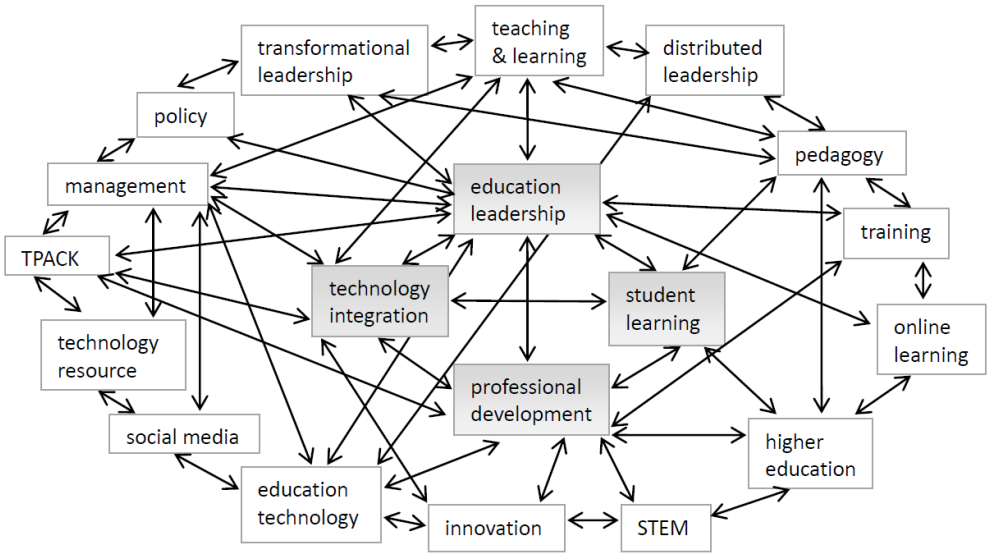

Figure 6: The adapted network of research on technology leadership

Although the research on technology leadership in view of the ever-evolving educational technology is facing unpredictable challenges, the rapid development of this research field provides opportunities for innovative management in educational organizations. With the coming of the artificial intelligence era, the popularization of various technologies and digital resources for mobile learning, studies on education technology leadership are becoming more indispensable. Many studies have pointed out that the role of technology leaders is critical in facing challenges in modern schools or colleges. In this rapidly changing process, future research should focus on new strategies and standards for leaders. That is, leaders should pay attention not only to the construction of software and hardware but also to the individual and organizational informatization process, including how to realize technology integration and improve the ability to use ICT. Only with effective technology leadership to use technologies like big data, artificial intelligence, cloud computing technology, and smart terminals in educational organizations, can administrators, teachers, and students face the challenges regarding enriching teaching resources, ensuring online learning, and creating the learning environment.

CONCLUSION

This study discussed the research focuses and the research trends in educational technology leadership based on visualizing bibliometric analysis. It showed that the amounts of academic research on technology leadership in the USA, Australia, and the United Kingdom ranked at the forefront of the world from 2010 to 2020, indicating that a gap between developing and developed countries in terms of the quantity of educational technology leadership research. Meanwhile, some researchers examined the role of educational technology leadership in the process of educational informatization, and regarded it as an essential requirement for leaders, teachers, and students to promote their self-efficacy and “soft skill” in the technology era. This review study offers an insight into finding ways to implement effective educational technology leadership, like enhancing communication among

all stakeholders, creating organizational culture, setting a shared vision, and promoting the use of ICT in teaching and learning.

These results reflected that research focuses on educational technology leadership in the past decade involved the following four aspects, namely technology leadership's influence on teaching and learning, technology integration, educational technology leadership strategies, and professional development training for technology usage. Changes in the number of yearly publications, changes in the clusters of co-citations, the keywords co-occurrence, and distribution in countries and organizations indicated the research trend was that educational technology leadership attracted increasing global attention due to more participation from various institutions. Thus, the correlations between technology leadership and pedagogy, technology leadership and digital learning environment, and technology leadership and ICT policy at distinct levels should be further studied with the rapid development of educational technology.

In general, this article extends our knowledge of the importance of educational technology leadership, which has become a vital factor affecting the construction and integration of educational technology. The research stakeholders of educational technology leadership in existing studies are comprehensive, including principals, leaders, administrators, head-teachers, and ICT coordinators. Thus, there is a need for further investigation on different technology leadership standards and strategies are to meet demands for all stakeholders at various levels. This review study using science mapping provides an overview of the informative landscape for newcomers to understand educational technology leadership and guides conduct the relevant studies in this field.

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