





An intriguing convergence between metaverse and sustainable human resource management

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Orientation: This research aims to shed light on emerging trends, key themes and future directions in the nascent field of the metaverse and sustainable human resource management (HRM).

Research purpose: This study aims to explore the intersection of the metaverse and sustainable HRM through a bibliometric analysis.

Motivation for the study: The rapid evolution of digital technologies and the growing emphasis on sustainability in business practices necessitate an understanding of how these domains converge. This study is motivated by the need to map the scholarly landscape of this intersection.

Research approach/design and method: A bibliometric analysis was conducted using data from Scopus database. The study employed various techniques, including co-citation analysis, co-occurrence analysis and network visualisation, to identify key publications, influential authors and prevalent research themes within the intersection of the metaverse and sustainable HRM.

Main findings: The analysis revealed a growing literature on the intersection. Key themes identified include the integration of virtual environments in HR practices, the role of the metaverse in enhancing engagement and training. Seminal works were mapped, highlighting the foundational contributions to this emerging field.

Practical/managerial implications: This study provides valuable insights for HR professionals and organisational leaders on leveraging the metaverse for sustainable HRM practices. It underscores the potential of virtual environments to foster sustainable employee engagement, training and development.

Contribution/value-add: The findings contribute to the academic discourse by outlining critical areas for future research and offering a foundational understanding of the convergence between the metaverse and sustainable HRM.

Keywords: metaverse; virtual reality; human resource management; performance management; talent acquisition.

Introduction

The concept of the metaverse, a sprawling digital realm comprising interconnected virtual environments, has rapidly transitioned from the realm of science fiction to a tangible reality (Ng, 2022). As we move further into the 21st century, the metaverse's emergence has captured the imagination of technologists, entrepreneurs and the general populace alike. It presents a profound paradigm shift in how we interact, work and even perceive reality (Hwang & Chin, 2022). This immersive digital ecosystem is anticipated to reshape industries ranging from entertainment and education to healthcare and commerce, offering unprecedented opportunities for innovation and engagement (Lee, 2023).

Simultaneously, discussions around sustainability have taken centre stage in various domains, including business and human resource management (HRM). The urgency of addressing environmental, social, and governance (ESG) concerns has prompted organisations to reevaluate their practices and incorporate sustainable principles into their operations.

This paper delves into the intriguing intersection of these two transformative phenomena: the metaverse and sustainable HRM. The metaverse's rapid evolution and the imperative for sustainable business practices have prompted an exploration of how these two forces can coalesce

to redefine HRM in an era characterised by digital innovation and environmental responsibility.

The idea of the metaverse, introduced by science fiction author Neal Stephenson in his 1992 novel *Snow Crash* (Dionisio et al., 2013), paints a vivid picture of a virtual universe where users immerse themselves in digital landscapes, connect with others and shape their surroundings in limitless ways (Díaz et al., 2020; Diaz-Chieng et al., 2022). It is underpinned by immersive technologies like virtual reality (VR), augmented reality (AR) and the blockchain, providing users with an immersive, interconnected and often limitless digital experience. A metaverse may be wholly or partially virtual; for instance, when entirely virtual like a VR system or in some cases simply a partial virtual setting such as AR (Avila, 2017). Metaverse is not merely another novel synonym of VR or AR but has more scope than AR and VR (Park & Kim, 2022). The metaverse represents a real paradigm shift, beyond the established definitions of AR or VR, because of its three essential attributes: 'shared', 'persistent' and 'de-centralised' (Hwang & Chin, 2022). In addition, artificial intelligence (AI) is a necessary technology to enable the functioning of the metaverse according to the laws set forth by the creator. In this regard, it is evident that the metaverse can include an AR or VR system to render virtual content, and it may include both AR and VR system elements, along with additional components that are necessary (Hwang & Chin, 2022).

Tech giants, gaming companies, and startups are investing heavily in the development of metaverse ecosystems, envisioning a future where the metaverse plays a central role in how we communicate, work, play and conduct business (Egliston & Carter, 2021; Kye et al., 2021).

Concurrently, sustainability has evolved into a critical theme in the world of HRM. Sustainable HRM encompasses strategies and practices aimed at fostering environmentally responsible, socially inclusive and ethically sound workplaces. Organisations are increasingly recognising that integrating sustainability into HRM can enhance their reputation, attract talent, reduce costs and mitigate risks. Sustainable HRM practices include diversity and inclusion initiatives, employee well-being programmes, carbon footprint reduction efforts and ethical recruitment and retention strategies. These practices align with broader corporate sustainability goals and contribute to a company's social licence to operate in an environmentally conscious world.

The metaverse's potential impact on HRM practices is multifaceted. It offers novel opportunities for talent acquisition, remote work, skill development and employee engagement, all of which can be harnessed to promote sustainability. In the metaverse space, community members can socially interact through gameplay, discussing issues,

collaborating on projects and learning through the resolution or experience of some sort of challenge (Jovanović & Milosavljević, 2022; Park & Kim, 2022). However, it also presents ethical and privacy challenges that must be navigated carefully.

This research paper embarks on a bibliometric analysis, dissecting existing literature to uncover trends, thematic clusters and research gaps in the exploration of how the metaverse can be leveraged for sustainable HRM. By understanding the evolving dynamics at this intersection, we aim to shed light on the metaverse's role in advancing HRM practices that are not only technologically innovative but also environmentally, socially and ethically responsible.

In the subsequent sections, we will delve deeper into the methodology, key findings, discussions and conclusions derived from our bibliometric analysis. This analysis seeks to contribute to the growing discourse on how the metaverse, as a digital frontier, can be a stepping-stone towards a more sustainable and responsible future for HRM.

Literature review

The literature review provides an overview of key concepts and themes related to the metaverse and its potential impact on sustainable HRM. It synthesises existing research, identifies trends and highlights critical gaps in understanding this evolving intersection.

The metaverse, rooted in science fiction, has gained substantial attention in recent years because of technological advancements. Notable works by Stephenson (1992) and Zuckerberg (2021) envision a future where the metaverse transforms social interaction, entertainment, education and business. The advantages of using this technology in human resource (HR) can be beneficial in a number of processes, according to the literature. Metaverse Technologies aid in advancing human resource processes like providing immersive experiences to the candidates during job interview or training (Muhanna, 2015; Van Krevelen & Poelman, 2010). According to Van Krevelen and Poelman (2010), VR also makes it possible to present the business environment, values and culture of the company in an interactive way. It can also help with the training of tacit knowledge among employees; promote a more thorough, easy and practical induction process, with information accessible at any time and conduct a non-face-to-face interview, allowing the company to save time and reduce travel costs for the candidate (Muhanna, 2015).

Research indicates that individuals can visualise phenomena and concepts that are challenging to perceive with the human eye (Reyes, 2020). Studies demonstrate its effectiveness in increasing learners' motivation and knowledge and skill acquisition. It utilises a combination of digital and physical elements to form rich learning landscapes that enhance students' proficiency

(e.g., communication, critical thinking and problem-solving) and practical skills (Huh, 2022).

Sustainability in HRM is motivated by the growing emphasis on ESG principles. Sustainable HRM practices include diversity and inclusion, employee well-being, responsible recruitment and carbon footprint reduction. Scholars such as Jackson and Ruderman (1995) underscore the importance of HRM in achieving sustainability goals.

Literature suggests several potential synergies between the metaverse and sustainable HRM. The metaverse can facilitate remote work, potentially reducing commuting-related carbon emissions (Graham et al., 2022). This aligns with sustainability goals. Virtual environments can be designed to be inclusive and accessible, promoting diversity and inclusion (Naschberger et al., 2021). The metaverse can serve as a platform for skills development and training, supporting employees' growth (Larsson et al., 2023). Immersive experiences in the metaverse can enhance employee engagement and well-being (Leigh & Edwards, 2020). The COVID-19 pandemic imposed challenges resulting in virtual site visits and online problem-solving, but simulation technologies such as virtual laboratories, tours and visits can adapt people's authentic experiences of site visits and problem-solving to a digital format (Díaz et al., 2020; Ng, 2022).

While the potential benefits are promising, literature acknowledges several challenges. The metaverse collects vast amounts of personal data, raising privacy concerns (Thompson & Johansson, 2021). The metaverse's accessibility and usage may exacerbate existing digital divides, potentially excluding some employees (Bonikowski & DiMaggio, 2022). Ensuring ethical use of metaverse

technologies in HRM, such as fair recruitment practices and avoiding discrimination is therefore of great importance (Lepak et al., 2023).

Research gaps

Existing literature reveals notable research gaps:

1. There are limited empirical studies exploring the actual implementation of metaverse technologies in HRM practices.
2. There is insufficient attention to the potential negative environmental impacts of metaverse infrastructure.

Research design

Methodology

We conducted a systematic search of academic databases using keywords related to 'metaverse' and 'sustainable HRM'. The authors initially screened many keywords by manually reading relevant literature. Multiple search iterations of the keywords were conducted to ensure the accuracy of the study, and the results of the search could be seen as an accurate reflection of the state of research in the concerned study. The analysis focused on articles published between 2010 and 2023. We employed bibliometric software to assess publication trends, identify key authors and journals and uncover thematic clusters within the literature. The Elsevier Scopus database was chosen in our research and was limited to the literature published and extracted on 14 May 2023, whereby only the Article and Conference Paper types were included in this review. Figure 1 gives the details of the data collection.

When it comes to bibliometrics, the two main areas of study are performance analysis and science mapping analysis. Performance analysis looks at different scientific people,

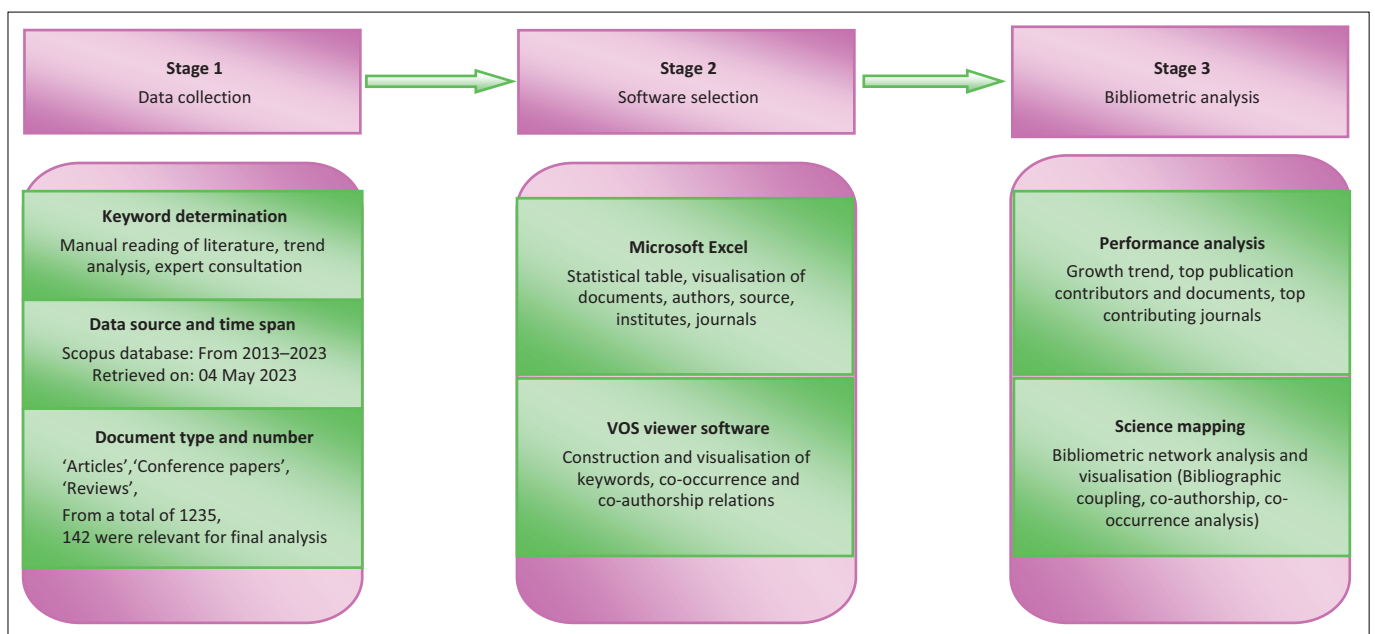


FIGURE 1: Process of bibliometric analysis.

like researchers, institutions and countries. Science mapping analysis looks at how the cognitive and social structures of a particular research field are represented in terms of topology and time. We employed VoS Viewer software to show the analytical data, and MS Excel was used for graphic analysis research.

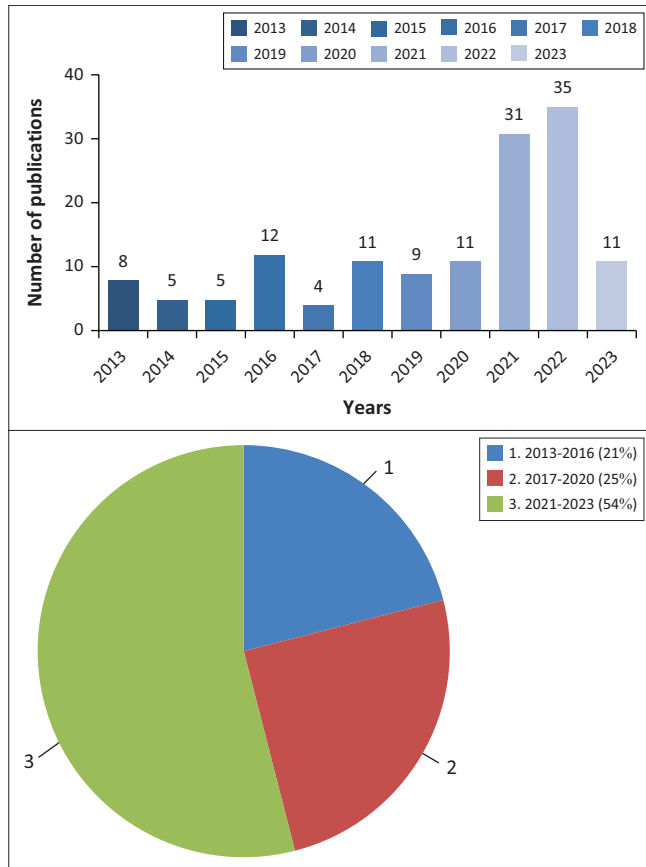


FIGURE 2: Annual publication growth from 2013 to 2023 in the area of metaverse and sustainable human resource.

TABLE 1: Most prolific titles.

Authors	Title	Source	Cited	Theme
Gavish et al. (2015)	Evaluating virtual reality and augmented reality training for industrial maintenance and assembly tasks	<i>Interactive Learning Environments</i>	400	Evaluation of the use of virtual reality (VR) and augmented reality (AR) platforms, for industrial maintenance and assembly (IMA) tasks training. According to the study, the AR platform should be used more for training employees to develop IMA skills
Makransky et al. (2019)	Motivational and cognitive benefits of training in immersive virtual reality based on multiple assessments	<i>Journal of Computer Assisted Learning</i>	157	Examination of the effectiveness of immersive virtual reality (VR) as a medium for delivering laboratory safety training. The study compared immersive VR simulation, a desktop VR simulation and a conventional safety manual.
Latu et al. (2013)	Successful female leaders empower women's behavior in leadership tasks	<i>Journal of Experimental Social Psychology</i>	92	Virtual reality medium was used to test the gender difference in the behaviour and also whether highly successful female role models empower women's behaviour in a leadership task
Yan et al. (2013)	Employee creativity formation: The roles of knowledge seeking, knowledge contributing and flow experience in Web 2.0 virtual communities	<i>Computers in Human Behavior</i>	70	Virtual communities using Web-2.0 were used to test models that explore those consequences of both knowledge seeking and knowledge contributing behaviour in the formation of creativity.
Tremmel et al. (2019)	Estimating cognitive workload in an interactive virtual reality environment using EEG	<i>Frontiers in Human Neuroscience</i>	49	Evaluation of the feasibility of passively monitoring cognitive workload via EEG while performing a classical n-back task in an interactive VR environment.
Langley et al. (2016)	Establishing the usability of a virtual training system for assembly operations within the automotive industry	<i>Human Factors and Ergonomics In Manufacturing</i>	47	Investigation of the effectiveness and efficiency of the virtual training system (VTS) developed within the Virtual Simulation and Training of Assembly and Service Processes in Digital Factories project using real end users

Note: Please see the full reference list of this article for more information. EEG, electroencephalogram.

Ethical considerations

This article followed all ethical standards for research without direct contact with human or animal subjects.

Results

Annual publication growth trends

The scientific literature pertaining to 'Metaverse' and 'Sustainable HR' witnessed constant growth from 2013 to 2023. With a mere eight productions in the year 2013, there were 35 scientific literatures available in 2022. The year 2023 had 12 publications already in less than half a year. Figure 2 displays the growth trend in research thus highlighting the enhancement of significance and concern for sustainability HR and the role of the metaverse in it.

Figure 2 depicts that the last three years have shown massive growth in the research area with 54% publications in the time spanning 2021 to May 2023. This shows the relevance of the field and that the future scope in the area is on the rise immensely.

Top cited articles and their authors

Table 1 depicts the most prolific productions based on the citations of the article. It also discussed the major themes talked about in the document. The higher citation of an article suggests that the topic has a considerable impact on other research, as it is a strategic topic with an established theoretical value. The article by Gavish et al. (2015) titled *Evaluating virtual reality and augmented reality training for industrial maintenance and assembly tasks* was the most prolific document with 400 citations. It was on evaluation of the use of VR and AR platforms for industrial maintenance and assembly (IMA) tasks training. According to the study, the AR platform should be used more for training employees to

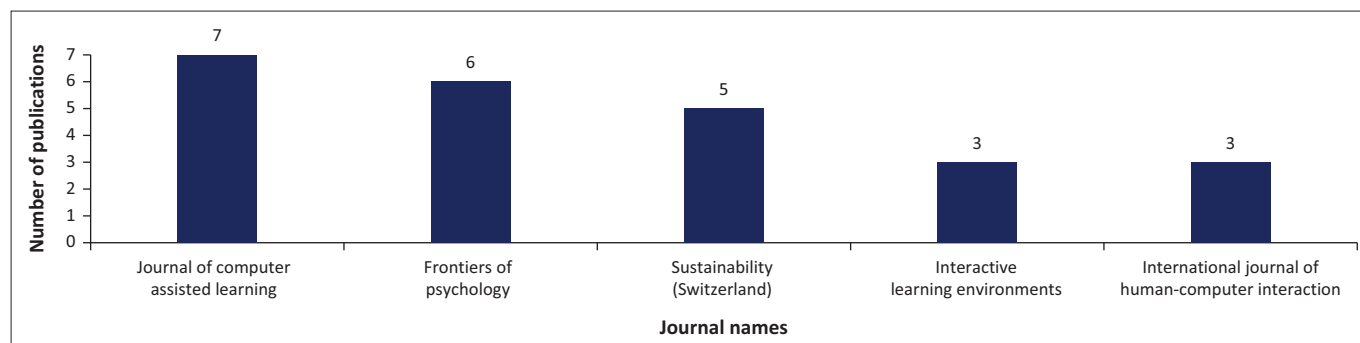


FIGURE 3: Major journals and their number of publications in the field from 2013 to 2023.

TABLE 2: Most prolific journals based on Scopus database.

Name of the journals	Number of citations
<i>Journal of Computer Assisted Learning</i>	6
<i>Sustainability (Switzerland)</i>	5
<i>Frontiers in Psychology</i>	4
<i>Interactive Learning Environments</i>	3
<i>International Journal of Human Computer Studies</i>	3
Grand Total	21

develop IMA skills. This document was followed by Makransky et al.'s (2019) article titled *Motivational and cognitive benefits of training in immersive virtual reality based on multiple assessments*.

Most contributing journals

Figure 3 shows the major contributing journals on sustainable HR and metaverse theme, and Table 2 lists the top five contributing journals from them. *Journal of Computer Assisted Learning* was the most contributing journal with six publications on the researched theme with six articles out of total 142 analysed. This was followed by *Sustainability (Switzerland)* and *Frontiers in Psychology* with five and four scientific publications on metaverse and sustainable HR.

Most cited countries

In order to comprehend the most prolific countries, citation analysis was conducted. The minimum number of documents by a country was taken as three. Out of 40 countries, 18 met the threshold.

As depicted in Table 3, the United States is the most prominent country in the research with 42 documents that have been cited by 484 studies. It is followed by Germany has 8 articles with 473 citation followed by Italy which has 9 articles that were cited 439 times. Spain, Denmark, the Netherlands and Switzerland are also major contributors to this field. The countries are visualised in Figure 4. The size of the appearance of country name is proportional to the citation they have.

Co-occurrence of author keywords

A network of intersecting blocks was constructed, with the size of each block representing the number of occurrences

TABLE 3: Most prominent countries based on citation.

Country	Documents	Citations	Total link strength
United States	42	484	18
Denmark	5	214	12
China	11	88	7
Germany	8	473	7
United Kingdom	9	65	5
Italy	9	439	4
Taiwan	4	44	4
Australia	6	80	3
Spain	8	414	3
The Netherlands	4	155	2
India	7	67	1
Portugal	4	12	1
South Korea	6	18	1
Brazil	4	11	0
Canada	3	37	0
Hong Kong	4	78	0
Poland	3	3	0
Switzerland	3	132	0

of a given keyword. The distances between the intersecting boxes, which are connected by curves, indicate the importance of the keywords in the network. The co-occurrence of author keywords was based on minimum three keywords, and out of 494 keywords, 16 met the threshold. The highest block in Figure 5 is designated by the keyword 'virtual reality', which also indicates the highest number of co-occurrences and the highest overall link strength.

It is evident from Table 4 that the keyword 'virtual reality' has a significantly higher total link strength than any other keyword, reaching 65 occurrences and 44 total link strengths. Each link is assigned a positive numerical value in accordance with the 'VoS Viewer Manual' which states that 'total link strength' is the number of times a keyword is co-occurred with other keywords (Guo et al., 2019).

Figure 5 is a colour-coded representation of a Metaverse field with three distinct clusters. The orange cluster contains the highest number of keywords, led by the keyword 'virtual reality'. It represents words related to 'Metaverse Technologies'. The words most associated with this cluster are 'augmented reality', 'cognitive load', 'multimedia learning', 'simulation', 'safety training', 'training effectiveness'. In the

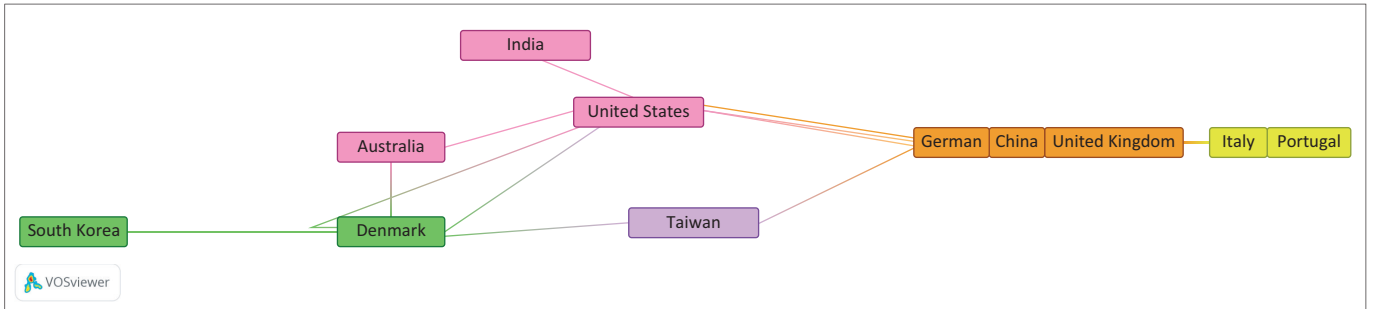


FIGURE 4: Most prolific countries based on citation.

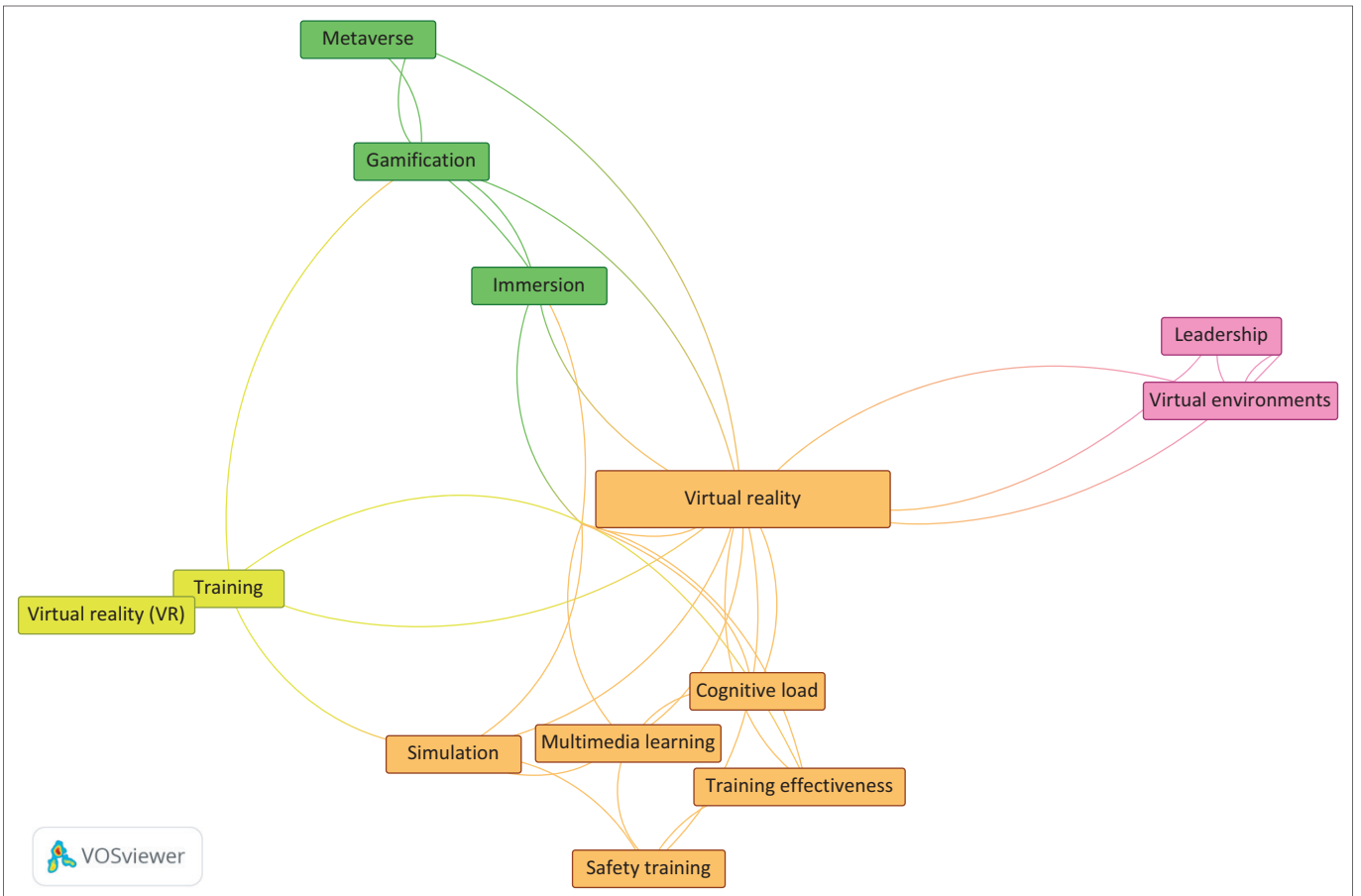


FIGURE 5: Network of co-occurrence of author keywords.

TABLE 4: Author keywords their occurrences, total link strengths and clusters.

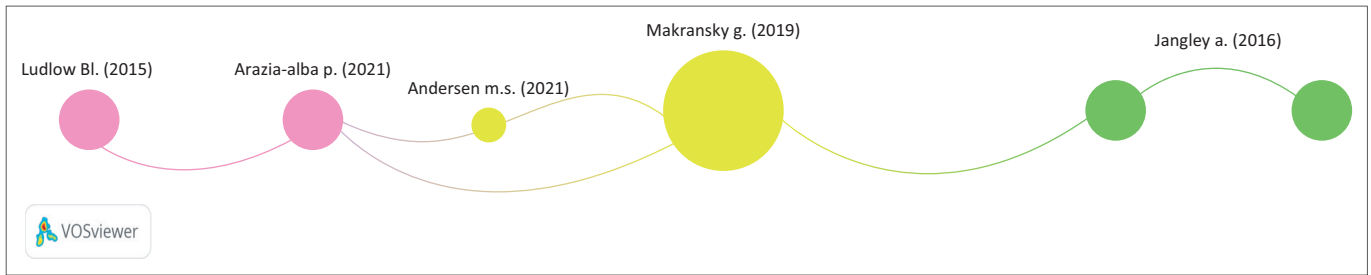
Keyword	Cluster	Occurrence	Total link strength
Virtual reality	1 (orange)	65	44
Augmented reality	1 (orange)	10	14
Training	2 (light green)	13	14
Simulation	1 (orange)	9	13
Safety training	1 (orange)	5	9
Gamification	3 (dark green)	5	8
Cognitive load	1 (orange)	4	6
Multimedia learning	1 (orange)	3	6
Training effectiveness	1 (orange)	4	6
Immersion	3 (dark green)	4	4
Leadership	4 (pink)	4	4

light green cluster, the main keywords related to network virtualisation are ‘training’, and ‘virtual reality VR systems’, which are related to topics related to ‘Sustainable HRM Practices’. The third cluster in pink colour includes

the keywords ‘leadership’, ‘virtual environments’, among others, representing, ‘Metaverse and Support Requirements’. The fourth cluster has keywords like ‘gamification’ and ‘immersion’ and ‘metaverse’, all of which refer to new techniques for sustainable HR practices and metaverse.

Co-authorship analysis

The analysis with the unit of analysis as author revealed that Smith M. J. had the maximum link strength of 22 and thus had co-authored maximum number of contributions followed by Smith J. D. with link strength of 19. The minimum numbers of documents published by an author were 2 that brought 23 authors in spotlight out of the total of 516 authors in the research area (see Figure 7).



Note: Please see the full reference list of this article for more information.

FIGURE 6: Bibliographic coupling.

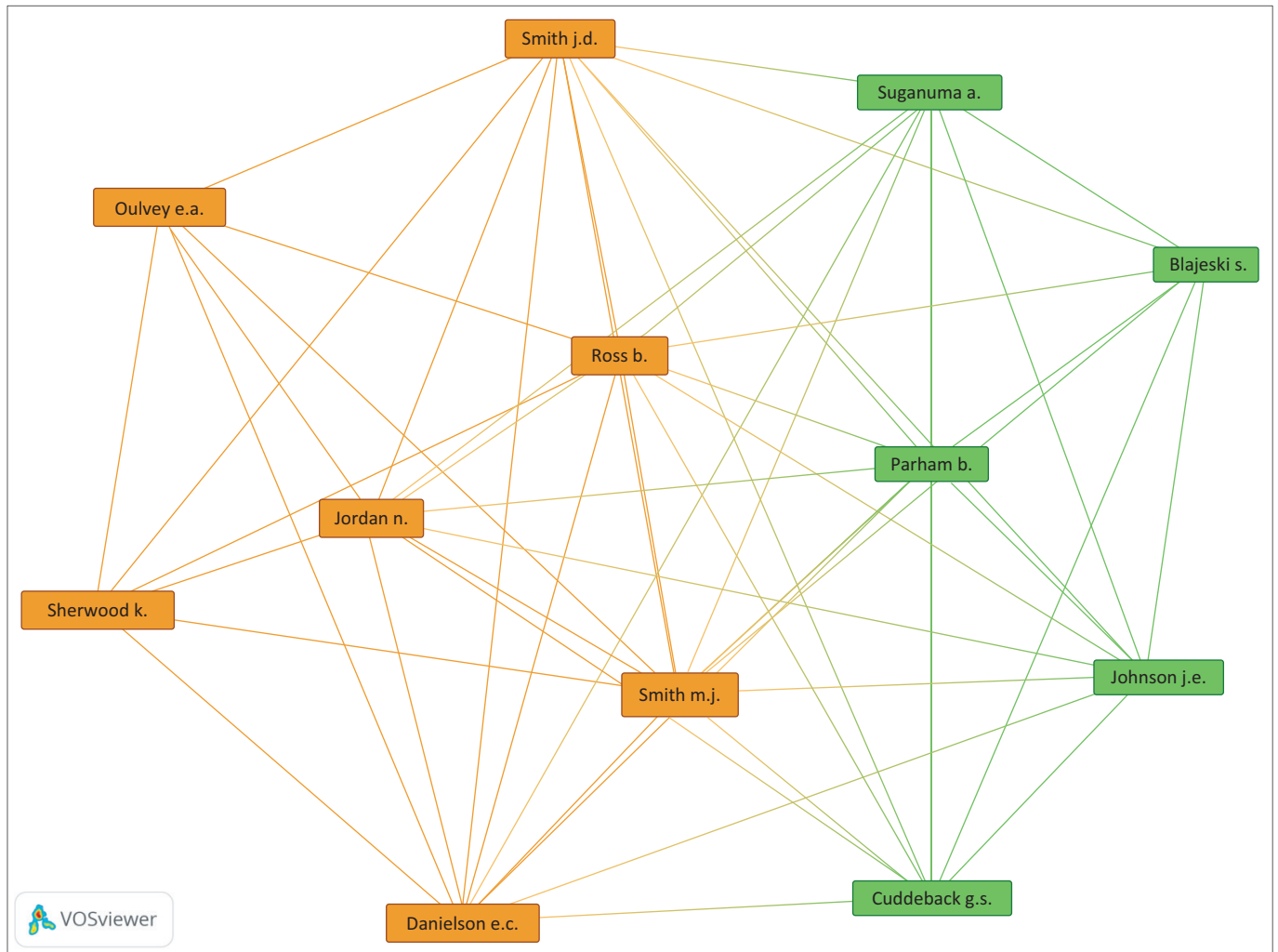


FIGURE 7: Co-authorship analysis.

There are two clusters as Figure 4 highlights. Cluster 1 (in orange) is more prominent with 17 authors who have collaborated together and studied on metaverse for sustainable HR. Cluster 2 (in green) has 5 authors coordinated together to study the concerned field of research.

Bibliographic coupling

In order to comprehend the relationship between the two scientific literatures, reference is made to a common third work in their respective bibliographies called bibliographic coupling. The unit of analysis was documents, and the minimum number of citations per document was

taken to be 25. Out of 142 documents, 15 met the threshold. Figure 6 represents the results of bibliographic coupling.

Figure 6 clearly depicts three clusters with Markansy G. being the most prominent having maximum link strength. Cluster 1 (yellow colour) depicts that Markansy G. and Andersen M. S. have cited the maximum number of common references and have the strongest link strength, thus conducting similar work in the concerned field. Similar conclusions could be drawn for other two clusters, namely, Langley (2016) and Schmid (2018) in cluster 2 (green colour) and Araiza –alba (2021) and Ludlow B. J. (2015) in cluster 3 (pink colour).

Findings and discussion

Our analysis revealed a gradual increase in publications related to the metaverse and sustainable HRM, with a notable surge in recent years. This suggests growing interest in the topic. We identified leading researchers contributing to this field, such as Smith M. J. and Smith J. D. Notable journals publishing relevant articles include *Journal of Computer Assisted Learning* and *Sustainability* (Switzerland) indicating the integration of this emerging theme into established academic discourse. Through cluster analysis, we identified several thematic clusters in the literature.

Metaverse technologies

This cluster examines the technical aspects of the metaverse, including VR, AR and their applications in HRM.

Sustainable human resource management practices

This cluster explores HRM practices that promote sustainability, such as diversity and inclusion, employee well-being and green HRM.

Metaverse and support requirements

This cluster investigates how metaverse technologies can be enhanced by leadership support and VR environments that promote it and excel employee engagement.

New techniques for sustainable human resource practices and metaverse

This cluster addresses techniques and tools applied for sustainable HR practices.

Because the metaverse is still in its infancy, it is attracting more and more research. The metaverse holds the potential to revolutionise HRM by offering innovative solutions to promote sustainability. For instance, immersive technologies can facilitate remote work and reduce carbon footprints, aligning with sustainable HRM goals. However, ethical and privacy concerns must be addressed to ensure responsible implementation.

Limitations

The study relies solely on the Scopus database, which may not capture all relevant literature. The research may exhibit a regional bias, especially if a significant portion of the analysed literature is concentrated in certain countries or regions. Sustainable HRM is still a growing concept. The lack of well-established frameworks in this area may lead to challenges in interpreting how sustainable HRM is practically aligned with the metaverse, thus limiting the study's practical applications.

Conclusion

This bibliometric analysis underscores the growing interest in the relationship between the metaverse and sustainable

HRM. As the metaverse continues to evolve, HR professionals, scholars and policymakers must explore its potential benefits and challenges to create a more sustainable future for HRM practices in a digital age. The US emerged as a major contributor to the field of knowledge along with Germany and Italy. The focus of new research initiatives is increasingly on human-computer interaction, user experience, as well as deep learning and human-centred computing. This is in line with the trend of reinforcing human-computer interaction and user experience in metaverse research. Further research and interdisciplinary collaborations are needed to fully understand and harness the metaverse's potential for sustainable HRM.

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Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

Authors' contributions

A.C. conceptualised the research, conducted the literature review and methodology design. A.C. also led the manuscript drafting process and performed bibliometric data collection and cleaning. S.K. contributed to the analysis of bibliometric data and the design of visualisation maps and interpreted the results. S.K. also provided critical revisions to align the study with its objectives.

P.D. assisted with the theoretical framework and writing of the introduction and discussion sections, managed referencing, ensured alignment with journal guidelines and contributed to proofreading and editing. P.P. oversaw the overall research direction and coordination among the team, provided final revisions and ensured the manuscript's readiness for submission. P.P. also contributed to the critical evaluation of findings. A.C., S.K., P.D. and P.P. reviewed and approved the final article.

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Data availability

The data that support the findings of this study are available from the corresponding author, S.K. upon reasonable request.

Disclaimer

The views and opinions expressed in this article are those of the authors and are the product of professional research. It does not necessarily reflect the official policy or position of any affiliated institution, funder, agency or that of the publisher. The authors are responsible for this article's results, findings and content.

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