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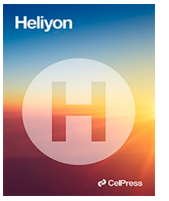

Review article

Educational technologies and elementary level education – A bibliometric review of scopus indexed journal articles

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ABSTRACT

This bibliometric study critically analyses 293 journal articles from the Scopus database, charting the trajectory of educational technology in primary and elementary education from 1986 to 2023. While limited to practical applications within primary or elementary contexts and excluding various scholarly work forms, the research unveils crucial insights. A significant uptick in publications during 2008–2016 and 2018–2023 highlights the growing importance and incorporation of digital technologies in early education. The analysis identifies recurrent themes like teacher education, game-based learning, and collaborative learning, pointing towards future research directions. The study also notes underexplored areas, including technology's role in specific subjects, ethical student engagement, gender and disability dynamics, and contributions from African contexts. It advocates for increased international collaboration, with a focus on partnerships with predominant Chinese institutions. Despite its limitations, this paper is foundational for future research, offering a roadmap for a nuanced understanding of technology's impact on young learners' educational experiences and outcomes globally.

1. Introduction

The role and impact of technologies on teaching and learning are indispensable, as emphasized by various studies [1,2]. The inception of educational technology may be traced back to the 1920s when radios were initially introduced into schools [3]. Throughout the years, several technologies have been introduced. These technological advancements include the adoption of overhead projectors in the 1930s, the utilization of videotapes and projectors in the 1950s, the gradual incorporation of mainframes and mini-frame computers into certain elementary school classrooms in the 1960s, the introduction of handheld calculators in the 1970s, the emergence of the first personal computers like laptops in the 1980s, and the subsequent introduction of the internet, smartboards, and interactive whiteboards in the 1990s [4]. The continuous progress of technology in educational environments has continually pushed the boundaries of learning to unprecedented levels.

In contemporary society, technology-assisted education is increasingly crucial [5], expanding the scope of teaching and learning activities beyond traditional environments [6]. Educational technologies facilitate the creation of teaching and learning opportunities

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for all, supporting student learning, teaching, and assessment [7]. Research on technology use in education has become a vibrant field [8], with a particular focus by some scholars on the use of educational technology at the primary and elementary levels.

Although there have been bibliometric reviews on educational technology (e.g. Refs. [9–12]), a review concentrating specifically on studies at the primary or elementary level is absent. Hence, a need for this review. The study by Chen et al. [9] was a bibliometric analysis of the publications published by the "British Journal of Educational Technology" from 1971 to 2018, while Phillips and Ologun [10] conducted a bibliometric review of the current literature in learning analytics in relation to educational technologies. Also, Chen et al. [11] used the bibliometric technique to analyse the trend in education technology research in a top-ranked called "Journal Computers & Education", while Elra Perdima et al. [12] present a bibliometric review of SCOPUS-indexed journal articles on educational technology in physical education learning. This review is important in that while educational technologies continue to revolutionise teaching and learning [13], the landscape of the studies that have been done on these technologies at the primary or elementary level of education, to the best of our knowledge appears to be an area that has not been brought to the fore. Hence, this review will bring to the fore what has been explored by scholars and propose other areas that scholars can consider by way of future research.

Literature within a specific research field is often reviewed using bibliometrics [14,15], an analytical technique that applies mathematical and statistical methods to the analysis of academic publications [16]. For instance, Chen et al. [9] undertook a bibliometric analysis of 3710 publications indexed in the Web of Science and published in the British Journal of Educational Technology from 1971 to 2018. Phillips and Ozogul [10], as well as Chen et al. [11], conducted similar analyses on learning analytics in educational technologies and a 40-year period of the Computers and Education journal articles, respectively. Additionally, Perdima et al. [12] analysed journal articles in the Scopus database related to educational technology in physical education. However, none of these reviews addressed studies on educational technology at the primary or elementary education level.

Bibliometric analysis proves useful in assessing and evaluating scholarly research output [17], identifying prominent researchers, establishing frameworks for assessing advancements, creating measures to evaluate scholarly output, identifying trending research topics, and generating valuable insights to guide future research [18]. It has been extensively used to overview research across various topics and disciplines, including but not limited to digital marketing (Krashen et al., 2021 [19]), digital technologies in healthcare [20, 21], digital platforms in public administration [22], social media in tourism [23–25], artificial intelligence in supply chain management (Riahi [26,27], smart technologies in urban planning [28], and financial technologies [29].

A thorough review of journal articles pertaining to educational technologies in primary or elementary education will offer insights into the development and status of technology in education at these levels. Such a review can encapsulate the status and trajectory of educational technology during the formative years of child development, addressing the following research questions.

1. What is the volume, growth trajectory, and geographic distribution of education technology in primary or elementary school education?
2. What journals, authors, and articles have evidenced the greatest impact?
3. What topical foci have attracted the greatest attention from scholars on primary or elementary school education technology?
4. What are the future research directions on education technology at the primary or elementary school level?

With the advent of technology-assisted education becoming more crucial in the contemporary educational landscape [5], it is imperative to understand its application and impact, especially in primary and elementary education, where foundational learning and development occur. The study aims to fill a gap in the existing literature by concentrating on educational technology at primary and elementary levels—a focus area often overlooked in previous bibliometric reviews (e.g., Refs. [9–12]. Through employing bibliometric analysis, the study not only evaluates and assesses scholarly output but also identifies influential researchers, trending topics, and provides valuable insights to guide future research in the field, building on the work of past scholars [17,18].

The remainder of the article is structured as follows: Section two outlines the methodology, detailing the search procedures employed to identify literature pertinent to educational technology in primary or elementary school education. Section three unveils the results, while section four engages in a discussion of these findings and underscores potential thematic areas warranting future research. Lastly, section five presents conclusions and suggests prospective directions for future research on educational technologies within primary or elementary educational contexts.

2. Methodology

This study adopted a bibliometric analysis technique. Bibliometric analysis enables researchers to understand a particular subject's research status and trend [11].

2.1. Search criteria

To access and evaluate the volume of work in the topical area without imposing a time constraint, this review did not define a specific time scope. It confined its topical scope to scholarly articles that examined "educational technology" OR "educational technologies" in conjunction with "primary school," "primary education," "elementary school," or "elementary education." The inclusion of studies on "primary education," "elementary school," or "elementary education" helped ascertain the depth of research focusing on the adoption and utilization of educational technologies at the primary or elementary level of education. The review exclusively considered publications indexed by Scopus, a database commonly employed for research reviews [30,31]. Although the Web of

Science (WoS) is frequently used for research reviews, recent scholarly findings suggest that Scopus may be a superior option due to its extensive coverage of relevant journals, particularly for research reviews in social science, business, and management [31,32].

The search criteria were designed to exclude books, book chapters, reviews, and conference papers not published in English, with the rationale that relying solely on peer-reviewed journal articles would yield more consistent and reliable results. Moreover, the search intentionally omitted journals focusing exclusively on post-primary or elementary education. Table 1 outlines the inclusion and exclusion criteria, along with the keywords used to select papers for this review.

2.2. Identification of sources

In this review, we adopted the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) standards while conducting systematic research reviews. The PRISMA framework outlines the procedures for documenting research documents' identification in systematic reviews (see Fig. 1). Our investigation aimed to ascertain the complete compilation of Scopus-indexed journal articles.

The Scopus search resulted in 715 journal articles published from inception to date (August 2023). Subsequently, we employed Scopus filters to exclude 360 extraneous documents, encompassing editorials, comments, conference papers, reviews, books, and book reviews. Further, we carefully examined the remaining journal articles, paying close attention to their titles and, when necessary, their abstracts to determine their relevance to the current review. This thorough analysis led to a final database of 293 articles, as illustrated in Fig. 1.

2.3. Data extraction and analysis

We stored the 293 eligible bibliographic records acquired from Scopus in a CSV file. This study utilized bibliometric analysis through Biblioshiny, an open-source bibliometric program available in RStudio [36,37]. Biblioshiny holds an advantage over other bibliometric tools as it provides a comprehensive array of statistical techniques and visualizations. This extensive toolset allows for an effective analysis of performance and facilitates the conceptual mapping of the study topic [38].

3. Results

This section presents the results of the bibliometric analysis. The presentation of the results is organized around the four research questions.

3.1. Main information and growth trajectory of articles

Table 2 shows the main information regarding educational technology research at the primary school level. The findings show that publications began in 1989 (34 years ago) with an annual growth rate of 7.59, suggesting that an average of 7 papers are published each year, with 823 keywords used by authors to describe the discourse on the subject matter.

Table 1
Inclusion and exclusion criteria.

Search Target	Inclusion	Exclusion	Comment
Time Period	From inception	Not applicable	The objective was to identify the trajectory of the discipline from the onset of scholarly discourse till date (August 2023)
Subject area	Social sciences, humanities and arts, mathematics, business and management, and psychology	Engineering, computer sciences, biological sciences, environmental sciences, geography and spatial systems, land and natural resources	We aim to focus more on social sciences, humanities and arts, mathematics, business and management, and psychology. Moreover, publications in engineering, computer sciences, biological sciences, environmental sciences, geography and spatial systems, and land and natural resources focus more on higher-level education.
Language	English only	Non-English languages (Chinese, German, Spanish, French, Portuguese)	English is the language that the authors understand
Document Stage and Type	Only published (Final) Journal articles	Editorials, doctoral dissertations, master's theses, textbooks, letters, erratum, literature reviews, review papers, reports, letters (to the editor), commentaries, feature articles and studies, and articles- in press	Journal articles contain the most rigorous and high-quality research [33]. They are often subjected to more rigorous peer review [34] than conference proceedings, books, book chapters, reviews, editorials, and doctoral theses.
Keywords	"Educational technology" OR "educational technologies" AND "primary school" OR "primary education" OR "elementary school" OR "elementary education".	Journals focusing on post-primary or elementary education	Our study aims to analyse publications on educational technologies in primary or elementary education.

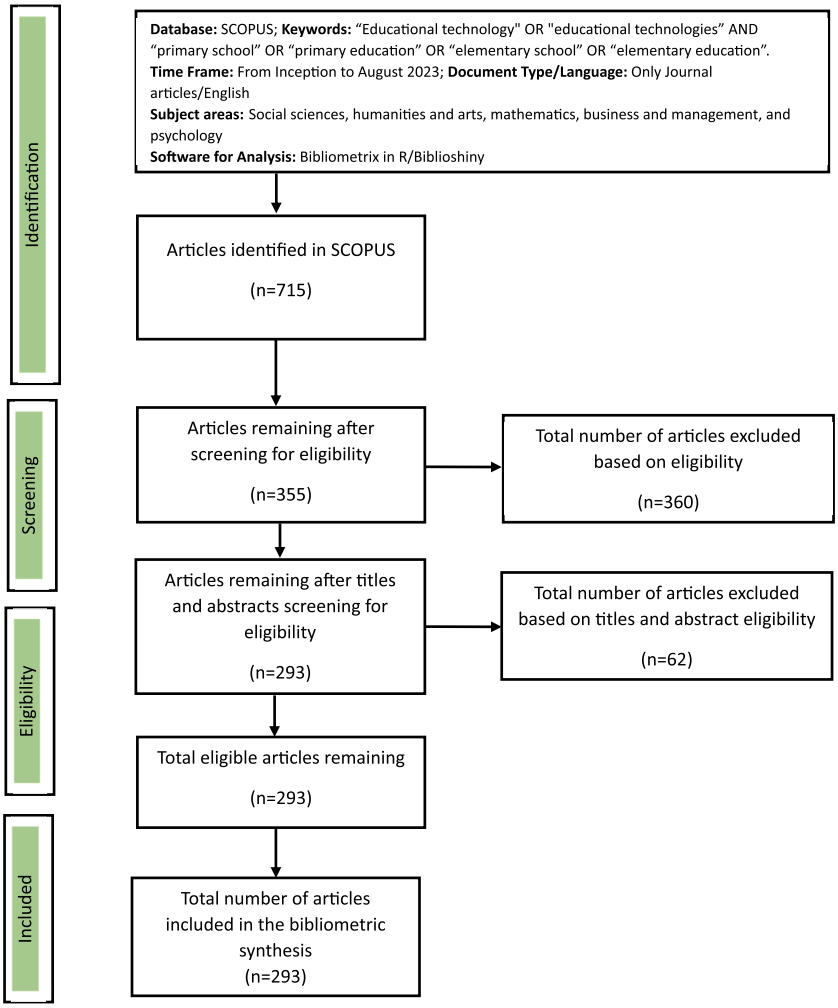

Fig. 1. PRISMA flow diagram on the identification and screening of sources.
Source Adapted from Moher et al. [35].

Table 2
Main information.

Description	Results
MAIN INFORMATION ABOUT THE DATA	
Timespan	1986:2023
Sources (Journals)	121
Documents	293
Annual Growth Rate %	7.59
Document Average Age	8.21
Average citations per doc	24.49
DOCUMENT CONTENTS	
Keywords Plus (ID)	603
Author's Keywords (DE)	823
AUTHORS	
Authors	767
Authors of single-authored docs	55
AUTHORS COLLABORATION	
Single-authored docs	60
Co-Authors per Doc	2.91
International co-authorships %	15.7
DOCUMENT TYPES	
Article	293

Fig. 2 presents a line chart depicting the annual publication trajectory of articles on educational technologies in primary or elementary school education.

The growth trajectory indicates that, of the 293 articles published over 34 years, the majority are concentrated within the last 15 years (2008–2023). Notably, 2013 saw the highest number of publications, followed closely by 2022 with 26 papers, and both 2020 and 2011 with 24 papers each. This distribution highlights an escalating interest among researchers in this pivotal research area, providing valuable insights for educators. However, 2017 marked a low point, with only four papers, appearing as an outlier in this distribution. Interestingly, before the noticeable increase in publications from 2008 onwards, the year 2003 previously held the record for the most publications, with four papers. It is also crucial to acknowledge a publication drought in the years 1987, 1988, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 2000, and 2004, spanning 13 years. Therefore, the data suggests that the first 22 years (1989–2007) saw relatively fewer publications since records began, while the subsequent 15 years experienced a surge in research interest on the topic. This upsurge in publications can be interpreted as a reflection of the growing importance and integration of digital technologies in early education in more recent years. Furthermore, this trend may also signify a broader recognition within the academic and educational communities of the importance of empirically studying the implications, applications, and effectiveness of technology-enhanced learning during the early years of education.

3.2. Most impactful publication outlets

Table 3 showcases the 20 most impactful journal publication outlets. This was determined by the impact (h-index). As noted by Norris and Oppenheim [39], the h-index, which takes into account both the productivity and citation impact of publications, is a valuable metric for identifying key sources in a specific research domain. Hence, the importance of a source should not solely be assessed based on its productivity; the number of citations it garners also plays a crucial role in establishing its significance [40]. According to the findings, "Educational Technology" leads in the number of publications, followed by the "Turkish Online Journal of Educational Technology" and "Computers in Education". However, "Educational Technology and Society" tops the list as the most impactful outlet due to having the highest number of publications. Interestingly, "Computers and Education" secures the second spot in terms of impact, despite being the third most productive outlet, while the "Turkish Online Journal of Educational Technology" is the third most impactful and second most productive. The discrepancy in the ranking positions based on productivity and impact (h-index) can be explained by the variations in the number of citations received by each journal.

3.3. Most impactful authors

Table 4 displays the top 20 authors based on their impact (h-index), which includes the total number of publications (TC), with Hwang G-J leading with nine papers, followed by Tsai C-C with six papers, and Hung C-M with five papers. In terms of impact, Hwang G-J stands out as the most impactful author, boasting an h-index of 9. This indicates that Hwang G-J has authored nine papers, each receiving at least nine citations (TC), contributing to a total of at least 81 citations. Following him are Hung C-M and Tsai C-C, each with an h-index of 5. This suggests that both authors have penned five papers that have garnered at least five citations each, resulting in a minimum of 25 citations per author. Additionally, Lee C-Y and Liu EZ-F each hold an h-index of 4, with each having authored four papers that have attracted at least four citations, totalling a minimum of 16 citations per author.

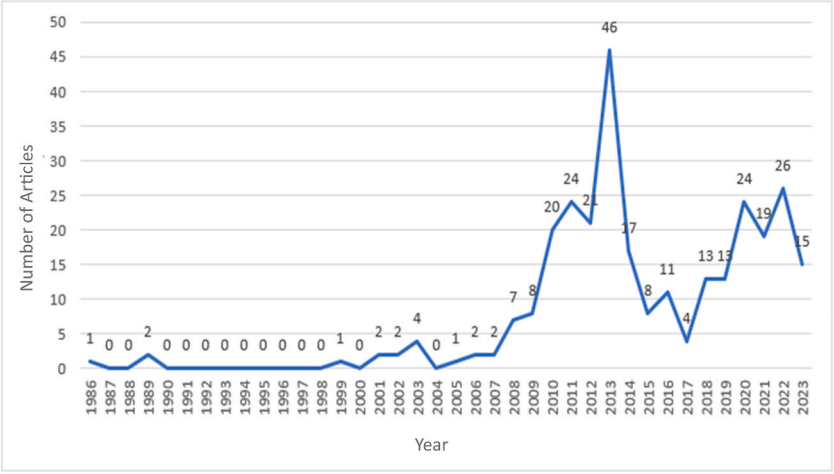

Fig. 2. Yearly growth trajectory of articles.

Table 3
Most impactful journal publication outlets.

Element	h_index	Total Citations	Number of Publications
Educational Technology and Society	22	1792	50
Computers and Education	18	1423	20
Turkish Online Journal of Educational Technology	14	691	42
British Journal of Educational Technology	11	575	17
Australasian Journal of Educational Technology	5	165	5
Education and Information Technologies	5	70	8
Computers in The Schools	4	92	5
Computers in Human Behavior	3	305	3
Comunicar	3	103	3
International Journal of Emerging Technologies in Learning	3	32	4
Techtrends	3	132	3
Education Sciences	2	23	2
Educational Technology Research and Development	2	83	2
Frontiers in Education	2	14	5
Frontiers in Psychology	2	10	3
International Journal of Artificial Intelligence in Education	2	32	2
Journal of Autism and Developmental Disorders	2	44	2
Journal of Computer-Assisted Learning	2	14	2
Kuram Ve Uygulamada Egitim Bilimleri	2	29	2
World Journal on Educational Technology: Current Issues	2	6	4
ACM Transactions on Computing Education	1	31	1

Table 4
Most impactful Authors.

Element	h_index	Total Citations	Number of Publications
Hwang G-J	9	896	9
Hung C-M	5	440	5
Tsai C-C	5	795	6
Lee C-Y	4	57	4
Liu EZ-F	4	99	4
Chai CS	3	351	3
Chen Y-L	3	144	3
Huang I	3	264	3
Lin Y-C	3	176	3
Vanderlinde R	3	99	3
Wong L-H	3	55	3
Abd Rahim N	2	11	2
Abrami Pc	2	36	2
Anastasiades PS	2	41	2
Atabek O	2	9	2
Bose K	2	29	2
Byker EJ	2	26	2
Chang I-H	2	85	2
Chang K-E	2	40	2
Chao P-Y	2	228	2

3.4. Country and institution analysis

The findings reveal that 299 institutions across 54 countries have contributed to the 293 publications included in this review. Fig. 3 visually presents the geographic distribution of the top 19 countries demonstrating significant productivity. China stands out as the top contributor with 68 articles, followed closely by Turkey with 24 articles. The USA holds the third position, contributing 22 papers to the field.

When examining collaborations on publications, it is evident that there is a higher frequency of collaborations among authors within the same country (Single-Country Publications or SCP) compared to collaborations between authors from different countries (Multi-Country Publications or MCP). China leads in the count of single-country publications, with Turkey and the USA following suit. While China also dominates in multi-country publications, it is noteworthy that all Turkish contributions come from authors residing in Turkey, indicating no international collaborations. Singapore is the next prolific contributor in terms of MCPs, with three publications, followed by the United Kingdom, Spain, and Italy, each with two MCPs.

Fig. 4 illustrates the countries with the most citations, with China leading significantly with 3056 citations. This number is approximately six times the citation counts of the USA and Singapore, which are the second and third most-cited countries, respectively. This disparity not only highlights China's active publication record but also indicates that the papers originating from China are highly valued and frequently referenced by scholars, underscoring China's influential role in shaping understanding in this research

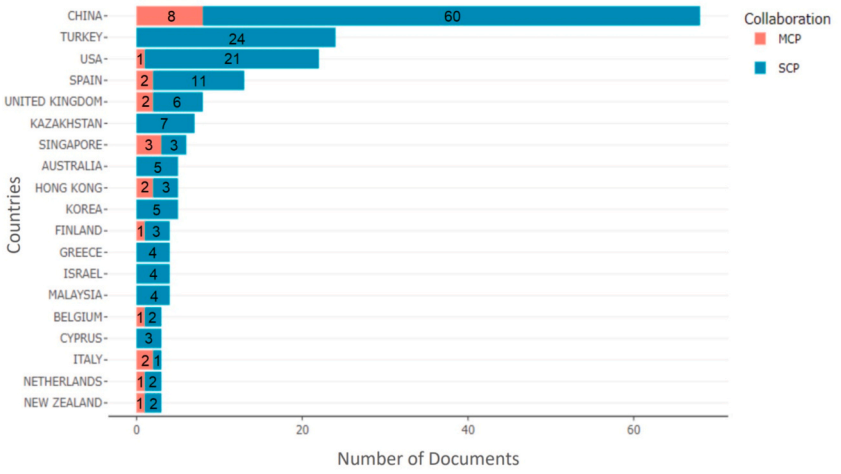

Fig. 3. Most contributing countries.

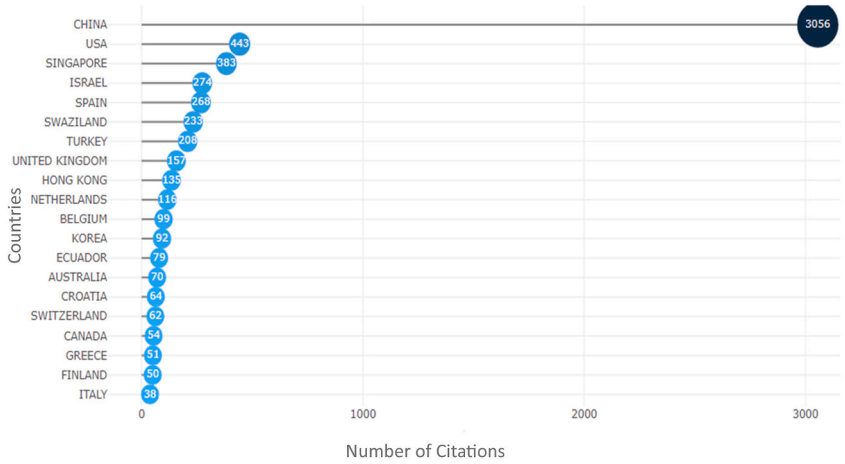

Fig. 4. Most cited countries.

Table 5
Most contributing institutions.

Affiliation	Country	Articles
National Central University	China	21
National Taiwan Normal University	China	19
National Taiwan University of Science and Technology	China	16
Nanyang Technological University	Singapore	11
Ghent University	Belgian	7
Korkyt Ata Kyzylorda University	Kazakhstan	7
Rosetta Stone Inc.	USA	7
The University of Hong Kong	Hong Kong	7
Federal University of Rio Grande Do Norte	Brazil	6
International Hellenic University	Greece	6
Istanbul University	Turkey	6
Monash University	Australia	6
National Dong Hwa University	China	6
National Pingtung University of Science and Technology	China	6
National Taipei University of Education	China	6
Complutense University of Madrid	Spain	5
Concordia University	Canada	5
Edith Cowan University	Australia	5
National Cheng Kung University	China	5
National Chiayi University	China	5

area.

Table 5, from an institutional viewpoint, highlights the top 20 most productive institutions based on the number of articles produced. National Central University leads with 21 articles. Followed by National Taiwan Normal University with 19 articles, and National Taiwan University of Science and Technology with 16 articles. Notably, all these institutions are in China. Further examination of Table 5 reveals that the majority of the significant contributing institutions are based in China, which is consistent with the finding that China is the leading country contributing to research on educational technologies in primary or elementary education.

3.5. Most cited articles

Table 6 displays the top 20 documents that have garnered the most citations in this study. The document with the highest citation count is by Lee and Tsai [41], with a total of 338 citations. Their study aimed to develop a framework to comprehend teachers' Technological Pedagogical Content Knowledge-Web (TPCK-W) in the context of integrating Web technology into pedagogical practices. This high citation count suggests a substantial interest from scholars in understanding teachers' pedagogical practices with the integration of TPCK-W.

The second most-cited document is a study by Chai et al. [42]. The study has received a total of 250 citations. In the study, they examined the construct validity of a TPACK framework among Singaporean primary school pre-service teachers, focusing on the pedagogical approaches utilized during a 12-week ICT course. This study is essential for scholars looking to understand the

Table 6
Most cited articles (first 20 articles).

Paper	Title and Source	Focus	Total Citations
Lee and Tsa [41]	"Exploring teachers' perceived self-efficacy and technological pedagogical content knowledge with respect to educational use of the World Wide Web". *Instructional Science*	Pedagogy	338
Chai et al. [42]	"Modeling primary school pre-service teachers' Technological Pedagogical Content Knowledge (TPACK) for meaningful learning with information and communication technology (ICT)". *Computers & education*,	Pedagogy	250
Hasler et al. [43]	"Learner control, cognitive load and instructional animation". *Applied Cognitive Psychology: The Official Journal of the Society for Applied Research in Memory and Cognition*	Learning pace	233
Chang et al. [44]	"Exploring the possibility of using humanoid robots as instructional tools for teaching a second language in primary school". *Journal of Educational Technology & Society*	Assistive robots	224
Hwang et al. [45]	"A concept map approach to developing collaborative Mindtools for context-aware ubiquitous learning". *British Journal of Educational Technology*	Ubiquitous learning	204
Chang and Hwang [46]	"Impacts of an augmented reality-based flipped learning guiding approach on students' scientific project performance and perceptions". *Computers & Education*	Augmented reality	202
Domingo and Garganté [47]	"Exploring the use of educational technology in primary education: Teachers' perception of mobile technology learning impacts and applications' use in the classroom". *Computers in Human Behavior*	Impact of technology on learning	179
Fridin [48]	"Storytelling by a kindergarten social assistive robot: A tool for constructive learning in preschool education". *Computers & education*	Assistive robots	173
Chu [49]	"Potential negative effects of mobile learning on students' learning achievement and cognitive load—A format assessment perspective". *Journal of Educational Technology & Society*	Negative impact of technology on students' learning	173
Hung et al. [50]	"A project-based digital storytelling approach for improving students' learning motivation, problem-solving competence and learning achievement". *Journal of Educational Technology & Society*	Digital storytelling	172
Liu et al. [51]	Outdoor natural science learning with an RFID-supported immersive ubiquitous learning environment. *Journal of Educational Technology & Society*	Ubiquitous learning	146
Jang and Tsai [52]	Exploring the TPACK of Taiwanese elementary mathematics and science teachers with respect to use of interactive whiteboards. *Computers & Education*	Pedagogy	145
Yien et al. [53]	"A game-based learning approach to improving students' learning achievements in a Nutrition course". *Turkish Online Journal of Educational Technology-TOJET*	Game-based learning	119
Cejka et al. [54]	Kindergarten robotics: Using robotics to motivate math, science, and engineering literacy in elementary school. *International Journal of Engineering Education*	Assistive robots	114
Cheng and Tsai [55]	"A case study of immersive virtual field trips in an elementary classroom: Students' learning experience and teacher-student interaction behaviors". *Computers & Education*	Virtual field trips	104
McClanahan et al. [56]	"A breakthrough for Josh: How use of an iPad facilitated reading improvement". *TechTrends*	Impact of technology on learning	100
Segers and Verhoeven [57]	"Multimedia support of early literacy learning". *Computers & Education*	Impact of technology on learning	97
Woo et al. [58]	Using a wiki to scaffold primary-school students' collaborative writing. *Journal of Educational Technology & Society*	Impact of technology on learning	93
Chin et al. [59]	"Impact of using an educational robot-based learning system on students' motivation in elementary education". *IEEE Transactions on learning technologies*	Assistive robots	90
Koh et al. [60]	"Demographic factors, TPACK constructs, and teachers' perceptions of constructivist-oriented TPACK". *Journal of Educational Technology & Society*	Pedagogy	88

Table 7
Articles that discuss disability and gender issues.

Category	Paper	Title and Source	Focus & Country	Findings
Gender	Huang et al. [61]	"Gender differences in the reading of e-books: Investigating children's attitudes, reading behaviors and outcomes". *Journal of Educational Technology*	Impact of E-book use among boys and girls – China	While girls primarily skimmed while reading, they outscored boys on retrieval tests. Although personalized reading technologies in education, such as reading e-books with IELS, tend to reduce the gender gap in technology adaptation, this work shows that gender differences are still significant in children's e-book reading.
	Shibazaki and Marshall [62]	"Gender differences in computer-and instrumental-based musical composition". *Educational Research*	• Investigates whether any gender differences existed between the attitudes of boys and girls towards the use of computers in creating musical compositions. • A compare the boys' and girls' attitudes between composing with instruments and composing with computers. England (UK)	Youngsters exhibited an understanding of the benefits and drawbacks associated with utilizing computers for musical composition.
Disability	Ratcliff and Anderson [63]	"Reviving the turtle: Exploring the use of logo with students with mild disabilities". *Computers in the Schools*	Use of Logo in Learning by Students with Mild Disabilities. – USA	The curiosity of the students were engaged by a traditional iteration of Logo. The aforementioned resource served as a valuable means of engaging students in interactive challenges and problem-solving activities, fostering a sense of accomplishment, internal motivation, pleasure, and a sense of personal investment in the learning process. The method of surmounting challenges encountered during programming activities using Logo holds particular advantages for students with minor disabilities.
	Yakubova et al. [64]	"Learning with technology: Video modelling with concrete–representational–abstract (CRA) sequencing for students with autism spectrum disorder". *Journal of autism and developmental disorders*	Examines the effectiveness of a video modelling intervention with concrete–representational–abstract instructional sequence in teaching mathematics concepts to students with autism spectrum disorder (ASD). – USA	Students maintained their response accuracy at a 3-week follow-up assessment for all skills, indicating the efficacy of the technology-based intervention (i.e., point-of-view video modelling instruction with CRA instructional sequence) used in this study.
	Ledbetter-Cho et al. [65]	"The effects of a teacher-implemented video-enhanced activity schedule intervention on the mathematical skills and collateral behaviours of students with autism". *Journal of Autism and Developmental Disorders*	The study evaluates the effects of a teacher-implemented video-schedule intervention on the mathematical skills and untargeted challenging behaviors of five elementary school students with autism. – USA	Participants' academic performance improved and their levels of difficult behaviors and stereotypy decreased after the intervention was implemented, suggesting that the program was successful. The fact that students were able to apply their newfound knowledge to new types of academic difficulties and in new contexts like working in small groups demonstrates the efficacy of this technology-based intervention.
	Tsuei [66]	"Mathematics synchronous peer tutoring system for students with learning disabilities". *Journal of Educational Technology & Society*	The study developed and explored the impact of a synchronous peer tutoring system, which integrated a structured peer tutoring strategy	The findings suggested that the proposed system could help kids with LD learn

(*continued on next page*)

Table 7 (*continued*)

Category	Paper	Title and Source	Focus & Country	Findings
			with technological advances, for students with learning disabilities (LD). – China	mathematics more effectively, particularly conceptual and application mathematics. Mathematical proficiency on conceptual issues also increased for students with LD. Students' ability to tutor one another and grasp mathematical concepts throughout the online activities was greatly improved thanks to the math objects offered by the synchronous peer tutoring system, as shown by the results.

implementation of TPACK in pre-service teacher education.

The third most cited paper, which has received 233 citations, was authored by Hasler et al. [43]. Their study explored the impact of learner-controlled pacing on instructional efficiency in educational animations. They investigated the use of audio-visual computer animations and narration-only presentations as teaching aids for primary school students. This paper is crucial for educators and researchers interested in the efficacy of different instructional methods and tools in primary education.

3.6. Spotlight on gender and disability

Out of the 293 articles analysed in this study, only four were identified as focusing explicitly on persons with disabilities, while two were dedicated to addressing gender issues. Table 7 lists the aforementioned papers that engage with disability and gender issues in detail. The studies echo that discernible gender differences exist in the interaction with educational technologies, necessitating tailored educational approaches to engage all students effectively. Educational technologies, particularly those incorporating visual and interactive elements and peer tutoring systems, have proven beneficial in supporting students with disabilities, with teachers playing a pivotal role in the successful implementation of these technology-based interventions.

3.7. Keywords and evolution trends

Fig. 5 presents a word tree that showcases the 20 most significant terms found in studies related to educational technology at the primary or elementary school levels. The size of each box in the word map is determined by the frequency of each specific keyword's use by authors. Identical keywords have been consolidated into a single column. From this visual representation, it is evident that

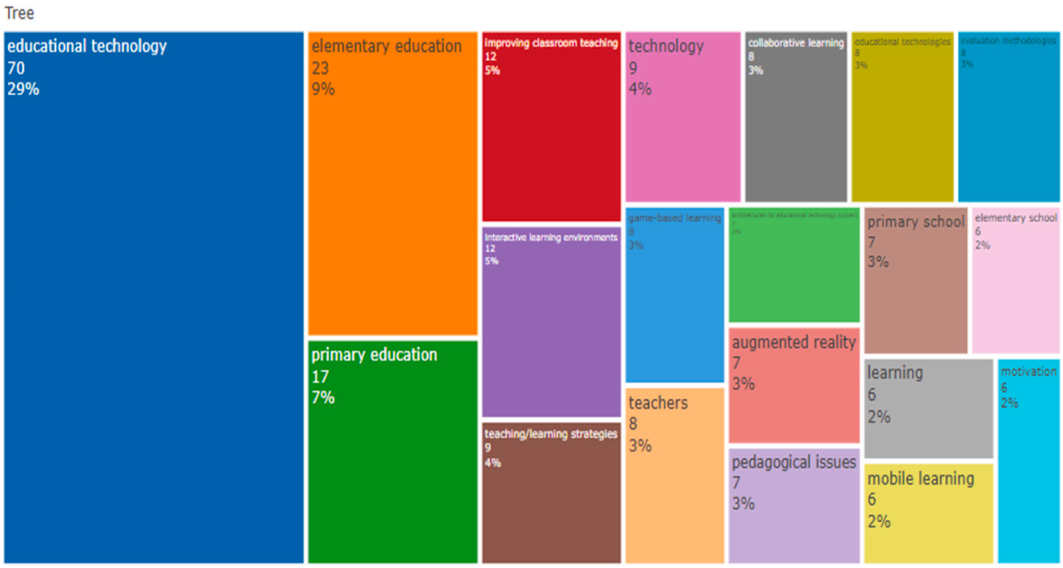

Fig. 5. Keyword analysis – Word Tree.

"educational technology" is the predominant keyword, appearing with a frequency of 70 occurrences, or 29% of the time. This is followed by "elementary education" and "primary education", with frequencies of 23 (9%) and 17 (7%) occurrences, respectively. Other notable terms include "improving classroom teaching" and "interactive learning environment", each appearing 12 times (5%), and "teaching/learning strategies", which is used nine times (4%). The prominence of these terms underscores the research focus on enhancing classroom teaching through interactive learning environments and effective teaching and learning strategies.

Fig. 6 presents findings that reveal an annual trend in themes, showcasing a distinct pattern in the frequency of keyword usage. Between the years 2021 and 2022, the four most prominent topics of interest include "educational technology," "augmented technology," "teacher education," and "pre-service teachers." Meanwhile, from 2018 to 2020, the subjects of "educational technology," "primary education," "virtual reality," "teacher training," and "reading" were notably prevalent.

The term "educational technology" is especially significant as it was not only the most frequently occurring theme over the entire period but also dominated the discussions in the year 2020 specifically. An area of particular interest to stakeholders in the educational sector is how educational technology can be leveraged to support mathematics education. According to the findings, the term "mathematics" was most frequently discussed in 2016, while "reading" was a focal point of discussions in 2018.

In effect, the trending topics from 2021 to 2022 suggest a recent concentration on the tools and technologies used in education, the training and education of current and future teachers, and the application of emerging technologies in the educational environment.

3.8. Keywords Co-occurrence

The use of keyword co-occurrence analysis has proven effective as a technique for understanding knowledge structures and discerning patterns in research trends, as noted by Altınay Ozdemir and Goktas [67]. This approach provides valuable insights into both primary and secondary literature. Fig. 7 visually represents the co-occurrence analysis. In this context, each node represents a keyword. The size of a node signifies the number of documents, while a line connecting two nodes indicates a linkage between the respective groups. A thicker line connecting two nodes represents a stronger connection between them.

This bibliometric analysis focuses on identifying and categorizing specific phrases. Notably, the term "educational technology" is represented by the red cluster. This cluster predominantly features discussions on education technology within the realm of "primary education". The green cluster, which is the next most significant, primarily explores "elementary education", and it maintains a strong connection with terms like "interactive learning environment" and "evaluation methodologies". The remaining clusters are the purple and blue ones. The purple cluster highlights themes of "collaborative learning" and "ubiquitous learning". In contrast, the blue cluster illuminates discussions on the "affordance" of educational technology at the "primary school" level. Each cluster reflects distinct but interrelated themes within the broader conversation on educational technology in early education.

3.9. Evolution of keywords

Various study topics have been identified to deepen understanding of the research outcomes. These existing themes can be strategically categorized and visualized through a graph to evaluate the significance and evolution of each research theme [68]. Fig. 8 presents a thematic map organized with density represented on the y-axis and centrality on the x-axis. A theme's value or significance is gauged by its centrality, while its expansion or development is assessed through its density level. The graph is sectioned into four quadrants.

In the upper right quadrant, the "motor themes" are located, which include "educational technology", "primary education", "number sense", "science education", "educational technologies", "digital storytelling", "elementary education", and "improving

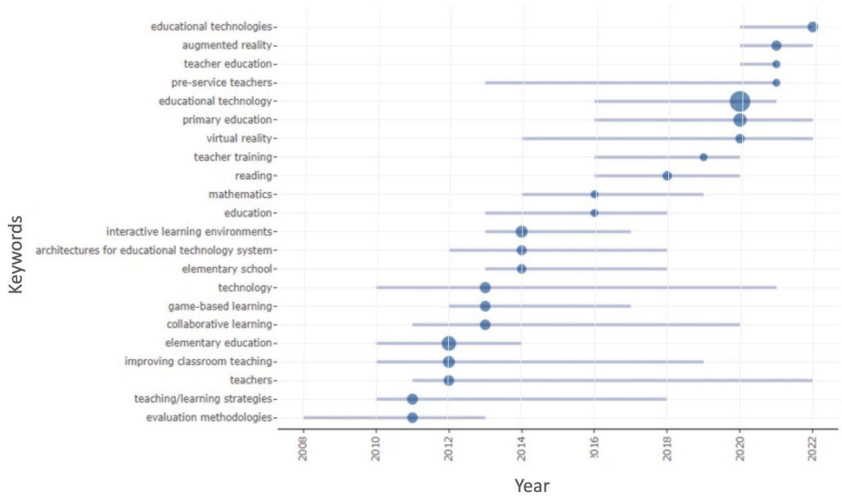

Fig. 6. Keyword analysis –Trending Topics.

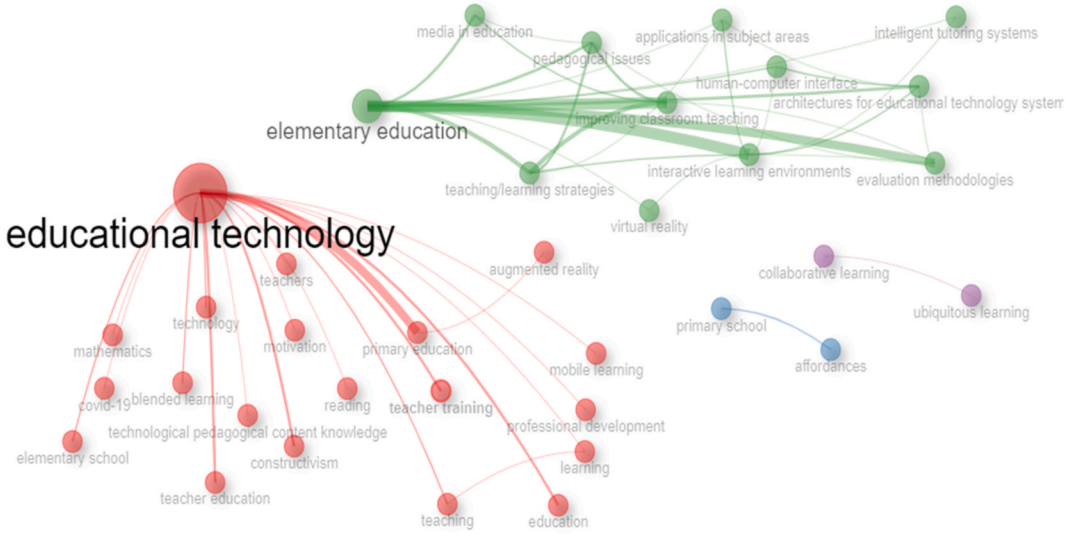

Fig. 7. Co-occurrence of keywords.

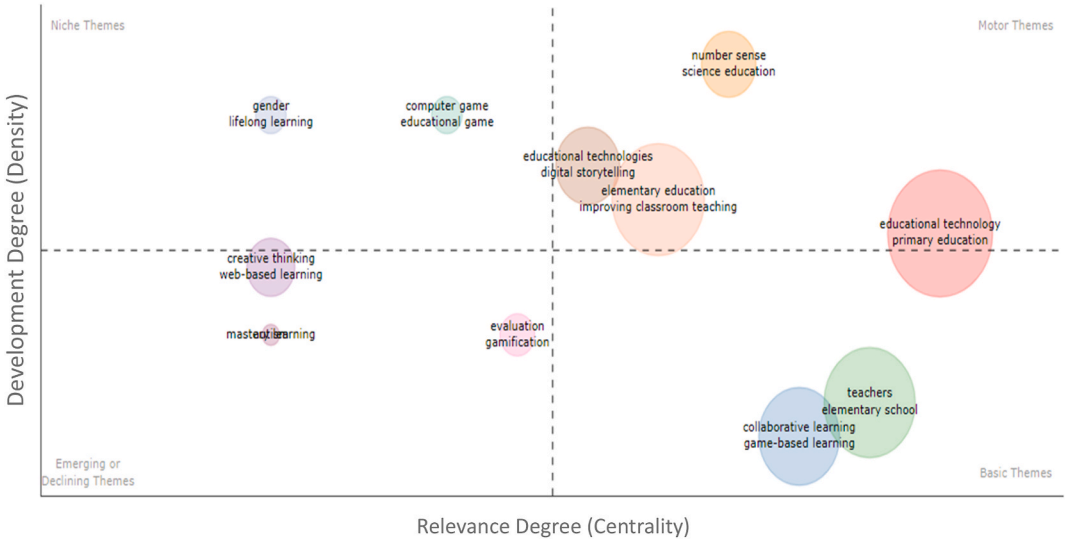

Fig. 8. Keyword thematic map for articles.

classroom teaching". These themes are pivotal, having gained momentum in the literature on educational technology at the primary education level. They represent significant and developed areas of study within the field.

The upper left quadrant houses the "niche themes", representing well-developed concepts within educational technology that are nonetheless specialized or niche in the broader research landscape. For this review, the niche themes identified are "gender", "lifelong learning", "computer game", and "educational game". In the lower left quadrant, "emerging or declining themes" are situated. These themes, including "creative thinking", "web-based learning", "mastery learning", "evaluation", and "gamification", are either on the rise, potentially advancing the field, or are waning in relevance and application.

Finally, the lower right quadrant contains the "basic theme", which serve as foundational principles in the field. Though these themes—"teachers", "elementary school", "collaborative learning", and "game-based learning"—have low density, indicating limited development, they are crucial for guiding future research in the area. These themes require further exploration and study to enhance their importance and relevance in the context defined by fundamental and established themes in the field.

Fig. 9 provides a visual depiction of the evolution of themes over time (with the time slice set to three), divided into five main subject categories, each marked by specific time periods and clusters of keywords (represented by coloured blocks). This automatically generated periods of between 1986 2011, 2012–2014, 2015–2020, and 2021–2023. Between 1986 and 2011, research on educational technologies at the primary or elementary levels primarily focused on themes like "ubiquitous learning" and "technology integration".

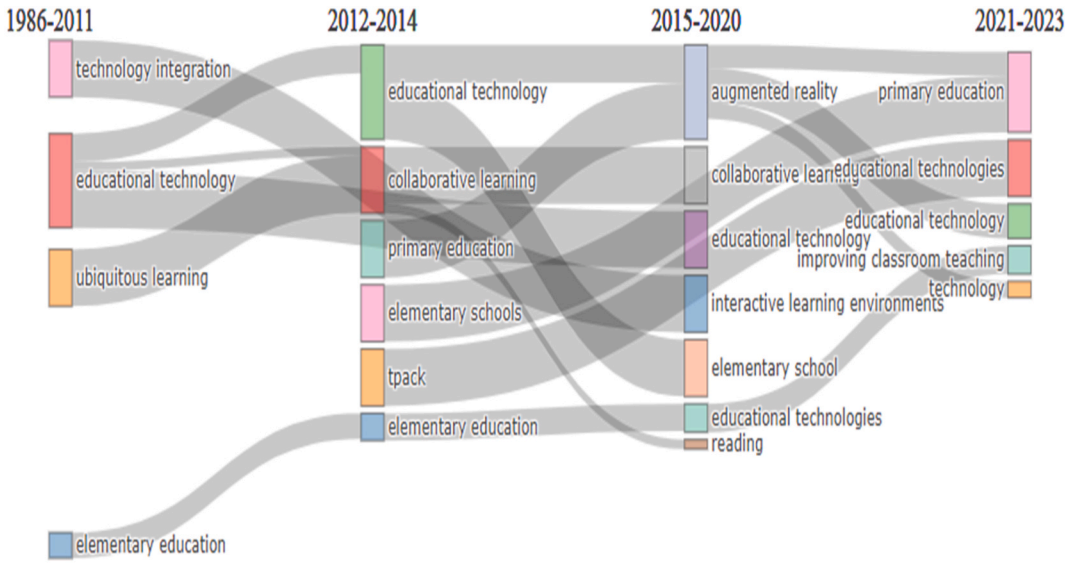

Fig. 9. Sankey diagram based on keyword thematic evolution.

During the subsequent period from 2012 to 2014, attention shifted towards "tpack" (technological, pedagogical, and content knowledge) and "collaborative learning" in the context of primary or elementary education and educational technologies.

Then, in the period from 2015 to 2020, keywords such as "augmented reality", "interactive learning environment", and "reading" gained prominence in studies on educational technologies in primary or elementary education. This shift indicates a growing interest in examining the effects of augmented reality in educational technologies, as well as how these technologies can foster interactive learning environments and support reading development among children.

In the most recent time frame, from 2021 to 2023, the focus expands to a broader exploration of "technology" and strategies for "improving classroom teaching". It's crucial to acknowledge the persistent interconnection among topics like "educational technology", "primary education", "elementary education", and "educational technologies" throughout the entire span from 1986 to 2023, as illustrated in Fig. 9.

4. Discussion and future research

This study aimed to consolidate research findings on educational technologies in elementary education, offering a platform for prospective inquiries. The discussion section synthesizes the salient findings and suggests future research directions.

1. **Yearly Publications:** The timeline from 2008 to 2016 and 2018 to 2023 witnessed a surge in publications, underscoring the sustained scholarly interest in educational technologies within elementary education over the last 15 years (See Fig. 2). This upsurge in publications can be interpreted as a reflection of the growing importance and integration of digital technologies in early education during more recent years [69]. Furthermore, this trend may also signify a broader recognition within the academic and educational communities of the importance of empirically studying the implications, applications, and effectiveness of technology-enhanced learning during the early years of education [70]. With recurrent themes cantered around "teachers", "elementary school", "collaborative learning", and "game-based learning", future research seems poised to expand upon these foundational areas, contributing to the burgeoning body of knowledge in the discipline.
2. **Most Cited Documents:** Lee and Tsai's (2010) work emerged as a pivotal reference, wielding considerable influence over subsequent scholarly endeavours (See Table 6). As Rodriguez [71] indicates, highly cited works often guide and shape the trajectory of academic exploration in the field, making the study by Lee and Tsai [41] a valuable resource for future investigations.
3. **Future Research Themes:** Cluster analysis reveals two prominent thematic clusters: one focused on "primary education" and the other on "elementary education", with the latter closely associated with "interactive learning environments" and "evaluation methodologies" (See Fig. 7). Notably, emerging keywords like "collaborative learning", "ubiquitous learning", and the "affordances" of technology in "primary education" are gaining traction, providing fertile ground for future research endeavours. Compared with the aforementioned findings regarding trending topics from 2021 to 2023 (See Fig. 9), there is a recurring emphasis on the necessity to enhance classroom teaching, through strategies including the training and education of both current and prospective teachers, and the application of emerging technologies (e.g., augmented reality and gamification) in the educational environment.
4. **Country Collaborations:** Institutions in China are at the forefront of this academic terrain, garnering citations approximately five times more than their U.S. counterparts (See Fig. 4). However, international collaborations remain sparse, indicating an

opportunity for scholars globally to forge partnerships with Chinese researchers to facilitate entry into this dynamic research domain (See Fig. 3).

5. **Research from Developing Countries:** The onset of the COVID-19 pandemic elevated the importance of educational technologies worldwide. However, there is a conspicuous underrepresentation of research contributions from African nations. Future research should endeavour to document and analyse the unique experiences, challenges, and opportunities related to the deployment of educational technologies in African contexts, thereby enriching the global dialogue on inclusive and accessible digital education solutions.
6. **Sample Groups:** While teachers predominantly constitute the sample groups in existing studies, there's limited research engagement with students. Future studies should navigate the ethical considerations involved in incorporating minors to garner deeper insights directly from the student demographic.
7. **Focus on Mathematics Education:** Despite a generalized focus on creating conducive learning environments through technology, there's a discernible gap in literature addressing the technology's impact on specific subjects, particularly mathematics (See Fig. 6). Given the perceived difficulty of the subject, future research should scrutinize the role of technology in facilitating mathematics education at the elementary level.
8. **Gender and Disability Dynamics:** The review illuminates that gender-focused studies are scant (See Table 7). An understanding of gender differences and the needs of disabled students is vital for crafting inclusive educational strategies. Hence, future research should emphasize generating knowledge that enables the incorporation of technology in ways that are inclusively beneficial, with a concerted effort from researchers and technology developers to create tools adaptable to the diverse needs and preferences of various student or learner groups. Additionally, these studies could benefit from incorporating theories of learning heutagogy and cybergogy.

5. Conclusion

This bibliometric review has mapped the academic landscape of educational technology within the realm of primary and elementary education, spotlighting seminal works, emergent themes, geographical concentrations of scholarly output, and areas where future inquiries are much needed. The evidence underscores a sustained and burgeoning interest in how technology can be adeptly integrated into early learning environments, reflected in the spike of publications within the examined period.

The study identifies that in terms of growth, there is a significant uptick in publications during 2008–2016 and 2018–2023, highlighting the growing importance and incorporation of digital technologies in early education. The analysis identifies recurrent themes like teacher education, game-based learning, and collaborative learning, pointing towards future research directions. The three journals that made an impact in the research area are "Educational Technology and Society", "Computers and Education" and "Turkish Online Journal of Educational Technology" while "Hwang G-J", "Hung C-M, and "Tsai C-C″ are the most impactful authors in the research area. The study also notes that while topics such as "educational technology, "elementary education" and "primary education", have been dominant, there are underexplored areas, including technologies role in specific subjects, ethical student engagement, gender and disability dynamics, and contributions from African contexts.

Moreover, it is apparent that as digital technologies evolve and become ever more embedded in the educational fabric, the academic discourse is progressively gravitating towards understanding their myriad applications, implications, and effectiveness in the pivotal early years of schooling. The recurrent and emergent themes–- notably those revolving around teacher education, game-based and collaborative learning, interactive environments, and technology affordances–- delineate the current foci and foreseeable future trajectories of research within this dynamic field.

However, the analysis also unveils significant gaps and uncharted territories in the literature, presenting valuable opportunities for scholarly exploration. Among these are the need for a more nuanced understanding of technology's role in specific subject areas, notably mathematics; the imperative to engage more directly and ethically with student samples; and the call for greater attention to gender and disability within the context of educational technology. Additionally, there is an urgent requirement to redress the geographical imbalances in research contributions, particularly concerning the underrepresented experiences and challenges of deploying educational technologies in the African context.

Institutional collaborations, especially international partnerships, are sparse yet represent an untapped reservoir of potential for enriching the global dialogue and praxis of educational technology in elementary education. The prominent position of Chinese institutions in this field beckons international scholars to forge alliances, facilitating a truly global exchange of ideas, findings, and best practices.

In navigating towards these unexplored or underexplored horizons, future researchers will invariably contribute to a more robust, nuanced, and inclusive body of knowledge on educational technologies in elementary education. This endeavour is not merely academic but is fundamentally tethered to the practical and urgent task of equipping educators, policymakers, and technology developers with the insights and tools necessary to harness the power of technology in fostering inclusive, engaging, and effective learning environments for all children in their formative years.

5.1. Limitations of the study

The research contributes valuable insights that align with and support the existing body of literature in this field despite operating within certain confines and limitations. One of the critical constraints of the study was its reliance on the Scopus database, which, while reputable, does not offer an exhaustive collection of all pertinent publications on the subject. The deliberate exclusion of various

forms of scholarly works, such as conference papers, dissertations, theses, and articles in the press, further narrows the scope of the review, potentially omitting valuable insights and findings present in these non-journal sources.

Furthermore, the research narrowly focuses on the practical applications of educational technology within the context of primary or elementary education. While this approach ensures relevance and specificity to the educational level under consideration, it inevitably leaves out potentially enlightening interdisciplinary contributions from fields such as engineering, computer sciences, and environmental sciences, among others.

Despite these limitations, the significance of the study's contribution cannot be understated. It provides a solid foundation for future investigations, offering a clearer direction for scholars and practitioners interested in the interplay between educational technology and elementary education. The research underscores the necessity for a broader, more inclusive review approach in subsequent studies. Future scholars in this domain would benefit from exploring various databases and considering a diverse array of scholarly works, employing a comprehensive set of keywords to capture the multifaceted nature of educational technology in primary education.

Further, we echo that there is a need to delve deeper into themes like collaborative and game-based learning within elementary settings to foster international collaborations, particularly with Chinese institutions, and to bolster contributions from underrepresented regions like Africa. Future research should also emphasize inclusivity, focusing on gender and disability dynamics, and address specific subjects like mathematics to gauge technology's subject-specific impact. Finally, the research implications, practical considerations and policy measures for the integration of advanced technologies, such as augmented reality and the metaverse, into innovative teaching and learning methods should be explored.

In conclusion, while circumscribed by its limitations, this study effectively serves as an initial exploration into the realm of educational technology within primary and elementary education settings. It illuminates the path for subsequent, more expansive research endeavours, thereby playing a crucial role in the ongoing scholarly conversation and the continual refinement and advancement of educational practices at the elementary level. Through cumulative efforts, the academic community can look forward to crafting a more inclusive, comprehensive, and nuanced understanding of how technology can be leveraged to enhance the educational experiences and outcomes for young learners around the globe.

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Data availability statement

Data will be made available on request.

Additional information

Not applicable.

CRediT authorship contribution statement

Sheena Lovia Boateng: Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Funding acquisition, Formal analysis, Data curation, Conceptualization, Project administration, Investigation, Resources, Software, Visualization. **Obed Kwame Adzaku Penu:** Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Investigation, Formal analysis, Data curation, Conceptualization, Methodology, Project administration, Resources, Supervision. **Richard Boateng:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Joseph Budu:** Writing – review & editing, Writing – original draft, Visualization, Supervision, Formal analysis, Conceptualization. **John Serbe Marfo:** Writing – review & editing, Visualization, Supervision, Methodology, Funding acquisition, Conceptualization. **Pasty Asamoah:** Writing – review & editing, Visualization, Methodology, Data curation.

Declaration of competing interest

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References

[1] A. Kirkwood, L. Price, Examining some assumptions and limitations of research on the effects of emerging technologies for teaching and learning in higher education, Br. J. Educ. Technol. 44 (4) (2013) 536–543, https://doi.org/10.1111/bjet.12049.

[2] M.D. Abdulrahaman, N. Faruk, A.A. Oloyede, N.T. Surajudeen-Bakinde, L.A. Olawoyin, O.V. Mejabi, A.L. Azeez, Multimedia tools in the teaching and learning processes: a systematic review, Heliyon 6 (11) (2020) e05312, https://doi.org/10.1016/j.heliyon.2020.e05312.

[3] R.A. Reiser, A history of instructional design and technology: Part I: a history of instructional media, Educ. Technol. Res. Dev. 49 (1) (2001) 53–64. https://www.jstor.org/stable/30220299.

[4] M. Russell, Technology and Assessment: the Tale of Two Interpretations, Information Age Publishing, 2006, pp. 137–152.

[5] M. Parai, P. Shenoy, K.Y. Loh, Students' perception of technology-assisted learning in undergraduate medical education–A survey, Soc. Sci. J. 52 (1) (2015) 78–82, https://doi.org/10.1016/j.soscij.2014.08.007.

[6] D.D. Sellnow, A. Limperos, B.N. Frisby, T.L. Sellnow, P.R. Spence, E. Downs, Expanding the scope of instructional communication research: looking beyond classroom contexts, Commun. Stud. 66 (4) (2015) 417–432, https://doi.org/10.1080/10510974.2015.1057750.

[7] K.F. Hew, T. Brush, Integrating technology into K-12 teaching and learning: current knowledge gaps and recommendations for future research, Educ. Technol. Res. Dev. 55 (2007) 223–252. https://www.jstor.org/stable/30221244.

[8] J.B. Harris, M.J. Hofer, Technological pedagogical content knowledge (TPACK) in action: a descriptive study of secondary teachers' curriculum-based, technology-related instructional planning, J. Res. Technol. Educ. 43 (3) (2011) 211–229, https://doi.org/10.1080/15391523.2011.10782570.

[9] X. Chen, D. Zou, H. Xie, Fifty years of British Journal of Educational Technology: a topic modeling based bibliometric perspective, Br. J. Educ. Technol. 51 (3) (2020) 692–708, https://doi.org/10.1111/bjet.12907.

[10] T. Phillips, G. Ozogul, Learning analytics research in relation to educational technology: capturing learning analytics contributions with bibliometric analysis, TechTrends 64 (6) (2020) 878–886, https://doi.org/10.1007/s11528-020-00519-y.

[11] X. Chen, G. Yu, G. Cheng, T. Hao, Research topics, author profiles, and collaboration networks in the top-ranked journal on educational technology over the past 40 years: a bibliometric analysis, Journal of Computers in Education 6 (2019) 563–585, https://doi.org/10.1007/s40692-019-00149-1.

[12] F.E. Perdima, S. Suwarni, N. Gazali, Educational technology in physical education learning: a bibliometric analysis using Scopus database, J. Sports Sci. 11 (14) (2022) 1–16, https://doi.org/10.6018/sportk.517091.

[13] J. Singh, K. Steele, L. Singh, Combining the best of online and face-to-face learning: hybrid and blended learning approach for COVID-19, post vaccine, & post-pandemic world, J. Educ. Technol. Syst. 50 (2) (2021) 140–171, https://doi.org/10.1177/00472395211047865.

[14] K. Hyland, F.K. Jiang, A bibliometric study of EAP research: who is doing what, where and when? J. Engl. Acad. Purp. 49 (2021) 100929 https://doi.org/10.1016/j.jeap.2020.100929.

[15] M.A. Fauzi, E-learning in higher education institutions during COVID-19 pandemic: current and future trends through bibliometric analysis, Heliyon 1 (2022) e09433, https://doi.org/10.1016/j.heliyon.2022.e09433.

[16] I. Zupic, T. Čater, Bibliometric methods in management and organization, Organ. Res. Methods 18 (3) (2015) 429–472, https://doi.org/10.1177/1094428114562629.

[17] C. Martínez-Climent, A. Zorio-Grima, D. Ribeiro-Soriano, Financial return crowdfunding: literature review and bibliometric analysis, Int. Enterpren. Manag. J. 14 (2018) 527–553, https://doi.org/10.1007/s11365-018-0511-x.

[18] M.K. Linnenluecke, M. Marrone, A.K. Singh, Sixty years of Accounting & Finance: a bibliometric analysis of major research themes and contributions, Account. Finance 60 (4) (2020) 3217–3251, https://doi.org/10.1111/acfi.12714.

[19] A.S. Krishen, Y.K. Dwivedi, N. Bindu, K.S. Kumar, A broad overview of interactive digital marketing: a bibliometric network analysis, J. Bus. Res. 131 (2021) 183–195, https://doi.org/10.1016/j.jbusres.2021.03.061.

[20] A.W.K. Yeung, S.T. Kulnik, E.D. Parvanov, A. Fassl, F. Eibensteiner, S. Völkl-Kernstock, A.G. Atanasov, Research on digital technology use in cardiology: bibliometric analysis, J. Med. Internet Res. 24 (5) (2022) e36086. https://preprints.jmir.org/preprint/36086.

[21] A. Sreenivasan, M. Suresh, Future of healthcare start-ups in the era of digitalization: bibliometric analysis, International Journal of Industrial Engineering and Operations Management 4 (1/2) (2022) 1–18, https://doi.org/10.1108/IJIEOM-10-2022-0046.

[22] D. Ravšelj, L. Umek, L. Todorovski, A. Aristovnik, A review of digital era governance research in the first two decades: a bibliometric study, Future Internet 14 (5) (2022) 2–27, https://doi.org/10.3390/fi14050126.

[23] K. Nusair, I. Butt, S.R. Nikhashemi, A bibliometric analysis of social media in hospitality and tourism research, Int. J. Contemp. Hospit. Manag. 31 (7) (2019) 2691–2719, https://doi.org/10.1108/IJCHM-06-2018-0489.

[24] K. Berhanu, S. Raj, The trustworthiness of travel and tourism information sources of social media: perspectives of international tourists visiting Ethiopia, Heliyon 6 (3) (2020) e09433, https://doi.org/10.1016/j.heliyon.2020.e03439.

[25] S. Idbenssi, L. Safaa, D. Perkumienė, M. Škėma, Exploring the relationship between social media and tourist experiences: a bibliometric overview, Soc. Sci. 12 (8) (2023) 2–15, https://doi.org/10.3390/socsci12080444.

[26] Y. Riahi, T. Saikouk, A. Gunasekaran, I. Badraoui, Artificial intelligence applications in supply chain: a descriptive bibliometric analysis and future research directions, Expert Syst. Appl. 173 (2021) 114702, https://doi.org/10.1016/j.eswa.2021.114702.

[27] R. Sharma, A. Shishodia, A. Gunasekaran, H. Min, Z.H. Munim, The role of artificial intelligence in supply chain management: mapping the territory, Int. J. Prod. Res. 60 (24) (2022) 7527–7550, https://doi.org/10.1080/00207543.2022.2029611.

[28] P. Bajdor, M. Starostka-Patyk, Smart city: a bibliometric analysis of conceptual dimensions and areas, Energies 14 (14) (2021) 1–28, https://doi.org/10.3390/en14144288.

[29] R. Benziane, S. Roqiya, M. Houcine, Fintech startup: a bibliometric analysis and network visualization, International Journal of Accounting & Finance Review 11 (1) (2022) 8–23, https://doi.org/10.46281/ijafr.v11i1.1715.

[30] I. Zupic, T. Čater, Bibliometric methods in management and organization, Organ. Res. Methods 18 (3) (2015) 429–472, https://doi.org/10.1177/1094428114562629.

[31] C. Salazar-Concha, P. Ficapal-Cusí, J. Boada-Grau, L.J. Camacho, Analyzing the evolution of technostress: a science mapping approach, Heliyon 7 (4) (2021) e06726, https://doi.org/10.1016/j.heliyon.2021.e06726.

[32] P. Mongeon, A. Paul-Hus, The journal coverage of Web of Science and Scopus: a comparative analysis, Scientometrics 106 (2016) 213–228, https://doi.org/10.1007/s11192-015-1765-5.

[33] W.L. Shiau, Y.K. Dwivedi, H.S. Yang, Co-citation and cluster analyses of extant literature on social networks, Int. J. Inf. Manag. 37 (5) (2017) 390–399, https://doi.org/10.1016/j.ijinfomgt.2017.04.007.

[34] V. Durieux, P.A. Gevenois, Bibliometric indicators: quality measurements of scientific publication, Radiology 255 (2) (2010) 342–351, https://doi.org/10.1148/radiol.09090626.

[35] D. Moher, A. Liberati, J. Tetzlaff, D.G. Altman, PRISMA Group*, Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement, Ann. Intern. Med. 151 (4) (2009) 264–269, https://doi.org/10.7326/0003-4819-151-4-200908180-00135.

[36] M.F. Ab Rashid, How to conduct a bibliometric analysis using R packages: a comprehensive guidelines, Journal of Tourism, Hospitality and Culinary Arts 15 (2023) 24–39.

[37] M. Yadav, P. Banerji, A bibliometric analysis of digital financial literacy, Am. J. Bus. 38 (3) (2023) 91–111, https://doi.org/10.1108/AJB-11-2022-0186.

[38] M. Gutiérrez-Salcedo, M.A. Martínez, J.A. Moral-Munoz, E. Herrera-Viedma, M.J. Cobo, Some bibliometric procedures for analyzing and evaluating research fields, Appl. Intell. 48 (2018) 1275–1287, https://doi.org/10.1007/s10489-017-1105-y.

[39] M. Norris, C. Oppenheim, The h-index: a broad review of a new bibliometric indicator, J. Doc. 66 (5) (2010) 681–705, https://doi.org/10.1108/00220411011066790.

[40] A. Makhija, R. Punia, S. Dahiya, A. Ohlan, A.S. MaanDevelopment trends of rare-earth luminescence: a bibliometric analysis, Mater. Today: Proc. 79 (2023) 11–17, https://doi.org/10.1016/j.matpr.2022.07.42.
[41] M.H. Lee, C.C. Tsai, Exploring teachers' perceived self efficacy and technological pedagogical content knowledge with respect to educational use of the World Wide Web, Instr. Sci. 38 (2010) 1–21. https://www.jstor.org/stable/23372538.
[42] C.S. Chai, J.H.L. Koh, C.C. Tsai, L.L.W. Tan, Modeling primary school pre-service teachers' Technological Pedagogical Content Knowledge (TPACK) for meaningful learning with information and communication technology (ICT), Comput. Educ. 57 (1) (2011) 1184–1193, https://doi.org/10.1016/j.compedu.2011.01.007.
[43] B.S. Hasler, B. Kersten, J. Sweller, Learner control, cognitive load and instructional animation, Appl. Cognit. Psychol.: The Official Journal of the Society for Applied Research in Memory and Cognition 21 (6) (2007) 713–729, 10.10.1002/acp.1345.
[44] C.W. Chang, J.H. Lee, P.Y. Chao, C.Y. Wang, G.D. Chen, Exploring the possibility of using humanoid robots as instructional tools for teaching a second language in primary school, J. Edu. Tech. Soc. 13 (2) (2010) 13–24. https://www.jstor.org/stable/10.2307/jeductechsoci.13.2.13.
[45] G.J. Hwang, Y.R. Shi, H.C. Chu, A concept map approach to developing collaborative Mindtools for context-aware ubiquitous learning, Br. J. Educ. Technol. 42 (5) (2011) 778–789, https://doi.org/10.1111/j.1467-8535.2010.01102.x.
[46] S.C. Chang, G.J. Hwang, Impacts of an augmented reality-based flipped learning guiding approach on students' scientific project performance and perceptions, Comput. Educ. 125 (2018) 226–239, https://doi.org/10.1016/j.compedu.2018.06.007.
[47] M.G. Domingo, A.B. Garganté, Exploring the use of educational technology in primary education: teachers' perception of mobile technology learning impacts and applications' use in the classroom, Comput. Hum. Behav. 56 (2016) 21–28, https://doi.org/10.1016/j.chb.2015.11.023.
[48] M. Fridin, Storytelling by a kindergarten social assistive robot: a tool for constructive learning in preschool education, Comput. Educ. 70 (2014) 53–64, https://doi.org/10.1016/j.compedu.2013.07.043.
[49] C.H. Chu, Potential negative effects of mobile learning on students' learning achievement and cognitive load—a format assessment perspective, J. Edu. Tech. Soc. 17 (1) (2014) 332–344. https://www.jstor.org/stable/10.2307/jeductechsoci.17.1.332.
[50] C.M. Hung, G.J. Hwang, I. Huang, A project-based digital storytelling approach for improving students' learning motivation, problem-solving competence and learning achievement, J. Edu. Tech. Soc. 15 (4) (2012) 368–379. https://www.jstor.org/stable/10.2307/jeductechsoci.15.4.368.
[51] T.Y. Liu, T.H. Tan, Y.L. Chu, Outdoor natural science learning with an RFID-supported immersive ubiquitous learning environment, J. Edu. Tech. Soc. 12 (4) (2009) 161–175. https://www.jstor.org/stable/10.2307/jeductechsoci.12.4.161.
[52] S.J. Jang, M.F. Tsai, Exploring the TPACK of Taiwanese elementary mathematics and science teachers with respect to use of interactive whiteboards, Comput. Educ. 59 (2) (2012) 327–338, https://doi.org/10.1016/j.compedu.2012.02.003.
[53] J.M. Yien, C.M. Hung, G.J. Hwang, Y.C. Lin, A game-based learning approach to improving students' learning achievements in a Nutrition course, Turkish Online Journal of Educational Technology-TOJET 10 (2) (2011) 1–10.
[54] E. Cejka, C. Rogers, M. Portsmore, Kindergarten robotics: using robotics to motivate math, science, and engineering literacy in elementary school, Int. J. Eng. Educ. 22 (4) (2006) 711–722.
[55] K.H. Cheng, C.C. Tsai, A case study of immersive virtual field trips in an elementary classroom: students' learning experience and teacher-student interaction behaviors, Comput. Educ. 140 (2019) 103600, https://doi.org/10.1016/j.compedu.2019.103600.
[56] B. McClanahan, K. Williams, E. Kennedy, S. Tate, A breakthrough for Josh: how use of an iPad facilitated reading improvement, TechTrends 56 (2012) 20–28.
[57] E. Segers, L. Verhoeven, Multimedia support of early literacy learning, Comput. Educ. 39 (3) (2002) 207–221, https://doi.org/10.1016/S0360-1315(02)00034-9.
[58] M. Woo, S. Chu, A. Ho, X. Li, Using a wiki to scaffold primary-school students' collaborative writing, J. Edu. Tech. Soc. 14 (1) (2011) 43–54. https://www.jstor.org/stable/10.2307/jeductechsoci.14.1.43.
[59] K.Y. Chin, Z.W. Hong, Y.L. Chen, Impact of using an educational robot-based learning system on students' motivation in elementary education, IEEE Transactions on learning technologies 7 (4) (2014) 333–345, https://doi.org/10.1109/TLT.2014.2346756.
[60] J.H.L. Koh, C.S. Chai, C.C. Tsai, Demographic factors, TPACK constructs, and teachers' perceptions of constructivist-oriented TPACK, J. Edu. Tech. Soc. 17 (1) (2014) 185–196. https://www.jstor.org/stable/10.2307/jeductechsoci.17.1.185.
[61] Y.M. Huang, T.H. Liang, C.H. Chiu, Gender differences in the reading of e-books: investigating children's attitudes, reading behaviors and outcomes, J. Edu. Tech. Soc. 16 (4) (2013) 97–110. https://www.jstor.org/stable/10.2307/jeductechsoci.16.4.97.
[62] K. Shibazaki, N.A. Marshall, Gender differences in computer-and instrumental-based musical composition, Educ. Res. 55 (4) (2013) 347–360, https://doi.org/10.1080/00131881.2013.844937.
[63] C.C. Ratcliff, S.E. Anderson, Reviving the turtle: exploring the use of logo with students with mild disabilities, Comput. Sch. 28 (3) (2011) 241–255, https://doi.org/10.1080/07380569.2011.594987.
[64] G. Yakubova, E.M. Hughes, M. Shinaberry, Learning with technology: video modeling with concrete–representational–abstract sequencing for students with autism spectrum disorder, J. Autism Dev. Disord. 46 (2016) 2349–2362, https://doi.org/10.1007/s10803-016-2768-7.
[65] K. Ledbetter-Cho, M. O'Reilly, L. Watkins, R. Lang, N. Lim, K. Davenport, C. Murphy, The effects of a teacher-implemented video-enhanced activity schedule intervention on the mathematical skills and collateral behaviors of students with autism, J. Autism Dev. Disord. 53 (2020) 553–568, https://doi.org/10.1007/s10803-020-04495-3.
[66] M. Tsuei, Mathematics synchronous peer tutoring system for students with learning disabilities, J. Edu. Tech. Soc. 17 (1) (2014) 115–127. https://www.jstor.org/stable/10.2307/jeductechsoci.17.1.115.
[67] M. Altınay Özdemir, L.S. Göktaş, Research trends on digital detox holidays: a bibliometric analysis, 2012-2020, Tourism & Management Studies 17 (3) (2021) 21–35, https://doi.org/10.18089/tms.2021.170302.
[68] H.M. Arslan, Y. Chengang, M. Bilal, Siddique, Y. Yahya, Influence of senior executives characteristics on corporate environmental disclosures: a bibliometric analysis, J. Risk Financ. Manag. 15 (3) (2022) 1–21, https://doi.org/10.3390/jrfm15030136.
[69] F. Aldhafeeri, I. Palaiologou, A. Folorunsho, Integration of digital technologies into play-based pedagogy in Kuwaiti early childhood education: teachers' views, attitudes and aptitudes, Int. J. Early Years Educ. 24 (3) (2016) 342–360, https://doi.org/10.1080/09669760.2016.1172477.
[70] H.P. Miranda, M. Russell, Understanding factors associated with teacher-directed student use of technology in elementary classrooms: a structural equation modeling approach, Br. J. Educ. Technol. 43 (4) (2012) 652–666, https://doi.org/10.1111/j.1467-8535.2011.01228.x.
[71] A. Rodríguez-Navarro, A simple index for the high-citation tail of citation distribution to quantify research performance in countries and institutions, PLoS One 6 (5) (2011) e20510, https://doi.org/10.1371/journal.pone.0020510.