



A scientometric analysis of technostress in education from 1991 to 2022

Lu Li¹ · Linlin Li² · Baichang Zhong³ · Yuqin Yang⁴

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Abstract

The increasingly ubiquitous use of information and communication technologies (ICTs) in education have brought vast boons to educators and learners but also caused technostress for some of them due to their maladaptation to ICT-supported work and learning. Scientific research on technostress in educational settings has been growing ever since this concept was first proposed in 1984 in the business sector. However, there is currently no systematic understanding of prior research on this issue. The present study aimed to bridge this gap by reviewing previous publications related to technostress in education through the bibliometric analysis approach, involving the joint use of Bibliometrix, CiteSpace, and VOSviewer. Based on the analysis of 125 publications retrieved from Scopus and Web of Science, this study found that the annual scientific production increased slowly from 1991 to 2018 but skyrocketed from 2019 to 2022, coinciding with widespread online learning caused by COVID-19. Most papers were published by the following countries: China, the USA, Spain, Malaysia, and India. The salient research themes included the effect of COVID-19 on technostress, technostress in higher education, technostress among teachers, and countermeasures against technostress. Thematic evolution analysis revealed the development of this topic over time. This study also identified the most productive authors, institutions, and landmark publications in this research field. This study facilitates a better understanding of technostress research in educational settings spanning about three decades and can inspire countermeasures against this issue so as to maximize the bright side associated with the use of ICT.

Keywords Technostress · Technologies · Education · Scientometric analysis · Bibliometrics

Lu Li and Linlin Li contribute equally to this work and share first authorship.

Extended author information available on the last page of the article

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1 Introduction

Information and communication technologies (ICTs) have extensively transformed people's personal and professional lives, and the COVID-19 pandemic has provided a new impetus to the use of ICTs for working remotely (Adedoyin & Soykan, 2020). ICTs facilitate individuals' work and enhance their performance, but the negative aspects resulting from the use of ICTs cannot be ignored (Qi, 2019). Technostress has been considered one of the "dark sides" associated with ICTs (Lee et al., 2014; Rohwer et al., 2022). Brod (1984) first coined the term of technostress and defined it as a maladaptation problem in the modern era caused by individuals' inability to cope with new technologies in a healthy manner. Further research (Wang et al., 2020; Wang & Yao, 2023) has expanded upon this definition by suggesting that technostress doesn't solely stem from technologies themselves; it also emerges from the evolving demands of work and life, intertwined with the utilization of ICTs.

Previous research on technostress has been mostly conducted in government and business sectors (e.g., Ayyagari et al., 2011; Ragu-Nathan et al., 2008). Researchers have progressively shifted their focus towards technostress within educational settings, driven by the swift advancement of ICTs in the realm of education. The issue of technostress is getting ever more attention due to the compulsory online education worldwide caused by the COVID-19 pandemic (Alsubaie et al., 2022; Penado Abilleira et al., 2021). With the publications on technostress in the educational field burgeoning in recent years, a variety of topics related to technostress in education have been explored for students and teachers across different school levels from pre-schools (e.g., Solís García et al., 2021) to institutes of higher education (e.g., Penado Abilleira et al., 2021), including technostress creators (e.g., Kasemy et al., 2022; Nang et al., 2022), technostress inhibitors (Rohwer et al., 2022; Nang et al., 2022), and consequences resulting from technostress to their work and life (Joo et al., 2016).

Recent research has illuminated the prevalence of technostress across diverse population groups in education, encompassing pre-service teachers (Maipita et al., 2023), novice educators (Wang & Yao, 2023), scholars (Falk & Hagsten, 2023), and students (Abd Aziz et al., 2023). For instance, Maipita et al. (2023) conducted a study investigating technostress among 491 pre-service teachers at an Indonesian university, exploring its interplay with organizational support, Technological Pedagogical Content Knowledge (TPACK), and work performance. Results indicated that while TPACK and organizational support did not alleviate technostress, they did not significantly impact work performance. This finding may be attributed to the abrupt shift to online learning necessitated by the COVID-19 pandemic, compelling educators to fulfill their duties regardless. Abd Aziz et al. (2023) delved into the impact of technostress creators, such as techno-overload (TO), techno-complexity (TC), and techno-insecurity (TIS), on university students' academic performance expectancy within the online learning realm, mediated by satisfaction. Their findings suggested that reducing TC and TIS could enhance student satisfaction and their expectations for improved academic performance. Furthermore, recent studies have explored the influence of emerging artificial intelligence (AI) technologies, like ChatGPT, on technostress dynamics (Huo & Siau, 2023; Kohnke et al., 2024). For example, Kohnke et al. (2024) investigated how the rapid advancement of generative AI tools, such as

ChatGPT, impacted technostress among English language educators in higher education. Drawing from qualitative interviews with 16 instructors, the study identified factors contributing to technostress, including inadequate training and limited experience, and proposed coping strategies such as targeted professional development, online engagement, and gradual integration to mitigate technostress.

Nonetheless, little is yet known regarding the research trends and the evolution of the research themes in this particular field. There have been few published review articles seeking to address this issue. For example, Borle et al. (2021) undertook a systematic review that focused on the technostress within various work environments including business and educational settings, among others. Rohwer et al. (2022) conducted a scoping review that solely covered on work-related technostress in educational and research institutions. Similarly, Nang et al. (2022) carried out a systematic review to investigate the technostress experienced by teachers during COVID-19. However, these review papers on technostress in the field of education are qualitative in nature, relying on manual appraisals to indicate research patterns and thus being likely to introduce subjectivity and reduce their reliability (Hammersley, 2001). Currently, there is no study yet that objectively delineates the scientific knowledge domain of technostress in educational settings and critically identify the research themes and their associated challenges in this research field. As such, it is imperative to examine and synthesize the existing knowledge on technostress in educational settings to provide a foundation for future academic research in this field.

The present study aims to bridge this gap by providing a comprehensive scientometric review of the topic of technostress in the educational field. A quantitative approach known as science mapping was employed in this study to comprehensively analyze the research trends, intellectual core, and knowledge landscape of technostress in education. The present scientometric review was guided by the following research questions:

RQ1: What is the annual scientific production, growth trajectory, and geographical distribution of the literature on technostress in educational settings?

RQ2: What authors, institutions, and articles have made significant contributions to the study of technostress in educational settings over the past three decades?

RQ3: What are the research foci and evolutionary trends in this field?

RQ4: What is the pattern of collaboration among the different authors and institutions?

This study utilized a dataset of 125 publications sourced from Scopus and Web of Science (WoS) databases between 1991 and 2022. Bibliographic data related to these articles were subjected to analysis using tools including Scopus, Bibliometrix, CiteSpace, and VOSviewer. The data analysis involved descriptive statistics, citation analysis, visualization of thematic analysis, and research collaboration analysis.

This scientometric review stands out from previous literature reviews on technostress in educational settings in two ways. First, it provides a comprehensive overview of technostress in education by covering prior studies in educational settings conducted from 1991 to 2022. The starting date was set to 1991 was because that the term of technostress was first appeared in educational research indexed in Scopus in 1991. Second, this review presents an informative quantitative analysis of the literature in this field using science mapping, thus to a certain extent offering a more

objective insight into the research trends of technostress in education (Al Mamun et al., 2022).

In what follows is an overview of the remainder of this paper. In Sect. 2, the methodological details were described, including the data source, data collection and scientometric analysis methods. In Sect. 3, the results of the scientometric analysis were presented in the form of a variety of knowledge graphs and tables. Section 4 presents the discussion, including contributions, implications, as well as limitations and future research.

2 Methodology

2.1 Data source

In this study, WoS Core Collection database and Scopus database were used for the initial systematic search. WoS is a widely recognized and multidisciplinary index database that provides access to academic literature worldwide and is a primary source for a scientometric analysis (Guo et al., 2021). Scopus is a comprehensive collection of peer-reviewed scientific literature abstracts and citations, and it is also commonly employed for a scientometric analysis (Lim & Aryadoust, 2022).

2.2 Data collection

According to the guidelines of the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA; Page et al., 2021), a series of actions were undertaken to identify and select relevant publications in the databases, as illustrated in Fig. 1. The year of 1984 was set as the starting time for literature scoping, as it was the time when technostress was first coined by Brod (1984). The ending time was set on August 18, 2022. After carefully examining a few articles on technostress in educational settings, the following terms were selected to be the search codes in Scopus and WoS databases: Article title, Abstract, Keywords/Topic = “digital stress” or technostress or “techno-stress” or “technological stress” or “techno-distress” or “technoeustress” AND Article title, Abstract, Keywords/Topic = education* or student* or teach* or academic* or staff or faculty AND Article title, Abstract, Keywords/Topic = school* or universit* or “higher education*” or college*; time boundaries = 1984-01-01 to 2022-08-18.

The Scopus and WoS Core Collection database search yielded 124 and 122 publications respectively. To improve search results, the compiled publications were manually reviewed to remove duplicates and unrelated documents. The researchers read through the article titles, journal names, and abstracts as necessary to ensure their relevance. These studies underwent comprehensive review to verify their alignment with the following inclusion and exclusion criteria:

- Non-English publications, conference reviews, and book chapters were excluded.
- The study should focus on technostress, so the studies pertaining to technophobia (i.e., the irrational fear or anxiety related to technology use; Martínez-Córcoles et

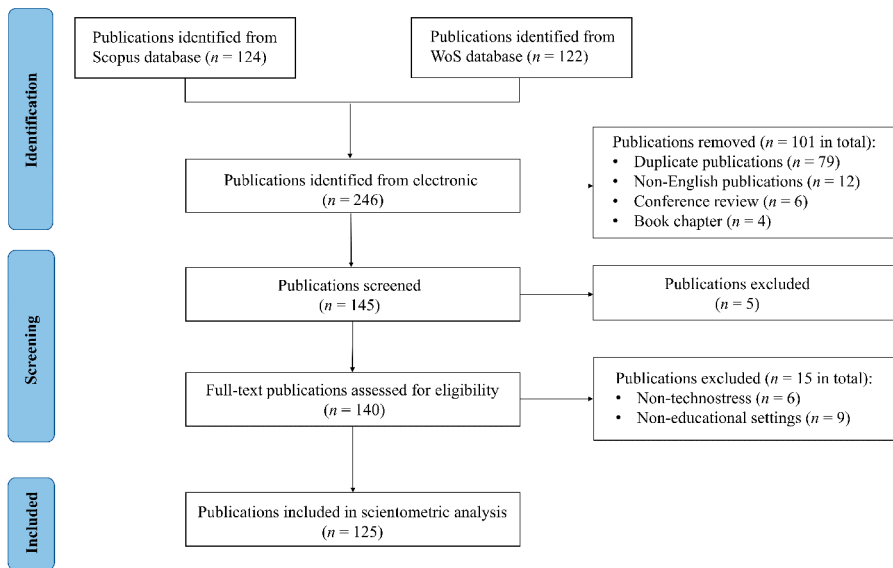


Fig. 1 Data collection flow diagram

al., 2017) were excluded.

- The study should examine technostress in educational settings, and hence the studies concerning company employees encountering technostress were excluded.

The final data set contained 125 publications (see Fig. 1), consisting of 111 articles, 4 reviews, 9 conference papers, and 1 data paper. Furthermore, all references from these articles were presented in the Supplementary File (List A1). It is acknowledged that the dataset did not include all publications on technostress in educational settings. Nevertheless, the collection process using these criteria led to the identification of high-quality and relevant publications which could sufficiently reflect the current state of research on technostress in education. The 125 publications were exported in comma-separated values (CSV) file format from the Scopus database for scientometric analysis. The stored data included detailed and comprehensive information, such as author names, author institutions, publication titles, abstracts, keywords, and citation information. The first article (Ballance & Rogers, 1991) on technostress in educational settings was published in the journal of *Psychological Reports* in 1991, and all publications in the data set are from 1991 to 2022, which covers about three decades. The basic information of the dataset was presented in Table 1.

2.3 Scientometric analysis methods

The term “scientometrics” was initially defined by Nalimov and Mulchenko (1971) as quantitative research on the advancement of science. Scientometrics refers to the analysis of scientific research, including the examination of development, structure,

Table 1 Information about the final dataset

Description	Results
Main information about data	
Timespan	1991:2022
Annual growth rate %	12.45
Document average age	3.44
Average citations per documents	11.19
References (<i>N</i>)	7314
Institutions (<i>N</i>)	160
Countries/territories (<i>N</i>)	40
Document contents	
Keywords plus (<i>N</i>)	562
Author's keywords (<i>N</i>)	373
Authors	
Authors (<i>N</i>)	434
Authors of single-authored docs (<i>N</i>)	11
Authors collaboration	
Single-authored documents (<i>N</i>)	11
Co-authors per documents (<i>N</i>)	3.77
International co-authorships %	23.2
Document types	
Article (<i>N</i>)	111
Conference paper (<i>N</i>)	9
Data paper (<i>N</i>)	1
Review (<i>N</i>)	4

interconnections, and productivity within a particular scientific field (Hood & Wilson, 2001). The scientometric analysis in this study consists of two parts. First, this study employed descriptive statistics and citation analysis to analyze the annual scientific production, growth trajectory, geographical distribution, the most productive authors, institutions, and journals, as well as the landmark publications within this research field. Second, a science mapping analysis was performed to reveal the knowledge structure and notable patterns.

For the scientometric analysis in this study, Bibliometrix (Version 4.1), CiteSpace (Version 6.1.R3), and VOSviewer (Version 1.6.18) were jointly used as they are complementary. Bibliometrix facilitates analysis procedures such as the initial data collection and preparation stages, while CiteSpace helps identify significant research clusters and trends through network analysis and VOSviewer complements the analysis by generating visually informative maps and representations. Together, they offer a comprehensive approach to bibliometric analysis, allowing researchers to gain a deeper understanding of the scholarly landscape, research collaborations, and emerging themes in a particular field.

3 Result

In this section, we presented the results according to the four research questions.

3.1 RQ1: What is the annual scientific production, growth trajectory, and geographical distribution of the literature on technostress in educational settings?

3.1.1 Annual scientific production of publications

As previously mentioned, the dataset comprised 125 publications spanning over a period of approximately three decades. Figure 2 shows the annual scientific production trajectory of the studies on technostress in education. The earliest article in the dataset was published in 1991 (Ballance & Rogers, 1991), followed by only one publication in each of the years of 1998, 2001, 2006, and 2008. During the period from 2014 to 2018, there was a continuous but relatively low levels of publication output, until 2019 when the number of annual scientific production on the topic reached a double-digit. Particularly, Fig. 2 displays a clear upward trend in the annual scientific production from 2019 to 2022. This may be due, in large part, to the COVID-19 pandemic outbreak, which forced to schools and universities to shift to purely remote and online education, despite the preexisting prevalence of online education in conventional learning settings (Torales et al., 2022). This abrupt transition posed great challenges for both educators and students who might struggle to adapt to the technology-intensive transformation (Aktan & Toraman, 2022).

3.1.2 Geographical distribution of publications

The heat map in Fig. 3 depicts the geographical distribution of publications related to technostress in educational settings. From 1991 to 2022, 40 countries/territories contributed to the publication of documents on technostress in educational settings. As shown in Fig. 3, China stood out as the leading contributor to this research field with 25 publications. The United States followed closely behind with 19 publications, while Spain led the contributions from Europe with 13 publications. The combined publications from these three countries constituted approximately 45.60% of the total publications analyzed in this study. Furthermore, Malaysia and India also made notable contributions to this research field with 13 and 10 publications, respectively. Figure 3 also reveals several regions of concentrated publication activity, including Western Europe as well as East and Southeast Asia.

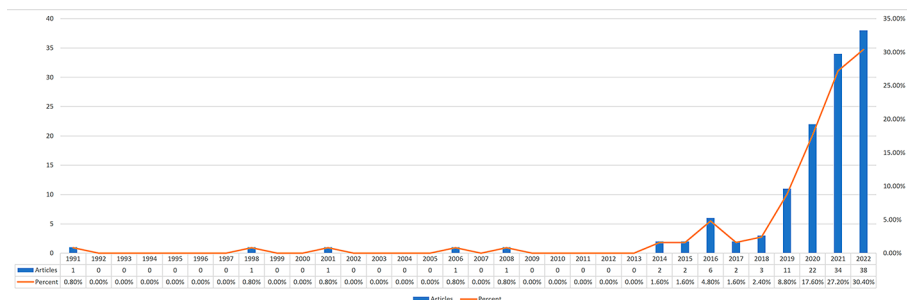


Fig. 2 Annual scientific production of publications on technostress in educational settings ($N=125$)

Examining the geographical distribution from a socioeconomical perspective, it becomes evident that a significant proportion of publications on technostress in education originate from developing countries. This observation implies that there might be a disparity in digital competence or skills among educators and students in developing nations when compared with their counterparts in developed countries (Hinostroza, 2018).

3.2.1 Most productive authors

3.2.2 Most productive institutions

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Table 2 Top 10 productive authors

Rank	Authors	Articles	Institutions	Country	CPP	H_index	PY_start
1	Xinghua Wang	6	Qingdao University	China	17	3	2019
2	Qiong Wang	4	Shaoyang University	China	2	2	2021
3	Guoqing Zhao	3	Beijing Normal University	China	1.7	1	2022
4	Nurul Nadia Abd Aziz	2	Universiti Teknologi MARA	Malaysia	2.5	1	2021
5	Ali Abdallah Alalwan	2	Al-Balqa Applied University	Jordan	2.5	1	2022
6	Merfat Ayeshe Alsubaie	2	King Faisal University	Saudi Arabia	2	1	2020
7	Rozilah Abdul Aziz	2	Universiti Teknologi MARA	Malaysia	2.5	1	2019
8	María Buenadicha-Mateos	2	University of Extremadura	Spain	3	1	2021
9	Xiongfei Cao	2	Hefei University of Technology	China	15	2	2019
10	Vincenza Capone	2	University of Naples “Federico II”	Italy	1	1	2022

Note: PY=publication year, CPP=citations per publication

Table 3 Top 10 productive institutions in technostress in educational settings studies

Rank	Institutions	Articles	Percent	Country
1	Qingdao University	6	4.80%	China
2	Beijing Normal University	4	3.20%	China
3	Nanyang Technological University	4	3.20%	Singapore
4	Shaoyang University	4	3.20%	China
5	Universiti Teknologi MARA	4	3.20%	Malaysia
6	Al-Balqa Applied University	2	1.60%	Jordan
7	Cornell University	2	1.60%	United States
8	Hefei University of Technology	2	1.60%	China
9	International University of La Rioja	2	1.60%	Spain
10	King Faisal University	2	1.60%	Saudi Arabia

tive institutions in this research field are presented in Table 3. Qingdao University tops the list with 6 articles, followed by Beijing Normal University, Nanyang Technological University, Shaoyang University, and Universiti Teknologi MARA with 4 articles each. Only these five institutions (3.125%) have published more than two articles in this research field, suggesting that the issue of technostress is gaining attention among education practitioners, although it has not yet received a substantial level of attention.

3.2.3 Most influential publications

The impact of a publication can be inferred by the number of citations it has received (Hallinger & Kovačević, 2019). Table 4 lists the top 10 most influential articles about technostress in educational settings ranked by the local citations (LC) up to the year 2022. These influential articles can be identified as landmark publications on technostress in education due to their widespread recognition among peers and their high influence. The global citations (GC) are also shown in Table 4. The GC represents the total number of Scopus citations received by an article, whereas the LC indicates the number of times a publication has been cited by the 125 articles included in the dataset. A number of meaningful trends can be identified from the analysis of these influential publications.

Table 4 Landmark articles related to technostress in education

Rank	Title	Journal	Author	PY	LC	GC
1	Technostress in ICT enabled collaborative learning environment: An empirical study among Indian academicians	Computers in Human Behavior	Jena,	2015	43	89
2	The effects of secondary teachers' technostress on the intention to use technology in South Korea	Computers & Education	Joo et al.,	2016	32	80
3	Investigating teacher stress when using technology	Computers & Education	Al-Fudail & Mellar,	2008	31	94
4	Technostress in university students' technology-enhanced learning: An investigation from multidimensional person-environment misfit	Computers in Human Behavior	Wang et al.,	2020	20	39
5	A double-edged sword? Exploring the impact of students' academic usage of mobile devices on technostress and academic performance	Behaviour & Information Technology	Qi,	2019	19	53
6	Relationships between teachers' technostress, technological pedagogical content knowledge (TPACK), school support and demographic variables: A structural equation modeling	Computers in Human Behavior	Özgür,	2020	14	35
7	Exploring the effect of compulsive social app usage on technostress and academic performance: Perspectives from personality traits	Telematics and Informatics	Hsiao et al.,	2017	14	55
8	Technostress in Spanish University Teachers During the COVID-19 Pandemic variables: A structural equation modeling	Frontiers in Psychology	Penado Abilleira et al.,	2021	13	31
9	Technostress inhibitors and creators and their impacts on university teachers' work performance in higher education	Cognition Technology & Work	Li & Wang	2021	10	30
10	Motivation and continuance intention towards online instruction among teachers during the COVID-19 pandemic: The mediating effect of burnout and technostress	International Journal of Environmental Research and Public Health	Panisoara et al.,	2020	9	61

Note: PY=publication year, LC=local citations, GC=global citations

First, these studies primarily focus on three areas, including “technostress among teachers” (e.g., Jena, 2015; Penado Abilleira et al., 2021), “technostress among university students” (e.g., Wang et al., 2020; Qi, 2019), and “countermeasures against technostress” (e.g., Özgür, 2020). Second, it is evident that there is a significant difference between the number of LC and GC in these influential publications, indicating that the issue of technostress in educational settings has captured the interest of scholars from other fields. Third, it is noteworthy that a majority of these influential publications were the result of collaborative efforts, suggesting that collaboration may be an effective approach to produce significant research outputs, thanks to the expertise contributed by researchers from different disciplines and the ease of communication facilitated by collaboration.

3.3 RQ3: What are the research foci and evolutionary trends in this field?

Utilizing keyword analysis facilitated by Bibliometrix, VOSviewer, and CiteSpace, this study identified and visualized the research foci and evolutionary trends within the realm of technostress in education. The patterns of publications in this research field were displayed through multiple analytical approaches including Word cloud, Word growth, keywords co-occurrence, burstiness of keywords, thematic map, and thematic evolution analysis.

3.3.1 Word cloud analysis

Word cloud is valuable for identifying the most frequently occurring terms and areas of focus in textual data (Chen et al., 2020). The largest font size in a word cloud means the most occurrences in the analyzed text material. To better present the most significant common words, general terms (e.g., education) and similar keywords (e.g., teachers, teacher) were removed and merged, respectively. Figure 4, which was



Fig. 4 Top 50 keywords by frequency in studies of technostress in education

generated by Bibliometrix, displays the top 50 author-defined keywords frequently used within the realm of research on technostress in education. The keywords that appeared most frequently were “technostress”, “COVID-19”, “higher education”, and “teachers”. The analysis of word cloud revealed several noteworthy findings.

Firstly, in addition to “technostress,” “COVID-19” emerges as the most prevalent keyword. This observation aligns with the notable surge in publications between 2019 and 2022, as illustrated in Fig. 2. Second, “higher education” is the most frequently occurring descriptor of educational settings. Third, the term “teachers” is the most common keyword regarding individuals who experience technostress, suggesting that the effects of technostress on teachers have sparked considerable attention from researchers. Finally, it is noteworthy to mention that “burnout” appears to be the most common negative symptom resulting from technostress, as evidenced by Fig. 4, which also includes keywords such as “anxiety”, “exhaustion”, and “fatigue”. This observation suggests that scholars in this field have taken notice of the relationship between technostress and these negative symptoms (e.g., Kasemy et al., 2022; Torales et al., 2022). For example, Torales et al. (2022) investigated the impact of technostress on the mental well-being of Paraguayan university students and found a statistically significant correlation between technostress and elevated levels of anxiety and depression.

3.3.2 Word growth analysis

As a supplementary analysis to the word cloud, a keyword growth analysis was performed to identify potential future research directions (Rejeb et al., 2022). The sudden increase in the frequency of keywords used by researchers may serve as an indicator of emerging and potential future research directions (Guo et al., 2021). Through Bibliometrix analysis, Fig. 5 presents the top 10 author-defined keywords

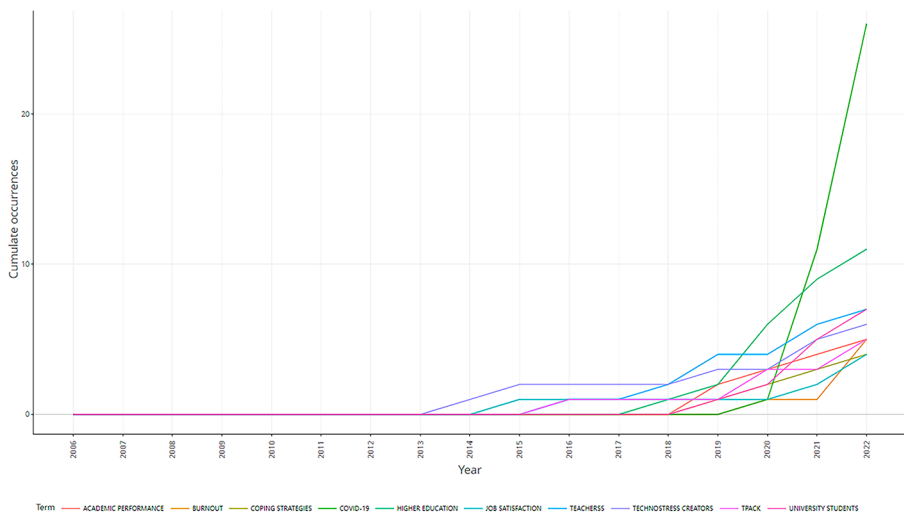


Fig. 5 The growth of the top 10 keywords by frequency in studies of technostress in education

by cumulative occurrences in the studies of technostress in education. For the purpose of presenting the most optimal result, the general and common keywords, such as “technostress”, “education”, were removed. As shown in Fig. 5, it is notable that the key terms “COVID-19” and “higher education” are the top 2 keywords with the highest occurrences, followed by “teachers” and “university students” with equal frequencies of occurrence. This finding reinforces the results obtained in the word cloud analysis that the effects of the COVID-19 pandemic on technostress, technostress in higher education, and technostress among teachers have become issues central to this research field.

3.3.3 Keywords co-occurrence analysis

The purpose of the keywords co-occurrence analysis is to uncover trends and patterns in the topical foci that have been investigated by researchers (Hallinger & Kovačević, 2019). VOSviewer was used to generate the keywords co-occurrence network (see Fig. 6). Multiple trials were performed to determine the most appropriate and meaningful cluster map. The unit of analysis of co-occurrence keywords was set to “author-defined keywords” and the minimum number of occurrences of each keyword was set to 3. Furthermore, it is necessary to use a thesaurus file to modify or replace terms (Hallinger & Kovačević, 2019). For example, in this study, general terms, such as “article” and “education” was removed and terms representing identical entities were merged, such as “COVID-19” and “coronavirus disease 2019”. A total of 35 keywords with the most co-occurrence frequency met the threshold, as demonstrated in Fig. 6.

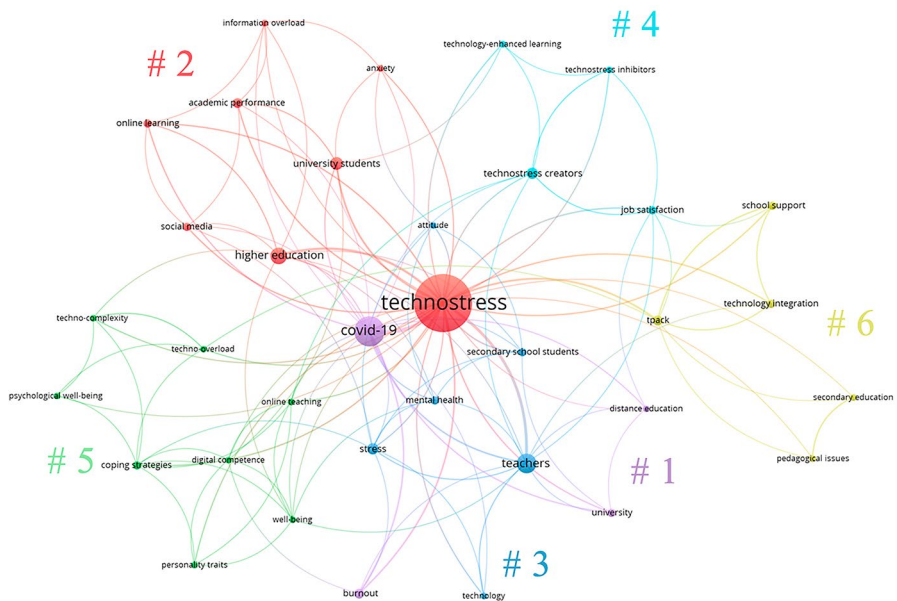


Fig. 6 Keywords co-occurrence network of the studies on technostress in education

In Fig. 6, nodes are sized according to the frequency of co-occurrence of terms, with each cluster represented by a distinct color. The lines indicate the connections between terms, while the thickness of the lines indicates how frequently the terms co-occur in different articles. The distance between terms indicates their relationship strength. Figure 6 presents six clusters, each represented by a different color, which reveals the research fronts and internal relationships within this research field. The terms within each cluster have a higher degree of similarity in terms of research themes (Pinto, 2015), indicating the existence of distinct research areas within the research on technostress in education. In what follows, the six themes were presented in detail.

Cluster 1 (in purple) is comprised of four terms. This cluster is concerned with the impacts of COVID-19 on technostress in education. In this cluster, “COVID-19” is the central keyword with terms such as “burnout”, “university”, and “distance education” closely related. These frequently co-occurred keywords suggest that the compulsory transition to online education in response to COVID-19 pandemic has raised concerns about the potential emergence of technostress among some teachers, particularly in the university sector. (e.g., Penado Abilleira et al., 2021; Shirish et al., 2021; Zheng et al., 2022). It is worth noting that in contrast to the prevailing focus on the adverse impacts of technostress in most studies, Shirish et al. (2021) delved into the concept of techno-eustress which concerns the positive appraisal of technostress.

Cluster 2 (in red) includes 8 terms. This cluster pertains to technostress particularly in higher education. In this cluster, “higher education” was the most frequency keywords, followed by “university students” and “academic performance”. The frequent co-occurrence of these keywords indicates that researchers tended to focus on identifying the impact of technostress on university students and their academic outcomes (e.g., Homaid, 2022; Yao & Wang, 2022). For example, Yao and Wang (2022) investigated undergraduates and found that the compulsive use of mobile phones as well as information overload were positively related to technostress, which in turn caused poor sleep quality and low academic self-perception.

Cluster 3 (in blue) consists of 6 terms. This cluster is concerned with individuals experiencing technostress in education, such as “teachers” and “secondary school students”. “Teachers” was the most frequently co-occurred keyword in this cluster. It is worth noting that a large number of previous studies have investigated impacts of technostress on teachers across various educational levels, including preschool education (e.g., Solís García et al., 2021), primary education (e.g., Estrada-Muñoz et al., 2020; Wu et al., 2022), secondary education (e.g., Joo et al., 2016; Wang & Yao., 2023), and higher education (e.g., Penado Abilleira et al., 2021; Zheng et al., 2022). For example, Wu et al. (2022) investigated the effect of technostress on innovative behaviours among teachers in rural primary and secondary schools in technology-supported teaching and found that technostress could hinder rural teachers in their efforts to integrate technology into classrooms. The terms closely linked to consequences of technostress such as “stress”, “burnout”, and “mental health” were also identified in this cluster, highlighting scholars’ attention on the wellbeing of individuals grappling with technostress (e.g., Bonanomi et al., 2021; Horwood & Anglim, 2019). For example, Bonanomi et al. (2021) investigated the impact of technostress on Italian academics’ psychological well-being during COVID-19 and found that

technostress was associated with “online fatigue”, which in turn had a detrimental impact on individuals’ psychological well-being.

Cluster 4 (turquoise) contains 4 terms, concerning the influences of technostress on work and study. There are four most frequently occurring terms, namely “technostress creators”, “technostress inhibitors”, “job satisfaction”, and technology-enhanced learning. Jena (2015) demonstrated that technostress creators exerted a negative impact on job satisfaction among academicians, while technostress inhibitors had a positive correlation with job satisfaction.

Cluster 5 (green) encompasses 8 terms. This cluster is more relevant to coping with the negative consequences of technostress, with the most frequently occurring keywords “coping strategies” and “digital competence”. Additionally, this cluster includes terms related to the technostress creators, such as “techno-overload” and “techno-complexity”. These findings reflect that the interest in coping with technostress has gained momentum, although the majority of extant studies were conducted to investigate the negative consequences of technostress. As an example, Zhao et al. (2022) investigated the phenomenon of technostress among university students. Their findings revealed a significant correlation between technostress and emotional exhaustion. Moreover, the study also identified that this relationship was influenced by the level of ICT competence, with competence acting as a moderating factor.

Cluster 6 (yellow) comprises 5 terms. These terms are pertinent to countermeasures relieving teachers’ technostress in educational practice. The most frequently co-occurring keywords are “technological-pedagogical content knowledge (TPACK)” and “school support”. The cluster also encompasses terms pertaining to educational environments, with a specific focus on “secondary education”. The frequent co-occurrence of these keywords implies that researchers have started to conduct studies to identify countermeasures against technostress, particularly for teachers in secondary education (e.g., Dong et al., 2020; Joo et al., 2016; Özgür, 2020). For example, Özgür (2020) conducted a study on in-service high school teachers to investigate the impact of school support and TPACK on technostress, and found that technostress level was negatively correlated with both TPACK and school support.

3.3.4 Burstiness of keywords analysis

Burstiness of keywords refers to a sudden and substantial increase of citations for a term over a specific timespan (Guo et al., 2021). A higher burst value suggests that a research topic is more popular and potentially represents a research frontier during the analyzed period (Hou et al., 2018). Using CiteSpace, the burstiness of keywords were calculated. This indicator can reveal the new topics, research hotspots, and trends in the studies of technostress in education during different periods. This study utilized keywords plus as the input, which refer to the frequently occurring words and terms in the titles of the references cited in an article and are capable of capturing an article’s content with in-depth and various perspectives (Song et al., 2019). Figure 7 presents the new and emerging themes in this research field since 1991 at a finer-grained level. As shown in Fig. 7, burst topics are labelled with “Keywords”, “Year” indicates the date at which the analysis begins, “Strength” indicates burst intensity, “Begin” and “End” indicate the starting and the ending year of the burst respectively.

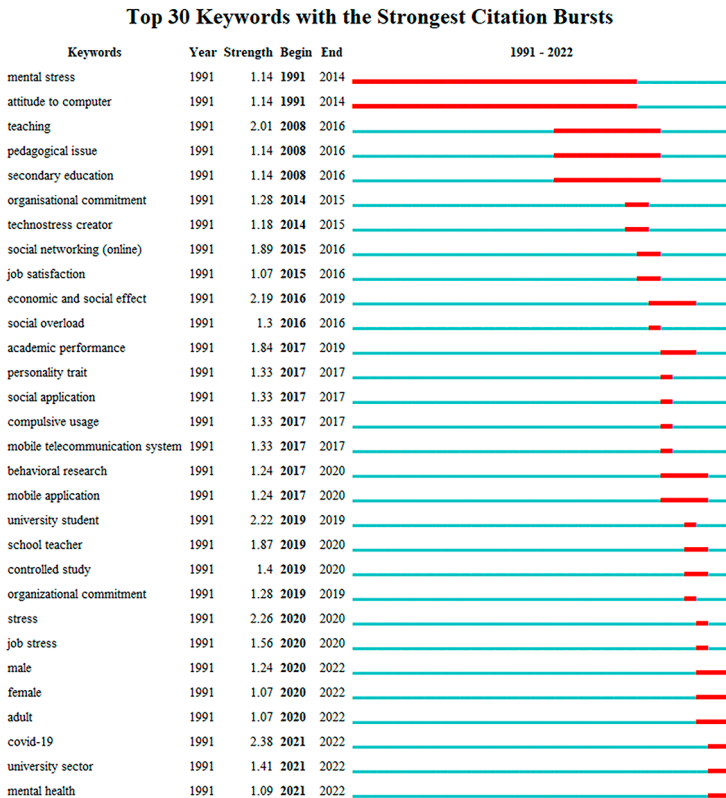


Fig. 7 Top 30 keywords plus with the strongest citation bursts in studies of technostress in education

The blue line specifies the time span from 1991 to 2022 and a red line indicates the burst period.

According to the temporal patterns in Fig. 7, “mental stress” and “attitude to computer” were the earliest burst terms and both terms had sustained burst for the longest time (from 1991 to 2014). The burst of the keyword “mental stress” is partly due to the fact that technostress was widely envisaged as a negative mental stress. For example, Anderson (1985) defined technostress as the stress and accompanying psychosomatic disorders resulting from the use of advanced technology. The burst of the keyword “attitude to computer” could be attributed to the fact that in the late 20th century, with the concept of “ubiquitous computing” proposed by Weiser (1991), computers began to be widely applied in various settings including educational settings. During this period, individuals’ attitudes to computers significantly affected the implementation of ICT in educational settings (Adekunle et al., 2007). As a result, individuals’ attitudes to computers became a significant dimension in studies on technostress in educational settings (e.g., Ballance & Rogers, 1991; Poole & Denny, 2001). Following the above terms, “teaching”, “pedagogical issue”, and “secondary education” had relatively longer sustained burst (starting in 2008 and ending in 2016). The burst of “teaching” infers that technostress suffered by teachers when conducting technology-

supported teaching has gained wide attention from researchers during this period. As to the burst of “secondary education”, this illustrates the emphasis that researchers placed on technostress in secondary education in that time (e.g., Al-Fudail & Mellar, 2008; Joo et al., 2016).

Moreover, it is worth noting that “male”, “female”, “adult”, “COVID-19”, “university sector”, and “mental health” are the current research hotspots in this research field and are still in the burst period. The burst of gender-related keywords suggests that researchers has paid close attention to the effect of individual factors on technostress. In addition to the gender differences (e.g., Estrada-Muñoz et al., 2020; Upadhyaya, 2021), it should be noted that other individual factors, such as differences in personality traits (e.g., Stan, 2022) and age (e.g., Estrada-Muñoz et al., 2020), also has become important research dimensions in this research field. For example, Estrada-Muñoz et al. (2020) examined the impact of gender differences on technostress (specifically, techno-anxiety and techno-fatigue) and revealed that male teachers suffered a greater prevalence of techno-anxiety and techno-fatigue than their female counterparts. The burst of keyword “university sector” reflects that research interest in technostress in higher education has increased in recent years. Additionally, the burst of “mental health” illustrates that the effect of technostress on the psychological well-being of participants in education have been receiving substantial attention, especially during COVID-19 pandemic. Moving to burst strength level, it is noteworthy that the keyword “COVID-19” shows the highest burst strength (2.38), further indicating the considerable influence of COVID-19 on the issue of technostress.

3.3.5 Thematic evolution analysis

Thematic evolution is an important strategy to identify the development of research in a particular area (Weismayer & Pezenka, 2017). It provides an overview of key research issues and their evolution, offering an outlook for research in the future (Chen et al., 2019). To illustrate the evolution of themes effectively, the thematic evolution was segmented into three stages in the Sankey diagram (see Fig. 8) generated by Bibliometrix based on author-defined keywords. The years 2019 and 2020

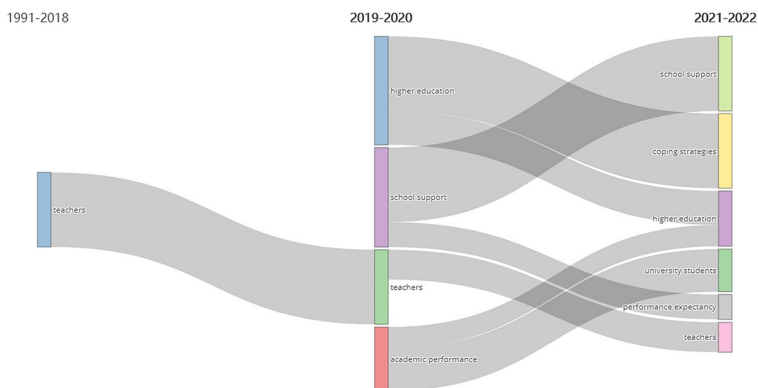


Fig. 8 Thematic evolution of the studies on technostress in education

were chosen as the division points. In Fig. 8, each box represents a theme, and the length of the box corresponds to the frequency of that theme. The thickness of the link between themes corresponds to the quantity of shared terms between the linked themes, reflecting their level of relationship.

Between 1991 and 2018, “teachers” was the prominent and distinct keyword across this research field, and it remained significant in the following two time periods, albeit with a reduced frequency in the last stage. This suggests that researchers have maintained a consistent focus on technostress among teachers steadily for a period spanning three decades. During the second time slice (2019–2020), the main themes identified in the analysis were “higher education”, “school support”, “teachers”, and “academic performance”. Additionally, it is worth noting that “Higher education” is the only keyword in the Sankey diagram that directly relates to educational settings. This observation supports the finding discovered in earlier sections (see Sect. 3.3.3 Keywords co-occurrence analysis) that technostress in higher education have attracted wide attention from researchers in recent years. It is divided into two themes in the subsequent period (2021–2022), including “higher education” and “coping strategies”. Moreover, the theme of “academic performance” which is related to the impact of technostress on students, is further divided into two themes (“higher education” and “university students”) in the subsequent period of 2021–2022. This highlights the significant attention that researchers have paid to the effects of technostress on the student population within higher education in recent years (Shirish et al., 2021; Torales et al., 2022). In addition, the keyword “school support” separated into two themes in the period of 2021–2022, including “school support” and “performance expectancy”.

In the third time slice (2021–2022), “school support” and “coping strategies” became the top-ranked keywords. This underscores the current emphasis on countermeasures against technostress in this research field. Additionally, the keyword “performance expectancy” in the period of 2021–2022 indicates that scholars have begun to focus on the correlation between technostress and performance expectancy (e.g., Abd Aziz et al., 2021; Hussain et al., 2022). For example, Abd Aziz et al. (2021) revealed that technostress (specifically, techno-complexity) was significantly negatively related to performance expectancy, while technostress (specifically, techno-uncertainty) was found to have a positive impact on the performance expectancy among university students who participated in the study. It is noteworthy that the time slice of 2021–2022 exhibits a larger number of themes compared to the previous two subperiods, highlighting the increasingly diverse and multifaceted characteristics of the research in this field at present. This suggests that the study of technostress in educational settings is currently undergoing a phase of active development. These results signal challenges as well, such as identifying countermeasures against technostress to minimize its negative impacts and maximize the benefits of ICT for educational purposes.

3.4 RQ4: What is the collaboration pattern among the different authors and institutions?

The advancement of communication technologies and the rise in academic exchanges have resulted in increased collaborative research efforts. Gaining insight into the current collaboration networks can aid in comprehending the current research status (Wilson, 2022). In view of this, this study visualized the collaboration networks among authors and institutions to understand collaboration patterns from micro and macro perspectives.

3.4.1 Co-authors network analysis

Analyzing the collaboration network of authors can help research institutions to form collaborative groups, provide individual researchers with valuable insights for seeking cooperation partners, and give publishers ideas for creating teams of editors to publish special issues or books (Zou et al., 2018). The tool of Bibliometrix was used to generate the co-authorship network (Fig. 9) in the studies of technostress in education. In Fig. 9, the boxes and linkages represent authors and acts of collaboration respectively. The thickness of the linkages indicates the intensity of collaboration, while the size of the boxes is proportional to the number of collaborations. To ensure that the network is easily understood, the appropriate number of boxes was set.

A total of 35 clusters are displayed in Fig. 9 and the clusters containing the top 10 most productive authors (see Table 2) have been numbered with 1 to 9. It is apparent that the majority of these productive authors in the field formed collaborative relationships with other researchers, yet the extent of their collaboration with each other was limited. Furthermore, the analysis of the main collaborative groups reveals that the majority of collaborations at the author level were primarily internal, occurring within the same institution or country/territory. For instance, cluster 6, which was the largest one, comprises seven authors affiliated with the University of Technology MARA in Malaysia, while all authors in cluster 8 were affiliated with various institu-



Fig. 9 Co-authors network in the studies of technostress in education

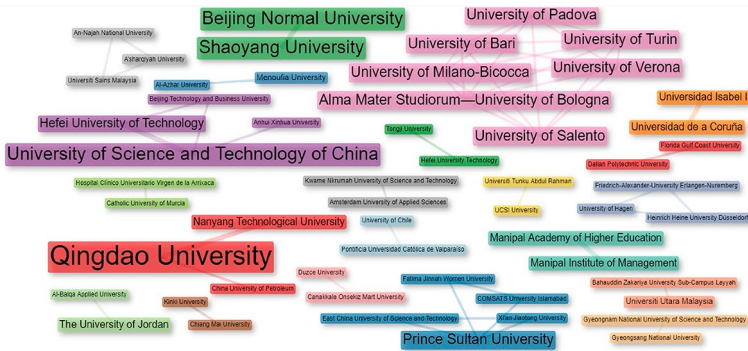


Fig. 10 Co-institutions network in the studies of technostress in education

tions but all of them based in China. This observation suggests a need for improvement in international collaboration and knowledge exchange among the authors in this research field.

3.4.2 Co-institutions network analysis

The examination of the collaboration network of institutions can aid in promoting collaborations and informing policy development (Ding, 2011). Figure 10 presents the collaboration network of institutions. In Fig. 10, each colored box and line represent an institution and their collaborative relationships with other institutions in the network. The width of the lines reflects the extent of cooperation, while the size of the boxes corresponds to the number of collaborations between institutions. The selection of the number of boxes aims to create a clear and easy-to-interpret network. Figure 10 demonstrates a total of 21 clusters, with each color indicating a collaboration group of institutions. As shown in Fig. 10, the visualization demonstrates that institutions have formed collaborations mainly internally within the same country or territory, echoing the results from the co-authors network analysis.

4 Discussion

This research review employed the technique of scientometric analysis to analyze a dataset of 125 Scopus-indexed publications published between 1991 and 2022. In what follows, important findings were discussed in relation to each research question. Subsequently, contribution and implications, and limitations were presented.

4.1 RQ1: What is the annual scientific production, growth trajectory, and geographical distribution of the literature on technostress in educational settings?

The analysis of annual scientific output reveals a continuous increase in the number of publications in this research field in recent years, with a noticeable spike from

2019 to 2022, which may result from the impact of COVID-19 on technostress in educational settings. The pandemic has spurred researchers to direct more attention and resources towards investigating this issue. For instance, many studies (e.g., Penado Abilleira et al., 2021; Solís García et al., 2021) have explored technostress among teachers who had to transition to online teaching during the pandemic. It worth noting that the research on technostress in education is crucial not just for successful adapting to technology-supported education in the context of Covid-19, but also for the sustained and healthy implementation of ICT in educational settings in the future. It is reasonable to anticipate that there will be dramatic changes in both the nature and quality of the research on this topic as digital transformation continues to shape education. The analysis of the geographical distribution of publications in this research field indicates that most papers were published by China, followed by the US, Spain, Malaysia, and India. This trend may be attributed to the rapid development of technologies and/or the aggressive implementation of new technologies in the educational systems in these countries.

4.2 RQ2: What authors, institutions, journals, and articles have made significant contributions to the study of technostress in educational settings over the past three decades?

The analysis of the most productive authors revealed that the top 10 most productive authors identified are Xinghua Wang, Qiong Wang, Ali Abdallah Alalwan, Merfat Ayesh Alsubaie, Rozilah Abdul Aziz, María Buenadicha-Mateos, etc. Surprisingly, none of the authors who entered the research field of technostress in educational settings prior to 2019 are listed among the top 10 most productive authors. A possible explanation for this observation is that before the COVID-19 pandemic, there were numerous alternative methods for teaching and learning besides online education, which made the issue of technostress in educational settings less prominent. Consequently, limited attention was paid to the issue of technostress in educational settings before 2019, and few of the researchers who had worked on this topic continued to conduct studies in this field. The analysis of the most productive institutions indicated that the top 10 most productive institutions identified are Qingdao University, Beijing Normal University, Nanyang Technological University, Shaoyang University, Universiti Teknologi MARA, Al-Balqa Applied University, Cornell University, etc. However, the number of publications from these institutions are relatively low, suggesting that universities worldwide, albeit with a limited number, are starting to actively contribute to the research on technostress in educational settings.

The analysis of the landmark publications identified the top 10 highly cited publications (e.g., Al-Fudail & Mellar, 2008; Jena, 2015; Joo et al., 2016). Notably, the influential publications identified in this study did not include review articles. This may be attributed to the fact that many scholars in this research field tended to prioritize conducting empirical research to examine the effects of technostress on educational practices and people within. Given the rapidly growing number of empirical studies contributing to the accumulation of knowledge of technostress in education, it can be inferred that review articles will play an increasingly important role in synthesizing and summarizing existing research findings in the future.

4.3 RQ3: What are the research foci and evolutionary trends in this field?

The analysis of keywords indicated that the impact of the COVID-19 pandemic on technostress in educational settings emerged as a primary research topic in the field. One possible explanation for this trend is the widespread impact of the COVID-19 pandemic on all sectors, including education, which led to the widespread adoption of remote online education to ensure the continuity of learning (Alsubaie et al., 2022). As a result, ICT became an essential component of teaching and learning, while also acted as a potential cause of stress for students and teachers (Harunavamwe, 2022; Le Roux & Botha, 2021). As a result, in the context of COVID-19, it has become imperative and pertinent to examine the technostress in this new educational landscape.

In addition, the results indicate that many studies on technostress were conducted in the setting of higher education. One potential explanation for this trend could be the increasing adoption of advanced ICT in universities worldwide, including smartboards, virtual-reality laboratories, and AI software, to enhance and modernize education (Rojas-Sánchez et al., 2023). Undoubtedly, technology-enhanced learning (TEL) in higher education is a laudable initiative that has the potential to enhance teaching and learning outcomes. However, it is important to acknowledge that TEL in higher education can also lead to technostress among students and faculty (Jena, 2015; Qi, 2019). Specifically, regarding technostress among university students, literature (e.g., Yao & Wang, 2022; Upadhyaya, 2021) has found that technostress caused by technology-enhanced learning (TEL) has a negative impact on university students' academic performance and productivity. When considering technostress among faculty, Penado Abilleira et al. (2021) found that technostress has the potential of leading to a decline in university teachers' job performance, particularly when they do not receive adequate institutional support and feel technologically ineffective. Overall, research on technostress in higher education is likely to remain an important topic of focus with the evolution of this research field.

Furthermore, throughout the evolution of research themes in this field from 1991 to 2022, research on countermeasures against technostress has become a current hot topic. With the issue of technostress in educational settings becoming increasingly prominent, scholars have paid close attention to identify effective countermeasures that can mitigate the negative impact of technostress in recent years. According to Dong et al. (2020) and Özgür (2020), effective countermeasures and coping strategies, such as TPACK, school support, and computer efficacy, have been found to be able to reduce the level of technostress. Overall, countermeasures against technostress deserve wide attention from researchers in order to maximize the positive impact of ICT on education.

4.4 RQ4: What is the collaboration pattern among the different authors and institutions?

The co-author network analysis (see Fig. 9) reveals that most of the highly productive authors have established their collaborative relationships with other authors, albeit the collaboration being mainly internal within an institution or country. The interdisciplinary nature of the studies of technostress in educational settings highlights the

importance of collaboration among researchers. Collaboration can not only enhance the quality of research but also promote knowledge innovation and sharing (Ying & Yang, 2015). As the topic of technostress in education garners increasing interest, collaborative efforts, both within and beyond individual institutions and national borders, are poised to become more commonplace.

The analysis of co-institutions network (see Fig. 10) reveals that the largest collaborative group formed internal collaborations among institutions within Italy, while the second largest collaborative group formed cross-national collaborations spanning across Saudi Arabia, Pakistan, and China. With the ongoing global investment in digital education transformation, it is reasonable to assert that an increasing number of institutions will prioritize research in this domain and actively promote policies supporting both internal and international collaborations.

4.5 Contributions

The current study offers significant contributions to the existing body of knowledge on technostress in education. Firstly, this review adds value by presenting a systematic and comprehensive examination of the characteristics and current state of research on technostress in education, employing scientometric methods. Prior studies on technostress in education have primarily taken an empirical approach, leaving a dearth of comprehensive review research that synthesizes existing studies and identifies trends and gaps within this field. Consequently, this study serves to enhance our comprehension of technostress within educational contexts and provides valuable insights for guiding future research directions.

Second, this review sheds light on primary research themes and hotspots in the studies of technostress in education, thereby fostering and guiding future investigations. While this area boasts a diverse range of research topics, no comprehensive summary of the most prominent ones has been available until now. Employing science mapping techniques, this study conducted keyword analysis to pinpoint and visually represent research focal points. The findings highlight key research areas, such as the impact of COVID-19 on technostress, technostress in higher education, and technostress among teachers. Notably, it also reveals evolving trends, particularly the increasing focus on countermeasures and coping strategies for technostress in educational contexts in recent years.

The third contribution of this study is its role in enhancing research on technostress in education. By identifying the most prominent authors, institutions, countries, and publications, this research equips future scholars interested in advancing this field with valuable insights to easily discover influential works that can guide their own contributions.

4.6 Implications

This study carries the following implications for future research and practices on technostress in educational settings. Firstly, it highlights geographical disparities within the literature on this subject. Some countries have yet to make substantial contributions to this field, primarily those with lower levels of technological advancement. It

is important to note that individuals in these less technologically developed regions are not immune to technostress within educational settings. Therefore, researchers are encouraged to give particular consideration to the challenges associated with technostress in these less advanced countries and territories.

Second, the countermeasures (e.g., digital competence, TPACK, school support) against technostress in educational settings have become research hotspots in recent years. Technostress has become increasingly pervasive as ICT have become integral to the teaching and learning processes in schools, universities, and colleges (Raja & Nagasubramani, 2018). Individuals experiencing technostress in educational environments are encouraged to employ these countermeasures to mitigate the adverse effects of technostress, rather than neglecting them. At the individual level, solutions like learners' digital competence and effective time management (Zhao et al., 2022; Qi, 2019) and teachers' proficiency in TPACK and computer use (Dong et al., 2020; Joo et al., 2016) play a significant role in combating technostress. On the organizational level, the support provided by educational institutions, including administrators, colleagues, and technical assistance, is highly valuable in alleviating technostress (Özgür, 2020). Furthermore, it is imperative that both researchers and practitioners continue to explore and emphasize the significance of these countermeasures in the context of technostress in educational settings.

Third, research in this field spans across diverse educational contexts and involves a wide range of individuals within the realm of education. Previous studies have illuminated the significant variations in technostress levels experienced by people within different educational settings. For instance, Upadhyaya (2021) found that female students tend to experience elevated levels of technostress concerning techno-complexity and techno-uncertainty. In contrast, Estrada-Muñoz et al. (2020) indicated that male teachers, particularly in terms of techno-anxiety and techno-fatigue, tended to grapple with higher technostress levels compared to their female counterparts. In light of these nuanced insights, it is imperative that educational systems adopt a more tailored and individualized approach when implementing technology-enhanced learning (TEL). Rather than relying on one-size-fits-all strategies. This approach is vital for harnessing the full potential of ICT in education and minimizing the negative aspects of technostress.

Fourth, it is noteworthy that contemporary research predominantly directs its attention towards investigating the adverse impacts of technostress. In contrast, there exists a notable gap in exploring the concept of techno-eustress, which refers to the positive evaluation of technostress (Shirish et al., 2021). In light of this, educational practitioners are strongly encouraged to refocus their efforts on revamping their instructional approaches, with an emphasis on leveraging collaborative ICT features and various ICT-enabled engagement techniques. This strategic shift aims to deliberately instigate techno-eustress among potential users. A comprehensive examination of techno-eustress promises to offer a more holistic and impartial comprehension of the overarching phenomenon of technostress.

Finally, with AI increasingly influencing the landscape of education, many practitioners in education may find themselves ill-equipped to navigate these AI-driven transformations (Wang et al., 2023). Consequently, technostress stemming from AI and the resulting shifts in their professional and personal lives is becoming gradually

prevalent. Thus, it is imperative for researchers to delve deeper into the mechanisms through which AI technologies exacerbate technostress and to explore targeted interventions or coping mechanisms to address this challenge effectively. This pursuit is vital not only for the successful integration of AI in education but also for safeguarding the wellbeing of educational stakeholders (Kohnke et al., 2024).

5 Limitations and future research

Despite the contributions and implications of this study, several limitations must be acknowledged. First, the analysis in this study relied on data from Scopus and WoS, which may have constrained the findings due to limited database coverage. The software tools employed lacked the capability to automatically integrate data from multiple databases. Consequently, it is advisable for future researchers to manually amalgamate publications from various databases or employ additional software tools with this capacity to broaden the global perspective of their research. Second, while this study offered a broad overview of the field, it did not delve deeply into content analysis. This limitation is inherent in scientometric analysis (Li et al., 2019) and warrants future studies to complement scientometric analysis with other methods such as critical review (Zhong et al., 2019) to attain a more comprehensive understanding of the findings. Third, it's important to recognize that the results of scientometric analysis, particularly in emerging and developing themes, may evolve rapidly over a short timeframe. To address this potential shortcoming, future studies are encouraged to employ a more extensive dataset encompassing diverse types of literature and a wider array of indicators for analysis. Notwithstanding these limitations, this study provides a comprehensive and lucid overview of the current state of research on technostress in educational settings. It offers valuable insights for future research directions and bears significant implications for both researchers and practitioners in the field of education.

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Declarations

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. The data used in this study are retrieved from Scopus and Web of Science.

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Authors and Affiliations

Lu Li¹ · Linlin Li²  · Baichang Zhong³ · Yuqin Yang⁴

✉ Linlin Li
linlin908@qdu.edu.cn

✉ Baichang Zhong
zhongbc@163.com

Lu Li
luli227qd@gmail.com

Yuqin Yang
yangyuqin@mail.ccnu.edu.cn

¹ School of Journalism and Communication, Qingdao University, 308 Ningxia Road, Qingdao, China

² Normal College, Qingdao University, Qingda 1st Road 16, Qingdao, China

³ School of Information Technology in Education, South China Normal University, No. 55, West of Zhongshan Avenue, Guangzhou 510631, China

⁴ Faculty of Artificial Intelligence in Education, Central China Normal University, 152 Luoyu Road, Wuhan, China