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Trends of virtual reality for learning empirical evidence from different fields

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Article Info

ABSTRACT

Virtual reality (VR) has been shown to be beneficial for educational purposes and has emerged as a prevalent topic for teaching and learning. However, there is very little that is currently known about VR in the context of learning from different fields. This research is a systematic literature review which intends to investigate the future trends of virtual reality for learning by analyzing real-world data obtained from Google Scholar, Crossref, and Google Trends; the first pertinent publication discovered in the database is included as the data of this study. In total, 451 relevant publications from Google Scholar and 999 relevant publications from Crossref have been identified by utilizing content analysis. Based on the findings, VR is an immensely new and emerging worldwide topic that involves authors and connections from various countries. Overall, the significant increase in publications on "virtual reality for learning" (as a source of knowledge) in recent years corresponds to the growing trend of Internet searches on "virtual reality for learning" (as a practical demand). These findings contribute to a reference, to promote, to adjust and re-align VR in workplace learning. This study only covers publication trends, including the number of publications per year and the source types of publications, as well as internet search trends from 2004 to 2022.

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1. INTRODUCTION

The study of virtual reality in education, particularly in the teaching and learning of languages, is gaining popularity. Since the coronavirus pandemic invaded our world, it has caused inefficiencies in our daily lives, particularly in the areas of teaching and learning [1]. Schools are required to carry out all their activities, both students and teachers, solely online due to the impact of the COVID-19 pandemic [2]. Furthermore, numerous governments implemented precautions to prevent the virus from spreading. It was assigned to assure the continuity of the educational process, and educational institutions around the world adopted online learning [3]. Virtual reality (VR) is an example of how educational media has evolved and can be used to supplement online learning during the coronavirus pandemic [4].

Recently, VR has been suggested as a potential topic in education, specifically in teaching and learning. The main purpose of this article is to give investigation towards the trends of VR in learning from various fields by utilizing related publications and internet searches. It is generally accepted that VR is an example of how educational media has evolved and can be used to supplement online learning [4]. In line with that view, VR is considered a component of microlearning [5], which focuses on a definite topic or idea

over a short time period [6]. It is supported by Solak and Erdem [7] that VR is defined as the use of simulated 3D environment that allows students to move around and observe objects in three dimensions from all angles. In short, VR is one of the alternatives to assist students in learning, specifically during the pandemic era.

Reviewing previous research, the first is in the context of technology and education, specifically VR technology, which is defined as simulated reality through 3D environment that creates people to interact and incorporate traditional multimedia and significantly improves user immersion, particularly at the level of visual perception [7]–[9]. This technology incorporates a variety of devices to create a realistic and multimodal experience (for example, head-mounted displays (HMDs), motion tracking) [10], [11]. Although VR is considered a recent media in learning [12], it is not a new concept in the realm of technology; it was invented by John Lanier in the 1980s [8]. VR can be a beneficial addition to language teaching and learning because it has the potential to introduce a whole new dimension to the realm of language training, resulting in improved learning, motivation, and engagement [8], [13].

In summary, the main advantages of using VR are: i) Providing a fun teaching and learning [14]–[16]; ii) Creating interactive environment [14], [17]; iii) Improving students' motivation on the learning activity [14], [16]–[23]; iv) Enhancing students' critical thinking skills [23]; and v) Providing students with the authentic learning material [14], [24].

Secondly, VR is being used in a variety of fields, with a focus on niche applications such as flight simulation [25] and military training [26]–[29]. Since then, virtual reality has progressed into a variety of industries, such as entertainment, gaming, and advertising and marketing, [8], [19], [30]. VR is also widely used in entertainment and gaming in Indonesia due to the fact that there would be more advantages if VR technology had been used in learning because it would greatly assist students in learning [31].

Despite the fact that virtual worlds have become more common and VR cost reduction and innovation are still in their early stages, there are only small number of studies which have scrutinized the VR trends for learning in various fields based on related publications and internet searches. The results can be used to promote, design, and implement virtual reality in the education, government, and intellectual sectors. An earlier study strongly suggests that the trend of "microlearning" publication is already in accordance with existing and growing internet searches for "microlearning" in recent years. This research attempts to fill this gap by reviewing actual information provided by Google Scholar, Crossref, and Google Trends; such information includes another applicable publication discovered in the database.

As a result, the following structure is used in this paper to examine the future trends of virtual reality for learning from various fields by analyzing actual information provided by Google Scholar, Crossref, and Google Trends-such information having the first noteworthy publication found in the database. This study is organized: discussing the research design and presenting the results. After that, the researchers consider the two distinct trends namely publications and internet searches. Lastly, we discuss the findings and make recommendations about this topic.

2. RESEARCH METHOD

This study conducted a systematic literature review (SLR) to examine the future trends of virtual reality for learning from different fields. A systematic approach was chosen for reviewing the literature on trends in VR for learning. Kitchenham [25] as well as Wahono [32] defined SLR as a method of identification, assessment, and interpretation from the total of empirical research evidence to deliver clear answers from specific research questions. In addition, this present study focused mainly on related publications and internet searches. The current study follows the steps modified by Wahono [32] as illustrated in Figure 1.

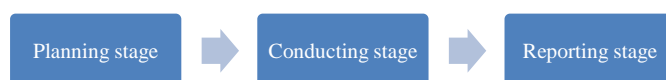Planning stage → Conducting stage → Reporting stage

Figure 1. The stages of systematic literature review

In the planning stage, we identified the need for a systematic review, which was to examine the global trends of VR for learning from different fields. For the conducting stage, firstly, we gathered and selected the data from Google Scholar, Crossref, and Google Trends. Then, the data were extracted, assessed, and synthesized by the writers. In the final stage, the data is reported in the findings section.

To sum up, this study was done in two sets of analysis. First, it examined the trend of publication in virtual reality for learning in various fields. The second, the internet searches trend based on virtual reality for learning from different fields was analyzed. Additionally, from these two analyses, we probed into the entire population of corresponding data sources. Data sources for the publication trend of VR for learning from different fields refers to all the VR for learning from different fields relevant literature reviews in the Google Scholar database since the year 1988 to 2022 and Crossref from 1993 to 2022. The data source for the internet searches trends based on VR for learning from different fields refers to all google search activities relating to VR for learning. from different fields from January 2004 to May 2022. Trends from internet searches presented by Google Trends were only captured from 2004. Although statistical generalizations regarding the sample under study are not practicable, we can draw analytical generalizations about trends by reviewing all accessible data sources. All in all, this study can portray a comprehensive overall picture of the trends of VR for learning from different fields in terms of relevant publications (from Google Scholar and Crossref) and the internet searches taken from the period of 2004 until 2022.

2.1. Research design
2.1.1. Publication trends of VR for learning from different fields

Data from Google Scholar and Crossref were collected to better understand the publication trend. Google Scholar is a database of abstracts and citations that includes nearly 451 titles from 97 publishers. We also retrieved 999 publications from Crossref from approximately 124 publishers. Crossref is an international digital object identifier (DOI) foundation-accredited DOI registration agency. It is a credible database since the plot demonstrates that the members do, in fact, update their metadata in accordance with their commitments. Referring to the data, we examine publication trends from four different perspectives: i) The number of related publications over time; ii) Publication source types; iii) Word frequency analysis I: based on titles; iv) Abstract-based word frequency analysis II.

These four perspectives were chosen because we have to conventionally incorporate to come up with a miscellaneous and a more thorough perspectives on patterns of publication. The four viewpoints chosen in this regard were the most convenient way to access the types of information that the database (Google Scholar and Crossref) and could generate for the purpose. The results are transparent and reproducible because the method used in this study is directly repeatable. Two crucial elements of systematic literature review research are transparent and reproducible, according to Fisch and Block [33]. Furthermore, a similar method has been used in other investigations as in the studies by [34]–[36].

2.1.2. Internet searches related to virtual reality for learning

First of first, we employed internet search analysis to get insight into trends in information claims related to knowledge in order to examine publication trends. In other words, we did the internet search study to gain a better understanding of how public interest in virtual reality for learning from various sectors has changed over time. Because the results of the internet search study reflect market needs, policymakers can use them as a reference.

In this study, we used Google Trends to search the trend of internet search in terms of "virtual reality for learning." A search term is defined as a keyword that a user enters into google to find information. Google Trends is a google-developed free public web service. It displays the frequency with which specific search terms are requested over a given time period. Google Trends is, in other words, a platform that aggregates the popularity in Google search queries.

Researchers have widely used Google Trends data to study human behavior and user interests in a variety of fields [37]. For example, Ginsberg [38] had revealed about the prediction of influenza epidemics spread using data from Google Trends-even before the centers for disease control and prevention. moreover, [39] performed the demonstration of the ways to employ Google search engine data to determine short-term economic values indices such as consumer confidence and unemployment numbers. [40] investigated the relevance of Google search activity and the financial education trend. Durmuşoğlu [41] demonstrated the way of assessing public environmental issues using Google Trends data.

In this study, Google Trends search terms such as keywords were collected during an 18-year period (May 2022). This chosen period corresponds to the publication analysis period undertaken above taken from the first pertinent article discovered. The data obtained is on google search engine users' search activity, specifically what these users are looking for over a specific time period. Furthermore, the geographical location parameter was set in Google Trends to "global," so the results reflect user activities from all over the world rather than any particular geographical region.

3. RESULTS AND DISCUSSION

We would present the findings of our analysis in this section. The findings of the study portray a thorough picture of global trends in virtual reality for learning from a variety of angles. The findings are related to the publication trends of VR for learning from different fields and the internet searches related to VR for learning from different fields.

3.1. Publication trends of VR for learning from different fields

3.1.1. The number of related publications over time

We discovered 451 related publications in total by searching on Google Scholar for publications containing the term "virtual reality for learning" in all selected areas, for instance: article title, abstract, keywords, and authors. Furthermore, Table 1 shows that from 1988 to 2009, the number of publications was less than 10 per year. It started to increase from 2010 to 2018, with the number of publications not exceeding 30 per year. Then, there is an upward tendency from 2019 with 43 publications, which rises to 48 publications in 2020.

Table 1. The number of related publications on "virtual reality for learning" over time based on Google Scholar

Year	Number of publications
1990	1
1991	1
1992	4
1993	3
1994	2
1995	3
1996	3
1997	6
1998	2
1999	3
2000	3
2001	6
2002	5
2003	5
2004	4
2005	8
2006	7
2007	9
2008	10
2009	11
2010	20
2011	10
2012	6
2013	13
2014	12
2015	21
2016	19
2017	44
2018	47
2019	66
2020	72
2021	19
2022	5
Grand total	450

Contrasting to the Crossref findings from Table 2, it revealed 999 related publications in total by searching in Crossref for publications by using the keywords "virtual reality for learning" in all selected areas, for instance: article title, abstract, keywords, and authors. Crossref showed more publications with the keywords "virtual reality for learning" compared to Google Scholar. Table 2 indicates the number of publications from 1993 to 2016 constantly increased until 36 publications. In 2017, it shows that the number of publications was approximately multiplied to 65 publications. Notably, the number of publications has grown significantly since 2019 to present.

Table 2. The number of related publications on "virtual reality for learning" over time based on Crossref

Year	Number of publications
1993	23
1994	6
1995	10
1996	10
1997	4
1998	11
1999	14
2000	9
2001	5
2002	22
2003	20
2004	14
2005	21
2006	33
2007	19
2008	17
2009	15
2010	32
2011	34
2012	36
2013	24
2014	25
2015	23
2016	31
2017	65
2018	54
2019	125
2020	120
2021	129
2022	48
Grand total	999

3.1.2.   Source types of publication

Table 3 shows the sources of types of publication from Google Scholar and Crossref. According to Table 3, only 2 source types of publications are found in Google Scholar. Meanwhile, the source types of publications retrieved from Crossref are varied, such as books, dissertations, peer-review, reference-entry, book-chapter, journal-article, posted-content, monograph, proceedings, dataset, proceedings-article, standards, and others.

Table 3. Source types of related publications on "virtual reality for learning" based on Google Scholar and Crossref

Database	Source types of publications												Grand total
	B	D	PR	RE	BC	JA	PC	M	P	D	PA	S	O	
Google Scholar	429	-	-	-	-	-	-	-	-	-	-	-	-	450
Crossref	5	9	22	17	307	302	11	2	3	3	308	7	3	999

Note: B (Book), D (Dissesrtation), PR (Peer review), RE (Refernce entry), BC (Book chapter), JA (Journal article), PC (Posted-content), M (Monograph), P (Proceedings), D (Dataset), PA (Proceedings-article), S (Standard), O (Other)

Journal articles are the key source type for "virtual reality for learning" related publications. It displays that 429 of the publications are in the form of journal articles, while only 21 are in the form of books. There are significant variations in the source types of publications in the data acquired from Crossref. As opposed to Google Scholar, which can only display two sources of types of publication, Crossref can filter up to 14 categories that can be identified and only one type that cannot be detected by the system. Table 3 depicts the most common source types of publications, which include proceedings-articles, book chapters, and journal articles, with over 300 of each. This also demonstrates that the findings of source types of publications in the form of journal articles with the keywords "virtual reality for learning" stand out in the two research databases.

3.1.3.   Term frequency analysis I: based on the titles

Figure 2 unveils the depth of research based on 451 related publications in total by searching on Google Scholar. The data were analyzed from an application system called "VOSviewer." The more concentrated the colors that appear in Figure 2, the more the research increases in number.
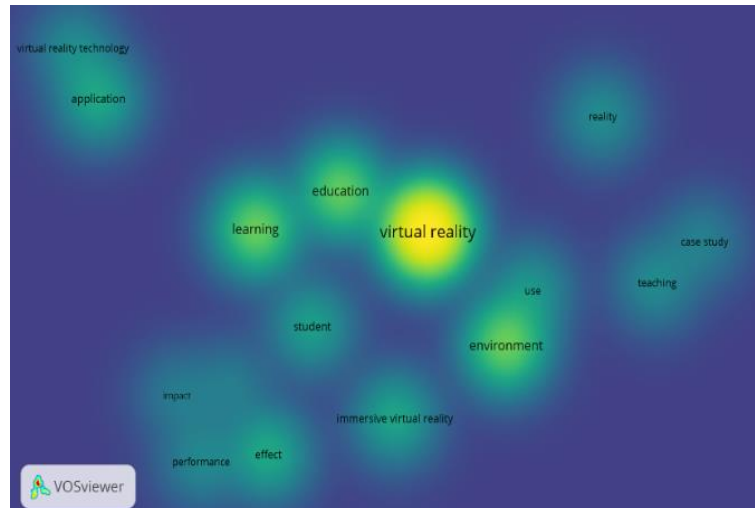
Figure 2. Visualization topic area using VOSviewer using density visualization

To support the visualization in Figure 2, Table 4 portrays the top ten most frequently occurring terms in the titles with the exact number. According to Table 4, the term "virtual reality" is the most frequently found in titles based on the publications extracted from Google Scholar. As we can see in Figure 2, the term "virtual reality" emerges with the most concentrated yellow color. Followed by other terms such as "environment" and "learning," which are also visualized in a more concentrated yellow color than other terms that occur less frequently. Given that a publication's title can be used to identify its central point, work, and situation, it also conveys a summary of its content; thus, the frequency of words found in the titles of the identified publications can indicate trends in related research in the field of "virtual reality for learning."

Table 4. Term frequency analysis I: based on the titles retrieved from Google Scholar

No	Terms	Occurrences
1.	Virtual reality	204
2.	Environment	87
3.	Learning	86
4.	Education	82
5.	Effect	38
6.	Application	36
7.	Immersive virtual reality	35
8.	Student	30
9.	Virtual reality technology	28
10.	Use	23

Along with the findings from Figure 2 and Table 4, Figure 3 and Table 5 present the results of the most frequent terms taken from the titles of the publications found in Crossref. Figure 3 shows the depth of the research based on 999 related publications extracted from Crossref. Figure 3 draws that a new phrase appears, namely "augmented reality," which is frequently associated with the terms "virtual reality," regarding to Huang *et al.* [42].

Table 5 portrays the top ten most frequently occurring terms in titles with the exact number to support the visualization in Figure 2. The top 3 terms displayed in Table 5 are virtual reality, learning, and education, with the total occurrences ranging from 82-423. However, the least number is related to the term "virtual" with 19 occurrences. Thus, the trends of terms that arise from titles are virtual reality, learning, and education, which emerge with more concentrated yellow.
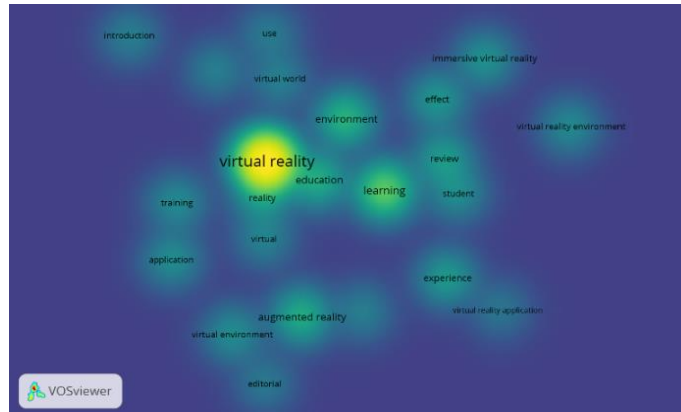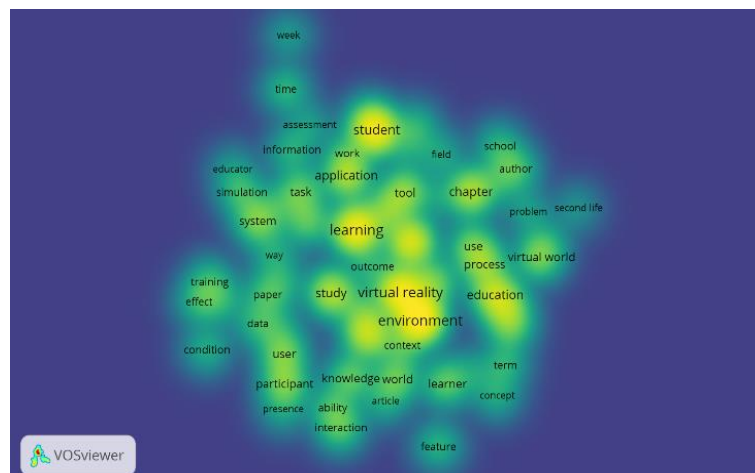
Figure 3. Visualization topic area using VOSviewer using density visualization

Table 5. Word frequency analysis I: based on the titles retrieved from Crossref

No	Terms	Occurrences
1.	Virtual reality	423
2.	Learning	110
3.	Education	82
4.	Augmented reality	56
5.	Reality	49
6.	Review	39
7.	Immersive virtual reality	30
8.	Virtual environment	27
9.	Student	26
10	Virtual	19

3.1.4. Term frequency analysis II: based on the abstracts

Figure 4 represents the depth of research focusing on the abstracts of 451 related publications found through Google Scholar. An abstract is intended to display an overview of publications. The data was evaluated using the "VOSviewer" application system. The more concentrated the colors that appear in Figure 4 indicate the research increases in number.
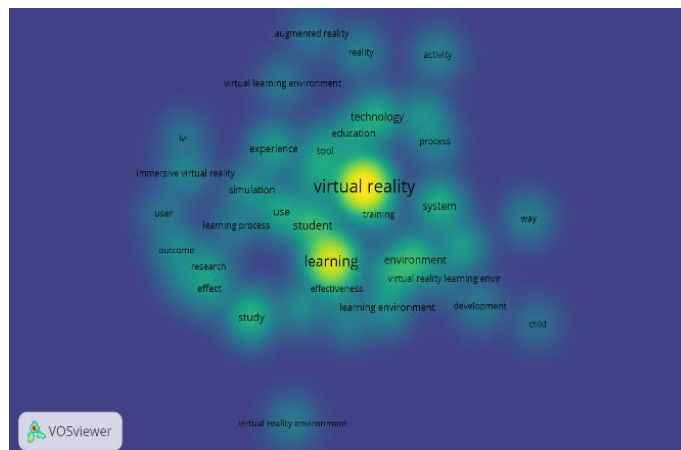
Figure 4. Visualization topic area using VOSviewer using density visualization

Table 6 provides the top ten terms discovered in abstracts to provide the actual number of the visualization in Figure 4. The top three terms illustrated in Table 6 are virtual reality, effect, and immersive virtual reality, which appear with the most concentrated yellow as seen in Figure 4. The term interactive voice response (IVR), which refers to immersive virtual reality, also appears in the 9th position. To conclude, the terms mentioned in Table 6 are the trends of related publications based on the abstracts.

Table 6. Term frequency analysis II: based on the abstracts retrieved from Google Scholar

No	Terms	Occurrences
1.	Virtual reality	435
2.	Effect	28
3.	Immersive virtual reality	21
4.	Reality	19
5.	Performance	18
6.	Virtual reality environment	16
7.	Virtual reality learning environment	13
8.	Augmented reality	12
9.	IVR	11
10	Child	10

Figure 5 shows the results of the most frequent terms derived from the abstracts of the publications found in Crossref, in addition to the previous findings. Additionally, Figure 5 reveals the depth of the research based on 999 related publications extracted from Crossref. Figure 5 elaborates the variations of terms based on the abstracts of 999 related publications extracted from Crossref.

Table 7 lists the top ten terms obtained in abstracts to offer the real number of the visualization in Figure 5. The terms "virtual reality," which formerly occupied the first place in Tables 4, 5, and 6, have moved to the third position, as seen in Table 7. Instead, the words "environment" come first, followed by the words "learning," which come with more concentrated color.

Figure 5. Visualization topic area using VOSviewer using density visualization

Table 7. Term frequency analysis II: based on the abstracts retrieved from Crossref

No	Terms	Occurrences
1.	Environment	160
2.	Learning	109
3.	Virtual reality	106
4.	Student	97
5.	Teachnology	83
6.	Experience	69
7.	Study	65
8.	Education	64
9.	Chapter	61
10	Participant	43

3.1.5. Internet searches related to virtual reality for learning

Figure 6 illustrates the "search volume indexes" for the terms "virtual reality for learning" from January 1st, 2004, to May 2022. The horizontal axis in these figures indicates time. Meanwhile, the number displays on the vertical axis, is the "search volume index." The index shows search interest in relation to highest point and time of the chart, which is from January 1st, 2004, to May 2022. A score of 100 indicates the term's highest popularity, while a score of 0 indicates no searches for the term.
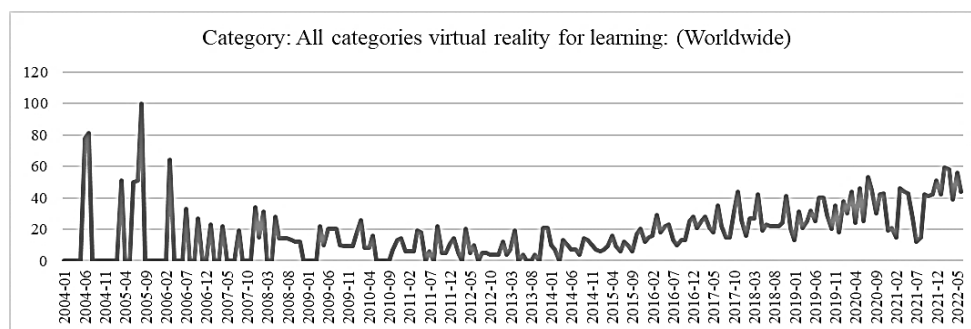
Figure 6. The search trend for the term "virtual reality for learning" from January 2004 to May 2022

As shown in Figure 6, the search activities for the term "virtual reality for learning" were highest in the year 2005. Then, from 2006 to 2015, it remained reasonably stable at a low level before beginning to rise in 2015 and until present, but not as high as the search activities in 2004-2005. As a result, we may infer that virtual reality for learning is constantly on the rise as a global trend, particularly in education.

Previous research has found a strong link between online searching behavior and public interest in a variety of social topics in the real world, such as flu prevention [38], movie visit forecasting [43], helath and conservation topics during COVID-19 pandemic [44] and Swiss tourism demand [45]. As a result, since 2015, we believe there has been an upward trend in the search pattern for "virtual reality for learning." As can be seen from Figure 5, there is a growing interest in virtual reality for learning.

4. CONCLUSION

This study has identified virtual reality for learning is still rising as global trends, especially in education. The publications from Google Scholar were found from 1988 to 2022, while Crossref showed that the publications were taken from 1993 to 2022. The findings presented that proceedings-articles, book chapters, and journal articles are the main source types of publication for both Google Scholar and Crossref. Using content analysis, 451 relevant publications from Google Scholar and 999 relevant publications from Crossref were discovered. According to the findings, virtual reality is a tremendously novel and rising global topic that incorporates authors and connections from all over the world. Overall, the steady increase in publications on "virtual reality for learning" (as a source of knowledge) in recent years corresponds to the growing trend of "virtual reality for learning" Internet searches (as a practical demand). These findings establish a reference point for promoting, adjusting, and re-aligning VR in workplace learning. This study only includes publication patterns from 2004 through 2022, including the number of publications each year and the source types of publications, as well as internet search trends.

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