Education and Information Technologies (2025) 30:2547–2575
https://doi.org/10.1007/s10639-024-12899-2

Digital education: Mapping the landscape of virtual teaching in higher education – a bibliometric review

Fatima Makda[1]

Received: 23 February 2024 / Accepted: 3 July 2024 / Published online: 27 July 2024

Abstract

Virtual teaching gained momentum for its ability to drive education continuity in times of disruption. As a result, the implementation of virtual teaching has piqued the attention of the higher education sector to leverage the affordances of this mode of instructional delivery, even in times of non-disruption. This study aims to conduct a review of virtual teaching in the higher education sector to reveal the key research trends of previous publications and areas of focus for future research. A bibliometric analysis is used to identify the key topics, themes, authors, sources, articles, and existing collaborations. To achieve this, papers indexed in the Scopus database between 2012 and 2023 were examined and analysed using VOSviewer. The findings of the study are provided through a quantitative analysis that gives a high-level overview of virtual teaching in the higher education sector and highlights the key performance indicators for the creation of articles and their citation through tables, graphs, and visualisation maps. The research yielded a total of 5,663 publications, of which 2,635 published articles were included in the analysis. The findings reiterate virtual teaching as a move in the direction of sustainable education as its assists in democratising knowledge. The analysis highlights the multifaceted nature of the research topic on virtual teaching, revealing six distinct yet interconnected thematic clusters. This study provides a holistic picture of virtual teaching in the higher education sector by integrating the analysis results with pertinent reviews of literature and makes recommendations for future research.

Keywords Virtual teaching · Virtual instruction · Higher education · Bibliometric analysis

✉ Fatima Makda
Fatima.Makda@wits.ac.za

[1] University of the Witwatersrand, Johannesburg, South Africa

1 Introduction

Virtual Teaching has gained momentum in the higher education sector for its ability to drive education continuity in times of disruption. As a result, the implementation of virtual teaching has piqued the attention and interest in education to leverage the affordances of this mode of instructional delivery within the higher education sector, even in times of non-disruption. The notion of teaching and learning environments has progressed from closed brick-and-mortar environments to an open education ecosystem (Dillenbourg, 2016; Dlamini, 2022). The rigid brick-and-mortar model of education is cracking under the pressure of accessibility, inflexibility, and outdated methods. Traditional education is facing numerous challenges, including limited access, inflexible schedules, ineffective teaching methods, and rising costs. Virtual teaching can revolutionise education offering a promising solution to these challenges by providing greater access, flexible learning options, personalised instruction, and more affordable educational opportunities (Dung, 2020). Teaching practices must be adapted given that virtual teaching is no longer an option imposed by pandemics, but a pedagogical approach that leverages technology while acknowledging the unique learning styles and preferences of contemporary students (Szymkowiak et al., 2021). Virtual teaching can also function as a possible education solution to achieve inclusivity and ubiquitous learning (Dlamini & Ndzinisa, 2020).

The increase in the growing number of students, natural disasters, pandemics, war zone areas, student unrest (Bartusevičienė et al., 2021), and the increasing demand for personalised and lifelong learning highlight the need for virtual teaching and online learning. To achieve this, there is a need to invest in infrastructure, create awareness, develop high-quality online courses, provide training for educators, and address equity concerns to transform education (Alemán de la Garza, 2019; Turnbull et al., 2021). Virtual teaching can be a powerful tool for transforming education, contributing to transformative learning experiences for students (Vaquero-Diego & Vazquez, 2022). Thus, providing students with an equitable opportunity to succeed.

This brings the need for further adoption and integration of virtual teaching methods potentially offering transformative empowerment. Students from underserved groups can access world-class lectures, professionals can upskill at their own pace, and geographically scattered students can learn together and collaborate (Dung, 2020) – virtual education transcends physical boundaries, democratising knowledge, affords ubiquitous teaching, and expands learning opportunities for students not bounded by time and space. Virtual classrooms and environments can be customised to individual learning styles, fostering deeper engagement, and encouraging self-directed exploration.

On the other hand, we cannot ignore the crucial challenges that exist in bridging the digital divide and nurturing human connection. Good internet connection, equipment, and content knowledge are required for an effective online environment (Adam et al., 2019; Welch et al., 2014). With strategic partnerships, deliberate investment in infrastructure, teacher training, and innovative digital pedagogy, virtual education can revolutionise learning, making it a mechanism of accessibility, flexibility, and personalisation, for all future students (Rana et al., 2021). Now is the opportune moment to foster innovation, devise solutions, and put them into action by exploring

unconventional methods using virtual teaching and online learning. This approach will persist in tackling challenges within the education sector, ensuring a dynamic teaching-learning process, and embracing the virtual mode of instructional delivery in higher education (Khandelwal & Shankar, 2022).

A bibliometric analysis spanning the past decade can help identify previous literature, the current developments, and gaps in the evolving environment of virtual teaching. This study will not only map the key trends and emerging areas but also reveal the real-world impact and knowledge gaps that call for further research. From uncovering influential voices and global perspectives to informing future research agendas and policy decisions, this study has the potential to guide academics, educators, and policymakers striving to navigate the future of education in our technology-driven world. Furthermore, by providing a refined picture of the past decade's developments in the virtual teaching space, this paper can pave the way for a more effective, equitable, and accessible virtual learning environment for all.

The paper aims to explore and analyse the literature on virtual teaching in higher education using bibliometric analysis to find the key topics, authors, sources, most cited articles, and collaborations. Furthermore, to understand the conceptual, intellectual, and social structure of the literature on the topic, as well as to identify the knowledge base of the use of virtual teaching in higher education and whether it is widely employed and integrated into teaching and learning processes. To achieve these aims, the objectives of the current study are to:

1. Identify the most prolific literature on virtual teaching in higher education.
2. Discover the key players in the field.
3. Demonstrate which topics are of most concern to researchers.
4. Indicate the keywords in the domain.
5. Investigate the topics and themes that can be addressed in future research in the area.

The current study will answer the following research questions and sub-research questions:

RQ1 What is the current status and key trends of research on virtual teaching in higher education?

SRQ1: Which articles are cited the most?
SRQ2: Which journals lead the literature?
SRQ3: Which authors lead the literature?
SRQ4: What are the main topics and themes that are researched?
SRQ5: What are the main words that are researched?
SRQ6: Which countries contribute most to the research production?

RQ2 What topics and themes can be addressed in future research?

The remainder of the paper is structured as follows: Section two provides a brief overview of virtual teaching whilst section three discusses the research methodology

and reports some of the initial data statistics of the analysis. Following this, the discussion of the bibliometric analysis and the key findings emanating from the analysis are presented and a write up of the findings and thematic classification is contained in section four. Section five provides an interpretation and discussion of the key findings presented in the previous sections. The study concludes in section six with a summary of the limitations of the study with possible future research ideas, and the theoretical and practical implications.

2 Virtual teaching

Virtual teaching is a mode of instructional delivery in the digital education space that can be delivered both synchronously and asynchronously (Amiti, 2020). It can be described as the delivery of instruction through technology, such as video conferencing software or online learning platforms (Grammens et al., 2022).

The notion of virtual teaching has emerged as a transformative tool in the higher education sector, offering a plethora of affordances and benefits that cater to diverse student needs and enhance educational experiences. One of the core affordances of virtual teaching is the unprecedented flexibility as online platforms allow students to access resources and coursework at their convenience (Tan et al., 2021), catering to diverse learning styles and schedules, and breaking free from the constraints of strict traditional classroom schedules. Students can access course materials and recordings anytime, anywhere, allowing them to learn at their own pace and around existing commitments (Shonhe et al., 2023). This empowers those with demanding schedules, such as working professionals or students with personal challenges, to pursue their academic goals without sacrificing flexibility. Online learning becomes a personalised journey, not a rigid timetable. This flexibility is particularly beneficial for non-traditional students, working professionals, and those with family responsibilities, enabling them to pursue higher education without compromising other life commitments (Remenick, 2019). Additionally, the digital nature of virtual teaching and online learning facilitates a more inclusive environment, accommodating students from various geographical locations and cultural backgrounds, and fostering a rich and diverse global learning community (Paudel, 2021).

Moreover, virtual teaching and online learning platforms often provide access to a wider range of resources by incorporating a variety of multimedia resources, interactive tools, and collaborative spaces that cater to multiple learning styles and preferences (Shonhe et al., 2023). Digital resources can enhance engagement, promote active learning, and encourage students to take ownership of their educational journey (Wekerle, 2022). Additionally, online learning environments provide opportunities for educators to employ innovative digital teaching and pedagogical strategies, such as flipped classrooms, gamification, augmented reality, and personalised learning pathways, to meet individual student needs and optimise learning outcomes (Sumathi, 2022). Furthermore, the scalability of virtual teaching allows institutions to reach a broader audience, potentially increasing enrolment rates and expanding access to quality education.

Beyond accessibility and flexibility, virtual teaching unlocks new avenues for engagement and personalised learning (Neifachas et al., 2022). Interactive exercises, simulations, and gamified content foster deeper understanding and active participation (Vlachopoulos & Makri, 2017). Virtual teaching and online learning with the support of AI-powered tools can offer individualised feedback and adaptive learning paths, tailoring the curriculum to each student's strengths and developmental areas (Essel et al., 2022). This approach can foster deeper engagement and cater to diverse learning styles, ensuring no student gets left behind.

While challenges such as ensuring digital equity, narrowing the digital divide, reducing technological barriers, and maintaining human connection exist, the affordances of virtual teaching and online learning in the higher education sector are undeniably beneficial as it democratises knowledge, empower students, and encourage engagement, allowing for a more accessible, flexible, and inclusive educational environment. The transformative power of virtual teaching and online learning is reshaping the rigid walls of traditional higher education. These innovative approaches offer a plethora of affordances and benefits, revolutionising knowledge delivery and accessibility in several key ways. In a world that is constantly changing, integrating virtual teaching is not just an option but a crucial step towards leveraging its affordances as a valuable tool to improve teaching and learning in the higher education sector. As technology continues to evolve, we can expect to see even more innovative and effective uses of virtual teaching in the future.

3 Research methodology

The current paper's focus pertains to virtual teaching in the higher education sector. This study aims to conduct a review of virtual teaching in higher education to reveal the key research trends of previous publications and areas of focus for future research.

This study follows a similar approach to the works of (Phan et al., 2022; Tandon et al., 2021). Based on these pieces of literature, articles and conference papers that explore the use of virtual teaching in higher education were identified, scanned, read, and analysed to collate the most relevant and appropriate dataset. The Scopus database was used to identify the most relevant and appropriate literature. This database was chosen due to its broad journal coverage (Hallinger & Nguyen, 2020). The study followed a two-step process to identify relevant publications: (1) Search words and search strings were used to identify the relevant literature from the Scopus database, and (2) Specific criteria for inclusion and exclusion of literature were used to further extract only appropriate and applicable literature to conduct the bibliometric analysis.

Pritchard (1969) was one of the earliest prominent figures who is often credited with coining the term "bibliometrics" in the mid-20th century. His work laid the foundation for the quantitative analysis of academic literature, particularly in the context of scientific research. Since then, numerous scholars across multiple disciplines have contributed to the development and refinement of bibliometric analysis, each bringing their insights and methodologies to the field. A bibliometric analysis is a widely recognised and systematic approach used to examine and evaluate exten-

Table 1 Criteria for search refinement

Criteria	Refine search limitations
Year	2012–2023
Subject Area	Social Sciences, Arts and Humanities
Document Type	Article and Conference Paper
Language	English
Source Type	Journal, Conference Proceeding

sive amounts of scientific data. It is a popular approach for exploring and examining extensive quantities of literature as it allows for analysis to deconstruct the shifts in the development of a particular field and identify collaboration patterns, while also highlighting the emerging trends within the field (Donthu et al., 2021). The current study makes use of a bibliometric analysis to gather many publications as data and objectively analysed these in terms of the volume of publications, citation patterns, authorship trends, country collaborations, institutional affiliations, and the overall impact of research outputs. Additionally, through the bibliometric analysis keywords were identified, influential literature was found, the main authors arose, emerging trends were recognised, and areas where further research is needed were identified. Overall, the goal of this bibliometric study was to enhance understanding and knowledge of the academic landscape within the domain of virtual teaching.

The literature was searched for using the keywords “Virtual Teaching”, “Virtual Instruction”, “Virtual Instructional Delivery”, “Online Teaching”, “Online Instruction”, “Virtual Mode of Instructional Delivery”, “Digital Instruction”, “Electronic Teaching”, “Internet-Mediated Teaching”, “Web-Based Teaching”, “Cyber Teaching”, “Higher Education”, “University”.

The search query that was used to conduct the advanced search on Tuesday, 24 October 2023, was as follows:

(TITLE-ABS-KEY (“Virtual Teaching” OR “Virtual Instruction” OR “Virtual Instructional Delivery” OR “Online Teaching” OR “Online Instruction” OR “Virtual Mode of Instructional Delivery” OR “Digital Instruction” OR “Electronic Teaching” OR “Internet-Mediated Teaching” OR “Web-Based Teaching” OR “Cyber Teaching”) AND TITLE-ABS-KEY (“Higher Education” OR “University”))

The first search resulted in 5,663 publications. Most publications from the first search resulted in false positives. In other words, some publications were not strongly related to the field, the document types were not limited to articles or conference papers and the publications were not all in the English language. Therefore, further refinement was done based on the criteria presented in Table 1 below. The criteria used were as follows:

The final search query that was used to conduct the advanced search with all the refinements was as follows:

(TITLE-ABS-KEY (“Virtual Teaching” OR “Virtual Instruction” OR “Virtual Instructional Delivery” OR “Online Teaching” OR “Online Instruction” OR “Virtual Mode of Instructional Delivery” OR “Digital Instruction” OR

"Electronic Teaching" OR "Internet-Mediated Teaching" OR "Web-Based Teaching" OR "Cyber Teaching") AND TITLE-ABS-KEY ("Higher Education" OR "University")) AND PUBYEAR > 2011 AND PUBYEAR < 2024 AND (LIMIT-TO (SUBJAREA, "SOCI") OR LIMIT-TO (SUBJAREA, "ARTS")) AND (LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "cp")) AND (LIMIT-TO (SRCTYPE, "j") OR LIMIT-TO (SRCTYPE, "p")) AND (LIMIT-TO (LANGUAGE, "English")).

After careful refinement, the dataset was reduced to a total of 2,635 publications. The findings and results are organised and presented according to several metrics, including yearly publication counts, publications by country, highly cited documents, publications per source, authorship distribution, co-authorship patterns, and the network of keyword co-occurrences. To create visual representations of these co-occurrence networks, VOSviewer, a powerful and user-friendly literature review tool to analyse and visually understand network data through interactive maps, was used (Van Eck & Waltman, 2011). This software simplifies the process of visualising bibliometric networks by displaying nodes exclusively within the network's visualisation. An outline of the research methodology and a summary of the research framework is illustrated in Fig. 1.

4 Analysis

A total of 2,635 articles on virtual teaching were extracted, 462 consisted of conference papers and 2,173 were journal articles. These were analysed on the publications per year, country, document source, source title, author, and co-authorship network. Analysis was also done on the most cited publications and the keywords.

4.1 Publications per year

As evidenced by the rise in publications, with 2020 marking a turning point with 293 publications and 2021 witnessing a doubling to 683 publications, research in this area has grown rapidly in recent years. While a slight dip in 2022 with 677 publications might suggest the initial surge settling, the overall trend signifies a robust field with active exploration and continuous evolution. It should be noted that the year 2023 is currently sitting at 509 publications and there is a high possibility that this will increase during the last quarter of the year. This is illustrated in Fig. 2.

The current exponential growth in research conducted in the virtual teaching space can be attributed to the pandemic serving as a catalyst, pushing institutions to rapidly explore, experiment, and implement virtual teaching in the higher education sector (Pokhrel & Chhetri, 2021). Thus, the growing research interest aligns with the increasing global adoption of virtual teaching practices across higher education institutions, highlighting the need for a deeper understanding of its variations and complexities. 805 (30%) of the publications contain the keywords "Covid" or "Pandemic". Research focus in the space is now occurring from access to equitable

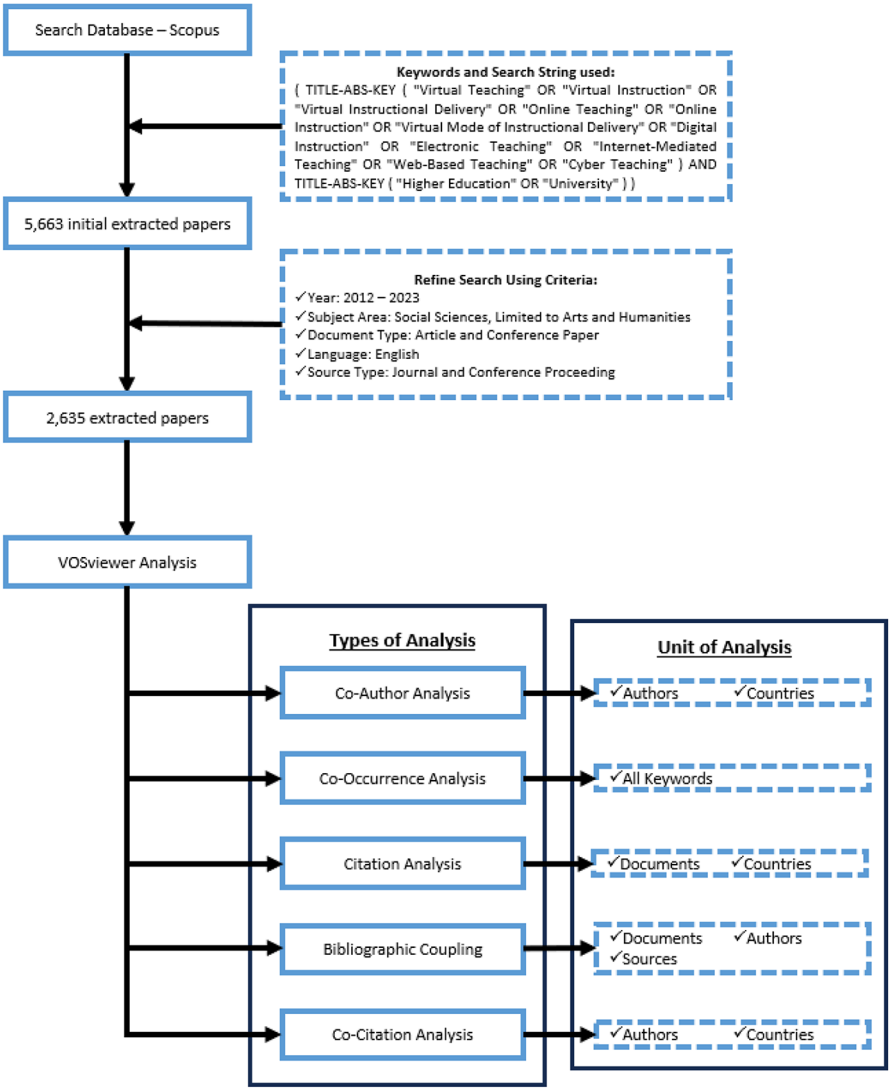

Fig. 1 An outline of the research methodology and a summary of the research framework

education to digital tools to student engagement to educator competencies needed in the virtual teaching space.

4.2 Publications per country

The publication per country analysis identified the number of publications per country. Countries with at least five research publications on virtual teaching that originated from the country were considered for this analysis. The USA dominates with a total of 596 publications and 7,483 citations. This is followed by China (301 papers,

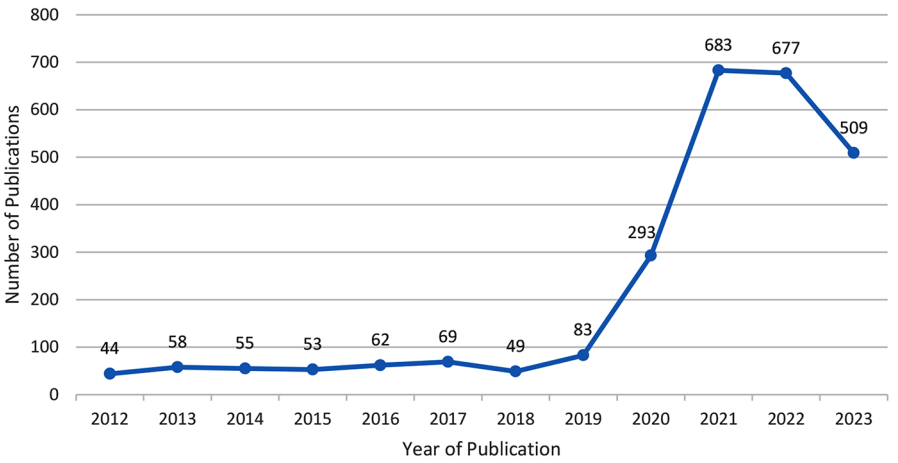

Fig. 2 Publications per year

Table 2 Publications and citations per country

Country	Publications	Citations
United States	596	7 483
China	301	2 886
Australia	185	4 103
United Kingdom	167	2 035
Spain	155	3 106
Malaysia	101	830
South Africa	100	469
India	95	1 798
Germany	76	784
Saudi Arabia	64	523
Canada	60	1 980
Hong Kong	54	1 029
Indonesia	46	112
Turkey	46	474
Portugal	42	1 783
United Arab Emirates	42	353
Romania	40	690
Thailand	36	98
Sweden	34	261
Italy	32	237

2,886 citations), Australia (185 papers, 4,103 citations), the United Kingdom (167 papers, 2,035 citations), and Spain (155 papers, 3,106 citations). South Africa comes in at 7th place, making the top 10, with 100 papers and 469 citations. Table 2 summarises the top 20 countries based on publications and citations.

Figure 3 illustrates a graphical representation of the countries with at least five research publications on virtual teaching.

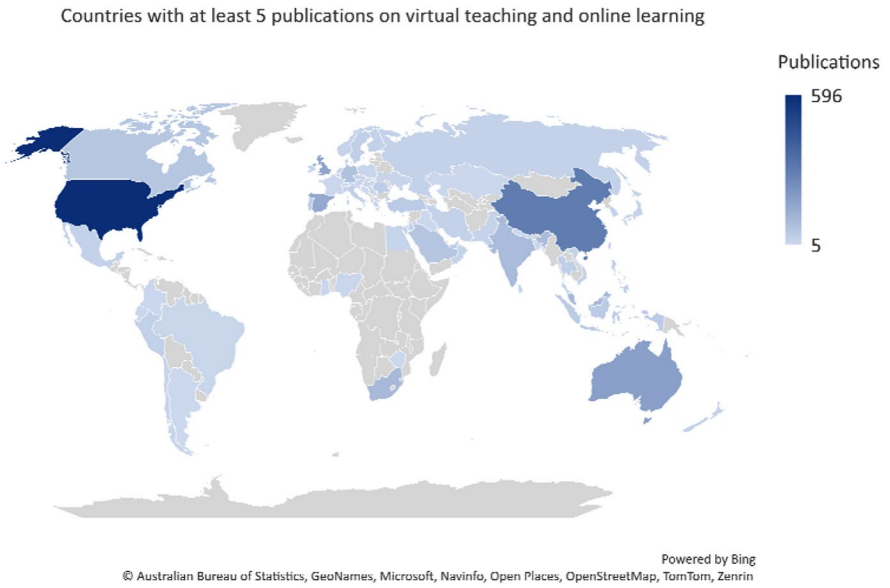

Fig. 3 Countries with at least 5 publications on virtual teaching and online learning

This illustration and findings confirm that research relating to virtual teaching is predominantly conducted in the global north. South Africa is the only Sub-Saharan African country in the top 10 and Zimbabwe, Ghana and Nigeria are the only other African countries with publications in the virtual teaching space. More research needs to be conducted on virtual teaching and digitalisation in the Sub-Saharan Africa region, especially given the contextual realities of developing countries that differ from other parts of the world (Adam et al., 2019; Dlamini, 2022).

4.3 Publications per document source on source title

The publications per document source on the source title were analysed. The top 10 journals based on the number of articles published in that journal are summarised in Table 3. The top journal with publications in this area is Sustainability (85 papers, 1,451 citations) which aims *"to encourage researchers to publish their experimental, computational, and theoretical research relating to natural and applied sciences, engineering, economics, social sciences, and humanities in detail to promote scientific and other understanding and to permit predictions and impact assessments of global change and development related to sustainability"*[1]. This can be indicative of virtual teaching use for sustainable education.

Sustainability is followed by Education Sciences (66 papers, 688 citations), International Journal of Emerging Technologies in Learning (58 papers, 386 citations), Education and Information Technologies (47 papers, 929 citations), and Online Learning Journal (44 papers, 1,052 citations).

[1] Retrieved from https://www.mdpi.com/journal/sustainability/about.

Table 3 Publications per source

Source	Publications	Citations
Sustainability (Switzerland)	85	1 451
Education Sciences	66	688
International Journal of Emerging Technologies in Learning	58	386
Education and Information Technologies	47	929
Online Learning Journal	44	1 052
Bmc Medical Education	33	538
Frontiers in Education	31	166
Proceedings of The European Conference on E-Learning, Ecel	30	59
Journal of Chemical Education	26	361
International Review of Research in Open and Distance Learning	22	628

Table 4 Citations per source

Source	Publications	Citations
Human Behavior and Emerging Technologies	5	1 505
Sustainability (Switzerland)	85	1 451
Postdigital Science and Education	5	1 091
Online Learning Journal	44	1 052
Education and Information Technologies	47	929
Computers and Education	15	781
Journal of Education For Teaching	9	734
Education Sciences	66	688
Computers in Human Behavior	8	651
International Review of Research in Open and Distance Learning	22	628

The top 10 journals based on the number of articles cited in that journal are summarised in Table 4. The top journal with citations in the area of virtual teaching is Human Behavior And Emerging Technologies followed by the Sustainability Journal. With this type of analysis and considering the research in virtual teaching only recently becoming predominant in the education space, it is not surprising to see Human Behavior and Emerging Technologies at the top as it "*advances the understanding of complex interactions between diverse human behavior and emerging digital technologies*"[2]. Human Behavior and Emerging Technologies is followed by Sustainability (Switzerland) (85 papers, 1,451 citations), Postdigital Science and Education (5 papers, 1,091 citations), Online Learning Journal (44 papers, 1,052 citations) and Education and Information Technologies (47 papers, 929 citations).

[2] Retrieved from https://onlinelibrary.wiley.com/journal/25781863.

4.4 Most cited publications

To fully grasp the understanding of research conducted in the virtual teaching and online learning space in education, it was necessary to analyse the extracted papers on the most cited documents and the focus areas that stem from them. From the 2,635 extracted papers, 13 of the publications have been cited more than 200 times. These are summarised in Table 5.

Based on the 13 publications and upon a frequency count and a brief thematic analysis of the keywords, the following focus areas emanate:

- Pandemic impact
- Remote teaching and online learning
- Online teaching and online learning
- Online learning readiness
- Online education
- Digital teaching and pedagogy
- Digitalisation

It should also be noted that most of these studies were qualitative and exploratory in nature. Based on this and the focus areas that were identified, a probable reason can be linked to an observation that virtual teaching and online learning only truly picked up during and after the Covid-19 pandemic. Consequently, the topic is still in its initial phases of research and experimentation. Therefore, it is imperative to understand the aspects of virtual teaching and online learning better and conduct future research in the area of actual virtual teaching implementation and its effect post-pandemic. Some areas of future research can include but are not limited to, areas of virtual teaching competencies, addressing social and emotional learning in virtual environments (Yu & Zhou, 2022), exploring AI-powered adaptive virtual learning (Muñoz et al., 2022), looking at the role of AI in virtual teaching and assessment, investigating culturally responsive virtual teaching, and virtual teaching and learning in metaverse applications (Sin et al., 2023).

4.5 Publication per author and Co-authorship Network

Co-authorship analysis sheds light on the collaborative networks and partnerships that drive research within a field (Donthu, 2021). There were 2,605 authors identified from the 2,635 extracted documents. This includes both the first authors and their co-authors. When we set the minimum number of documents per author at 2, only 39 authors were revealed. This indicates that there are 39 authors through solo authorship or co-authorship who have published more than one document. The overlay visualisation co-authorship network in Fig. 4 shows some clusters of co-authorship and others that are independent. This can be due to some authors in the current dataset not co-authoring with each other, which could be due to several reasons, such as different disciplines or even research interests. The authors and their well-cited publications are Rapanta C.; Botturi L.; Goodyear P.; Guàrdia L.; Koole M. (2 papers, 988 citations), Moorhouse B.L. (2 papers, 259 citations), Peimani N.; Kamalipour

Table 5 Top cited publications (>200)

Title	Cited	Type of Study	Method	Data Source	Keywords
COVID-19 and online teaching in higher education : A case study of Peking University	1 152	Qualitative	Case Study	Observations	COVID-19; Instructional strategies; Online education
Online University Teaching During and After the Covid-19 Crisis : Refocusing Teacher Presence and Learning Activity	886	Qualitative	Explorato-ry Study	Interviews	Covid-19; Emergency situation; Higher education; Instructional design; Online teaching; Pedagogical content knowledge
A Literature Review on Impact of COVID-19 Pandemic on Teaching and Learning	875	Qualitative	Review	Literature Review	Internet Use; Learning; Pedagogy; Teaching (Academic)
Online teaching-learning in higher education during lockdown period of COVID-19 pandemic	840	Mixed Methods	Explorato-ry Study	Questionnaire, Interview	COVID-19; Lockdown period; Online education; On-line teaching-learning modes; Outbreak; Pandemic; Perception
COVID-19 and teacher education: a literature review of online teaching and learning practices	449	Qualitative	Review	Literature Review	Covid-19; Online learning; online practices; teacher education
Online teaching and learning in higher education during the coronavirus pandemic: Students' perspective	427	Mixed Methods	Explorato-ry Study	Semi-structured questionnaire	E-learning platform; Higher education; Online information assimilation; Online teaching; Students' preferences
Online education and its effective practice : A research review	362	Qualitative	Explorato-ry Study	Content Analysis	Asynchronous learning; Cognitive presence; Online education; Online higher education; Online learning community; Online teaching; Social presence; Teach-ing presence
U.S. faculty and administrators' experiences and approaches in the early weeks of the COVID-19 pandemic	296	Quantitative	Explorato-ry Study	Survey	COVID-19; Emergency remote teaching; Online learning; Remote learning; Remote teaching
Adaptations to a face-to-face initial teacher education course 'forced' online due to the COVID-19 pandemic	259	Qualitative	Reflexive	Experience	Adapting to online teaching; COVID-19 pandemic; Initial teacher education; synchronous online teaching
Online learning readiness among university students in Malaysia amidst Covid-19	216	Quantitative	Explorato-ry Study	Questionnaire	Covid-19; Online learning; Online learning readiness; University students
Comparative analysis of Student's live online learning readiness during the coronavirus (COVID-19) pandemic in the higher education sector	209	Quantitative	Explorato-ry Study	Survey	Coronavirus; COVID-19; Heterotrait-monotrait; Higher education; Learning readiness; Live online learning; Multi-group analysis; Pandemic; Post hoc test

Table 5 (continued)

Title	Cited	Type of Study	Method	Data Source	Keywords
Profiling teachers' readiness for online teaching and learning in higher education: Who's ready?	207	Quantitative	Exploratory Study	Survey	COVID-19 pandemic; Higher education; Online teaching and learning; Teacher readiness; TPACK
A systematic review of research on online teaching and learning from 2009 to 2018	202	Qualitative	Review	Systematic Review	Distance education; Online Learning Research; online teaching and learning; Research Themes; Systematic Review

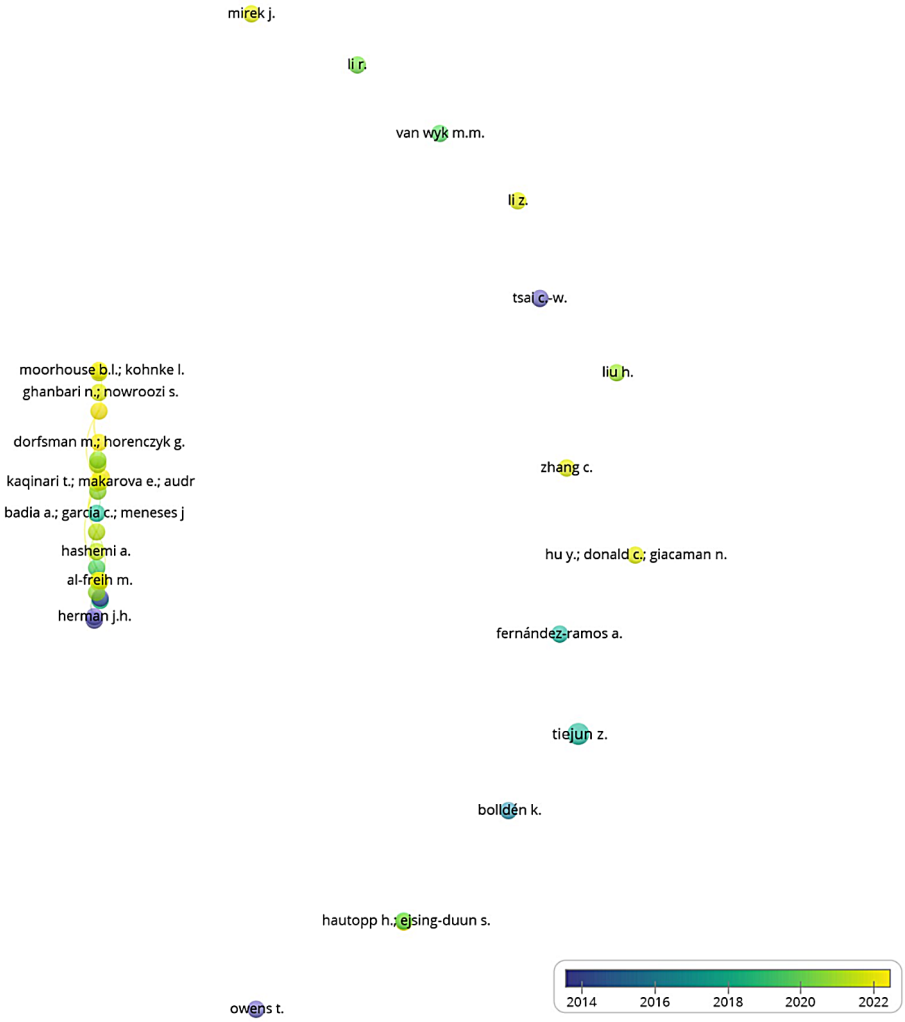

Fig. 4 Overlay visualisation co-authorship network

H. (2 papers, 116 citations), Herman J.H. (2 papers, 77 citations) and Moorhouse B.L.; Kohnke L. (2 papers, 60 citations). The data in Table 6 is an extract of the Top 10 authors sorted by publication from then by citations. A limitation of this analysis is that the data retrieved from Scopus that is analysed in VOSviewer stores all the publishing author(s) names in one author data column which results in the total citation count per document and not per author. For example, in the snippet provided in Table 6, the author Moorhouse B.L has a total of 4 publications and 319 citations.

Owens, T, Meyer K.A; Murrel V.S, Herman J.H, Carceller C.; Dawson S.; Locky, and Tsai C.W were the earlier set of authors that were publishing in the virtual teaching space given our time restriction of 2012–2023. These co-authorships can be seen in the purple colour on the map and existed from 2014 to 2016. The most recent

Table 6 Extract of authors based on the number of publications per author (solo and co-author)

Author	Publications	Citations
tiejun z.	3	32
rapanta c.; botturi l.; goodyear p.; guàrdia l.; koole m.	2	988
moorhouse b.l.	2	259
peimani n.; kamalipour h.	2	116
herman j.h.	2	77
moorhouse b.l.; kohnke l.	2	60
badia a.; garcia c.; meneses j.	2	55
tsai c.-w.	2	48
hashemi a.	2	46
meyer k.a.; murrell vs.	2	43

authors publishing in the virtual teaching space can be seen in the yellow represented on the map. There are many authors represented recently which may be indicative of the pandemic acting as a catalyst for studies in this researched field.

4.6 Research focus based on co-occurring keywords

A co-occurring keyword analysis is important to identify and analyse patterns in the literature. This analysis involves examining the frequency with which certain keywords appear together in the existing extracted literature (Donthu, 2021). When conducting a co-occurrence map using the bibliographic data extracted, it is important to set the minimum number of co-occurrences for the keywords to be extracted. This can assist with the appropriate clustering of keywords into themes that are used to explain the extent of research done in virtual teaching. This is a valuable analysis as it helps to identify themes, topics, relationships, trends, patterns, and outliers or gaps in research (Donthu, 2021).

The current study used the predefined minimum number of co-occurring keywords as 10. This choice was made to find a balance by eliminating inadequate results and reducing the occurrence of repeated words. This implies that for a keyword to be extracted, it must have a minimum of ten instances of co-occurrence with the author and source-indexed keywords. The analysis revealed a total number of 8,164 Keywords for all 2,635 extracted publications. Out of these keywords, 248 met the threshold of 10 co-occurrences and were further grouped into six clusters. Figure 5 shows the network visualisation map for the 248 co-occurring keywords and their 6 different clusters. At the centre of it are the keywords “Online Teaching”, “Online Learning”, “Higher Education” and “Covid-19” to which most of the other keywords are linked.

4.6.1 Cluster 1 technology enabled teaching

Represented by the red region on the map with 62 keywords. This cluster highlights the pervasive role of technology in shaping virtual teaching with a strong focus on leveraging technological platforms and digital tools to deliver and manage educational content. The prominence of keywords like “online learning,” “distance learning,” “learning management system,” “blended learning,” and “technology” suggests

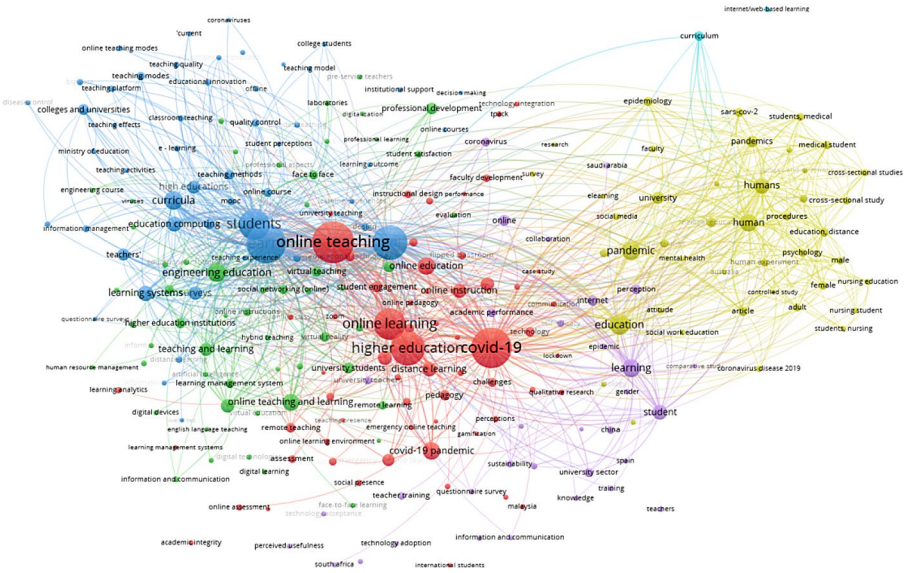

Fig. 5 Network visualisation map for co-occurring keywords

a strong theme of technological tools and platforms in virtual teaching. Keywords like "active learning," "collaborative learning," "flipped classroom," "engagement," and "pedagogy" point towards another theme focused on effective teaching and learning strategies and approaches in the virtual environment. This can suggest efforts to incorporate engaging and interactive pedagogy for student engagement and satisfaction (Chamorro-Atalaya, 2021). Keywords like "assessment," "online assessment," "feedback," and "student engagement" indicate research in areas of research and assessment with a concern for measuring and improving learning outcomes in virtual settings. The presence of keywords like "case study," "qualitative research," and "action research" suggests that many studies within this cluster employ qualitative research methods to explore the experiences and perspectives of stakeholders in virtual teaching (Merriam & Grenier, 2019). These research methods align with the period and maturity of the topic at hand, considering that it is an emerging field of study. Keywords like "emergency remote teaching," "covid-19," and "lockdown" highlight the impact of the COVID-19 pandemic on virtual teaching, potentially indicating an emerging area of research on adapting to unforeseen circumstances. It may be helpful to learn from the events of the pandemic and see how we can adapt the positive experiences of virtual teaching during the pandemic period and incorporate it into non-disruptive teaching periods to provide high-quality education to reach a larger number of students across multiple geographical areas (Ewing, 2021). Furthermore, it will be helpful to explore specific digital technologies and digital pedagogies that can be used successfully to increase student engagement and learning outcomes in the virtual space, given the connections between technology and pedagogy revealing using technology effectively to promote active learning and collaboration in the virtual teaching and learning environment (Roe, 2022).

4.6.2 Cluster 2 educator development

Represented by the green region on the map with 56 keywords. This cluster underscores the importance of empowering educators for success in virtual teaching. It seems to centre around the core aspects of the educational process in teaching and learning in virtual settings, as evidenced by keywords like "learning and teaching," "teaching practices," "student learning," "motivation," and "engagement." These keywords suggest a focus on adapting and refining teaching methods for online environments. There is also an emphasis on professional development illustrated by keywords like "professional development," "faculty development," "training," and "academic staff". This suggests a strong theme of supporting educators in adapting to and thriving in virtual teaching environments. The close connection between professional development and teaching practices highlights the need for training programs that directly address the challenges and opportunities of virtual teaching (Fernández-Batanero et al., 2022). There is a need to equip educators with the necessary skills and knowledge needed to effectively teach in virtual teaching environments (Chi & Oanh, 2023). Assessment and evaluation also come into play through the keywords "assessment," "evaluation," "feedback," and "student satisfaction" which indicate a continued concern for measuring and improving learning outcomes in virtual environments, but from a different angle compared to the first cluster. This cluster is more indicative of educators' role and influence in the design and development of assessments in the virtual teaching and online learning space. The presence of keywords like "case study," "action research," and "survey" suggests that many studies within this cluster also employ qualitative and quantitative research methods to explore the experiences and perspectives of the various stakeholders in virtual teaching. The keywords "social learning," "community of practice," and "collaboration" highlight the importance of building communities and fostering social interaction within virtual learning environments for the development of educational experiences (Garrison et al., 1999; Garrison & Anderson, 2003). Keywords like "digitalization," "digital tools," and "information and communication technologies" strengthen the analysis results from the first cluster as they suggest an ongoing focus on leveraging technology to enhance learning and teaching. This cluster emphasises the crucial role of institutional support in providing ongoing professional development and building collaborative networks for educators (Garrison & Anderson, 2003; Rice & Deschaine, 2020). Building on the analysis from this cluster, it will be helpful to conduct further research on competencies and professional development programs for virtual teaching and innovative assessment practices focused on student motivation and performance. Furthermore, research could delve into the design and effectiveness of professional development programs specifically tailored to virtual teaching needs, fostering a supportive ecosystem for educators to thrive in this evolving virtual space.

4.6.3 Cluster 3 leadership, policy, and governance

Represented by the blue region on the map has 51 keywords. This cluster focuses on the broader framework and governance of virtual teaching in higher education. It emphasises the need for robust policies and leadership structures that promote

innovation, inclusivity, and quality assurance in virtual teaching. This cluster seems to centre around the broader context and governance of virtual teaching in higher education, as evidenced by keywords like "educational leadership," "policy," "decision making," "innovation," and "quality assurance." These keywords highlight the need for strategic leadership and policy development to effectively manage and guide the integration of virtual teaching practices (Wajdi et al., 2020). The link between "policy" and "innovation" suggests a focus on developing policies that encourage and support innovative approaches to virtual teaching. Keywords like "higher education," "university," "institution," "administration," and "resources" suggest a strong theme of how higher education institutions are adapting and responding to the challenges and opportunities of virtual teaching indicating an emphasis on institutional factors. This reveals a concern for how universities are adapting their structures and resources to accommodate this evolving paradigm. Keywords like "student success," "student support," "equity," "inclusion," and "accessibility" indicate a continued concern for student-centred approaches in ensuring positive learning outcomes and experiences for all students in virtual settings. This can also indicate a commitment to ensuring that all students benefit from and have equitable access to quality virtual learning experiences. The presence of keywords like "survey," "questionnaire," and "interviews" suggests that many studies within this cluster employ quantitative and qualitative research methods to gather data from different stakeholders involved in virtual teaching. Keywords like "open education," "MOOCs," and "online learning platforms" highlight the increasing adoption of open and flexible learning models in higher education. Keywords like "sustainability," "environmental impact," and "green campus" suggest an emerging focus on the environmental implications of virtual teaching and promoting sustainable practices. It will be helpful to conduct further research on specific policies and strategies for supporting student success in virtual environments or institutional initiatives for promoting virtual and open education as well as the impact of virtual teaching on climate change. Further research could investigate the impact of different policy frameworks on virtual teaching and explore effective strategies for navigating the challenges and opportunities associated with implementing virtual teaching across diverse institutional contexts.

4.6.4 Cluster 4 student perspectives and experiences

Represented by the yellow region on the map has 43 keywords. This cluster delves into the student-centred aspect of virtual teaching. It highlights the importance of gathering student feedback and understanding their diverse experiences to inform pedagogical practices and improve virtual learning environments. Keywords like "student satisfaction," "student engagement," "motivation," "perception," and "attitude" highlight a strong focus on students' attitudes and understanding how students feel about and respond to virtual learning environments. It highlights the importance of understanding how students perceive and respond to virtual learning environments. Keywords like "challenges," "barriers," "advantages," "benefits," and "difficulties" suggest an emphasis on the challenges and opportunities that this cluster explores in the dual nature of virtual teaching, with both drawbacks and positive aspects for students being researched. Keywords like "anxiety," "stress," "isolation,"

"support," and "community" indicate a more social and emotional dimension in the concern for the well-being and social-emotional experiences of students in virtual settings. The connection between "student attitudes" and "social and emotional dimensions" emphasises the need to consider not only academic outcomes but also the well-being of students in virtual settings. The presence of keywords like "survey," "questionnaire," and "interviews" suggests that many studies within this cluster likely employ quantitative and qualitative research methods to gather data directly from students about their virtual learning experiences. Keywords like "self-directed learning," "autonomy," and "independence" highlight the potential for virtual teaching to foster student agency and self-reliance. Keywords like "diversity," "inclusion," and "equity" suggest an emerging focus on ensuring that virtual learning environments are accessible and beneficial for all students, regardless of their backgrounds or learning styles. It will be helpful to conduct further research on specific challenges faced by different student groups in virtual settings and effective strategies for promoting student engagement and emotional well-being potentially revealing valuable recommendations for improving the virtual learning experience for students (Tan et al., 2021). Additionally, future research can delve more into exploring strategies to address social and emotional needs and foster a sense of community within virtual learning environments, fostering collaboration, and mitigating feelings of isolation among students in online settings is needed.

4.6.5 Cluster 5 technology infrastructure

Represented by the purple region on the map has 33 keywords. This cluster focuses on the technological foundation and infrastructure of effective virtual teaching. It emphasises the need for careful planning and investment in appropriate technology infrastructure that supports pedagogical goals and accessibility. Keywords like "learning management system," "educational technology," "software," "hardware," "platform," and "infrastructure" highlight a strong theme of exploring both technology infrastructure and the tools and resources necessary for supporting virtual teaching and learning. It highlights the importance of selecting and implementing robust technological tools and platforms. Keywords like "accessibility," "usability," "interface," "design," and "interoperability" provide emphasis on accessibility and usability for ensuring that virtual learning technologies are easy to use and inclusive for all students. This indicates a concern for ensuring that technology is user-friendly and inclusive for all students by incorporating instructional design principles and universal design for learning (UDL) practices. Keywords like "integration," "collaboration," "communication," "engagement," and "interaction" indicate a focus on how technology can be used to create engaging and interactive virtual learning environments. The link between "technology" and "integration" highlights the need for seamless integration of technology into teaching and learning practice. In other words, using technology to create interactive and engaging virtual learning experiences. The presence of keywords like "case study," "pilot study," and "evaluation" suggests that many studies within this cluster likely employ case studies and evaluation methods to assess the effectiveness of specific technologies or platforms in virtual teaching settings. Keywords like "artificial intelligence," "virtual reality,"

and “augmented reality” highlight the potential for emerging technologies to further enhance virtual learning experiences. Keywords like “cloud computing,” “big data,” and “learning analytics” suggest an interest in using data-driven approaches to personalise and optimise learning in virtual environments. It will be helpful to conduct further research on specific technologies used for accessibility purposes or the challenges and opportunities associated with emerging technologies in virtual teaching. Further research could explore the effectiveness of different learning management systems and technological tools, investigate best practices for technology integration in virtual teaching, and address challenges associated with accessibility and digital equity in virtual environments (Dlamini, 2023).

4.6.6 Cluster 6: Curriculum design and delivery in distance and web-based learning

Represented by the light blue region on the map has 3 keywords. This cluster highlights the need for modification and transformation of curriculum design and delivery in the context of distance and web-based learning. This cluster seems to centre around the instructional design and delivery of virtual teaching through the development and implementation of learning experiences specifically designed for distance and web-based environments. The “curriculum” keyword highlights the importance of structuring content and learning activities effectively for self-directed and online learning. “Distance learning” and “self-instruction” emphasise the need for independent learning strategies and autonomous engagement with the material. The tight connections between curriculum, self-instruction, and internet technologies reveal a focus on creating student-centred, autonomous learning experiences that leverage the unique capabilities of online platforms. Keywords like “internet” and “web-based learning” once again point towards the integration of technology with the prevalence of technology as a platform for delivering and accessing learning content. The focus is not just on online access, but on building learning experiences that leverage the unique affordances of internet technologies such as multimedia, interaction, and collaboration. Despite the focus on technology, the keywords suggest a student-centred approach with a concern for tailoring the curriculum and learning approaches to the needs of individual students. The focus on student-centredness might involve the use of qualitative research methods such as surveys, interviews, and observations to gather data on student experiences and learning outcomes in online settings. “Self-instruction” implies flexible and personalised learning paths, while “distance learning” necessitates consideration of student autonomy and motivation in virtual settings. Keywords from other clusters like “open education” and “MOOCs” hint at the increasing popularity of flexible and accessible online learning resources. Mohapatra and Mohanty (2017) recognise MOOCs as a potential solution for providing wider access to quality education at an affordable cost. This highlights the potential for democratising education, catering to diverse student needs, and providing affordable access to education. “Adaptive learning” and “personalized learning” suggest an emerging focus on dynamic curricula and learning pathways that adjust to individual student progress and preferences, optimizing the learning experience for each student. It will be helpful to conduct further research on how to effectively design and implement curricula for self-instruction that empower students, foster

self-directed learning, and harness the potential of innovative web-based technologies for optimal learning outcomes in distance and online settings (Tan et al., 2021).

4.7 Research focus base on year of publication

Figure 6 shows the network visualisation map for the 248 co-occurring keyword clusters based on time i.e. in the different years of publication. With a minimum of 10 occurrences, it was observed that the research conducted in 2021–2023 in the virtual teaching and learning space related to "Covid-19", "pandemic(s)", "Emergency remote teaching" and "remote teaching". This can be seen in the yellow represented on the map in Fig. 6. Research done between 2020 and 2021 in this area was related to "online teaching", "online learning", "e-learning" and "higher education". This can be seen in the greenish colour represented on the map in Fig. 6. Research done between 2019 and 2020 in this area was related to "computer-aided instruction", "online instruction", "learning management system" and "distance education". This can be seen in the purple areas represented on the map in Fig. 6.

The observations are logically sound as virtual teaching stems from digitalising distance education. We can also see the growth of research areas done over the last five years. A trend to note is that although there are 'many' research areas, newer keywords are 'synonyms' for the older keywords. Further research should be conducted in areas of access challenges, student engagement, lecturers' competencies needed for successful implementation, and frameworks for virtual teaching and online learn-

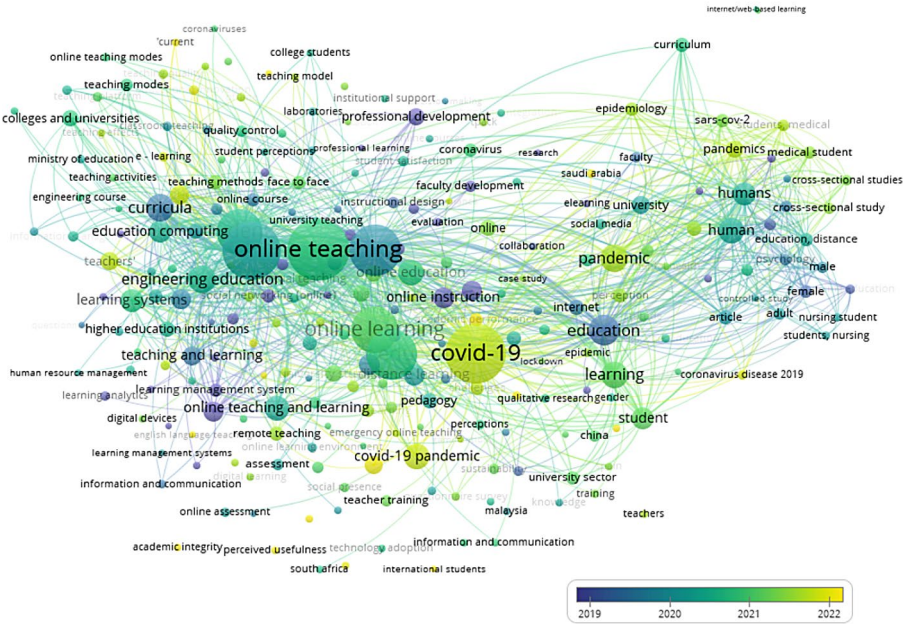

Fig. 6 Network visualisation map for co-occurring keywords over time

ing. These areas need to be given considerable attention as studies on virtual teaching continue to emerge.

5 Discussion

Virtual teaching is a long-standing approach in both the education sector and within the literature. However, virtual teaching gained momentum for its ability to drive education continuity in times of disruption. During the pandemic and forced lockdown in 2020, there was a rise in the adoption of virtual teaching. The significant increase in publications, particularly post-pandemic (2020–2023), aligns with the surge in virtual teaching adoption. The dominance of keywords like "Covid-19" and "pandemic" in these publications underscores the pandemic's role as a catalyst for research on emergency remote teaching and adaptation to unforeseen circumstances (Ewing, 2021). Consequently, learning from the experiences of the pandemic, higher education institutions and educators realised the affordances of virtual teaching and its beneficial impact, evolving beyond emergency remote teaching measures. The growing number of students, combined with the increasing demand for lifelong learning and personalised education, highlight the long-term need for virtual teaching and online learning options. Virtual classrooms transcend physical limitations, democratising access to knowledge and creating a more inclusive learning environments for students across the globe. The shift from traditional brick and mortar classrooms to a more open educational ecosystem positions virtual teaching as a transformative tool in higher education. By leveraging technology and adapting teaching practices to cater to diverse student needs and preferences, virtual education offers a plethora of benefits, including greater access, flexibility, personalisation, and potentially lower costs. In other words, virtual teaching is no longer a temporary solution but a powerful pedagogical approach shaping the future of higher education.

The analysis and findings identified in this study highlight a multifaceted approach encompassing technology, pedagogy, leadership, student experience, infrastructure, and curriculum design. This underscores the critical role of technology in enabling virtual teaching, while simultaneously emphasising the importance of effective digital pedagogy. The centrality of technology in virtual teaching, with a focus on leveraging platforms, digital tools, and learning management systems (LMS) for content delivery and management and creating engaging and interactive learning experiences is necessary. The focus on teaching practices, student learning, motivation, and engagement aligns with the need to adapt and refine teaching methods and assessments for online settings. This adds emphasis on the importance of integrating effective pedagogy, teaching, and learning strategies with technology to promote student engagement and active learning (Chamorro-Atalaya, 2021). Research on assessment strategies suggests a concern for measuring and improving learning outcomes in virtual environments. This becomes necessary as there is a need to redesign assessments in virtual environments differently to traditional assessments. This underlines the importance of empowering educators for success in both teaching and assessing in virtual environments. Professional development programs become necessary due to

the need to equip educators with the necessary skills and knowledge to thrive in this evolving space (Fernández-Batanero et al., 2022; Chi & Oanh, 2023).

For the effective integration of virtual teaching in higher education institutions there is a need for strong leadership, strategic planning, and policy development to effectively manage and integrate virtual teaching practices so that it moves beyond substitution but to a level of transformation. It becomes necessary to develop policies that encourage exploration of new and effective approaches in virtual teaching with a commitment to ensuring positive learning outcomes and experiences for all students in diverse virtual settings. This highlights the importance of understanding student experiences and perspectives to inform pedagogical practices and improve virtual learning environments. By designing the virtual environment to be more student centred, it will not only address academic needs but also consider students' well-being and social-emotional experiences (Tan et al., 2021).

This study focused on research trends for virtual teaching, but it's also important to consider the broader implications for virtual teaching in higher education. Virtual teaching can offer cost benefits, such as reduced need for physical classroom space. However, ensuring equitable access for students with limited technology or internet resources requires investment in infrastructure and support services. Research on cost-effective and sustainable models for virtual teaching is crucial. Consequently, there is a need for careful planning, design, development, and investment in appropriate technology infrastructure to support virtual teaching and learning. As we move forward, ongoing research and development are vital to optimise virtual teaching practices. Exploring the effectiveness of various approaches, addressing social and emotional considerations, and integrating culturally responsive digital pedagogy are key areas for future research. More research needs to be conducted on virtual teaching and digitalisation in the Sub-Saharan Africa region, especially given the contextual realities of developing countries that differ from other parts of the world (Adam et al., 2019; Dlamini, 2022). Further investigating the potential use of Artificial Intelligence and Virtual Reality for immersive experiences in virtual environments holds significant promise as it suggests the potential of emerging technologies to further enhance virtual learning experiences. By embracing these trends and fostering a culture of innovation, higher education institutions can harness the power of digital education and virtual teaching to create dynamic and accessible learning opportunities for a diverse student, shaping the future of higher education in the process.

6 Conclusion

Virtual teaching presents a transformative opportunity for higher education. By addressing the research gaps identified, embracing future trends, and considering the broader social and institutional implications, higher education institutions can create a future where virtual teaching empowers educators, promotes student success, and expands access to equitable high-quality education for all. Virtual teaching in higher education is undergoing a dynamic transformation, fuelled by rapid technological advancements, shifting pedagogical paradigms, accessible and equitable education, and a growing demand for flexible learning models. Through a comprehensive bib-

liometric review, this research study mapped the current status and key trends of research on virtual teaching in higher education and identified topics and research areas that can be further addressed in future research. This study underscores the critical role of technology in enabling virtual teaching, while simultaneously emphasising the importance of effective pedagogy and educator development. It highlights the need for leadership that promotes innovation and policies that ensure equitable access and student success. Furthermore, the study emphasises the importance of understanding and addressing student perspectives and experiences to create engaging and supportive virtual teaching environments.

6.1 Theoretical implications

The prominence of technology-driven teaching and student-centred learning suggests a potential shift towards constructivist and student-centred paradigms in virtual teaching environments. This challenges traditional teacher-centred models and necessitates research on effective student engagement strategies and personalised learning pathways within online settings. While this emphasises educator support and professional development which stresses the need for understanding how best to equip educators with the skills and knowledge needed to thrive in this evolving paradigm. This opens avenues for research into transformative pedagogical approaches and collaborative learning communities for educators in virtual settings. Furthermore, the focus on navigating policy and governance in the virtual teaching space highlights the need for theoretical frameworks and best practices for integrating virtual teaching into the broader infrastructure of higher education. This could involve research on policy formulation, resource allocation, and leadership models conducive to effective virtual teaching implementation.

6.2 Practical implications

To optimise virtual teaching and online learning experiences, a multifaceted approach is crucial. Curriculums can be redesigned to exploit the strengths of learning management systems, incorporating interactive activities, multimedia resources, and opportunities for student collaboration. The insights from technology-driven, student centred and digital pedagogy-focused teaching environments can inform the design and development of engaging and interactive learning experiences within virtual platforms. Virtual platforms themselves can be leveraged to promote active learning through online discussions, simulations, case studies, and problem-solving activities. There is a need to support and empower educators with an emphasis on educator training for their practical needs through the design and implementation of effective professional development programs tailored to virtual teaching competencies, pedagogy adaptation, and technology integration. This also highlights the importance of building communities of practice and peer support networks for educators navigating this shift in developing technological proficiency and pedagogical strategies that synergistically capitalise on the affordances of online platforms. Personalisation is another key advantage, as virtual platforms can be used to deliver adaptive content, differentiated instruction, and feedback tailored to individual student needs. Fur-

thermore, understanding student perspectives and experiences is crucial for creating access to equitable and supportive virtual learning environments. However, ensuring accessibility is paramount. Higher education institutions must provide accessible technologies, training, and support services for students. Beyond technical concerns, offering support services tailored to student needs in virtual environments is essential. This includes technical support, academic coaching, and other resources to ensure student well-being and success in online learning environments.

6.3 Limitations and future scope of research

This bibliometric study contributes to the ever-growing body of scholarly knowledge, however, not without limitations. A data limitation exists as this bibliometric review was restricted to published literature existing in the Scopus database. This potentially overlooks published literature from other databases as well as unpublished research or perspectives from marginalised communities. Future research can extend the literature of other reliable databases. Another limitation is that the current bibliometric analysis focused on English-language article publications and conference paper proceedings in the Social Sciences, Arts and Humanities. Future research should broaden the scope to include diverse cultural contexts and educational systems to achieve a more comprehensive understanding of virtual teaching practices globally. Moreover, given that the field of virtual teaching is dynamic and rapid technological advancements necessitate ongoing research and adaptation, future research should incorporate emerging technologies and explore their potential impact on learning models and pedagogical practices. Future research should also investigate how institutional policies and leadership practices can best support the implementation and scaling up of effective virtual teaching initiatives. Lastly, further research is needed to explore effective strategies for harnessing the affordances of digital technology and virtual teaching to enhance student engagement, personalise learning experiences, and promote deeper understanding in virtual environments that contribute to students' overall educational experience.

Funding No funding was received for this research. Open access funding provided by University of the Witwatersrand.

Data availability The author confirms that all data generated or analysed during this study are included in this published article. Furthermore, primary and secondary sources and data supporting the findings of this study were all publicly available at the time of submission.

Declarations

Competing interests The author declares that they have no competing interests.

References

Adam, I. O., Effah, J., & Boateng, R. (2019). Activity theory analysis of the virtualisation of teaching and teaching environment in a developing country university. *Education and Information Technologies*, *24*, 251–276.

Amiti, F. (2020). Synchronous and asynchronous E-learning. *European Journal of Open Education and E-Learning Studies*, *5*(2). https://doi.org/10.46827/ejoe.v5i2.3313

Bartusevičienė, I., Pazaver, A., & Kitada, M. (2021). Building a resilient university: Ensuring academic continuity—transition from face-to-face to online in the COVID-19 pandemic. *WMU Journal of Maritime Affairs*, *20*(2), 151–172. https://doi.org/10.1007/s13437-021-00239-x

Chamorro-Atalaya, O., Morales-Romero, G., Quispe-Andía, A., Trinidad-Loli, N., Caycho-Salas, B., León-Velarde, C., & Gamarra-Mendoza, S. (2021). Distance education and student satisfaction regarding the pedagogical support services provided in virtual teaching-learning environments. *International Journal of Emerging Technologies in Learning (IJET)*, *16*(20), 255–262.

Chi, D. P., & Oanh, D. T. K. (2023). Proposing a process for training online teaching competence for lecturers at higher education institutions. *Journal of Education and e-Learning Research*, *10*(3), 502–512. https://doi.org/10.20448/jeelr.v10i3.4893

de la Alemán, L., Anichini, A., Antal, P., Beaune, A., Crompton, H., & Tsinakos, A. (2019). Rethinking pedagogy: Exploring the potential of digital technology in achieving quality education.

Dillenbourg, P. (2016). The evolution of research on digital education. *International Journal of Artificial Intelligence in Education*, *26*, 544–560. https://doi.org/10.1007/s40593-016-0106-z

Dlamini, R. (2022). *Towards a critical perspective on Digitalisation and initial teacher education*. Moving Beyond the Brick and Mortar.

Dlamini, R. (2023). Interactivity, the heart and soul of effective learning: The interlink between internet self-efficacy and the creation of an inclusive learning experience. *South African Journal of Higher Education*, *37*(2), 77–92.

Dlamini, R., & Ndzinisa, N. (2020). Universities trailing behind: Unquestioned epistemological foundations constraining the transition to online instructional delivery and learning. *South African Journal of Higher Education*, *34*(6), 52–64.

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research*, *133*, 285–296. https://doi.org/10.1016/j.jbusres.2021.04.070

Dung, D. T. H. (2020). The advantages and disadvantages of virtual learning. *IOSR Journal of Research & Method in Education*, *10*(3), 45–48.

Essel, H. B., Vlachopoulos, D., Tachie-Menson, A., Johnson, E. E., & Baah, P. K. (2022). The impact of a virtual teaching assistant (chatbot) on students' learning in Ghanaian higher education. *International Journal of Educational Technology in Higher Education*, *19*(1), 1–19.

Ewing, L. A. (2021). *Rethinking higher education post COVID-19. The future of Service Post-COVID-19 Pandemic* (Vol. 1, pp. 37–54). Rapid Adoption of Digital Service Technology.

Fernández-Batanero, J. M., Montenegro-Rueda, M., Fernández-Cerero, J., & García-Martínez, I. (2022). Digital competences for teacher professional development. Systematic review. *European Journal of Teacher Education*, *45*(4), 513–531.

Garrison, D. R., & Anderson, T. (2003). *E-learning in the 21st Century*. Routledge Falmer.

Garrison, D. R., Anderson, T., & Archer, W. (1999). Critical Inquiry in a text-based environment: Computer conferencing in Higher Education. *Internet and Higher Education*, *2*(2–3), 87–105. https://doi.org/10.1016/S1096-7516(00)00016-6

Grammens, M., Voet, M., Vanderlinde, R., Declercq, L., & De Wever, B. (2022). A systematic review of teacher roles and competences for teaching synchronously online through videoconferencing technology. *Educational Research Review*, *37*, 100461.

Hallinger, P., & Nguyen, V. T. (2020). Mapping the landscape and structure of research on education for sustainable development: A bibliometric review. In Sustainability (Switzerland) (Vol. 12, Issue 5). https://doi.org/10.3390/su12051947

Khandelwal, P., & Shankar, P. (2022). Marching ahead in difficult Times: The changing Face of Academia. *ECS Transactions*, *107*(1), 7017.

Merriam, S. B., & Grenier, R. S. (Eds.). (2019). *Qualitative research in practice: Examples for discussion and analysis*. Wiley.

Mohapatra, S., & Mohanty, R. (2017). Adopting MOOCs for affordable quality education. *Education and Information Technologies*, *22*(5), 2027–2053.

Muñoz, J. L. R., Ojeda, F. M., Jurado, D. L. A., Peña, P. F. P., Carranza, C. P. M., Berríos, H. Q., & Vasquez-Pauca, M. J. (2022). Systematic review of adaptive learning technology for learning in higher education. *Eurasian Journal of Educational Research*, *98*(98), 221–233.

Neifachas, S., Butvilas, T., & Kovaitė, K. (2022). Virtual learning environments: Modeling a new learning policy strategy. *Acta Paedagogica Vilnensia*, *49*, 98–114.

Paudel, P. (2021). Online education: Benefits, challenges and strategies during and after COVID-19 in higher education. *International Journal on Studies in Education (IJonSE)*, 3(2).

Phan, T. T. T., Vu, C. T., Doan, P. T. T., Luong, D. H., Bui, T. P., Le, T. H., & Nguyen, D. H. (2022). Two decades of studies on learning management system in higher education: A bibliometric analysis with Scopus database 2000–2020. *Journal of University Teaching & Learning Practice*, *19*(3), 09.

Pokhrel, S., & Chhetri, R. (2021). A literature review on impact of COVID-19 pandemic on teaching and learning. *Higher Education for the Future*, *8*(1), 133–141.

Pritchard, A. (1969). Statistical bibliography or bibliometrics. *Journal of Documentation*, *25*(4), 348–349. https://doi.org/10.1108/eb026482

Rana, S., Singh, A. K., Singhania, S., Verma, S., & Haque, M. M. (2021). Revisiting the factors influencing teaching choice framework: Exploring what fits with virtual teaching. *Global Business Review*, 09721509211015369.

Remenick, L. (2019). Services and support for nontraditional students in higher education: A historical literature review. *Journal of Adult and Continuing Education*, *25*(1), 113–130.

Rice, M. F., & Deschaine, M. E. (2020, April). Orienting toward teacher education for online environments for all students. *The Educational Forum* (Vol. 84, pp. 114–125). Routledge. 2.

Roe, Y., Wojniusz, S., & Bjerke, A. H. (2022). The digital transformation of higher education teaching: four pedagogical prescriptions to move active learning pedagogy forward. In Frontiers in Education (Vol. 6, p. 583). Frontiers.

Shonhe, L., Jain, P., & Akakandelwa, A. (2023). Students' experiences with the utilisation of the 4IR technologies in online learning: A case study of institutions of higher learning in Botswana and Zambia.

Sin, Z. P., Jia, Y., Wu, A. C., Zhao, I. D., Li, R. C., Ng, P. H., & Li, Q. (2023). *Towards an edu-metaverse of knowledge: Immersive exploration of university courses*. IEEE Transactions on Learning Technologies.

Sumathi, D. (2022). Innovative teaching strategies. Psycho-technological approaches in heutagogy, 25–27.

Szymkowiak, A., Melović, B., Dabić, M., Jeganathan, K., & Kundi, G. S. (2021). Information technology and Gen Z: The role of teachers, the internet, and technology in the education of young people. *Technology in Society*, *65*, 101565.

Tan, K. H., Chan, P. P., & Mohd Said, N. E. (2021). Higher education students' online instruction perceptions: A quality virtual learning environment. *Sustainability*, *13*(19), 10840.

Tandon, A., Kaur, P., Mäntymäki, M., & Dhir, A. (2021). Blockchain applications in management: A bibliometric analysis and literature review. *Technological Forecasting and Social Change*, *166*, 120649.

Turnbull, D., Chugh, R., & Luck, J. (2021). Transitioning to E-Learning during the COVID-19 pandemic: How have higher Education Institutions responded to the challenge? *Education and Information Technologies*, *26*(5), 6401–6419.

Van Eck, N. J., & Waltman, L. (2011). VOSviewer manual. Manual for VOSviewer version, 1(0).

Vaquero-Diego, M., & Vazquez, B. L. (2022). An opportunity for transformative learning in higher education through virtual teaching innovation. *Journal of Management and Business Education*, *5*(3), 231–246.

Vlachopoulos, D., & Makri, A. (2017). The effect of games and simulations on higher education: A systematic literature review. *International Journal of Educational Technology in Higher Education*, *14*(1), 1–33.

Wajdi, M. B. N., Kuswandi, I., Faruq, A., Zulhijra, U., Khairudin, Z., K., & Khoiriyah, K. (2020). Education Policy Overcome Coronavirus, A Study of Indonesians. EDUTEC: Journal of Education and Technology, 3(2), 96–106.

Wekerle, C., Daumiller, M., & Kollar, I. (2022). Using digital technology to promote higher education learning: The importance of different learning activities and their relations to learning outcomes. *Journal of Research on Technology in Education*, *54*(1), 1–17.

Welch, A. G., Napoleon, L., Hill, B., & Roumell, E. (2014). Virtual teaching dispositions scale (VTDS): A multi-dimensional instrument to assess teaching dispositions in virtual classrooms. *Journal of Online Learning and Teaching*, *10*(3), 446.

Yu, H., & Zhou, J. (2022). Social support and online self-regulated learning during the COVID-19 pandemic. *Asia Pacific Journal of Education*, 1–15.