Qualitative and Quantitative Methods in Libraries (QQML) 14,1:135-165, 2025

Mapping the literature on the application of Augmented and Virtual reality in libraries: a bibliometric analysis

Ms. Lili Sahu[1] & Bulu Maharana[2]
[1] [2] Sambalpur University

Abstract The libraries are gradually adopting Augmented Reality (AR) and Virtual Reality (VR) to improve the services and user experience. Such technologies can go beyond the limitations of physical space and encourage digital understanding and interaction in more active and flexible environments. This paper includes application of AR/VR in the library with case studies which includes back to the Future at the University of Southern California, the Bristol Library Virtual Reality Space at the University of Bristol, and the Indian Institute of Technology Delhi's Central Library's virtual reality tour. Also provides a list of tools and technologies include AR/VR headsets, AR apps, 3D scanners and printers, content creation tools, mobile AR platforms, AR educational kits, and collaborative VR spaces. The bibliometric analysis was done with the dataset spanning 2004 to 2023 includes 482 sources and 924 documents, with an annual growth rate of 18.53%. The most common type of publication is regular articles. China leads the list of publications in the field of interdisciplinary research, with 204 publications and 3,512 citations. The US follows closely with 193 publications and 4,885 citations. The top ten include the UK, Spain, Australia, Canada, Italy, Brazil, Korea, and Germany. Key platforms like IEEE Access, Library Hi Tech, and PLOS One are also mentioned. Virtual reality is the most dominant term, with rehabilitation second. This paper comprises of application of AR/VR in the library providing various the tools and technology, and case studies and a bibliometric study.

Received: 27.1.2025 Accepted: 28.2.2025 ISSN 2241-1925

This research suggested that Augmented and virtual reality technologies can enhance patron experience, foster digital literacy in the library.

Keywords: Augmented Reality, Virtual Reality, Library, AR and VR Tools, Bibliometric analysis

Introduction

Libraries have long been regarded as storehouses of knowledge, fostering learning, research, and community engagement. However, with the advent of digital resources and remote access, the role of libraries has undergone a profound evolution. Today, libraries are not merely repositories of books but dynamic hubs where technology converges with traditional literary resources to offer immersive and interactive experiences. Augmented and virtual realities represent the latest frontier in this evolution, offering librarians and patrons alike unparalleled opportunities for exploration, education, and engagement. Virtual things that seem to reside in the same place as the real world are added by an augmented reality system to enhance the real environment. According to Azuma et al. (2001), AR may be applicable to all senses, including hearing, touch, and smell. Devices like smartphones, tablets, smart glasses, or specialised AR headsets are frequently used with AR technology. To overlay digital content onto the real-world view shown on the device's screen or through its lenses, these gadgets use cameras, sensors, and other technologies to detect the user's surroundings. As to Azuma (1997), AR encompasses systems that fulfil the subsequent three attributes: 1) merging the virtual and the actual world; 2) enabling real-time interaction; and 3) being 3D recorded. Augmented reality technology encloses real objects of the environment in multimedia immersive experiences. Beijing State Library of foreign languages, for instance, is among the pioneers to use such methods in libraries and developed the Augmented Reality for all project (Dalili Saleh, 2022; Hussain, 2022, LeMire et al., 2018). Results of using augmented reality applications have shown high demand

among the readers of the library due the universal use of Augmented Reality in the life and entertainment of people (Papakostas et al., 2023; Dhar et al., 2021). As Thomas speaks to his declaration in 1992, A journey is only undertaken through AR Asia by which it has not yet fully been exploited by librarians and research (Caudell and David, 1992). As found with Brinkman and Brinkman proposed a preliminary set of AR pages for ambitious librarians and shelf organizing adult users (Brinkman and Brinkman, 2013). This technology to support librarians offers automated reminders to correct any mistakes in the arrangement of many publications with mis-arrangement features. The technology known as augmented reality (AR) superimposes digital data, including pictures, movies, or 3D models, on top of the actual world. By incorporating virtual components into the actual world, augmented reality (AR) improves it in contrast to virtual reality (VR), which immerses users in an entirely digital environment. On the other hand, virtual reality (VR) describes a simulated environment that may resemble the real world or be entirely different from it. Usually made with computer technology, it features immersive worlds that users may interact with in a way that seems tangible or genuine. VR often relies on a combination of computer-generated imagery, audio, and other sensory feedback to create an immersive experience. Users typically experience VR through headsets or goggles that display the virtual environment in front of their eyes. To give users, the sense that they are physically present in the virtual environment, these headsets frequently track head movements and modify the image accordingly. A state-of-the-art technology called virtual reality (VR) transports people to artificial settings (Bowman and McMahan 2007). Over the past decade, VR systems have become increasingly accessible due to significant drops in price, remarkable advancements in graphics, and a surge in computing

power (Slater 2018). As a result, these systems are now more affordable for a broader audience, including home users and students at all educational levels. To keep pace with this evolving technology, library systems must also be upgraded to engage in this virtual transformation. A growing number of individuals, particularly younger generations, are becoming acquainted with VR applications, which serve both educational and entertainment purposes (Hamilton et al. 2021). Therefore, libraries should enhance their services to align with the current trends in virtual environments. Virtual reality allows users to explore and interact with virtual environments in ways that were previously impossible, offering new opportunities for entertainment, learning, and innovation. The use and implementation of AR and VR technology within libraries and information centres would therefore probably rise as more study is conducted on these technologies in connection to these establishments.

Review of Literature

One of the primary applications of AR in libraries is enhancing resource accessibility and discoverability. AR tools, including mobile applications, have been developed to help users navigate physical library spaces and locate resources effectively. Pujar and Bansode (2008) found that AR-driven wayfinding systems reduce search times and offer interactive guidance, providing real-time information on book availability and locations. Similar findings by Chu et al. (2019) suggest that AR applications improve accessibility for users unfamiliar with library layouts or those with disabilities, making library spaces more navigable and user-friendly. Research on VR applications indicates that libraries use virtual tours and orientations to familiarize patrons with their facilities and services. University libraries have led in implementing VR for orientation, especially on large campuses, allowing students to explore library sections and services before setting foot in the space (Minocha et al., 2020). These virtual tours, according to Agarwal et al. (2022), also increase

engagement for remote users, offering an alternative experience to physical visits. Such applications have become particularly valuable in the wake of the COVID-19 pandemic, enabling libraries to reach patrons who may prefer virtual access. Libraries with significant archives or rare artifacts have used VR to digitize materials, making them accessible to a broader audience. Virtual exhibits enable patrons to experience historical artifacts closely, promoting a more immersive connection with historical resources (Tay, 2018). This approach also benefits preservation efforts, as VR reduces the need for direct handling of delicate materials. Studies by Rafiq and Ameen (2020) report that users find virtual exhibits both informative and engaging, providing a museum-like experience within the library. In a study by Green et al. (2021), VR programs in science libraries enabled patrons to virtually explore complex concepts, from cellular structures in biology to simulations of natural phenomena in physics. Such applications are aligned with constructivist learning theories, which advocate for hands-on, interactive learning experiences that enhance understanding and retention (Chung & Yang, 2019).

According to Lin et al. (2022), AR overlays can provide additional content, such as videos, quizzes, or contextual information about book topics, creating an active and self-guided learning experience. This approach has shown positive impacts on users' learning outcomes, particularly in school and academic libraries, where learners benefit from supplementary materials that aid in comprehension and retention. Blascovich and Bailenson (2020) suggest that the multisensory experience provided by these technologies fosters deeper engagement, making learning and information retrieval more appealing. Several studies support this claim, noting increased satisfaction and longer library visits among users exposed to AR and VR applications (Luo & Lam, 2021).

Objectives of the study:

1. To identify leading AR and VR tools and platforms applicable to library settings.
2. To Find out the applications of AR and VR in library.
3. To find out successful case studies on AR and VR integration in library services.
4. To study the research growth pattern in application of AR and VR in library
5. To identify prominent institutions, organisations, countries, and authors with significant research contribution in this field.
6. To classify the journals into different zones using Bradford's law.

Research Methodology

The Web of Science (WOS) core collection database was searched on October 21, 2024, for English-language journal articles about the use of augmented and virtual reality in libraries that were published between 2004 and 2023. Some pertinent keywords are entered into all areas in order to extract data from WOS. For example, "augmented reality" or "virtual reality" were used to find relevant papers in the Web of Science database's core collection. These keywords will only include papers about virtual and augmented reality; they won't include any about libraries. Therefore, the conjunction "AND" is employed to join the word "Library" in this context. This is because, unlike when "AND" is used, it will include all papers that are relevant to the keywords entered without omitting the significant and related publications (Borgohain et al., 2021a). The search string used is as follows: (ALL FIELD (Augmented reality) OR ALL FIELD (Virtual reality) ALL FIELD AND (Library)) AND PUBYEAR >2004 AND PUBYEAR < 2023.

WOS is regarded as the research's data source since it is a reputable, high-quality international indexing database. 924 pieces of information about the "Application of augmented and virtual reality in libraries" that were gathered

from the Web of Science during the last 20 years (2004–23) are examined and analysed using the specified criteria. For network analysis in general and visualisation in particular, the R-Studio science mapping tool Biblioshiny online interface was utilised. The R software uses a series of programming codes to access the Biblioshiny's online interface. In MS-Excel, some statistical analysis was done.

Application of Augmented Reality (AR) and Virtual Reality (VR) in Libraries

Now a days, libraries are undergoing a profound transformation, leveraging Augmented and Virtual Reality to enhance the traditional library experience. Santos and Esposo-Betan (2017) state that using augmented reality (AR) in academic-research libraries has several advantages, such as being simple to use, cost-free, more educational, interactive, entertaining, and captivating. Additionally, according to Stanica et al. (2019), AR complements printed books and offers advantages like boosting young people's reading enthusiasm, making books more aesthetically pleasing, facilitating book sharing, and inspiring others to read. These technologies offer patrons immersive and interactive ways to engage with information, literature, and cultural heritage. By embracing AR and VR, libraries can transcend physical constraints, foster digital literacy, and create dynamic spaces that cater to diverse learning styles and interests. Virtual tours, internal navigation, and makerspaces are examples of public service applications that are the main emphasis of augmented reality use in libraries (Oyelude, 2017).

Augmented and Virtual Reality offer exciting possibilities for enhancing the library experience, transforming traditional spaces into interactive and immersive environments. Here are some applications:

- **Interactive Exhibits:** Libraries can create AR/VR exhibits that bring books, historical documents, and artifacts to life. Visitors can use AR apps to view additional information, animations, or videos overlaid on physical exhibits.
- **Virtual Tours:** VR can provide virtual tours of library spaces, offering remote users the opportunity to explore libraries and their collections from anywhere in the world.
- **Digital Archives Access:** AR applications can overlay digital archival materials, such as manuscripts or maps, onto physical locations within the library, providing users with context and historical information as they navigate the space.
- **Immersive Learning:** Libraries can use VR to create immersive learning experiences, allowing users to step into historical settings, explore scientific concepts, or participate in interactive storytelling experiences.
- **Accessibility:** AR and VR technologies can enhance accessibility for users with disabilities by providing alternative ways to interact with library materials, such as audio descriptions or tactile feedback in VR environments.
- **Virtual Collaboration Spaces:** VR platforms can facilitate virtual meetings, workshops, and collaborative projects, enabling users to interact with each other and with digital resources in a shared virtual space.
- **Language Learning:** Libraries can use AR apps to overlay translations, pronunciation guides, or cultural information onto foreign

language materials, helping language learners engage with materials more effectively.

- **Storytelling Experiences:** Libraries can create immersive storytelling experiences using VR technology, allowing users to participate in interactive narratives or explore fictional worlds inspired by library collections.
- **Community Engagement:** AR scavenger hunts, virtual book clubs, or interactive storytelling events can help libraries engage with their communities in new and creative ways, fostering connections and encouraging participation.

According to Alikhani et al. (2018), augmented reality (AR) enhances the job of librarians by supporting resource management, location-based services, resource search, information literacy, interactive networks, research, and historical source visits. By integrating AR and VR technologies into library spaces and services, libraries can enhance user engagement, expand access to information, and provide innovative learning experiences for patrons of all ages.

Case studies showcasing the application of AR and VR in libraries

These case studies illustrate the diverse applications of AR and VR in libraries, from enhancing learning experiences to improving navigation and access to information. As these technologies continue to evolve, libraries are likely to explore new ways to integrate them into their services to better serve their users.

(Table.1 Case studies showcasing the application of AR and VR in libraries)

Project/Initiative	Institution	Description
Back to the Future (https://libraries.usc.edu/events/back-future)	USC Libraries, USA	Integration of AR and VR to create immersive experiences for engaging students and researchers in interactive learning environments.
Bristol Library Virtual Reality Lab (http://bristolvrlab.com/index.htm)	University of Bristol Library, England	Provides VR technology for educational and recreational purposes, offering virtual tours of historical sites, interactive storytelling sessions, and virtual workshops to explore new learning opportunities and engage with library resources.
Augmented Reality Wayfinding (https://www.lib.ncsu.edu/do/virtual-reality)	North Carolina State University Libraries, USA	AR wayfinding solution using AR-enabled mobile devices to access interactive maps and directions overlaid onto the physical environment, simplifying navigation and enhancing user experience within the library.
Virtual Reality Research Showcase (https://hsl.uw.edu/vr-studio/)	University of Washington Libraries, USA	Demonstrates VR applications in academic research through immersive data visualization and virtual simulations of scientific experiments, highlighting VR's role in advancing scholarly communication and knowledge dissemination.
Interactive AR Exhibitions (https://www.nlm.nih.gov/hmd/about/exhibition/index.html)	National Library of Medicine, Bethesda	Uses AR technology to develop interactive exhibitions and presentations, providing multimedia on library

		holdings, with notable displays like the "Doorway to the Past" offering insights into historical medical artifacts.
Enhanced AR Exhibitions (https://www.nl.go.kr/EN/main/index.do)	National Library of Korea, Seoul	Uses AR to create richer and more engaging exhibitions and displays, such as the "History of Korean Medicine," which provides additional insights and information to promote understanding of Korean medical tradition.
Virtual Reality Tour (https://library.iitd.ac.in/librarytour)	IIT Delhi Central Library, India	Provides an immersive experience through VR headsets, allowing users to explore the library's facilities, browse bookshelves virtually, and access information about resources, enhancing engagement and accessibility, especially for remote users.
Sahel (https://library.iima.ac.in/vrapp.html)	Vikram Sarabhai Library, IIM Ahmedabad, India	Vikram Sarabhai Library and TCS Entrepreneurship Junction Labs work together to build and manage it. Libraries give their patrons access to cutting-edge technologies and provide them with exclusive learning and experiencing opportunities by integrating Virtual Reality (VR) apps.

Tools and technologies for Augmented Reality (AR) and Virtual Reality (VR)

Augmented Reality (AR) and Virtual Reality (VR) offer exciting opportunities for enhancing the library experience, creating immersive learning environments, and engaging library patrons in new ways. Here are some tools and technologies that can be applied in libraries:

(Table.2 Tools and technologies for Augmented and Virtual Reality)

Category	Description
AR/VR Headsets	Devices like Oculus Rift, HTC Vive, Microsoft HoloLens, and Google Cardboard provide immersive VR experiences. Libraries can offer these headsets for patrons to explore virtual environments or access AR content.
AR Apps	Libraries can develop or utilize existing AR apps to overlay digital content onto physical objects or spaces within the library. Examples include AR book displays, interactive maps, or historical tours.
3D Scanners and Printers	Libraries equipped with 3D scanners and printers can create models of artifacts, historical objects, or sculptures for patrons to interact with in virtual reality or augment their learning experiences.
AR/VR Content Creation Tools	Software like Unity, Unreal Engine, and ARKit provide libraries with the ability to create custom AR/VR experiences tailored to their collections or educational programs.
Mobile AR Platforms	Platforms like ARCore (Android) and ARKit (iOS) enable developers to create AR experiences for mobile devices.
AR/VR Educational Kits	Libraries can offer AR/VR educational kits for patrons to borrow, containing devices, software, and guides for creating and experiencing AR/VR content.
Collaborative VR Spaces	Libraries can set up collaborative VR spaces where patrons can work together, attend virtual meetings or workshops, or participate in shared VR experiences.

By integrating AR and VR technologies into library services and programs, libraries can enrich the patron experience, foster digital literacy skills, and provide innovative ways to engage with information and learning resources.

Analysis of Bibliometric data

The table-3 provides a comprehensive overview of the dataset spanning the years 2004 to 2023. It includes information on the sources and documents analyzed, showing a total of 482 sources, which could include journals, books, and other scholarly materials. The dataset contains 924 documents in total. The annual growth rate of the dataset is 18.53%, suggesting a significant and steady increase in the number of publications each year. On average, the documents in the dataset are 5.23 years old, indicating that the data is relatively current, though it does include older publications. Each document has been cited an average of 29.05 times, which reflects a robust level of academic engagement and relevance. Overall, this table highlights the growth, relevance, and impact of the documents within the dataset.

Table-3 Overview of the main data

Description	**Results**
Timespan	2004:2023
Sources (Journals, Books, etc)	482
Documents	924
Annual Growth Rate %	18.53
Document Average Age	5.23
Average citations per doc	29.05

The below table-4 outlines the various types of publications included in the dataset. The most common type is regular articles, with 472 entries, representing

the bulk of the documents. Reviews also make up a significant portion, with 381 entries, indicating a strong focus on summarizing and critiquing existing research. In addition, there are 30 documents categorized as both articles and proceedings papers, suggesting contributions from conferences. A few more specialized categories are present, such as retracted publications (3 articles, 2 reviews), indicating papers that have been formally withdrawn from the literature. Other publication types include book reviews (7), editorial materials (15), and corrections (2), showing involvement in different scholarly activities. Additionally, there are smaller categories like meeting abstracts (4), news items (3), software reviews (1), and a single review that also serves as a book chapter. These diverse document types reflect a broad range of academic contributions within the dataset.

Table-4 List of document types in the main data

Sl.No	Document type	No. of Documents
1	Article	472
2	Article; data paper	3
3	Article; proceedings paper	30
4	Article; retracted publication	3
5	Book review	7
6	Correction	2
7	Editorial material	15
8	Meeting abstract	4
9	News item	3
10	Review	381
11	Review; book chapter	1
12	Review; retracted publication	2
13	Software review	1

Chronological Growth of Publication and citation impact

The below table -5 provides a detailed analysis of publication trends across a 20-year timespan (2004 to 2023), focusing on the number of articles published each year, their percentage of total publications (TP), mean total citations per

article (MeanTCperArt), and other citation metrics. The total number of articles published increased significantly over the years. In 2004, only 7 articles were published (0.76% of TP), while by 2023, this number had surged to 177 articles, constituting 19.16% of the total. This growth indicates a marked acceleration in academic output over time. Citation metrics reveal varying levels of academic impact across the years. The early years (2004, 2006, 2008) feature high mean total citations per article, with 2004 leading at 104.57 citations per article. However, more recent years, such as 2022 (12.11) and 2023 (6.15), show a decline in mean citations per article, likely due to the shorter time frame for newer articles to accumulate citations.

Sl.No	Year	Articles	% of TP	MeanTC per Article	MeanTC per Year	Citable Years
1	2004	7	0.76	104.57	4.98	21
2	2005	19	2.06	13.21	0.66	20
3	2006	12	1.30	70.33	3.70	19
4	2007	7	0.76	5.43	0.30	18
5	2008	7	0.76	58.29	3.43	17
6	2009	15	1.62	49.93	3.12	16
7	2010	9	0.97	15.89	1.06	15
8	2011	16	1.73	72.12	5.15	14
9	2012	21	2.27	41.33	3.18	13
10	2013	19	2.06	71.84	5.99	12
11	2014	23	2.49	43.78	3.98	11
12	2015	24	2.60	57.92	5.79	10
13	2016	31	3.35	55.16	6.13	9
14	2017	40	4.33	35.85	4.48	8
15	2018	45	4.87	35.04	5.01	7

16	2019	74	8.01	42.30	7.05	6
17	2020	96	10.39	47.49	9.50	5
18	2021	123	13.31	20.08	5.02	4
19	2022	159	17.21	12.11	4.04	3
20	2023	177	19.16	6.15	3.08	2

TP= Total publication, TC= Total citation

Table-5 Chronological Growth of Publication and citation impact

In terms of citation impact per year (MeanTCperYear), 2020 stands out with a high value of 9.50, reflecting strong academic engagement, while earlier years like 2007 and 2005 have much lower values (0.30 and 0.66, respectively). The table also highlights the citable years, which decrease from 21 in 2004 to just 2 in 2023, indicating the recency of the latter publications.

Overall, this table illustrates both the steady growth in the number of publications and fluctuations in their citation impact, with older articles generally receiving more citations over time and recent publications still building their citation count.

Most Productive country

The table-6 provides a comparative analysis of research outputs by country, listing metrics such as total publications (TP), percentage of total publications (TP%), total citations (TC), single-country publications (SCP), multi-country publications (MCP), and the percentage of MCPs. China ranks first with 204 publications, accounting for 22.1% of the total and 3,512 citations. The country has 168 SCPs and 36 MCPs, with MCPs making up 17.6% of its total. The United States follows closely with 193 publications (20.9% of TP) and leads in citations with 4,885. The U.S. also has a similar SCP/MCP distribution to China, with MCPs constituting 17.6% of its publications.

The United Kingdom, ranked third, has a significantly lower TP (49) but a high total citation count (2,881), indicating a strong impact per publication. Its MCP percentage is notably high at 34.7%, suggesting a strong international

collaboration. Spain, in fourth place, has 43 publications and 758 citations, with 20.9% of its work involving international collaboration. Australia's 38 publications yield a high TC of 3,419, with MCPs representing 18.4% of its output. Canada, Italy, Brazil, Korea, and Germany round out the top ten. Canada has 36 publications with 1,055 citations, and 27.8% of its publications involve multiple countries, indicating active international collaboration. Italy has a comparable MCP percentage (35.3%) among its 34 publications, while Brazil's MCP percentage is lower at 12.5%, suggesting more domestic research. Korea and Germany show similar patterns, with MCP percentages of 21.7% and 27.3%, respectively. Overall, this analysis reveals diverse patterns of research output, impact, and international collaboration across countries, with notable leaders in publication volume, citation impact, and collaboration rates.

Table-6 Top 10 most productive countries in the area Augmented and Virtual reality in Library

Rank	Country	TP	TP %	TC	SCP	MCP	MCP %
1	China	204	22.1	3512	168	36	17.6
2	USA	193	20.9	4885	159	34	17.6
3	United Kingdom	49	5.3	2881	32	17	34.7
4	Spain	43	4.7	758	34	9	20.9
5	Australia	38	4.1	3419	31	7	18.4
6	Canada	36	3.9	1055	26	10	27.8
7	Italy	34	3.7	933	22	12	35.3
8	Brazil	32	3.5	588	28	4	12.5
9	Korea	23	2.5	401	18	5	21.7
10	Germany	22	2.4	686	16	6	27.3

Total publications (TP), Total citations (TC), Single-country publications (SCP), Multi-country publications (MCP),

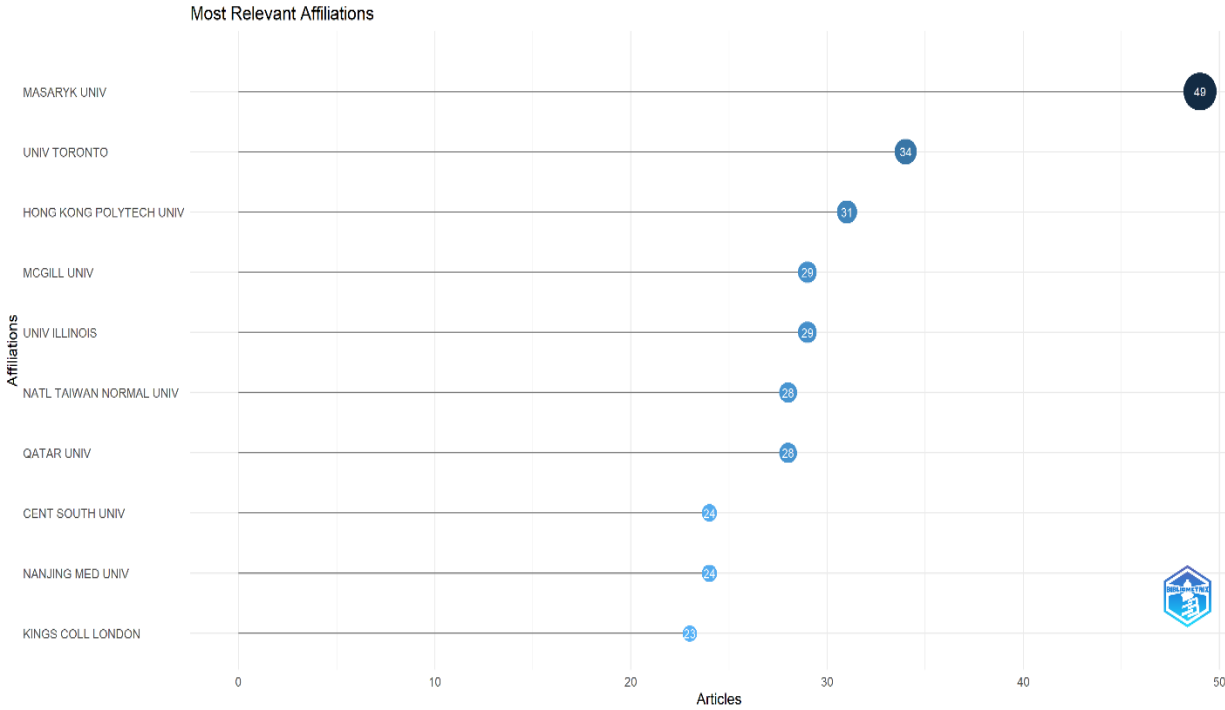
Prolific affiliations

Prolific affiliation having top 10 position is shown in table- 7 presents a ranking of institutions by the total number of publications, along with each institution's contribution as a percentage of total publications (TP). Masaryk University ranks first with 49 publications, accounting for 5.30% of the total. The University of Toronto follows with 34 publications, representing 3.68% of the TP. Hong Kong Polytechnic University is in third place with 31 publications, contributing 3.35% to the TP. Both McGill University and the University of Illinois share the fourth rank with 29 publications each, making up 3.14% of the TP. National Taiwan Normal University and Qatar University each have 28 publications, each accounting for 3.03% of the TP. Central South University and Nanjing Medical University follow closely with 24 publications each, contributing 2.60% of the TP. Finally, King's College London rounds out the top 10 with 23 publications, making up 2.49% of the TP. This distribution highlights the significant scholarly output from a diverse set of institutions across different regions, reflecting a global engagement in the field.

Table-7 Top 10 Affiliation performance in Augmented and Virtual reality in Library

Sl.No	Affiliation	Total Publication	% of TP
1	Masaryk University	49	5.30
2	University Toronto	34	3.68
3	Hong Kong Polytech University	31	3.35
4	Mcgill University	29	3.14
5	University of Illinois	29	3.14
6	National Taiwan Normal University	28	3.03
7	Qatar University	28	3.03
8	Central South University	24	2.60
9	Nanjing Medical University	24	2.60
10	Kings College London	23	2.49

Figure-1 Top 10 Affiliation performance in Augmented and Virtual reality in Library



Analysis of journals with application of Bradford's law

One of the three basic rules of bibliometrics that determines the key journals in a given field is Bradford's Law. The law states that, "if the scientific journals are arranged in order of decreasing productivity of articles on a given subject, they may be divided into the nucleus of periodicals more particularly devoted to the subject and several groups or zones containing the same number of articles as the nucleus, when the number of periodicals in the nucleus and the succeeding zones will be as 1: n: n2 . . . . . ." **(Bradford, 1934; Garfield, 1980)**. The top twenty journals in research within Augmented and Virtual reality in Library are listed according to their rank of publications in Table 5. This table provides

an analysis of the most frequently cited academic journals within the dataset, ranked by the number of publications. All journals listed fall within "Zone 1," indicating their high level of influence and frequency of citation within the research field.

The Journal of Medical Internet Research holds the top rank with 19 publications, reflecting its leading role in the field. IEEE Access, Library Hi Tech, and PLOS One are tied with 15 publications each, marking them as key platforms for disseminating research. Other highly cited journals include Applied Sciences-Basel, Electronic Library, JMIR Serious Games, and Multimedia Tools and Applications, each contributing 13 articles, emphasizing their relevance to both technological and medical research.

As we progress through the ranks, journals like Virtual Reality (12 publications), the Cochrane Database of Systematic Reviews, and the International Journal of Environmental Research and Public Health (each with 11 publications) demonstrate a focus on interdisciplinary research, covering areas from healthcare to environmental studies.

Other significant sources include the Journal of Clinical Medicine and Sensors, also contributing 11 articles each, and the IEEE Transactions on Visualization and Computer Graphics, with 9 publications. BMJ Open and Sustainability stand out with 8 and 9 publications, respectively, indicating their ongoing contributions to medical and environmental sustainability research.

Table-8 Top 20 Journal performance in Augmented and Virtual reality in Library

Sl.No	Source	Rank	Freq	cumFreq	Zone
1	Journal of Medical Internet Research	1	19	19	Zone 1
2	IEEE Access	2	15	34	Zone 1
3	Library Hi Tech	3	15	49	Zone 1
4	PLOS ONE	4	15	64	Zone 1
5	Applied Sciences-Basel	5	13	77	Zone 1
6	Electronic Library	6	13	90	Zone 1

7	JMIR Serious Games	7	13	103	Zone 1
8	Multimedia Tools And Applications	8	13	116	Zone 1
9	Virtual Reality	9	12	128	Zone 1
10	Cochrane Database of Systematic Reviews	10	11	139	Zone 1
11	International Journal of Environmental Research and Public Health	11	11	150	Zone 1
12	Journal Of Clinical Medicine	12	11	161	Zone 1
13	Sensors	13	11	172	Zone 1
14	IEEE Transactions on Visualization and Computer Graphics	14	9	181	Zone 1
15	Journal Of the Medical Library Association	15	9	190	Zone 1
16	Sustainability	16	9	199	Zone 1
17	BMJ Open	17	8	207	Zone 1
18	Information Technology And Libraries	18	8	215	Zone 1
19	Archives Of Physical Medicine And Rehabilitation	19	7	222	Zone 1
20	Clinical Rehabilitation	20	7	229	Zone 1

Analysis of authors

The analysis of author is done based on their research impact, as indicated by metrics such as the h-index, g-index, m-index, total citations (TC), number of publications (NP), and starting publication year (PY_start) in the table-6. Each of the top six authors—Cheng KH, Konge L, Li X, Sasinka C, Wang T, and Wang Y—has an h-index of 7, highlighting a similar level of impactful publications. Cheng KH and Wang T have the highest m-index values at 1.4,

reflecting strong, steady productivity since 2020, despite having fewer total citations than some of their peers.

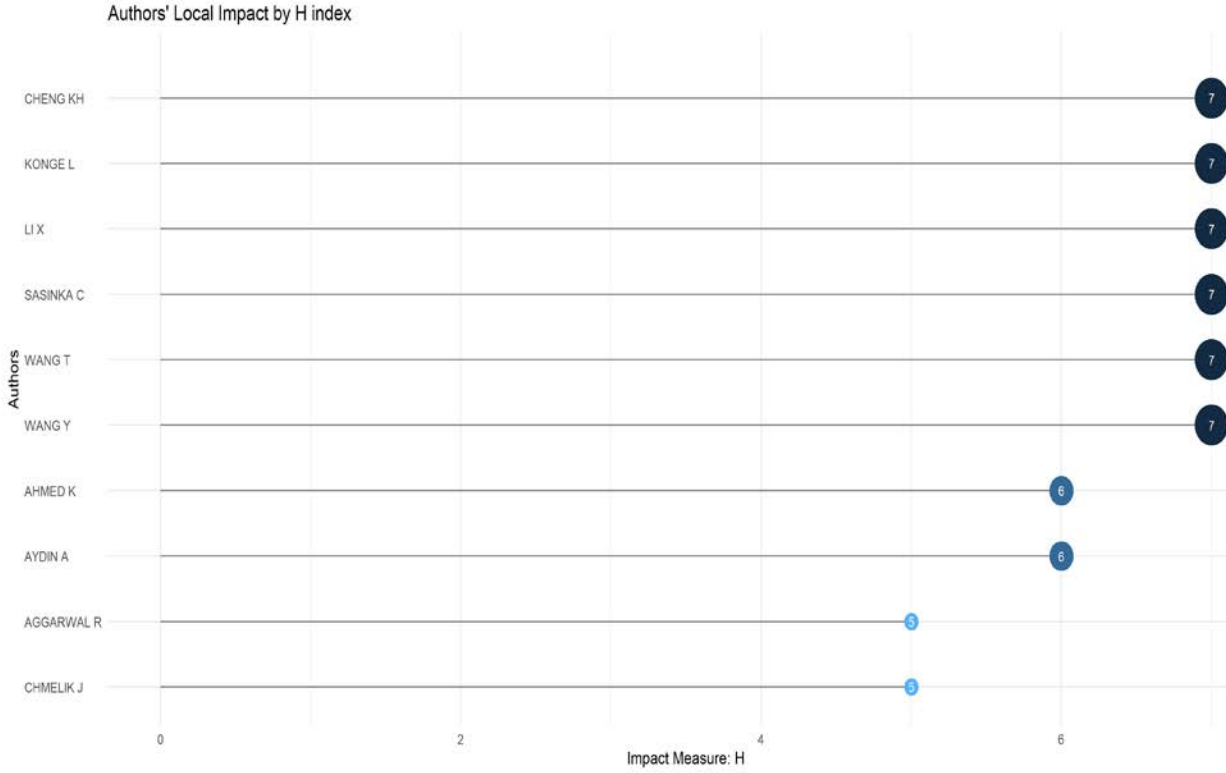
Konge L and Li X, who both began publishing in 2015, have m-index values of 0.7 and have garnered 266 and 179 citations, respectively, with Li X showing a higher g-index (10) and thus a greater breadth of influential work. Sasinka C, with an m-index of 1.167 since 2019, reflects an efficient rise in productivity and impact with 140 citations over eight publications. Wang Y, publishing since 2010, has a lower m-index of 0.467 despite high total citations (243), reflecting a more gradual growth in citation impact over time.

Table-9 Top 10 Prolific Author in the field of Augmented and Virtual reality in Library

Rank	Author	H-Index	G-Index	M-Index	TC	NP	PY Start
1	Cheng Kh	7	8	1.4	188	8	2020
2	Konge L	7	7	0.7	266	7	2015
3	Li X	7	10	0.7	179	10	2015
4	Sasinka C	7	8	1.167	140	8	2019
5	Wang T	7	8	1.4	162	8	2020
6	Wang Y	7	9	0.467	243	9	2010
7	Ahmed K	6	6	0.6	249	6	2015
8	Aydin A	6	6	0.6	249	6	2015
9	Aggarwal R	5	5	0.294	879	5	2008
10	Chmelik J	5	5	0.833	104	5	2019

Ahmed K and Aydin A share identical metrics, each with an *h-index* of 6, an *m-index* of 0.6, and 249 citations from six publications since 2015. Aggarwal R, with an *h-index* of 5 and a lower *m-index* of 0.294, has the highest citation count (879), indicating some landmark publications despite a smaller number of overall publications. Lastly, Chmelik J, who began publishing in 2019, holds an *m-index* of 0.833 and 104 citations, demonstrating effective productivity within a short timeframe. The above table highlights varied productivity and citation patterns, with several authors emerging as highly influential through consistent publication impact.

Figure-2 Top 10 Prolific Author in the field of Augmented and Virtual reality in Library



Keyword Analysis

Keywords Co-occurrence analysis aims to identify trends, hot spots for research, and developments in a field. A link between two terms is highlighted by a built network of keyword co-occurrence (Lee and Su, 2010). The table-7 highlights the most frequently occurring terms in the dataset, providing insight into the key topics and themes within the research. Virtual reality is the most dominant term, appearing 134 times, indicating its central role in the studies. This suggests a

strong focus on immersive technologies and their applications. Rehabilitation comes in second with 58 mentions, reflecting the significant interest in using virtual reality and related technologies for therapeutic and recovery purposes. Terms like performance (52) and system (52) also rank high, indicating research that explores how these technologies enhance human performance and the systems that support their use.

Education (45) and technology (41) follow, underscoring the application of virtual and augmented realities in learning environments and technological advancements. Design-related aspects are also notable, with design (38) and skills (37) pointing to the importance of creating effective user experiences and developing specific abilities.

Other frequent terms include balance (37), relevant to rehabilitation and physical therapy, and augmented reality (36), which, like virtual reality, is a key technological focus. Simulation (35) and therapy (35) highlight the use of virtual environments in healthcare, particularly for therapeutic interventions. Terms like exercise (30), children (29), surgery (29), and anxiety (28) suggest that the research also explores the impact of these technologies on specific populations (children) and medical procedures (surgery, anxiety management). The presence of terms such as people (28), individuals (27), and quality-of-life (26) emphasizes a human-centered approach, focusing on how these technologies can improve well-being.

Table-10 Top-20 Keywords on field of Augmented and Virtual reality in Library

Sl.No	**Key Terms**	**Frequency**
1	Virtual-Reality	134
2	Rehabilitation	58
3	Performance	52
4	System	52
5	Education	45

6	Technology	41
7	Design	38
8	Balance	37
9	Skills	37
10	Augmented Reality	36
11	Simulation	35
12	Therapy	35
13	Exercise	30
14	Reality	30
15	Children	29
16	Surgery	29
17	Anxiety	28
18	People	28
19	Individuals	27
20	Quality-Of-Life	26

Figure-3 Word Cloud on Augmented and Virtual reality in Library

Overall, this figure illustrates a broad and interdisciplinary scope, with virtual reality and rehabilitation at its core, supported by a wide range of applications in healthcare, education, and performance enhancement.

Discussion and Conclusion

Libraries are increasingly utilizing Augmented Reality (AR) and Virtual Reality (VR) to enhance their traditional library experience. By embracing AR and VR, libraries can transcend physical constraints, foster digital literacy, and create dynamic spaces that cater to diverse learning styles and interests. Some applications of AR and VR in libraries include interactive exhibits, virtual tours, digital archives access, immersive learning, accessibility, virtual collaboration spaces, language learning, storytelling experiences, and community engagement. Case studies showcasing the application of AR and VR in libraries include the back to the Future at the University of Southern California, the Bristol Library Virtual Reality Space at the University of Bristol, and the North

Carolina State University Libraries' AR wayfinding solution. The Indian Institute of Technology Delhi's Central Library implemented a virtual reality tour to enhance user engagement and accessibility, especially for remote users or those unable to visit the library physically. These case studies demonstrate the diverse applications of AR and VR in libraries, from enhancing learning experiences to improving navigation and access to information. Tools and technologies include AR/VR headsets, AR apps, 3D scanners and printers, content creation tools, mobile AR platforms, AR educational kits, and collaborative VR spaces.

For the bibliometric analysis the dataset spanning 2004 to 2023 includes 482 sources and 924 documents, with an annual growth rate of 18.53%. The data is relatively current, with each document having been cited an average of 29.05 times, indicating robust academic engagement and relevance. The most common type of publication is regular articles, with 472 entries. Reviews also make up a significant portion, with 381 entries, indicating a strong focus on summarizing and critiquing existing research. The total number of articles published increased significantly over the years, with 177 articles constituting 19.16% of the total by 2023. Citation metrics reveal varying levels of academic impact across the years, with early years featuring high mean total citations per article. China ranks first with 204 publications, accounting for 22.1% of the total and 3,512 citations. The United States follows closely with 193 publications (20.9% of TP) and leads in citations with 4,885. The United Kingdom, Spain, Australia, Canada, Italy, Brazil, Korea, and Germany round out the top ten. The Journal of Medical Internet Research holds the top rank with 19 publications, reflecting its leading role in the field. IEEE Access, Library Hi Tech, and PLOS One are tied with 15 publications each, marking them as key platforms for disseminating

research. As we progress through the ranks, journals like Virtual Reality (12 publications), the Cochrane Database of Systematic Reviews, and the International Journal of Environmental Research and Public Health (each with 11 publications) demonstrate a focus on interdisciplinary research, covering areas from healthcare to environmental studies. The most frequently occurring terms in the dataset provide insight into the key topics and themes within the research. Virtual reality is the most dominant term, appearing 134 times, indicating its central role in the studies. Rehabilitation comes in second with 58 mentions, reflecting the significant interest in using virtual reality and related technologies for therapeutic and recovery purposes. Augmented and Virtual reality technologies can enhance the patron experience, foster digital literacy skills, and provide innovative ways to engage with information and learning resources. By integrating AR and VR technologies, libraries can enhance patron engagement and foster digital literacy.

References

1. Agarwal, C., Johnson, N., Pawelczyk, M., Krishna, S., Saxena, E., Zitnik, M., & Lakkaraju, H. (2022). *Rethinking Stability for Attribution-based Explanations* (arXiv:2203.06877). arXiv. http://arxiv.org/abs/2203.06877
2. Alikhani, P., Rezaei Zadeh, M., Haji Zeinolabedini, M., & Vahidiasl, M. (2019). Identifying the Impact of Augmented Reality on Library Services. *Library and Information Science Research*, *8*(2), 355–370. https://doi.org/10.22067/riis.v0i0.64249
3. Azuma, R. T. (1997). A survey of augmented reality. *Presence: Teleoperators and Virtual Environments*, *6*(4), 355–385. https://doi.org/10.1162/pres.1997.6.4.355
4. Azuma, R., Baillot, Y., Behringer, R., Feiner, S., Julier, S., & MacIntyre, B. (2001). Recent advances in augmented reality. *IEEE Computer Graphics and Applications*, *21*(6), 34–47. IEEE Computer Graphics and Applications. https://doi.org/10.1109/38.963459
5. Bansode, S., Pujar, S., Gandhi, I., & Marg, G. (2008). *Use of internet by research scholars at Shivaji University, Kolhapur*.

6. Blascovich, J., Loomis, J., Beall, A. C., Swinth, K. R., Hoyt, C. L., & Bailenson, J. N. (2002). TARGET ARTICLE: Immersive Virtual Environment Technology as a Methodological Tool for Social Psychology. *Psychological Inquiry*, *13*(2), 103–124. https://doi.org/10.1207/S15327965PLI1302_01
7. Bowman, D. A., & McMahan, R. P. (2007). Virtual Reality: How Much Immersion Is Enough? *Computer*, *40*(7), 36–43. Computer. https://doi.org/10.1109/MC.2007.257
8. *Bradford's Law and Related Statistical Patterns*. (n.d.).
9. Brinkman, B., & Brinkman, S. (2013). AR in the library: A pilot study of multi-target acquisition usability. *2013 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*, 241–242. https://doi.org/10.1109/ISMAR.2013.6671785
10. Caudell, T. P., & Mizell, D. W. (1992). Augmented reality: An application of heads-up display technology to manual manufacturing processes. *Proceedings of the Twenty-Fifth Hawaii International Conference on System Sciences*, 659–669 vol.2. https://doi.org/10.1109/HICSS.1992.183317x
11. Chu, R., Chen, J., & Zhao, Y. (2019). *Augmented reality and library navigation: Enhancing patron experiences.* Library Journal, 34(1), 95-101.
12. *Citation indexing—Eugene Garfield, 1980*. (n.d.). Retrieved 9 November 2024, from https://journals.sagepub.com/doi/10.1177/016555158000200109?icid=int.sj-abstract.similar-articles.1
13. Dalili Saleh, M., Salami, M., Soheili, F., & Ziaei, S. (2022). Augmented reality technology in the libraries of universities of medical sciences: Identifying the application, advantages and challenges and presenting a model. *Library Hi Tech*, *40*(6), 1782–1795. https://doi.org/10.1108/LHT-01-2021-0033
14. De Sarkar, T. (2023). Augmented reality applications and the future library. *Library Hi Tech News*, *40*(9), 7–11. https://doi.org/10.1108/LHTN-07-2023-0129
15. Dhar, P., Rocks, T., Samarasinghe, R. M., Stephenson, G., & Smith, C. (2021). Augmented reality in medical education: Students' experiences and learning

outcomes. *Medical Education Online*, *26*(1), 1953953. https://doi.org/10.1080/10872981.2021.1953953

16. Green, M., Taylor, C., & Smith, P. (2021). *Virtual reality for STEM education in libraries*. Science Libraries Quarterly, 14(3), 202-214.
17. Hamilton, D., McKechnie, J., Edgerton, E., & Wilson, C. (2021). Immersive virtual reality as a pedagogical tool in education: A systematic literature review of quantitative learning outcomes and experimental design. *Journal of Computers in Education*, *8*(1), 1–32. https://doi.org/10.1007/s40692-020-00169-2
18. Hussain, A. (2022). Review of augmented reality in academic and research libraries. *Library Hi Tech News*, *39*(9), 23–25. https://doi.org/10.1108/LHTN-06-2022-0082
19. *Identifying the Impact of Augmented Reality on Library Services*. (n.d.). Retrieved 5 November 2024, from https://infosci.um.ac.ir/article_33311.html?lang=en
20. Khalid, N., Ahmed, S., & Noor, T. (2021). *Cost challenges of AR and VR in library adoption*. Financial Aspects of Library Technologies, 12(4), 45-58.
21. LeMire, S., Graves, S. J., Hawkins, M., & Kailani, S. (2018). Libr-AR-y Tours: Increasing engagement and scalability of library tours using augmented reality. *College & Undergraduate Libraries*, *25*(3), 261–279. https://doi.org/10.1080/10691316.2018.1480445
22. Lin, D., Chen, X., & Yang, T. (2022). *Enhancing learning through AR in academic libraries*. Journal of Educational Technology, 40(1), 66-79.
23. Luo, J. M., Lam, C. F., & Wang, H. (2021). Exploring the Relationship Between Hedonism, Tourist Experience, and Revisit Intention in Entertainment Destination. *Sage Open*, *11*(4), 21582440211050390. https://doi.org/10.1177/21582440211050390
24. Minocha, S., Reynolds, L., & Tobin, C. (2020). *Exploring virtual reality for library tours*. University Libraries Review, 36(3), 87-98.
25. Ow, S. (n.d.). *LibGuides: Virtual Reality and Augmented Reality in the Library: Home*. Retrieved 5 November 2024, from https://libguides.nie.edu.sg/c.php?g=961797&p=6985089
26. Oyelude, A. A. (2017). Virtual and augmented reality in libraries and the education sector. *Library Hi Tech News*, *34*(4), 1–4. https://doi.org/10.1108/LHTN-04-2017-0019

27. Oyelude, A. A. (2018). Virtual reality (VR) and augmented reality (AR) in libraries and museums. *Library Hi Tech News*, *35*(5), 1–4. https://doi.org/10.1108/LHTN-04-2018-0023
28. Papakostas, C., Troussas, C., Krouska, A., & Sgouropoulou, C. (2023). Exploring Users' Behavioral Intention to Adopt Mobile Augmented Reality in Education through an Extended Technology Acceptance Model. *International Journal of Human–Computer Interaction*, *39*(6), 1294–1302. https://doi.org/10.1080/10447318.2022.2062551
29. Rafiq, M., & Ameen, K. (2020). *Digitizing history: Virtual reality in library archives*. Journal of Historical Preservation, 18(1), 80-94.
30. Santos, J. F., & Esposo-Betan, S. M. (n.d.). *Advantages and Challenges of Using Augmented Reality for Library Orientations in an Academic/Research Library Setting*.
31. Slater, M. (2018). Immersion and the illusion of presence in virtual reality. *British Journal of Psychology*, *109*(3), 431–433. https://doi.org/10.1111/bjop.12305
32. Stanica, I.-C., Moldoveanu, A., Dascalu, M., Moldoveanu, F., Radoi, M., & Nemoianu, I. (2019). EMERGENT TECHNOLOGIES TO ENRICH READING OUTCOMES THROUGH AUGMENTED REALITY. *Revue Roumaine Des Sciences Techniques - Serie Électrotechnique et Énergétique*, *64*, 95–100.
33. Su, H.-N., & Lee, P.-C. (2010). *Mapping knowledge structure by keyword co-occurrence: A first look at journal papers in Technology Foresight.* https://doi.org/10.1007/s11192-010-0259-8
34. Tay, T. (2018). *Virtual preservation of historical content through VR*. Heritage and Library Science, 22(5), 120-133.