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# Virtual Environments' Knowledge Base: A Bibliometric Analysis

Wakara Ibrahimu Nyabakora[1]

The Local Government Training Institute, P. O. Box 1125, Dodoma, Tanzania

[1] ORCID: 0000-0003-2324-7906, nyabakora2019@spuvvn.edu

**Abstract**

The goal of this research is to explore the scientific literature on virtual environments by conducting a bibliometric analysis. This provides the insight into the main topics, most contributing sources, most-cited articles, prolific authors, and countries that are involved in the research. Additionally, this analysis acts as a tool for understanding the intellectual foundation of the structure, worldwide research concentration on this domain, and social structure of the literature on the subject, as well as the knowledge base associated with the use and integration of virtual environments. The research was conducted by analyzing articles indexed in the Scopus database, which is believed to be the top-most database in scope regarding social sciences research. Using the PRISMA sampling technique and VOSviewer software, the data was analyzed to provide an overview of the virtual environment domain, and we reported tables, graphs, and maps to highlight the main performance indicators for the production of articles and their citation. The results show that terms such as "innovation management," "social media analysis," "business development," "digital technology," "customer engagement," "firm performance," "technology management," "virtual environment," "digital capability," and "market performance" have been used regularly. In addition, the density map reveals some of the newer topics of research, such as "industry 4.0," "sustainable development," "digital business strategies," "virtual environment," "artificial intelligence," and "big data technology." This study's results offer a deeper understanding of how the past, present, and future are connected and shed light on any topics that remain unexplored.

**Keywords**: Bibliometric analysis, Co-citation analysis, Co-occurrences, Virtual environments, VOSviewer.

## 1. Introduction

Virtual reality (VR) is a computer-generated simulation of a situation that allows individuals to be immersed in and abstracted from the real environment when interacting with the virtual environment in a manner that appears to be real [1]–[3]. According to [4], a virtual environment is an artificial simulation of a physical or abstract environment that is designed to be as interactive and lifelike as possible, allowing users to feel as if they are part of it. Virtual reality and virtual environments differ from virtual worlds in that the latter term refers to online social spaces that are experienced as ongoing over time and have large populations [5]. The distinction between virtual reality and virtual worlds lies in the fact that virtual worlds are persistent online social spaces. These spaces are experienced as ongoing over time and feature large populations of people who interact together in them [5]. Therefore, virtual reality (VR) encompasses technologies that immerse users in interactive simulated environments through devices like headsets, offering a multisensory experience within digital realms. While virtual environments span a broader range, including both immersive experiences like VR and less immersive ones such as digital displays or projections that depict simulated environments, they vary in their levels of sensory engagement. In this case, virtual environment encompasses diverse degrees of digital environment representation, spanning from deeply

immersive to less interactive forms. This review generalized the keywords as applied in the keyword search to review research done in virtuality in general.

In the early 1970s, the beginnings of virtual development were seen, and thereafter, by the beginning of the 1990s, public demonstrations of virtual reality began to be exhibited, and industry observers had high hopes for what could be accomplished with the technology [6]. Today, the field of VR has grown and become incredibly advanced. VR is integral to Industry 4.0, as their combination can drastically increase the efficacy of businesses in both service and manufacturing [7]. For instance, using VR technologies and tools can be beneficial for corporate businesses in the HR realm ("hiring, training, developing, and evaluating employees") and operational processes (3D visualization, cyber security, modelling production processes, pinpointing areas of improvement, big projects, assessing IT risks, automation, etc.) [6]. The application of these technologies (VR) includes professional training (medical, military, etc.) [8], simulations, education, rapid prototyping, product ergonomics, and more [6]. The implementation of Industry 4.0 poses some novel technological challenges as people gradually become familiar with and embrace digitalization.

The use of VR technology in product development results in improved performance and quality. By incorporating customer feedback into the design process, a greater level of understanding of specific requirements and needs is achieved [9]. This requires resources such as customer and market analysis, engineering research, and effective collaboration between all stakeholders. Smart products resulting from Industry 4.0 consist of mechanical, electronic, and often software components, necessitating the need for a multidisciplinary team to work towards a unified goal [6].

The success of a product is highly dependent on the accuracy and clarity of the requirements defined in the early stages of the development process. Typically, incorporating customer requirements into the design phase requires a lot of back and forth, which can lengthen the timeline and inflate the cost [6]. The utilization of Industry 4.0 technologies and VR in particular can help to avoid the issue of products becoming too costly or being delayed in the market [7]. These digital and smart technologies provide an integrated product life cycle, a shorter production phase, improved flexibility, and better performance at an economical cost [6]. VR is a tool of Industry 4.0 that replicates the real world on computer-based systems, allowing product development to take place without the need for a physical environment [8]. This is especially important for the development process when higher performance standards are required. In this case, it is important to involve customers in the design process and let them understand the technical, safety, and legal requirements. This can be done through a shared platform where the cost of prototyping and improving the product to meet customer demands and legal standards is significantly reduced. The increased usage of Internet technology and the expansion of the mobile technology market all point to the potential of VR applications [6].

Despite the vast amount of research conducted in virtual environments, bibliometric analysis has not been as widely used in this field as it could be. Combining bibliometric analysis with social network analysis techniques can provide a way to statistically describe scholarly networks by looking at data such as collaborations, citations, co-citations, keywords, and correlations between fields of study. This information can then be organized into networks, which can be used to gain insight into the subject [10]. To gain a deeper understanding of the issue, an extensive appraisal of the available research is essential. This will provide a more solid foundation for comprehending the subject matter and illuminate the condition of the field by evaluating the different aspects of the virtual environment conversation globally. However, it is still unclear what direction the inquiry will take with regard to the trend towards virtual environments.

This bibliometric review intends to give scholars a more profound knowledge of the ongoing and previous trends in the virtual environment and to discover potential areas for future study [11]. Furthermore, it aims to pinpoint the leading authors and other participants in this

subject. We employed a science mapping technique to conduct a bibliometric assessment of research on virtual environments, with a primary focus on the following research queries:

Q1: How has the study of virtual environments evolved over time?
*Q2:* What is the intellectual structure of the virtual environment knowledge base?
Q3: What are the main areas of focus in the field of virtual environments?
Q4: Who are the leading contributing agents in virtual environment research?

## 2. Materials and Methods

This paper seeks to explore how virtual environments have evolved over the last three decades, from the 1990s to 2023. The choice of the virtual environment as the focus of this research was due to its current importance and relevance, particularly the Scopus database entries [12]. A thorough review of 772 articles was conducted on this topic. The findings from the examined parameters (co-citation, co-occurrence of terms, citations, etc.) were displayed graphically using VOSviewer [13], free software that creates and visualizes bibliometric networks.

VOSviewer can process data concerning researchers, publications, topics, journals, and countries and form clusters based on citation, co-citation, and co-occurrences [13]. This data is then graphically presented to make it more comprehensible [12]. This tool utilizes data from Scopus databases or the Web of Sciences and presents the important information in a map format. This research looks at the virtual environment from 1998 to 2023. By analyzing the concept over a long period of time, the shift in perception about virtual environments can be tracked.

Before we began to gather information, the criteria for inclusion were established based on the PRISMA framework [14]. PRISMA ("Preferred Reporting Items for Systematic Reviews and Meta-Analyses") is an evidence-backed collection of items that assist authors with detailing a range of systematic reviews, usually employed to determine the advantages and disadvantages of a healthcare intervention. PRISMA emphasizes methods that aid authors in ensuring that this kind of research is accurately and transparently reported [15].

### 2.1 Data Sources

[16] contested the idea that the Web of Science's limited range translates to better-quality sources, arguing instead that this must be verified based on the specific discipline. This was in response to [17], who determined that the Scopus index was a more thorough source of information when it came to searching and extracting papers in the social sciences based on their empirical studies. Moreover, the exporting capabilities of Scopus are more advanced than those of Google Scholar [13], [18]. Additionally, Scopus has a uniform system for indexing documents [13]. The interdisciplinary assessment conducted by [19] showed that there is a strong association between Scopus and Web of Science articles and citations.

### 2.2 Data Search Criteria

On March 11, 2023, we ran our initial research on the Scopus database with the search string we had previously established. We employed the PRISMA approach, as outlined by [18], and used the "TITLE-ABS-KEY" operator to search the Scopus Database and collect only double-blind peer-reviewed material. Our search was restricted to English documents classified as final papers, published through March 11$^{th}$, 2023. We employed criteria for inclusion and exclusion to limit our results, resulting in 3,432 articles. We then underwent a four-step process to narrow down the articles relevant to our review (Figure 1). The search was restricted to articles from the fields of business, management, accounting, economics, econometrics, finance, and social sciences, which resulted in 2,263 results. We then used keywords to narrow it down to those related to virtual environments, leaving 785 articles. After going through the articles and discarding 13 that were not in English, we were left with 772 articles to be included in our bibliometric review.

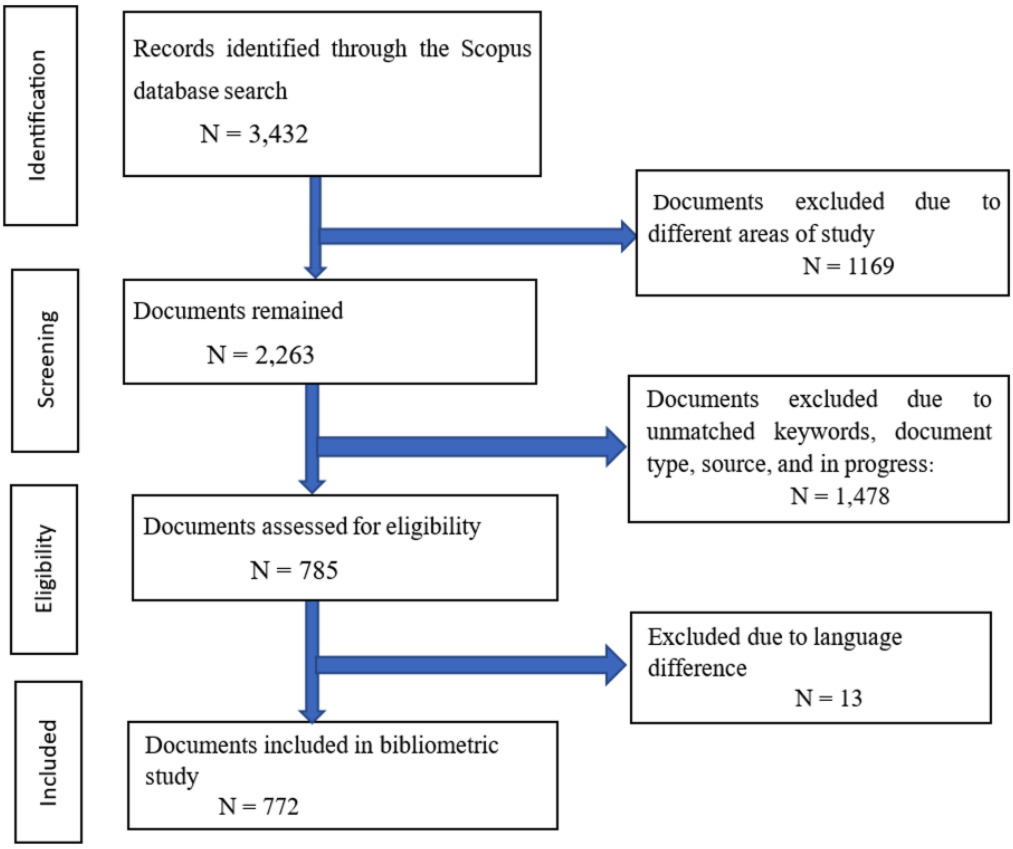



**Figure 1** The PRISMA Flowchart Showing Systematic Sampling Stages [10]

The search for documents was guided by the PRISMA approach [18], and parentheses were included to ensure accuracy. The inclusion of a question mark ("?") and an asterisk ("*") allowed for the expansion or reduction in the scope of the search terms, respectively. The search employed boolean operators ("AND" and "OR") to refine the terms ("virtual world" OR "virtual environment" OR "virtual reality" OR "online world" OR "digitized space" OR "digital world" OR "synthetic universe" OR "online universe" OR "cyber world" OR "digital environment" OR "immersive world"). These terms were used in the Scopus database to find relevant records. The search initially provided 3,432 documents; however, after taking away those that did not fit the criteria and those that were not considered of enough importance, the total number was decreased to 772 (Figure 1).

# 3. Results

The bibliographic details of the 772 documents were saved to be used in further processes. To have a more in-depth understanding of the findings, a bibliometrics technique was applied, which involved taking into account citation and co-citation analysis as well as presenting a graphical representation of the similarities in author co-citation and keyword co-occurrence analysis [13], [18]. Using Scopus analytics like Excel, Tableau, and VOSviewer bibliometric software, a bibliometric study was conducted [13], [18]. This section presents the findings from investigating the knowledge base related to virtual environments. The four research questions were explored in the following sequence:

## 3.1. Direction of Research Growth in Virtual Environments

The development of understanding surrounding virtual environments has been illustrated by the growth of research in the field. As evidenced by a search of the Scopus database, 772 articles discussing virtual environments have been published since 1998, the first of which was Holstrum G.L. and Hunton J.E.'s "New forms of assurance services for new forms of in-

formation: The global challenge for accounting educators," published in the International Journal of Accounting in 1998. This was followed by a lull until 2000, when Grimshaw B. and Cairns G.'s study on "Chasing the Mirage: Managing Facilities in a Virtual World" was released. Since 2017, the number of publications concerning virtual environments has been increasing, reaching a peak of 175 articles per year in 2022. To evaluate this trend, a review of 772 publications was conducted, which showed that the publications had an increasing trend between 2018 and 2022. The majority of these publications (503, or 65 percent) were published within the last five years (2019–2023). This indicates that academics are more and more interested in researching virtual environments, suggesting a very positive outlook for this field of study (Figure 2).

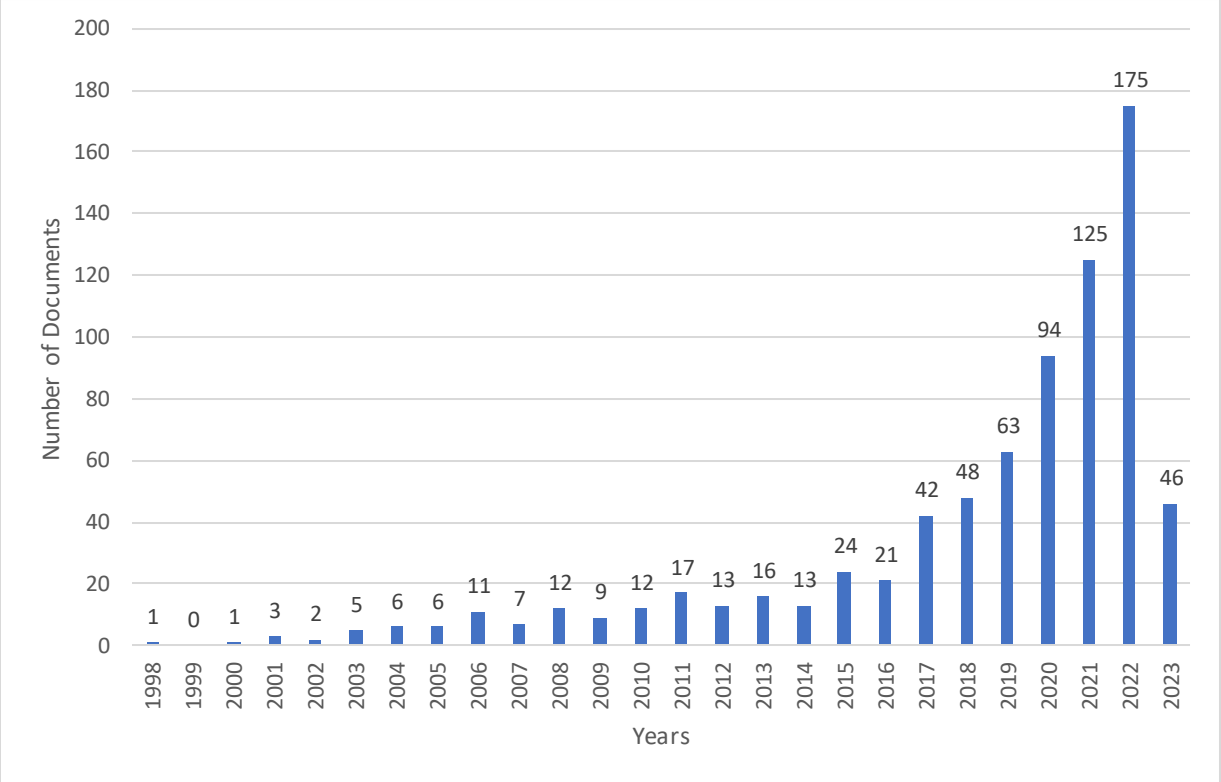
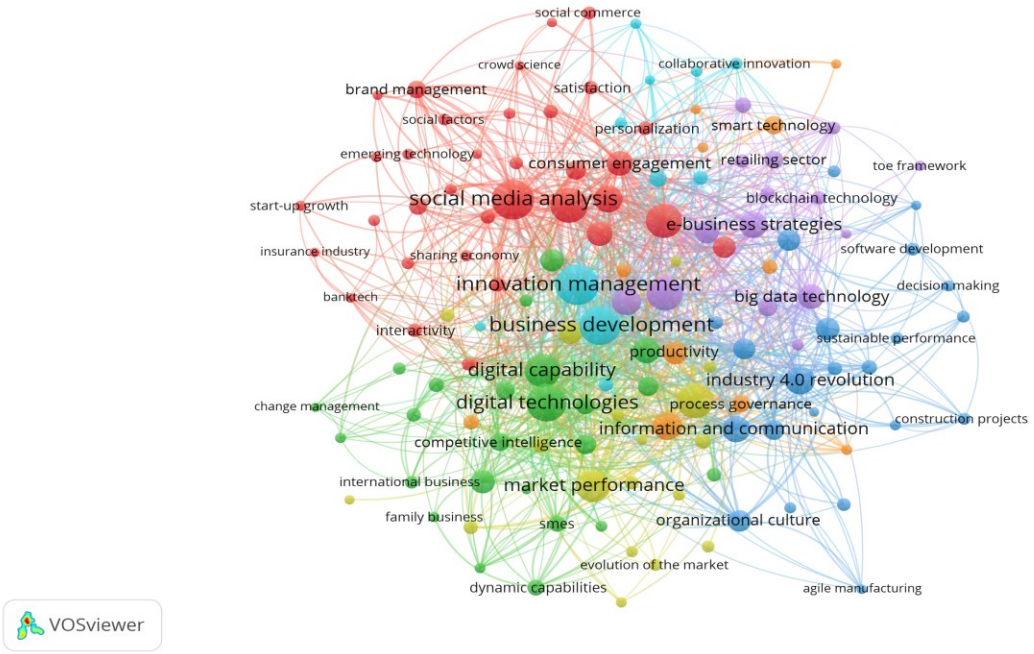



**Figure 1** Longitudinal evolution of virtual environment literature, 1998–2023 (n = 772)

### *3.1.1 General Keywords Growth*

To understand how views on virtual environments have changed, the VOSviewer was used to measure the number of times and the relationship between keywords in documents published from 1998–2023. By setting a rule that a keyword had to be used in at least five articles, the total number of keywords decreased from 754 to 140 (Figure 3). It is vital to pinpoint the most frequently discussed topics related to virtual environments in order to reach the goals detailed in this paper.

Figure 3 of VOSviewer's co-occurrence network illustrates that the size of the bubbles reflects how frequently each individual is used by researchers, with the bigger ones representing the more influential ones. Additionally, the clusters of bubbles, which range in different hues (Figure 3), classify keywords into distinct fields of study depending on their co-occurrence connections. A detailed analysis of Figure 3 shows that the connections between keywords represent how often they have been used in different studies.




Legend for keywords:
Cluster one (Red) = customer engagement and virtual environment
Cluster two (Green): digital technology and virtual environment
Cluster three (blue): information and communication technology and virtual environment
Cluster four (Yellow): business performance in a virtual environment
Cluster five (Purple): advancement of technology and virtual environment
Cluster six (light blue): innovation management and virtual environment
Cluster seven (Orange): virtual environment and sustainable development

**Figure 3** Author keywords co-occurrences network for virtual environment 1998-2023

In this case, we conducted a keyword analysis to look into the topics discussed in the virtual environment literature. We employed VOSviewer to identify the most commonly used terms at the start of our investigation. Figure 3's density map shows that "innovation management" was mentioned the most with 91 occurrences, followed by "social media analysis" (87), 'business development" (84), "digital technology" (78), "customer engagement" (68), "firm performance" (67), "technology management" (66), "virtual environment" (64), "digital capability" (62), and "market performance" (55). This analysis of the keywords revealed that the main topic of our concern (the virtual environment) has lost its frequency. This might be due to the use of interchangeable words like "virtual reality," "virtual world," "online world," "digitized space," "digital world," "synthetic universe," "online universe," "cyber world," "digital environment," and "immersive world," among others. This was established using VOSviewer to generate a "chronological keyword map" (Figure 3) with a minimum of five co-occurrences [11], [20]. There were no huge node differences to identify the main keywords that could link the others. This map examined the distribution of the keywords among documents based on the date of their publication, and the documents were divided into three groups for analysis (Table 1).

**Table 1** The Top Fifteen Keywords Growth Trend in Virtual Environment knowledge base

| | 1998-2023 | | | 1998-2010 | | | 2011-2019 | | | 2020-2023 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Id | Label | OC | %age | Label | OC | %age | Label | OC | %age | Label | OC | %age |
| 1 | Innovation management | 91 | 3.86 | Electronic commerce | 27 | 19.29 | Social media analysis | 38 | 9.05 | Digital technologies | 70 | 11.33 |
| 2 | Social media analysis | 87 | 3.69 | Virtual environment | 21 | 15.00 | Technology management | 34 | 8.10 | Innovation management | 59 | 9.55 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | Business development | 84 | 3.56 | Internet technology | 12 | 8.57 | Innovation management | 29 | 6.90 | Digital capability | 51 | 8.25 |
| 4 | Digital technologies | 78 | 3.31 | Customer engagement | 9 | 6.43 | Business development | 27 | 6.43 | Social media analysis | 49 | 7.93 |
| 5 | Customer engagement | 68 | 2.88 | Technology management | 9 | 6.43 | Customer engagement | 26 | 6.19 | Firm performance | 41 | 6.63 |
| 6 | Firm performance | 67 | 2.84 | ICT | 8 | 5.71 | Online platform management | 20 | 4.76 | Business development | 40 | 6.47 |
| 7 | Technology management | 66 | 2.80 | Web performance | 8 | 5.71 | Digital technologies | 19 | 4.52 | Technology management | 34 | 5.50 |
| 8 | Virtual environment | 64 | 2.71 | Innovation management | 7 | 5.00 | ICT | 19 | 4.52 | Customer engagement | 33 | 5.34 |
| 9 | Digital capability | 62 | 2.63 | Market performance | 7 | 5.00 | Virtual environment | 19 | 4.52 | Market performance | 33 | 5.34 |
| 10 | Market performance | 55 | 2.33 | Online platform management | 7 | 5.00 | Consumer engagement | 18 | 4.29 | Industry 4.0 | 32 | 5.18 |
| 11 | Sustainable development | 44 | 1.87 | Business development | 5 | 3.57 | Service dimensions | 18 | 4.29 | Sustainable development | 32 | 5.18 |
| 12 | Industry 4.0 revolution | 42 | 1.78 | Firm performance | 5 | 3.57 | Web performance | 18 | 4.29 | Digital business strategy | 29 | 4.69 |
| 13 | Internet technology | 42 | 1.78 | Communication technologies | 5 | 3.57 | Electronic commerce | 17 | 4.05 | Virtual environment | 26 | 4.21 |
| 14 | Online platform management | 40 | 1.70 | E-business strategies | 5 | 3.57 | Firm performance | 17 | 4.05 | Artificial intelligence | 24 | 3.88 |
| 15 | ICT | 39 | 1.65 | Performance management | 5 | 3.57 | Market performance | 17 | 4.05 | Big data technology | 24 | 3.88 |

**Source:** Developed by author
**Notes:** ICT = Information and Communication Technology, OC = Occurrences

The study observed that electronic commerce was significantly associated with the virtual environment, with about 19.3 percent of the keywords that met the threshold of having at least five co-occurrences in the first sub-period, from 1998 to 2010, being related to it. Virtual environments made up 15 percent of the keywords, followed by internet technology with 8.6% of the occurrences. The remaining keywords with their descriptions are displayed in Table 1.

The study found that of the articles published between 2011 and 2019 (second sub-period), nine percent of the keywords that met the threshold of having at least five co-occurrences related to social media analysis were linked to virtual environments. The most common keywords were presented in Table 1, displaying the top fifteen keywords and their respective percentages, which are related to virtual environments. This list of terms was updated compared to the previous period and now includes technology management, digital technology, consumer engagement, service dimensions, and firm performance. All of these keywords accounted for more than 20 percent of the total.

The 2020-2023 period had a shorter publication period when compared to the analysis of the previous sub-periods, yet this data is still necessary to include in the evaluation due to the rise in the number of published papers. When looking at the 483 keywords used in the papers of this period, only 88 were highlighted in five or more publications (Table 1). During this time, research suggested that digital technologies were closely tied to virtual environments. It accounted for 11.3 percent of the keywords associated with virtual environments. The innovation management keyword makes up about ten percent of the total keywords. Table 1 displays the fifteen most commonly used keywords and the percentage of their usage. New additions in comparison to the previous period include industry 4.0, sustainable development, digital business strategies, artificial intelligence, digital capability, and big data technology.

The research conducted on the third sub-period revealed an increase in the occurrence of keywords related to the virtual environment for the three sub-periods, including innovation management (7, 29, 59), social media analysis (0, 38, 49), business development (5, 27, 40), and digital technologies (0, 19, 70), among others. This means that the virtual environment topics are still hot with high growth (Table 1). Therefore, the key topics to be addressed for future research are digital technologies, innovation management, digital capability, social

media analysis, firm performance, business development, technology management, customer engagement, market performance, industry 4.0, sustainable development, digital business strategies, virtual environments, artificial intelligence, and big data technology.

### *3.1.2 The Growth of the Top Five Current Research Topics in Virtual Environments*

Having an awareness of the history of growth helps to enrich our understanding and the readers' comprehension of the major subjects that are the most significant to the virtual environment. During the first period of time, the growth rate of digital technologies was not mentioned in the top fifteen articles. Its first appearance on the list was in the second sub-period, when it started with 4.5 percent. Interesting enough, it jumped to 11.3 percent and became the leading keyword in the third sub-period. Overall, it is evident that digital technologies are a significant phenomenon, with the average growth rate of their occurrences being 3.3 percent (Table 1).

Innovation management was found in all three sub-periods. In the first sub-period, innovation management accounted for five percent of all occurrences; this rate subsequently increased to seven percent in the second sub-period. In the third sub-period, however, innovation management was the second most frequently occurring keyword, accounting for about ten percent of all co-occurrences. In total, innovation management had an average growth rate of about four percent and became the leading keyword of the overall sub-periods (Table 1). The popularity of the concept has grown due to the advancement of technology.

Investigation into digital capability has seen a gradual rise over the years, beginning with a more than 8 percent growth rate in its introduction stage as a new term in the third sub-period (Table 1). This area of research is still fairly new, as indicated by the lack of publications in the Scopus database from 1998 to 2023, which had an average of 2.6 percent.

The use of "social media analysis" was introduced in the top fifteen list of keywords in the second sub-period and became the leading keyword, having a 9 percent growth rate, then declined to 8 percent in the following sub-period (Table 1). The average rate of co-occurrences was 3.7 percent, and it became the second-top keyword overall.

The keyword "firm performance" is steadily growing in frequency, as shown by its 3.6 percent, 4 percent, and 6.6 percent growth rates in the three sub-periods. This steady rise has put it in the top ten most frequent keywords, with an average growth rate of 2.8 percent.

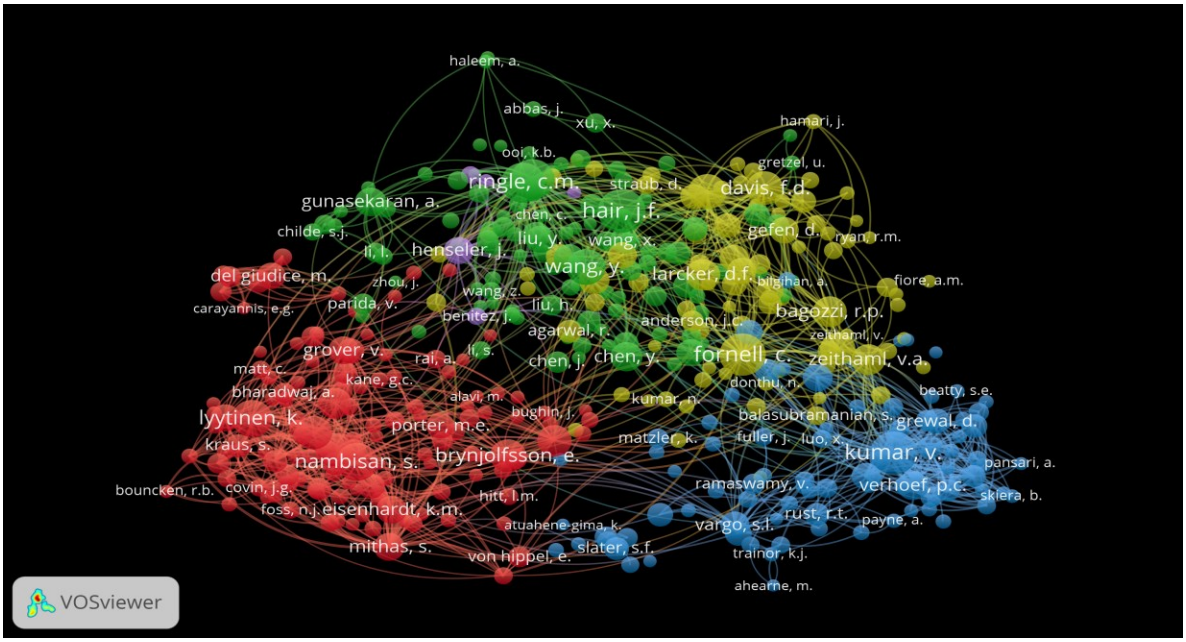
## 3.2 Intellectual Structure of the Virtual Environment Knowledge Base

Scientists can gain insight into the current status of research on virtual environments by analyzing their "intellectual structure" [21]. They can do this by utilizing scientific mapping and review procedures. A VOSviewer-generated network map can be used to visualize the conceptual structure of virtual environments' knowledge base by examining the authors' co-citation analysis [18]. This approach can help pinpoint the most and least studied topics in the field.

Researchers have discovered that when authors are cited together in the same publications, they often have similar scholarly perspectives [16]. To show this, the VOSviewer software can generate a network map that demonstrates the shared concepts of authors referenced in our virtual environment database [20].

Figure 4 of VOSviewer's co-citation map illustrates 427 academics that have been referenced in a minimum of 25 other writings. The size of the bubbles reflects how frequently each individual is cited by other researchers, with the bigger ones representing the more influential ones. Additionally, the clusters of bubbles, which range in different hues (Figure 4), classify researchers into distinct fields of study depending on their co-citation connections. A detailed analysis of Figure 4 shows that the connections between authors represent how often they have been cited together. The map offers insight into four separate philosophical perspec-

tives. At the same time, the four clusters and the interconnections between them demonstrate the interconnectedness of the knowledge base. This indicates that Hair, J. F., Kumar, V., Fornell, C., and Nambisan, S. were the most important nodes on the map. Those located at the center of the clusters indicate their ability to bridge the gap between ideas from the four schools (Figure 4).




**Legend:** Cluster one is Red, Cluster two is green, Cluster three is blue, and Cluster four is yellow.

**Figure 4** Co-citation to cited authors network map of the virtual environment, min. 20, (n = 772)

## 3.3 Topical Concentrations of the Virtual Environment Knowledge Base

Gaining insight into the main themes and topics of the literature on virtual environments is beneficial for a variety of stakeholders. It can help researchers pinpoint important topics and areas that have not yet been explored, provide a framework for understanding current research, point to potential future directions, and aid practitioners in recognizing areas of research that may be of interest to them.

We used VOSviewer to construct a chronological keyword map with a minimum of five co-occurrences (as shown in Figure 3). This type of analysis evaluates how often certain keywords are used in documents based on the publication date. To explore the topics discussed in the field of virtual environments, we conducted a keyword analysis. Figure 3 displays that innovation management is the most frequently used phrase, with 91 co-occurrences, while social media analysis comes in second with 87 co-occurrences. Business development, digital technologies, and customer engagement are respectively the third, fourth, and fifth most often used terms, with 84, 78, and 68 mentions, respectively. Firm performance, technology management, virtual environment, digital capability, and market performance are the least referred to with 67, 66, 64, 62, and 55 occurrences, respectively. This co-occurrence with the cited author showed that all of the clusters were tied to the main theme, though the theme used different wordings to mean the main theme (virtual environment). This was evident in the frequently occurring keywords, which can all impact or be impacted by the digital environment. To further examine how the keywords were distributed, we used VOSviewer to create a “chronological keyword map” (Figure 3) with a minimum of five co-occurrences [10]. This chronological co-word analysis (Figure 3) provides insight into the distribution of the keywords.

## 3.4 The Scope of the Most Contributing Agents in the Virtual Environment Knowledge Base

Understanding the key authors and documents in the field of virtual environments can provide insight into the current state of knowledge and can also point to potential areas for new research and ideas. Furthermore, it can give researchers a better idea of which countries, journals, authors, and documents are most important and should be consulted for more comprehensive information.

### *3.4.1 Fruitful Countries in the Virtual Environment Knowledge Base*

By researching the most productive countries in terms of virtual environments, researchers can identify which countries are most actively researching this topic, stay up-to-date on the trends in virtual environment research, and gain an understanding of the standards for virtual environment practices. Additionally, looking at where the authors of these studies are located can give an indication of where the majority of scholarly attention is being focused on the subject of virtual environments.

The work in Table 2 was created in 60 different countries, showing that the subject of virtual environments is globally interesting. The majority of the related research was conducted by scholars from the United States (151), the United Kingdom (97), China (72), Italy (58), Germany (51), India (43), France (43), Spain (42), Taiwan (40), and Malaysia (37). These ten countries were the primary sources of knowledge and studies on the topic. Further, out of the ten nations that are highest in the list based on the number of citations, more than half of the virtual environment citations studied in this review originated from scholars in the USA (8,572), the UK (6,685), Hong Kong (3,004), Germany (2,492), India (2,132), France (2,004), China (1,568), Italy (1,557), Spain (1,445), and the Netherlands (1,128), as is presented in Table 3. In conclusion, research into virtual environments is mainly focused on developed and emerging countries, leaving work in developing countries largely neglected. This has a profound effect on academia, with the countries mentioned previously having a substantial influence and their research having a substantial impact.

**Table 2** Rank Order of the Fruitful Countries by Documents Published

| Id | Label | Documents | Citations |
|---|---|---|---|
| 1 | United States | 151 | 8572 |
| 2 | United Kingdom | 97 | 6685 |
| 3 | China | 72 | 1568 |
| 4 | Italy | 58 | 1557 |
| 5 | Germany | 51 | 2492 |
| 6 | India | 43 | 2132 |
| 7 | France | 43 | 2004 |
| 8 | Spain | 42 | 1445 |
| 9 | Taiwan | 40 | 1051 |
| 10 | Malaysia | 37 | 777 |

**Source:** Developed by author

**Table 3** Rank Order of the Most Prolific Countries by Citations

| Id | Label | Documents | Citations |
|---|---|---|---|
| 1 | United States | 151 | 8572 |
| 2 | United Kingdom | 97 | 6685 |
| 3 | Hong Kong | 21 | 3004 |
| 4 | Germany | 51 | 2492 |
| 5 | India | 43 | 2132 |
| 6 | France | 43 | 2004 |
| 7 | China | 72 | 1568 |
| 8 | Italy | 58 | 1557 |
| 9 | Spain | 42 | 1445 |
| 10 | Netherlands | 14 | 1128 |

**Source:** Developed by author

### *3.4.2 Analysis of the Most Fruitful Publication Sources*

This analysis provides a comprehensive overview of the most prominent journals in the field of virtual environments, helping researchers and practitioners keep up with the latest research and developments and find the journals that are most likely to accept their work. The 772 virtual environment publications were spread across 340 sources. Despite the fact that the majority (68 percent) of sources had multiple publications, the top fifteen sources (shown in Table 4) comprised more than half of the overall corpus. Sustainability (Switzerland) was the most productive source, with 72 articles, but all 340 sources combined made up 25,915 citations. Out of the total sources, 39 had no citations (the list is not attached), and the top fifteen most cited sources accounted for more than 60 percent of all citations (Table 5). The leading source was Tourism Management, with 2,495 citations from six publications, while the details of the other prominent sources are provided in Table 5.

**Table 4** Rank Order of the Most Fruitful Source by Documents

| id | Label | Documents | Citations |
|---|---|---|---|
| 1 | Sustainability (Switzerland) | 72 | 612 |
| 2 | Journal of business research | 25 | 841 |
| 3 | Technological forecasting and social change | 22 | 609 |
| 4 | Information and management | 17 | 1510 |
| 5 | International journal of information management | 17 | 1652 |
| 6 | Journal of cleaner production | 14 | 749 |
| 7 | Journal of retailing and consumer services | 14 | 425 |
| 8 | International journal of production economics | 12 | 628 |
| 9 | Technology in society | 10 | 220 |
| 10 | Information systems research | 9 | 275 |
| 11 | International journal of operations and production management | 8 | 463 |
| 12 | Journal of business and industrial marketing | 8 | 111 |
| 13 | Technovation | 8 | 373 |
| 14 | Industrial marketing management | 7 | 413 |
| 15 | Internet research | 7 | 567 |

**Source:** Developed by author

**Table 5** Rank Order of the Most Fruitful Sources by Citations

| Id | Label | Documents | Citations |
|---|---|---|---|
| 1 | Tourism Management | 6 | 2495 |
| 2 | International Journal of Information Management | 17 | 1652 |
| 3 | Information and Management | 17 | 1510 |
| 4 | Management Decision | 4 | 881 |
| 5 | Journal of Business Research | 25 | 841 |
| 6 | Journal of Cleaner Production | 14 | 749 |
| 7 | MIS Quarterly : Management Information Systems | 6 | 714 |
| 8 | Journal of Manufacturing Technology Management | 6 | 703 |
| 9 | Journal of Management Information Systems | 4 | 653 |
| 10 | International Journal of Production Economics | 12 | 628 |
| 11 | Sustainability (Switzerland) | 72 | 612 |
| 12 | Technological Forecasting and Social Change | 22 | 609 |
| 13 | Internet Research | 7 | 567 |
| 14 | Industrial Management and Data Systems | 5 | 565 |
| 15 | Journal of Interactive Marketing | 2 | 541 |

**Source:** Developed by author

### *3.4.3 Most Influential Authors in Virtual Environment Literature*

Table 6 shows that [22] had the highest citation count (1,875) for their publication that studied "Progress in information technology and tourism management: 20 years on and 10 years after the internet-the state of e-tourism research." They were followed by Gupta, S., who had 793 citations from his four publications. Other authors besides the fifteen listed in Table 6 may have made notable contributions to the field of virtual environments. However, we did

not use their h-index as a metric since this index takes into consideration all of their academic work, not just the papers they have written on virtual environments [10]. Therefore, the citations in Table 6 reflect the authors' contributions to the field of virtual environments.

**Table 6** Rank Order of the Most Prolific Authors by Citations

| Id | Label | Documents | Citations |
|---|---|---|---|
| 1 | Buhalis D. | 1 | 1875 |
| 2 | Law R. | 1 | 1875 |
| 3 | Gupta S. | 4 | 793 |
| 4 | Balasubramanian S. | 4 | 782 |
| 5 | Sashi C.M. | 1 | 742 |
| 6 | Lu Y. | 4 | 719 |
| 7 | Zhang H. | 3 | 616 |
| 8 | Ghobakhloo M. | 2 | 606 |
| 9 | Duan Y. | 2 | 602 |
| 10 | Zhao L. | 3 | 576 |
| 11 | Aarts G. | 1 | 561 |
| 12 | Coombs C. | 1 | 561 |
| 13 | Crick T. | 1 | 561 |
| 14 | Dwivedi R. | 1 | 561 |
| 15 | Dwivedi Y.K. | 1 | 561 |

**Source:** Developed by author

### *3.4.4 Most Influential Documents in Virtual Environment Literature*

Table 7 shows the most cited papers in the field based on the frequency of citations within the Scopus core collection. This analysis was conducted to evaluate the impact of the researchers' work in the field. [22], with 1,875 citations, is the most widely cited article in this field. The other influential documents with their citations can be seen in Table 7.

**Table 7** Rank Order of the Most Contributing Documents by Citations

| Id | Label | Description | Sources | Citations |
|---|---|---|---|---|
| 1 | Buhalis D and Law, R (2008) | Progress in information technology and tourism management: 20 years on and 10 years after the internet-the state of e-tourism research | Tourism Management | 1875 |
| 2 | Sashi C.M. (2012) | Customer engagement, buyer-seller relationships, and social media | Management Decision | 742 |
| 3 | Ghobakhloo M. (2018) | The future of manufacturing industry: a strategic roadmap toward industry 4.0 | Journal of Manufacturing Technology Management | 603 |
| 4 | Dwivedi Y.K. (2021) | Artificial intelligence (ai): multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy | International Journal of Information Management | 561 |
| 5 | Chen Y.-H. (2007) | Initial trust and online buyer behaviour | Industrial Management and Data Systems | 524 |
| 6 | Kannan P.K. (2017) | Digital marketing: a framework, review and research agenda | International Journal of Research in Marketing | 480 |
| 7 | Malthouse E.C. (2013) | Managing customer relationships in the social media era: introducing the social CRM house | Journal of Interactive Marketing | 473 |
| 8 | Pletikosa Cvijikj I. (2013) | Online engagement factors on Facebook brand pages | Social Network Analysis and Mining | 471 |
| 9 | Zhang H. (2014) | What motivates customers to participate in social commerce? The impact of technological environments and virtual customer experiences | Information and Management | 461 |
| 10 | Gomber P. (2018) | On the fintech revolution: interpreting the forces of innovation, disruption, and transformation in financial services | Journal of Management Information Systems | 440 |
| 11 | Wu F. (2003) | An analysis of e-business adoption and its impact on business | Journal of the | 358 |

| | | | | |
|---|---|---|---|---|
| | | performance | Academy of Marketing Science | |
| 12 | Lee Y. (2006) | Investigating the effect of website quality on e-business success: an analytic hierarchy process (ABP) approach | Decision Support Systems | 325 |
| 13 | Kamboj S. (2018) | Examining branding co-creation in brand communities on social media: applying the paradigm of stimulus-organism-response | International Journal of Information Management | 310 |
| 14 | Füller J. (2006) | Community based innovation: how to integrate members of virtual communities into new product development | Electronic Commerce Research | 302 |
| 15 | Rowley J. (2006) | An analysis of the e-service literature: towards a research agenda | Internet Research | 287 |
| 16 | Van Oosterhout M. (2006) | Change factors requiring agility and implications for it | European Journal of Information Systems | 281 |
| 17 | Syam N. (2018) | Waiting for a sales renaissance in the fourth industrial revolution: machine learning and artificial intelligence in sales research and practice | Industrial Marketing Management | 264 |
| 18 | Balasubramanian S. (2003) | Customer satisfaction in virtual environments: a study of online investing | Management Science | 264 |
| 19 | Jung T.et al., (2015) | The determinants of recommendations to use augmented reality technologies: the case of a Korean theme park | Tourism Management | 252 |
| 20 | Bernardes E.S. (2009) | A theoretical review of flexibility, agility and responsiveness in the operations management literature: toward a conceptual definition of customer responsiveness | International Journal of Operations and Production Management | 249 |

**Source:** Developed by author

**Table 8** The Topical Relevance Documents Contributing to the Domain

| Id | Label | Description | Sources | Citations |
|---|---|---|---|---|
| 1 | Chandra and Kumar (2018) | Exploring factors influencing organizational adoption of augmented reality in e-commerce: empirical analysis using technology-organization-environment model | Journal of electronic commerce research | 71 |
| 2 | Itani and Hollebeek. (2021) | Light at the end of the tunnel: visitors' virtual reality (versus in-person) attraction site tour-related behavioral intentions during and post-covid-19 | Tourism management | 88 |
| 3 | Cao Q. (2005) | The impact of alignment between virtual enterprise and information technology on business performance in an agile manufacturing environment | Journal of operations management | 123 |
| 4 | Manis and Choi (2019) | The virtual reality hardware acceptance model (VR-HAM): extending and individuating the technology acceptance model (TAM) for virtual reality hardware | Journal of business research | 153 |
| 5 | Casaló L.V. (2010) | Relationship quality, community promotion and brand loyalty in virtual communities: evidence from free software communities | International journal of information management | 158 |
| 6 | Casaló L. (2007) | The impact of participation in virtual brand communities on consumer trust and loyalty: the case of free software | Online information review | 224 |
| 7 | Jung, et al,. (2015) | The determinants of recommendations to use augmented reality technologies: the case of a Korean theme park | Tourism management | 252 |
| 8 | Balasubramanian S. (2003) | Customer satisfaction in virtual environments: a study of online investing | Management science | 264 |
| 9 | Füller et al. (2006) | Community based innovation: how to integrate members of virtual communities into new product development | Electronic commerce research | 302 |
| 10 | Zhang H. (2014) | What motivates customers to participate in social commerce? The impact of technological environments and virtual customer experiences | Information and Management | 461 |

**Source:** Developed by author

Table 8 exhibits the ten documents that were not among those with the highest citations but from the same data set that met the specification criteria and directly mentioned the keywords in the research query in studying the virtual environment domain, regardless of their

position and number of citations. The contributions of five of them to the virtual environment knowledge base are explained hereunder:

[23] investigated the determinants impacting the inclination of e-commerce companies to embrace augmented reality (AR) technology. The research employed the technology-organization-environment (TOE) framework as the foundational theory. By concentrating on AR technology, which has garnered relatively limited notice within the realm of information systems (IS) research, this paper makes a noteworthy contribution. Moreover, it applied the TOE framework to delve into the adoption intentions of AR technology, focusing specifically on the standpoint of a business entity. The article further pinpointed the critical elements influencing e-commerce enterprises' inclination to adopt AR. These factors encompass endorsement from top-level management, the expertise of decision-makers, technological proficiency, financial capacity, comparative benefits, competitive influence, and consumer preparedness. Moreover, the paper offers insights pertinent to both research and practical application.

[24] studied the influence of the COVID-19 pandemic on individuals' intentions to visit attractions, whether in physical locations or through virtual means. It was rooted in the protection-motivation theory. The research constructed and evaluated a model that delves into how consumers' assessments of the threats posed by COVID-19 and their strategies for coping with those threats affect their adherence to social distancing measures. This, in turn, impacted their preferences for engaging in site tours either using virtual reality (VR) technology or by physically visiting the sites [24]. Furthermore, the study explored the diversity in consumers' demands for VR-based tours and their intentions to endorse such tours, contingent on their level of adherence to social distancing measures. This research makes a valuable addition to existing knowledge by utilizing the protection motivation theory in the tourism domain. It also scrutinizes the significance of social distancing as a coping mechanism in response to COVID-19. Additionally, the study ventured into the feasibility of utilizing VR technology as an alternative avenue for providing services at attraction sites.

[25] enhanced the body of knowledge regarding the acceptance of virtual reality hardware by refining and customizing the initial technology acceptance model (TAM) to suit this particular context. The research introduced and evaluated a fresh framework termed the VR hardware acceptance model (VR-HAM), which introduced perceived enjoyment as a foundational factor alongside four contributing factors: age, curiosity, prior experience, and willingness to pay a certain price. The study discovered that factors such as willingness to pay a certain price, perceived ease of use, and perceived enjoyment significantly predict intention regarding VR hardware, attitude, and perceived usefulness. Additionally, the research revealed that age, past experience, and curiosity play a role in shaping perceived ease of use, while willingness to pay and curiosity impact the perceived enjoyment aspect. The findings of this paper offer both theoretical and practical insights with regards to acceptance, intention to purchase VR hardware, and utilization.

[26] explored the determinants that impact the willingness to adopt and suggest augmented reality (AR) applications among tourists who visit a theme park in South Korea. The study assesses the system's functionality, personalized service, and how the quality of content influenced user satisfaction and their intention to advocate for marker-based AR applications. Additionally, the study investigated how personal innovativeness acts as a moderating factor in the connection between quality and satisfaction. The findings of the study demonstrated that the three quality dimensions all contributed positively to user satisfaction, which in turn influenced the intention to endorse AR applications. Furthermore, the research identified that personal innovativeness plays a moderating role in the association between system quality and satisfaction, as well as between content quality and satisfaction, though this moderating effect was not observed in relation to personalized service quality and satisfaction. This study makes a noteworthy contribution to the field of augmented reality (AR) acceptance and endorsement by employing a quality framework within a tourism setting and by investigating how personal innovativeness influences this dynamic.

[27] introduced an approach to incorporating online community members into the procedures for developing new products. This approach, referred to as community-based innovation (CBI), comprises a sequence of four phases: "defining user indicators," "identifying relevant communities," "designing virtual interaction," and "facilitating user access and participation." The paper exemplified the implementation of the CBI framework through a case study conducted at Audi AG (a car company). In that instance, customers were invited to collaboratively devise infotainment systems for automobiles. The article deliberated upon the advantages and obstacles related to community-based innovation (CBI), encompassing merits like enhancement of customer contentment, commitment, and cost and risk reduction, as well as addressing legal and competitive concerns. Moreover, the paper outlined potential pathways for future investigation in the realm of CBI. These could involve evaluating its efficiency and efficacy, delving into the motivations and viewpoints of both producers and consumers, and gauging the influence of jointly developed products on the attainment of innovative success.

# 4. Conclusion, Research Gap, and Limitations

## 4.1 Conclusion

This study serves as a baseline for structuring and organizing the present scientific understanding of virtual environments. We used multiple quantitative bibliometric approaches, such as software and algorithmic processes, to assess the transmission of knowledge in this subject. We have compiled a robust overview of the current understanding of the topic, pinpointed potential research opportunities, and created a plan for a continued study that reflects the evolving nature of the subject.

This analysis of studies reveals the large amount of research on virtual environments that has been conducted since 1998, when the first related scholarly article was published in the Scopus database. This boom of literature on the topic has been largely concentrated in the last decade, likely due to advancements in technology. The review found common topics for examination, including innovation management, social media analysis, business development, digital technologies, customer management, firm performance, technology management, virtual environments, digital capability, and market performance.

Recent studies in the field of virtual environments have predominantly investigated topics such as Industry 4.0, sustainable development, digital business strategy, artificial intelligence, and big data technology. Consequently, these are the areas that require the most attention from researchers due to the fact that they are still new not only to developing countries, as the analysis shows, but also to most developed countries.

This research adds to the existing understanding of virtual environments by inspecting what has already been done, pinpointing common patterns, and recognizing topics that have not been thoroughly examined and need additional investigation. It can give researchers an extensive overview of the topic or provide an in-depth analysis of the reference system. This can assist teachers in advancing the already existing knowledge regarding virtual environments by pinpointing the most researched areas, being aware of the latest developments, and understanding the direction the field is heading in.

This research into virtual environments has identified the countries and journals that have been the most productive and most highly cited, providing researchers and other stakeholders with invaluable information for making informed decisions about research and publication in this field.

## 4.2 Implications of the Findings

This research provides an extensive overview of the evolution and current state of virtual environments. It is a great resource for researchers in information and communication technology, accounting, finance, economics, and business management, as it provides them with

key sources of information, publications, and ideas for the future direction of the field. Additionally, this research is valuable for anyone who wants to learn about virtual environment literature.

## 4.3 Research Gaps

*First,* recent studies in the field of virtual environments have predominantly investigated topics such as Industry 4.0, sustainable development, digital business strategy, artificial intelligence, and big data technology. Consequently, these are the areas that require the most attention from researchers, due to the fact that they are still new not only to developing countries, as the analysis shows, but also to most developed countries (Tables 1 and 2).

*Second,* the research conducted on the third sub-period revealed an increase in the occurrence of keywords related to the virtual environment for the three sub-periods, including innovation management (7, 29, 59), social media analysis (0, 38, 49), business development (5, 27, 40), and digital technologies (0, 19, 70), among others. This means that the virtual environment topics are still hot with high growth (Table 1). Therefore, the key topics to be addressed for future research are digital technologies, innovation management, digital capability, social media analysis, firm performance, business development, technology management, customer engagement, market performance, industry 4.0, sustainable development, digital business strategies, virtual environments, artificial intelligence, and big data technology.

## 4.4 Limitations

The use of the Scopus database in this study has its benefits, but it is also limited. It is possible that documents from other databases such as Inform/ProQuest, ABI, and the Web of Sciences were not taken into consideration, which is a common issue in bibliometric studies (Jacsó, 2008). In addition to the findings of this search, other documents such as conference proceedings, national journals, and editorial content that could be just as relevant when discussing virtual environments should be taken into consideration [28]. Similar to the work of [29] and [18], this research used co-citation, key-word searches, co-occurrence, and co-author analysis. Supplementing the findings with bibliographic coupling may be advantageous. However, the shortcomings discussed suggest potential ways to enhance future bibliometric studies.

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I, the author, state that there are no conflicts of interest concerning this research or its publication.

## Availability of Data and Materials

The data generated and evaluated in the present research can be accessed through the Scopus database and can be obtained from the author upon request.

# References

[1] S. M. C. Loureiro, J. Guerreiro, and F. Ali, “20 years of research on virtual reality and augmented reality in tourism context: A text-mining approach,” *Tour. Manag.*, vol. 77, no. November 2019, 2020, doi: 10.1016/j.tourman.2019.104028.

[2] S. M. C. Loureiro, J. Guerreiro, S. Eloy, D. Langaro, and P. Panchapakesan, "Understanding the use of Virtual Reality in Marketing: a text mining-based review," *J. Bus. Res.*, no. 351, 2019, doi: doi.org/10.1016/j.jbusres.2018.10.055.

[3] C. Flavián, S. Ibáñez-Sánchez, and C. Orús, "The impact of virtual, augmented and mixed reality technologies on the customer experience," *J. Bus. Res.*, vol. 100, no. October 2018, pp. 547–560, 2019, doi: 10.1016/j.jbusres.2018.10.050.

[4] M. Vafadar, "Virtual Reality: Opportunities and Challenges," *Int. J. Mod. Eng. Res.*, vol. 3, no. 2, pp. 1139–1145, 2013, [Online]. Available: www.ijmer.com

[5] R. Schroeder, "Defining Virtual Worlds and Virtual Environments," *J. Virtual Worlds Res.*, vol. 1, no. 1, pp. 1–3, 2008, doi: 10.4101/jvwr.v1i1.294.

[6] A. C. Firu, A. I. Tapîrdea, A. I. Feier, and G. Draghici, "Virtual reality in the automotive field in industry 4.0," *Mater. Today Proc.*, vol. 45, pp. 4177–4182, 2021, doi: 10.1016/j.matpr.2020.12.037.

[7] E. Baran and T. K. Polat, "Classification of Industry 4.0 for Total Quality Management: A Review," *Sustain.*, vol. 14, no. 6, pp. 1–20, 2022, doi: 10.3390/su14063329.

[8] R. Bhagavathula, B. Williams, J. Owens, and R. Gibbons, "The reality of virtual reality: A comparison of pedestrian behavior in real and virtual environments," *Proc. Hum. Factors Ergon. Soc.*, vol. 3, pp. 2056–2060, 2018, doi: 10.1177/1541931218621464.

[9] P. S. R. Nethravathi *et al.*, "Business intelligence appraisal based on customer behaviour profile by using hobby based opinion mining in India: a case study," *Econ. Res. Istraz.* , vol. 33, no. 1, pp. 1889–1908, 2020, doi: 10.1080/1331677X.2020.1763822.

[10] P. K. Priyan, W. I. Nyabakora, and G. Rwezimula, "A Bibliometric Review of the Knowledge Base on Financial Inclusion," *SN Bus. Econ.*, pp. 1–21, 2023, doi: 10.1177/09722629221140190.

[11] P. K. Priyan, W. I. Nyabakora, and G. Rwezimula, "A Bibliometric Review of the Knowledge Base on Capital Structure Decisions," *Vision*, pp. 1–13, 2023, doi: 10.1177/09722629221140190.

[12] L. Vagner, K. Valaskova, P. Durana, and G. Lazaroiu, "Earnings management: A bibliometric analysis," *Econ. Sociol.*, vol. 14, no. 1, pp. 249–262, 2021, doi: 10.14254/2071-789X.2021/14-1/16.

[13] R. Benziane, S. Roqiya, and M. Houcine, "Fintech Startup: a Bibliometric Analysis and Network Visualization," *Int. J. Account. Financ. Rev.*, vol. 11, no. 1, pp. 8–23, 2022, doi: 10.46281/ijafr.v11i1.1715.

[14] D. Moher, A. Liberati, J. Tetzlaff, and D. G. Altman, "Academia and Clinic Annals of Internal Medicine Preferred Reporting Items for Systematic Reviews and Meta-Analyses :," *Ann. Intern. Med.*, vol. 151, no. 4, pp. 264–269, 2009.

[15] D. Gough, S. Oliver, and J. Thomas, *An introduction to Systematic Reviews*. London ECIY ISP: SAGE Publications Ltd, 2012. [Online]. Available: https://b-ok.asia/book/2718381/a08a63

[16] P. Hallinger and J. Kovačević, "A Bibliometric Review of Research on Educational Administration: Science Mapping the Literature, 1960 to 2018," *Rev. Educ. Res.*, vol. 89, no. 3, pp. 335–369, 2019, doi: 10.3102/0034654319830380.

[17] P. Mongeon and A. Paul-Hus, "The journal coverage of Web of Science, and Scopus: A comparative analysis," *Scientometrics*, vol. 126, no. 6, pp. 5113–5142, 2016, doi: 10.1007/s11192-021-03948-5.

[18] P. Hallinger and V. T. Nguyen, "Mapping the landscape and structure of research on education for sustainable development: A bibliometric review," *Sustain.*, vol. 12, no. 5, pp. 1–16, 2020, doi: 10.3390/su12051947.

[19] É. Archambault, D. Campbell, Y. Gingras, and V. Larivière, "Comparing bibliometric statistics obtained from the web of science and Scopus," *J. Am. Soc. Inf. Sci. Technol.*, vol. 60, no. 7, pp. 1320–1326, 2009, doi: 10.1002/asi.21062.

[20] N. J. Van Eck and L. Waltman, "Citation-based clustering of publications using CitNetExplorer and VOSviewer," *Scientometrics*, vol. 111, no. 2, pp. 1053–1070, 2017, doi: 10.1007/s11192-017-2300-7.

[21] S. P. Nerur, A. A. Rasheed, and V. Natarajan, "The intellectual structure of the strategic management field: An author co-citation analysis," *Strateg. Manag. J.*, vol. 29, no. 3, pp. 319–336, 2008, doi: 10.1002/smj.659.

[22] D. Buhalis and R. Law, "Twenty years on and 10 years after the Internet: The state of eTourism research," *Tour. Manag. Rev.*, no. 852, pp. 1–32, 2008, doi: 10.4324/9780080481425.

[23] S. Chandra and K. N. Kumar, "Exploring factors influencing organizational adoption of augmented reality in e-commerce: Empirical analysis using technology-organization-environment model," *J. Electron. Commer. Res.*, vol. 19, no. 3, pp. 237–265, 2018.

[24] O. S. Itani and L. D. Hollebeek, "Light at the end of the tunnel: Visitors' virtual reality (versus in-person) attraction site tour-related behavioral intentions during and post-COVID-19," *Tour. Manag.*, vol. 84, no. July 2020, pp. 1–12, 2021, doi: 10.1016/j.tourman.2021.104290.

[25] K. T. Manis and D. Choi, "The virtual reality hardware acceptance model (VR-HAM): Extending and individuating the technology acceptance model (TAM) for virtual reality hardware," *J. Bus. Res.*, vol. 100, no. January 2018, pp. 503–513, 2019, doi: 10.1016/j.jbusres.2018.10.021.

[26] T. Jung, N. Chung, and M. C. Leue, "The determinants of recommendations to use augmented reality technologies: The case of a Korean theme park," *Tour. Manag.*, vol. 49, pp. 75–86, 2015, doi: 10.1016/j.tourman.2015.02.013.

[27] J. Füller, M. Bartl, H. Ernst, and H. Mühlbacher, "Community based innovation: How to integrate members of virtual communities into new product development," *Electron. Commer. Res.*, vol. 6, no. 1, pp. 57–73, 2006, doi: 10.1007/s10660-006-5988-7.

[28] M. del P. Casado-Belmonte, M. de las M. Capobianco-Uriarte, R. Martínez-Alonso, and M. J. Martínez-Romero, *Delineating the Path of Family Firm Innovation: Mapping the Scientific Structure*, vol. 15, no. 8. Springer Berlin Heidelberg, 2021. doi: 10.1007/s11846-021-00442-3.

[29] V. Tiberius, H. Schwarzer, and S. Roig-Dobón, "Radical innovations: Between established knowledge and future research opportunities," *J. Innov. Knowl.*, vol. 6, no. 3, pp. 145–153, 2020, doi: 10.1016/j.jik.2020.09.001.