Building the Metaverse:
Design Considerations, Socio-Technical Elements, and Future Research Directions of Metaverse

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ABSTRACT

Virtual worlds are progressing toward a holistic abstraction of the metaverse. While there is abundant literature and synthesis on virtual worlds and related constructs, the linkages between above scholarly work and the "metaverse" are scarce. This research study addresses this gap by focusing on three specific research pursuits: a comprehensive definition of the metaverse that subsumes virtual world literature and looks at the metaverse as a sociotechnical stack, exploring the design elements of the metaverse, and a synthesis of future research direction associated with metaverse. For achieving the above goals, a hybrid research methodology comprising bibliometric analysis and a rigorous qualitative analysis of case studies across four major metaverse players with varied end goals was employed. The interpretive qualitative analysis was further distilled by mapping the emergent themes to the theoretical lens of affordances. This work presents a novel framework of metaverse design, establishing theoretical linkages between the sociotechnical fabric and applications of the metaverse.

KEYWORDS

Affordances, Bibliometric analysis, Gaming World, Literature Review, Metaverse, Virtual world

DOI: 10.4018/JGIM.321755
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1. INTRODUCTION

The expanding ecosphere of the web and internet platforms known as “the metaverse” has become an essential aspect of modern cyberculture. The metaverse, which represents a new paradigm, is made up of virtual worlds created using technologies for extended reality (XR), mixed reality (MR), virtual reality (VR) (Alduailij et al. 2022; Alsharif et al. 2022), and augmented reality (AR) (Dolata & Schwabe, 2023; Kumar et al., 2022). When one thinks of the metaverse, which is still more of a concept than an actual enterprise application, one may think of the virtual worlds of video games. As time has progressed, this conceptualization of the metaverse has also progressed, both in the digital and physical realms. Users no longer have to just stare at their computer screens; they can now fully immerse themselves using headphones, gloves, headsets, or even full bodysuits. This opens up avenues for value creation in the spheres of business, society, and humanitarian causes. To realize the full potential of the metaverse, businesses and organizations need to go beyond simply transposing present reality into the virtual world. Creating this value necessitates an objective and tangible understanding of the metaverse and its elements. From an information system (IS) perspective, this can be viewed as delineating the elements of the metaverse stack.

The metaverse can be viewed as the inevitable outcome of technological advances from Web 1.0 to Web 2.0 to where we are now, with the advent of Web 3.0 or the Spatial Web (What is Web 3.0?, 2019), where people, spaces, and things, both digital and physical, are semantically intertwined. Socioeconomic activities will flourish in the metaverse, creating value by establishing on-and-off ramps between physical and digital assets.

The true value of the metaverse may entail disruptive rather than incremental changes. For example, accessing the metaverse will involve embracing new gateway interfacing devices, such as AR, MR, and VR glasses, haptic wearables, or even brain–computer interaction systems. We are likely to create and hold more value in digital assets than in physical goods. This is more than just comparing virtual products to their physical counterparts. For example, a digital Gucci Dionysus Bag was sold for more than USD 4,000, a retail price much higher than that of its physical counterpart (TFL, 2021). The metaverse is a distinct sociotechnical phenomenon (Sarker et al., 2019) that now exists in different academic and popular discourses. First, it is built on the complex set of technologies that we call the Internet, and to see complex 3D worlds, one needs a lot of computing power. Second, these worlds need to fit a likewise complex social system that participates in and actively shapes this world. These characteristics—instrumental and humanistic—cannot be defined in terms of conventional IS elements. Conventional ISs represent some real-world phenomenon, augment a physical device, or constitute a game in which some player pursues some goal. The metaverse builds on the confluence and integration of varied immersive social experiences that move beyond the physical limitations of what we commonly perceive to be the real world, and it is likely to play an important role in a variety of social activities and economic transactions (Turel & Qahri-Saremi, 2022). It is not simply the next generation of video games or a new type of VR but needs to be understood as a novel IS that beckons further theoretical understanding and exploration.

Our research is not limited to understanding how the confluence of emerging technologies and human interactions with these technologies are shaping and will shape individuals’ perceptions and behaviors in this XR. Rather, its objective is to go a step further by informing the design of the metaverse in terms of the design and sociotechnical elements and, in so doing, arrive at a sociotechnical framework for metaverse design. With this aim, our key research questions are as follows:

RQ1: Specify a comprehensive definition for the metaverse that positions it as a novel IS distinct from other related technologies.
RQ2: What are the key design considerations, affordances, and socio-technical elements that encompass the metaverse?
RQ3: How do these design considerations and elements inform metaverse design?

We achieve our objective through a multistep process. First, we build upon extant literature, synthesize the scholarly dialogue on the metaverse, and explore near-metaverse industry applications to develop a comprehensive working definition of the metaverse. This is done to guide the next step of a comprehensive bibliometric analysis to arrive at the key design and sociotechnical elements of the metaverse. In the third step, we complement our understanding of these elements with case studies of popular metaverse implementations. We theoretically augment our emerging understanding with the theory of affordance-based design in the fourth step to arrive at a sociotechnical framework for metaverse design.

1.1 Defining Metaverse

As delineated above, we begin by comprehensively defining the metaverse in this research by summarizing the existing definitions of the metaverse in the literature. This would help us understand and extract the essential aspects of the metaverse. Table 1 summarizes the conceptualizations of metaverse definitions available in the extant literature.

To approach our research pursuit of arriving at a framework of metaverse design, it is important to first understand and distinguish the metaverse from related terms, such as VR, AR, and virtual worlds (Animesh et al., 2011). Among the earliest works documenting a taxonomy from virtual to real is the famous reality–virtuality continuum by Milgram and Kishino (1994). They view the real world as a left extreme compared to the virtual world, which is a right extreme, with MR in between being referred to as AR and augmented virtuality (AV), depending upon the distance from the left extreme. Mann (2002) added the dimension of mediation to the continuum, which is based on the use of devices that enable the modification of real or virtual environments by altering sensory inputs. Mann proposed four possibilities based on the above: AR, AV, mediated reality, and mediated virtuality. Over the years, other authors have discussed amplified reality (Schnabel et al., 2007) and visio-haptic reality (Jean & Choi, 2009). Bringing together earlier work and embedding elements of human technology interaction (HTI) (Flavián et al., 2019) present the embodiment-presence-interactivity (EPI) cube. The EPI cube places various existing and emerging technologies across the eight vertices; one of the vertices presents VR with haptic devices that closely represent the virtual worlds of today. Virtual worlds have been extensively discussed and researched in the IS literature. Therefore, it is easier to go up or down the level of abstraction. Virtual worlds are online, computer-made places where people from different places in the real world can talk to each other in real time for work or play. Virtual worlds are a subset of VR applications, which is a broader term for computer-made simulations of three-dimensional (3D) objects or environments in which the user can interact in a way that seems real, direct, or physical (Lin, 2022).

People used to think of the metaverse as a bigger version of a single virtual world, but now they think of it as a large network of virtual worlds that are all connected. AR space can be thought of as part of the metaverse, which connects environments that are only virtual with environments that are only real or tangible. Similar to any virtual world system, AR constructs use assets and data from a self-contained or shared world state of the metaverse to emerge. We expect bibliometric techniques to help us study evolution and changes across time with respect to the conceptualization of the metaverse.

In recent years, few bibliometric studies of the metaverse have been conducted. In addition, there have also been several studies in which the construct of the metaverse has been defined. There have been recent literature review–based research attempts to synthesize the growing body of "metaverse" research. Some have focused on the potential to extend the physical world using XR, AR, and VR technologies (Dwivedi et al., 2022), while others have focused on virtual world applications in a specific business sector (Gursoy et al., 2022).

The current research study, however, focuses on the key design considerations and sociotechnical elements of the metaverse, which requires exploring and explaining, "What makes a metaverse a metaverse?" To accomplish this, the literature was scoured for articles exploring constituent properties of the metaverse and related constructs and developing arguments with evidence from industry about

Table 1.
Metaverse definitions from the extant literature

Author, Year	Paper/Other	Definition of Metaverse	Keywords
Stephenson (1992)	"Snow Crash" novel	Metaverse is a parallel universe of computer-generated virtual reality to which avatars from all over the world have access and to which they can connect by wearing glasses and headphones. Avatars are customizable digital bodies that metaverse users construct. (Bloomberg, 2022)	Avatars, interaction, customizable digital bodies (agents)
Rymaszewski et al. (2007)	Second life: The official guide	Metaverse is a place where you can make your own character, quickly go to other places, look at a huge amount of architecture, and shop. (Rymaszewski et al., 2007)	Virtual characters, virtual places
Collins (2008)	Looking to the future: Higher education in the metaverse	It is an interactive network with a seamless, immersive, and 3D virtual business and leisure environment.	Seamless/ real-time immersive
Davis et al. (2009)	Avatars, people, and virtual worlds: Foundations for research in metaverses	Metaverses are immersive, 3D virtual environments in which users interact as avatars with one another and with software agents, employing the metaphor of the actual world but without its physical constraints	Software agents, virtual environment, interaction
Farjami et al. (2011)	Multilingual problem based learning in metaverse	A universe in which individuals may "live" according to the rules established by the creator.	Individual (agents)
Suzuki et al. (2020)	Virtual experiments in the metaverse and their applications to collaborative projects: The framework and its significance	A universe of dimensions in which the avatar represents the users in the actual world	Avatar, universe
Meta (2021)	Meta (renamed from Facebook)	The metaverse creates a highly immersive, embodied version of the Internet in which users have a sense of presence in a location and/or with another person or many other people, as opposed to only being spectators.	Presence, users
Lee et al. (2021)	All one needs to know about metaverse: A complete survey on technological singularity, virtual ecosystem, and research agenda	"Metaverse" is a combination of the prefix "meta" (which implies transcendence) with "universe"; it refers to a hypothetical synthetic environment related to the physical world.	Space/ environment
Mystakidis (2022)	Metaverse	The metaverse is the post-reality world, a permanent and persistent multiuser environment that fuses physical reality with computer simulation. It is built on the convergence of technologies that provide multimodal interactions with virtual environments, digital items, and people, including virtual reality (VR) and augmented reality (AR).	Persistent, multimodal, digital items
Cheng et al. (2022)	Will metaverse be next internet? vision, hype, and reality.	Metaverse combines seamlessly the physical and the simulation worlds, i.e., through digital twin and digital economies (e.g., cryptocurrencies), which are based on and incorporates technologies like 5G, AR/VR/MR, blockchain, machine learning, and human computer interface.	Simulated worlds/space

how these constituent properties converge to yield affordances capable of delivering value in the near immersive cyber-physical future.

It is important to develop a working definition of the metaverse before determining what constitutes it. To be objective and comprehensive in arriving at this definition, we searched the literature for properties that are critical for virtual worlds, VR, and AR. To line up these properties with the abstraction that put the metaverse at the highest level, we had to take the intersections of these properties, combine them into meaningful metaverse features, and reach a theoretical saturation that gave us the necessary definition of the metaverse. The literature has identified nine properties that operationalize the "metaverse": shared temporality, real time, shared spatiality, one logical shard, software agents, virtual interaction, non-pausable, persistence, and avatars (Nevelsteen, 2018). Details of these individual property elements are provided as follows:

- Shared temporality: Cumulatively sharing abstractions of time (timelines overlap). In simpler terms, this means events happening in a place where time is moving simultaneously for all. The following examples elucidate how abstractions of time are cumulatively shared: "two people in a telephone conversation" share real-world time; however, two players playing email chess, making moves at completely different times of the day (even in the same time zone), do not share real-world time. Sharing time (or an abstraction of time) is different from occurring in real time.
- Real time: This specifies that agents can perform actions simultaneously, the virtual world is available, and action immediacy is part of the virtual world design.
- Shared spatiality: Singhal and Zyda (1999) describe "a shared sense of space" such that "all participants have the illusion of being located in the same world (same place)"—physically or virtually.
- Single distributed database: This refers to a virtual world being contained in a single shared data space. The virtual world is shared as a continuous entity where updates are synchronous and spread ubiquitously.
- Software agents: The concept of an agent refers to a system that can be differentiated from its environment and is capable of direct and continued interaction with that environment. In simpler terms, software agents refer to virtual conceptions capable of interacting with the virtual environment.
- Virtual interaction: This property means that users can interact with people (Girvan, 2013) (other human agents in the virtual world) and interact with the world (Girvan, 2013; Bartle, 2010) (interact with software agents and act or react to things and the virtual environment).
- Non-pausable: Satisfying the "non-pausable" property requires the absence of an active pause. An "active pause system" (Nevelsteen, 2018) is wherein agents can be allowed to effectively freeze virtual time relative to real-world time. In simpler terms, events flow continuously as per virtual time, which can be the same or different from real-world time. Imagine that this virtual time is similar to time on Planet X (hypothetically). We have a means to convert it to Earth time, but whether, at any instance, Earth time is equal to Planet X time is not necessary. This is also true in the virtual world, with one exception: virtual time can be altered independently of real-world time, allowing a loaded state to persist to storage and reload.
- Persistence: A persistent virtual world "continues to exist and develop internally even when there are no people interacting with it" (Bartle, 2003).
- Avatars: Bartle (2010) describes an avatar as a "virtual self" through which all their in-world activity is channeled.

To understand how each of these properties can lead to a definition, we must first realize that the ensemble of these properties exists in various virtual worlds or environments. For this section of the research, we considered seven companies—Gather Town, Fortnite, Roblox, Decentraland, Niantic Labs' Pokémon Go, Microsoft Mesh, and Facebook Metaverse (Meta) (Metaverse Companies, 2022)—to see how the aforementioned identified properties manifest in these near-metaverse applications. For example, if we use these nine properties to look at how the metaverse of Niantic Labs' Pokémon Go (see Table 2), which is a consumer metaverse application that uses mobile devices with GPS to locate, capture, train, and battle virtual creatures (called Pokémon) that appear as if they are in the player's real world, operates, we find a distinct combination of property 1, property 2, and property

3 in their virtual environment offering. This distinct feature of Niantic Labs' Pokémon Go virtual environment can be described as a "real-time shared spatiotemporal virtual environment." Similarly, from Table 2, we can infer the presence of "Shared Spatiality" within "One Shard" in Decentraland and the interaction between various "Software Agents" in most of the virtual environments considered. These ensembles of features, definitions, and keywords from Tables 1 and 2, when put together, yield our definition of the metaverse, which is as follows: *"A simulated environment where many agents can virtually interact with each other, act, and react to things, phenomena, and the environment; agents can be zero or many humans, each represented by many entities called a 'virtual self' (an avatar), or many software agents; all action/reaction/interaction must happen in a real-time shared spatiotemporal, non-pausable virtual environment; the environment may consist of many data spaces, but the collection of data spaces should converge in one persistent data source."*

Now that we have a working definition, we look at the whole metaverse ecosystem and combine what we've learned from theory and practice to figure out how the different parts of the metaverse work together to create value. To understand the authors' approach in this paper, it would be helpful if the metaverse ecosystem could be imagined as a stack with sociotechnical components. There will

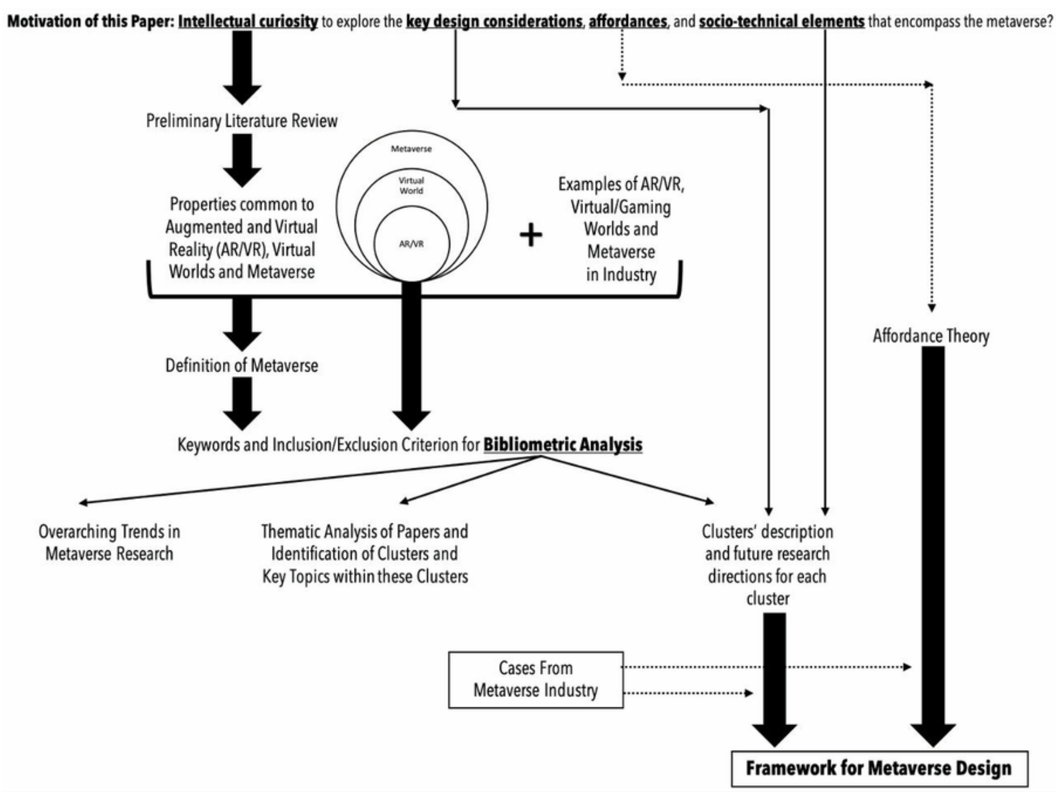
Table 2.
Mapping of properties of abstractions of virtual worlds with industry metaverse applications

Property Number	**Property Name**	**Virtual worlds in industry considered to look at presence and ensembles of nine properties (features)**						
↓	↓	**Gather Town**	**Fortnite**	**Roblox**	**Decentraland**	**Niantic Labs' Pokémon Go**	**Microsoft Mesh**	**Facebook (Meta) Metaverse**
		Gather Town is an interactive virtual space that simulates real-life, in-person interactions.	In Fortnite, players collaborate to survive in an open-world environment by battling other characters who are controlled either by the game itself or by other players.	The Roblox Metaverse focuses primarily on the creation of an immersive virtual world in the existing gaming platform and technology.	3D, user-owned, Ethereum-based open-world metaverse that allows users to play games, exchange collectibles, buy and sell digital real estate or wearables for avatars, socialize, and interact with each other.	A consumer metaverse application that uses mobile devices with GPS to locate, capture, train, and battle virtual creatures (called Pokémon) that appear as if they are in the player's real-world	Microsoft Mesh allows users to connect with presence, share across space, and collaborate in an immersive manner as if they were in person, regardless of their physical location.	3D spaces in the Facebook Metaverse allows users to socialize, learn, collaborate, and play.
1	**Shared Temporality**	Present	Present	Present	Absent	Present	Present	Present
2	**Real Time**	Present	Absent	Absent	Present	Present	Present	Absent
3	**Shared Spatiality**	Absent	Present	Present	Present	Present	Absent	Present
4	**Single Distributed Database**	Present	Absent	Absent	Present	Present	Absent	Absent
5	**Software Agents**	Present	Present	Present	Present	Present	Present	Present
6	**Virtual Interaction**	Present	Present	Present	Present	Present	Present	Present
7	**Non-Pausable**	Absent	Present	Present	Present	Present	Absent	Absent
8	**Persistence**	Absent	Present	Present	Present	Present	Present	Absent
9	**Avatars**	Present	Present	Present	Present	Present	Present	Present

be infrastructural elements, human- or machine-related elements, and value elements (Brdesee et al., 2022). The brief work done in Section 1 was to guide where to look and what to look for in the literature. It can be thought of as the anchor motivation for screening articles during bibliometric analysis, coming up with inclusion or exclusion criteria, and putting together a final summary of insights with respect to the design elements and sociotechnical elements of the metaverse. Figure 1 provides the overarching flow and organization of the research paper.

This research paper is organized as follows. Section 1 is the introduction. It gives an overview of why and how this study was conducted and provides a clear definition of the metaverse. This is followed by Section 2, in which the details of the research methodology are described. This is followed by Section 3, which encompasses the results and analysis of bibliometric analysis. There are three specific subsections within Section 3: overarching trends in metaverse research, mapping the intellectual structure of metaverse—thematic analysis of metaverse articles from 1987 to 2021—and explanation of clusters and future research directions. To add rigor and triangulate the findings from Section 3, evidence was searched for in practice by studying the cases of four metaverse platforms, as envisaged in Section 4. Section 5 encompasses the theoretical implications of the research in terms of propositions and the proposed framework for metaverse design. Section 6 presents the limitations and conclusion.

Figure 1.
Overarching the organization of the paper



2. RESEARCH METHODOLOGY

A three-stage process was followed for data retrieval, selection, and analysis (Figure 2). In the first stage, we decided on keywords based on the working definition developed in Section 1. We consulted a few scholars and received feedback to affirm the keywords (Rathi et al., 2022; Zupic & Cater, 2015). Thus, the retrieval process included “metaverse,” “virtual world,” and “gaming world” as keywords. Next, a data retrieval source was identified. The Scopus online database was selected to retrieve the research articles. It is a comprehensive database that extracts unique citations compared to Google Scholar and Web of Science (WoS) (AlRyalat et al., 2019) and offers broader coverage of journals than WoS (Block et al., 2020). In addition, Scopus is widely used for bibliometric analysis, as it provides metadata records and curates author profiles and abstracts from journals (Bhatia et al., 2021). The reviews and empirical and meta-analysis articles in the English language from peer-reviewed journals were selected. We considered business, management and accounting, social sciences, computer science, engineering, decision sciences, psychology, arts and humanities, economics, econometrics and finance, physics, and multidisciplinary subject areas. The data were retrieved on 14 April 2022 and returned articles for 35 years, from 1987 to 2021. The preliminary search on Scopus yielded 3,992 documents.

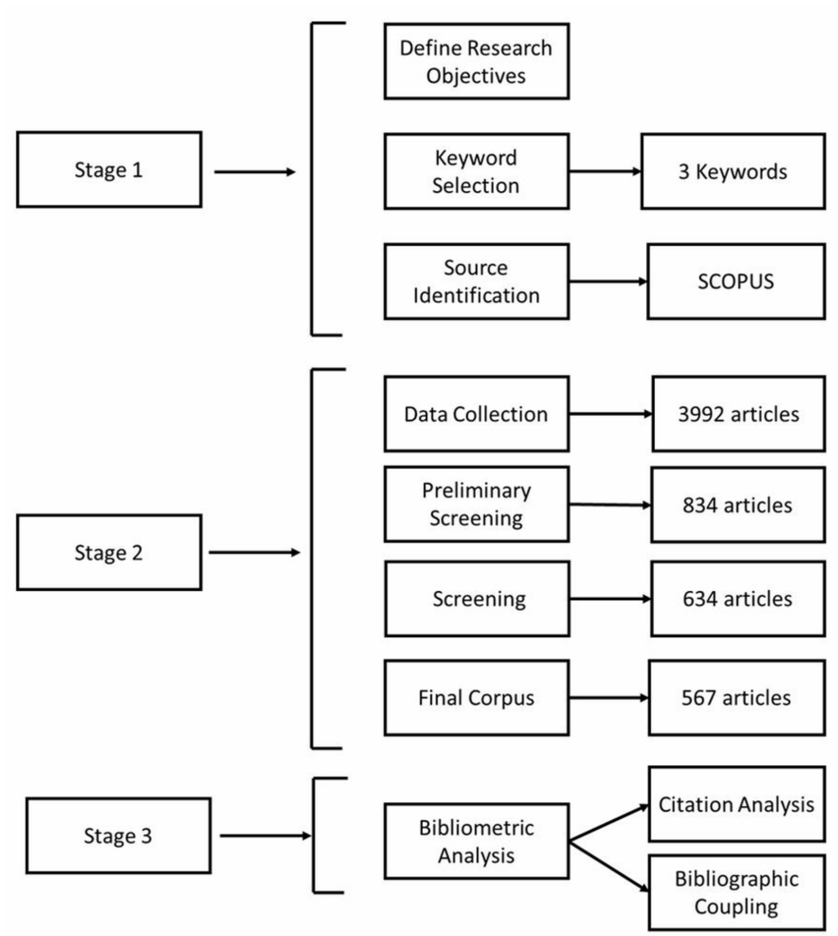
The second stage comprised four key steps leading to the final corpus. First, we employed the following preliminary screening criteria to shortlist the research articles: journals listed in the Australian Business Dean Council (ABDC) A*, A, and B categories OR Association of Business Schools (ABS) 4*, 4, and 3 categories OR the top 10 journals based on the number of articles published (Khanra et al., 2020; Maggon, 2022). This resulted in 834 articles. Next, articles were screened by examining the title and keywords, resulting in 634 documents. Subsequently, the abstract, title, and keywords were read for final screening to remove irrelevant articles. This resulted in 567 documents forming the final corpus.

In the third stage, bibliometric analysis was employed. It is one of the systematic review types: structured review focusing on widely used methods, theories, and constructs (Rosado-Serrano et al., 2018), hybrid-narrative with a framework for setting future research agenda (Dabić et al., 2020), framework-based (Paul & Benito, 2018), meta-analysis (Knoll & Matthes, 2017), theory-based review (Gilal et al., 2019), bibliometric review (Randhawa et al., 2016), and review aiming for model or framework development (Paul, 2019). Bibliometric analysis has recently gained immense popularity in business research (Donthu et al., 2021). It is a globally recognized research method, as it allows us to evaluate each other’s contributions in an area (Roig-Tierno et al., 2017). It was introduced in 1969 as a modeling and statistical tool (Pritchard, 1969). It has advanced to capture a comprehensive view of any research field by concisely mapping trends, enabling researchers to draw meaningful insights. A bibliometric analysis has several advantages over other systematic literature review methods, such as handling large datasets and having a broader research scope (Donthu et al., 2021). The analysis was performed using Visualization of Similarity Viewer (VOSviewer) software, which succinctly maps the area graphically and simplifies interpretation (Kruggel et al., 2020). After identifying the chronological structure, its intellectual structure was analyzed using bibliographic coupling.

3. ANALYSIS, RESULTS, AND INSIGHTS

Using the methodology discussed above, a final corpus of 567 research articles was built, which served as the dataset for further analysis. The chronological trends of the research articles and focus areas of research were explored. Furthermore, top contributing authors and countries were identified to better understand the concentration of research in various geographies. Bibliographic coupling was then conducted to identify the major themes in the research.

Figure 2.
Flowchart of the research methodology (bibliometric analysis)



3.1 Overarching Trends in Metaverse Research

Metaverse has been an active area of academic research since the late 1980s. It has seen two periods of heavy activity during the mid-1990s and early 2010s. Figure 3 indicates the number of metaverse research articles published over the last 35 years.

It is also pertinent to note that there was a sharp decline in research activity during the early 2000s. This may have been an outcome of the "dotcom crash," which led to the demise of many established technology firms and startups.

Table 3 highlights the "Top 10" authors with the most contributions to the field of metaverse research. The authors were ranked based on the citations of their research output. It is of interest to note that there does not appear to be significant variation in terms of the number of research articles published, but there are still significant differences in the citations, which reflects the impact of the research.

Table 4 lists the major countries where significant metaverse research is being conducted. The research output of the United States is the largest in terms of the number of research articles, followed by that of the United Kingdom. By examining the average citations received by each research article, their impact on the literature can be assessed. Canada ranks first in terms of impactful research, followed by the United States.

Figure 3.
Chronological view of research papers with selected keywords

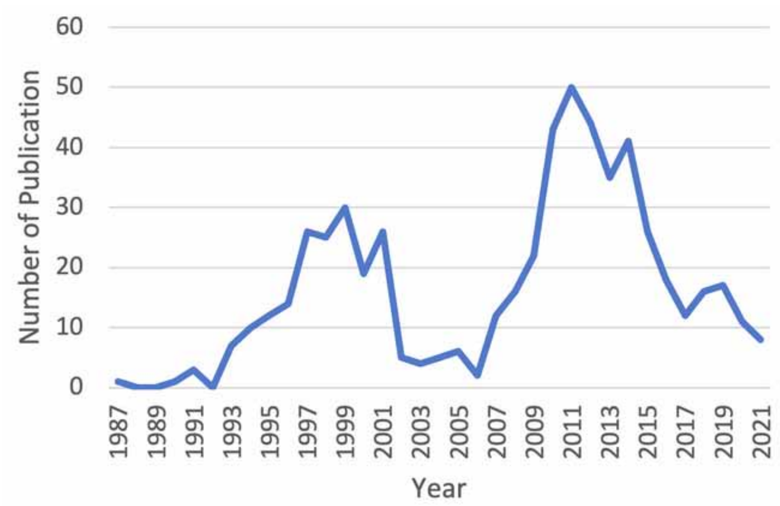


Table 3.
Top 10 contributing authors

Author	Documents	Citations
Slater M.	4	535
Barfield W.	3	445
Hendrix C.	3	445
Bruder G.	4	435
Steinicke F.	4	435
Callaghan V.	3	357
Gardner M.	3	357
Jarmon L.	4	334
Friedman D.	3	268
Barnes S.J.	3	197

3.2 Mapping the Intellectual Structure of Metaverse: Thematic Analysis of Metaverse Articles from 1987 to 2021

The thematic structure of the metaverse articles was assessed using bibliographic coupling (Weinberg, 1974). The analysis divided the final corpus into eight thematic clusters, capturing a variety of themes in research related to the specific strategic and sociotechnical elements of the metaverse. The clusters were segregated based on the link strength between the articles and calculated through the number of common references (Wallin, 2005).

The analysis used affordance theory and the affordance framework from *"The Design Framework: An Organizing Artifact for Enhancing the Fidelity of Educational Research, Implementation, and Assessment"* to theoretically ground the conceptualized clusters and the underpinning themes. To put names into clusters, we mapped the evolved clusters onto the affordance design framework to further our pursuit of

Table 4.
Top 10 contributing countries

Country	Documents	Citations	Citations/Document
Australia	26	920	35.38
Canada	30	2927	97.57
France	23	597	25.96
Germany	29	1076	37.10
Italy	21	318	15.14
Japan	36	892	24.78
Spain	38	1175	30.92
United Kingdom	84	2655	31.61
United States of America	192	10042	52.30

synthesizing the extant literature into coherent ensembles of metaverse design elements. To better understand and resonate with the grounding in affordance theory, it must be understood that the concept of artifact is guided by the assumption that artifact use is firmly grounded in social cognition and cultural learning (Casler & Kelemen, 2005, 2007; Kalish, 1998; Kelemen & Carey, 2007; Tomasello, 1999).

Table 5 presents the central focus, major topics explored, and leading articles for each cluster.

Figure 4 below captures the proportion of academic output in each of the identified cluster focus areas of metaverse research, bucketed into five-year time windows. The initial spurt of research in the mid-1990s focused on exploring distributed virtualization, virtual objects, and navigation. Concurrently, many companies were making initial attempts to create metaverses.

In contrast, the second spurt in the early 2010s focused on psychosocial affordances, knowledge creation, identity, capability augmentation, and user experience. This coincided with innovations in smartphone technology, allowing users to experience the power of the metaverse through mobile devices.

3.3 Explanation of Clusters and Future Research Directions

3.3.1 Cluster 1: Psychosocial Affordances

The first cluster identified covers 20% (96 out of 470) of publications and accounts for the third largest (i.e., 18%; 3,053 of 17,008) in terms of citations. This cluster brings together the notion of psychosocial behavior through the lens of affordances (Zhang & Jung, 2022). This essentially means the possibility of engaging in social behaviors that may lead to various outcomes, including the creation and development of structure and governance, as well as the genesis of possible business models for a specific type of metaverse. The subthemes that have been identified as contributing to Cluster 1 include sensemaking, user attitude, governance, social presence, motivations, and privacy. We briefly touch upon each subtheme and its link to psychosocial affordances. Sensemaking is an established higher-order capability that enables a group of founders, owners, or managers to decide and forecast how their business or product should evolve. For metaverse owners, founders, or organizations, this forms a central aspect and reason for existence, which is strongly influenced by the motivation of the group. Sensemaking and motivation further determine other important features of the specified metaverse, such as the nature of social presence and the nature of governance, thus ensuring a need for privacy and rules given the context (e.g., these may be different in an ordinary social product such as meta vs. an online game). The expected behavior of the end user or the expected user attitude is itself a creation of the central group based on the expected behavior of the final target audience. However, the actual user attitude toward the features determines the actual affordance actualization

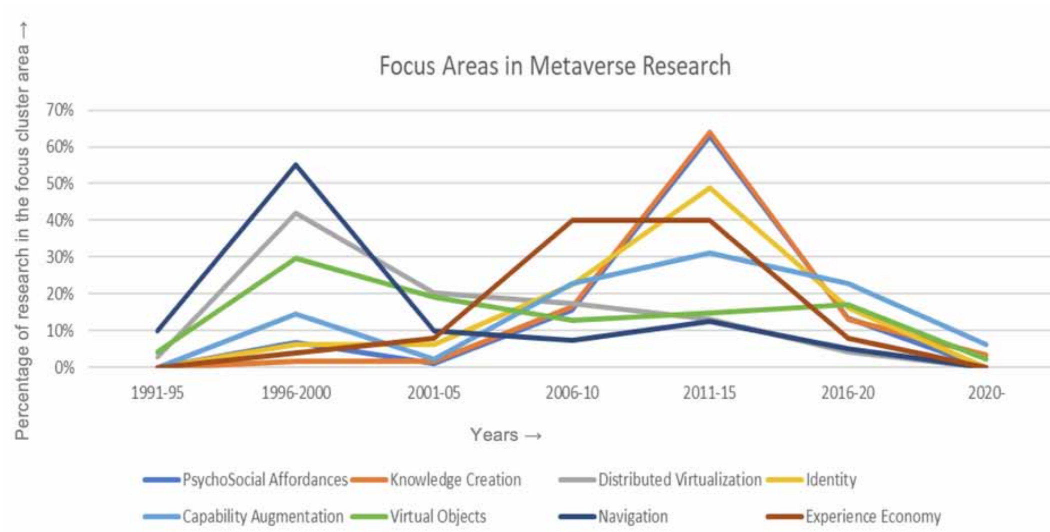
**Table 5.
Overview of clusters**

Cluster Number	Number of Paper	Cluster Focus	Major themes explored	Top 3 cited papers
				Authors(s) Year(s) and Citations
1	96	Psychosocial Affordances	1. Sense Making 2. User Attitude 3. Governance 4. Social Presence 5. Motivations 6. Privacy	Billieux J., Van Der Linden M., Achab S., Khazaal Y., Paraskevopoulos L., Zullino D., Thorens G. (2011) - 205 Guo Y., Barnes S. (2013) - 135 Fox J., Bailenson J.N., Tricase L. (2011) - 123
2	75	Knowledge Processes	1. Instructional design 2. Instructional delivery 3. Instructional outcomes 4. Learner traits and capabilities	Potkonjak V., Gardner M., Callaghan V., Mattila P., Guetl C., Petrović V.M., Jovanović K. (2016) - 354 Bulu S.T. (2012) - 192 Pellas N. (2014) - 153
3	73	Distributed Virtualization	1. Peer to Peer Collaboration (Agent to Agent, Agent=Human/Digital Bot) 2. Decentralized Infrastructure 3. Interoperability (mobility) 4. Surfaces (Search and Navigational) - Visual, Audio, Touch based 5. Context and Content Generation	Rickel J., Johnson W.L. (1999) - 285 Taubin G., Horn W.P., Lazarus F., Rossignac J. (1998) - 134 Hindmarsh J., Fraser M., Benford S., Greenhalgh C., Heath C. (2000) - 108
4	53	Identity (or Avatar Persona)	1. Avatars 2. Sovereignty 3. Demographics 4. Social Interaction 5. Emotions	Papagiannidis S., Bourlakis M., Li F. (2008) - 79 Jung Y., Kang H. (2010) - 78 Mueller J., Hutter K., Fueller J., Matzler K. (2011) - 75
5	52	Capability Outcomes	1. Physical Capability Augmentation (Senses & Locomotion) 2. Cognitive Capability Augmentation (increased perception, increased social abilities, decreased stress)	Steinicke F., Bruder G., Jerald J., Frenz H., Lappe M. (2010) - 328 Maria R., Johnson A., Moher T., Leigh J., Vasilakis C., Barnes C. (1999) - 168 Mohler B.J., Creem-Regehr S.H., Thompson W.B., Bülthoff H.H. (2010) - 125
6	50	Virtual Object Design	1. Haptics (touch & sensation) 2. Lighting & Occlusion 3. Stereoscopy 4. Virtual Object Synthesis 5. User experience (UX)	Feiner S., Macintyre B., Seligmann D. (1993) - 548 Adams R.J., Hannaford B. (1999) - 491 Kanade T., Rander P., Narayanan P.J. (1997) - 419
7	41	Navigation & Movement	1. Wayfinding and Movements 2. Spatial Orientation 3. Risks and consequences of real world - virtual world interactions	Brooks Jr. F.P. (1999) - 417 Stanney K.M., Mourant R.R., Kennedy R.S. (1998) - 326 Basdogan C., Ho C.-H., Srinivasan M.A., Slater M. (2000) - 288
8	30	User Experience	1. Experience Design 2. User Participation (Active, Passive) 3. Engagement (Immersive, Absorptive) 4. Experience Evaluation	Merchant Z., Goetz E.T., Cifuentes L., Keeney-Kennicutt W., Davis T.J. (2014) - 660 Dickey M.D. (2005) - 341 Jarmon L., Traphagan T., Mayrath M., Trivedi A. (2009) - 309

and the corresponding success of psychosocial affordances. Overall, this cluster determines the nature and reason of a metaverse and its possible evolution in the future.

The integrated way of looking at psychological phenomena is based on the notion that one psychological process consists of different body reactions and that these reactions are highly correlated with each other.

Figure 4.
Trends in metaverse research – cluster focus areas



3.3.2 Cluster 2: Knowledge Processes

The second cluster accounts for 16% (75) of the publications and 12% (2010) of citations. This cluster primarily contains research focused on learning environments, including virtual classrooms and virtual learning worlds. Research in this cluster focuses on the impact of individual characteristics (cognitive load, self-efficacy, etc.) and characteristics of the virtual environment (e.g., the kind of embodiment, co-presence, or social presence afforded) on learning outcomes (student engagement, interactivity, satisfaction, etc.). In addition, this cluster deals with aspects related to instructional design and delivery, specifically from curricular and pedagogical standpoints.

3.3.3 Cluster 3: Distributed Virtualization

The third cluster has been identified as contributing 15% (73) publications and the second-highest citations of 10% (1,638). It would not be incorrect to call this cluster the infrastructure cluster to some extent. This need for a metaverse-like environment brings to the fore the requirements for peer-to-peer collaboration (agent-to-agent, where an agent may be a human or a digital bot), decentralized infrastructure, and interoperability, which are the identified subthemes within the cluster. The need for scale and rapid computation makes metaverses a fit case for distributed architecture. Furthermore, collaboration in a metaverse may be between any two entities or more; therefore, the capability to set this context becomes a key part of delivery. Furthermore, the linkages between decentralized notions being brought in by blockchains and various unique crypto products to be used within metaverses is another important requirement for the product, both for gaming and e-commerce alike. Moreover, given the need for end users to navigate various metaverses, easier transitions can be ensured by using interoperability across metaverses. Lastly, the need for a secure and decentralized identity is also a fundamental requirement for metaverses (Singla et al., 2022).

3.3.4 Cluster 4: Avatar Persona

This cluster accounts for 11% (53) publications and 7% (1,196) citations. As the name is fairly self-explanatory, this cluster is all about the research around creation of “avatar” or the animated digital persona with varied capabilities, such as capability to express cultural, national, or racial aspects through the digital persona (demographics), ability to express emotions, sovereignty of the said avatar (this is closely related to both governance and privacy aspects we mentioned in Cluster 1), and ways and means to ensure co-presence of linked groups (related to the nature of social presence subsumed in Cluster 1). This represents an important thread of research, especially given the greater focus on diversity and multicultural themes among recent work on human resources and formal teams.

3.3.5 Cluster 5: Capability Outcomes

This cluster covers 11% (52) publications and the highest citations of 10% (1,708) citations. Research in this cluster explores how VR and AR affordances interact with users' real-world capabilities to augment or constrain their human capabilities. Within this cluster, one strand of research has focused on the VR or AR affordances affecting the physical capabilities of humans, such as the effect of visual cues in the virtual world on the sense of taste in the real world and the augmentation of the physical boundaries available for movement in the virtual world in comparison to real physical movement. Another strand of research has focused on the effects of VR or AR affordances on the cognitive capabilities of humans, such as reduced stress, social presence, and gender identification.

3.3.6 Cluster 6: Virtual Object Design

This cluster comprises 11% (52) of the articles and is the smallest, with 17% (2925) citations. The research in this cluster deals with the appropriate design of virtual objects to enhance the realism of virtual worlds, thereby providing users with a more immersive experience. Visual and audio cues are essential for a realist perception of the virtual world. Hence, a substantial amount of research in this cluster has explored the design aspects related to light effects, occlusion of virtual objects, shadows, etc., along with stereophonic effects. With the development of haptic technology, an emerging stream of literature also focuses on the feel of virtual objects as perceived through the sense of touch. Most research in this cluster is based on user experience (UX) evaluations by users and assesses the effect of a combination of visual, audio, and haptic cues on users' sense of presence in the virtual environment.

3.3.7 Cluster 7: Navigation and Movement

This cluster consists of about 9% (41) publications and 14% (2,393) citations, yet its importance for academia and practice cannot be sufficiently underscored. One of the essential affordances of virtual worlds is the users' ability to move and navigate through the virtual space. Research in this cluster emphasizes these aspects by exploring the physical orientation of the virtual world and its navigability. A specific aspect that this research has focused on is the psychosomatic risks and consequences (stress, nausea, etc.) of virtual environments for users. Research in this cluster shows that ergonomic design, spatial orientation, and visuomotor adaptations are essential for a psychosomatically pleasing experience in virtual worlds.

3.3.8 Cluster 8: User Experience

This cluster covers about 6% (30) publications and 12% (2,085) citations. This indicates an area that requires more attention from research and practice owing to the essentiality of user experience for adopting virtual environments. At the macro level, this cluster of research is interested in the experiential outcomes (e.g., learning) of virtual worlds for users. Research in this cluster studies the interactive experience (active, interactive, or collaborative) as well as the technosocial experience (e.g., embodied sociality) of the users of virtual worlds. It also highlights the importance of usability and underscores the immersive, reflective, analytical, and solutioning potential of virtual worlds from the perspective of problem-solving. We also provided future research directions for each cluster and tabulated them in Table 6.

Table 6.
Future research questions emerging from clusters

Cluster	Cluster Name	Research Questions
1	PsychoSocial Affordances	1. How do traditional social media and the Metaverse influence psycho-social processes? 2. How do the basic motives rooted in people's personality (e.g. achievement, social affiliation, power etc.) guide real users' actions in the Metaverse? 3. What are the complexities of user perceptions and intentions in different Metaverse virtual worlds? 4. What role does participants' satisfaction with their bodies play in the eating habits of their Metaverse avatars and any appearance changes? 5.. How does the use of Metaverse impact governance of real user national, group, and individual culture? 6. How will the governance and regulatory framework evolve for avatar-based innovations in Metaverse? 7. How is the representation of pregnancy, birth, and maternity in Metaverse of their real users mediated in different social settings along with their governance? 8. How should firms better design and operate metaverses to benefit (as opposed to hurt) consumers' physical and psychological well-being? How should vulnerable groups (e.g., minors) be safeguarded in metaverses? 9. What are the public policy and regulatory implications (e.g., how to ensure that metaverse technology are used ethically and responsibly; how to enforce extant laws such as anti-harassment laws in metaverses effectively; what new policies and regulations might be needed)? 10. What should individual consumers do to protect and improve their and their family members' well-being in the age of metaverses?
2	Knowledge Creation	1. How is value created and harvested in the Metaverse to bring about benefits for individuals, firms, and the broader society? 2. How should system dynamics be integrated to improve Metaverse knowledge creation paradigms? 3. How will multiple Metaverse environments place presence, social presence, co-presence, and learning satisfaction for students in their virtual worlds? 4. What is the relationship between the flow experience in Metaverse and other significant psychological factors (e.g. self-regulation) with students' engagement? 5. How can data mining algorithms help discover usage behaviors and engagement in an Educational Metaverse? 6. What is the relation between Metaverse hostility and online addiction & depression with different knowledge creation groups? 7. How can metaverse classrooms improve the learning of non-gamers, women, and other disadvantaged? 8. How may Metaverse facilitate knowledge and knowing processes?
3	Distributed Virtualization	1. What are the enablers of the formation of a democratic metaverse? 2. How can team management improve in distributed virtual world collaboration in Metaverse? 3. Can switching to simpler animation/deformation techniques for lower levels of detail in Metaverse help reduce the network traffic? 4. How can performance and user experience for extended avatar fidelities and appearances, including speech interaction, improve in Distributed Social Virtual Reality? 5. How can a content-rich decentralized & interoperable virtual environment support many concurrent participants in Metaverse? 6. How will Metaverse-based virtual exhibitions drive human collaborations with the flexibility to relax temporal and spatial constraints to allow users to attend exhibitions anytime and anywhere? 7. How can modeling virtual surfaces in Metaverse be enhanced using attention to topological structures, cognitive modebenefitthe interactions with surfaces?
4	Avatar Persona	1. How do avatar embodiment and metaverse-based interactions affect consumers' identity, sense of self, and implications for their subsequent behavior (online and offline)? 2. How will gossip regulate moral life in the Metaverse in different social, geographical, and economic contexts? 3. How will the experience of the bodies & emotions of avatars corresponding to the real users in Metaverse be defined? 4. How are avatars' different sex and same sex relationships in Metaverse for real users defined in divergent circumstances? 5. How will inter-community relationships evolve for LGBT communities in the Metaverse? 6. How are the Digital divide and information inequalities amplified by the Metaverse?
5	Capability Outcomes	1. How can thermal taste with other stimuli, such as visual, auditory, touch, and smell stimuli, enhance Metaverse experience & adoption? 2. How do consumers interact with each other in metaverses? How might such behavior differ from other environments? 3. How do social norms emerge in metaverses (e.g., how close should another avatar stand next to yours)? 4. How can haptic feedback (with thermal sources inside the compact form factor of a face cushion, complex feedback patterns) help create better effects in Metaverse? 5. How can experimentation using real and virtual walking by users improve user's Metaverse Avatar physical & cognitive capability? 6. How does metaverse usage impact consumers' physical well-being? What are the short-term and long-term implications (e.g., disorientation, vision issues)? Under what conditions are these likely to occur? How can metaverses be leveraged to improve physical health? 7. How does metaverse usage impact consumers' psychological well-being? When and for whom does metaverse immersion enhances psychological well-being (e.g., increased freedom of expression, increased socialization)? When and for whom might such immersion be detrimental to psychological well-being (e.g., addiction, disconnection from reality)?
6	Virtual Objects Design	1. How can we design artifacts for an immersive Metaverse? 2. How will the user's performance be affected by different decisions made in designing 3D illustrations in Metaverse? 3. How can Metaverse be more resilient to improve imperfect calibration, correspondence finding, and mesh generation for virtual objects? 4. How can Mixed reality (MR) augment the real world with synthetic electronic data to help better Metaverse experiences? 5. Which psychological cyberspace and cybertherapy are most appropriate to pursue with Metaverse advantages, limitations, and ethical issues? 6. Can an image captured by a user's camera help reduce the cost of constructing and maintaining the landmark database in Metaverse?

continued on following page

**Table 6.
Continued**

Cluster	Cluster Name	Research Questions
7	Navigation & Movement	1. How can we plan a better user experience by constructing a virtual environment in Metaverse in real-world forms? 2. How can we extend theories on spatial cognition to improve the design of multiscale traveling tools in the Metaverse? 3. What are ergonomic design principles for better device performance in Metaverse? 4. How can Metaverse be used to evaluate historical sites before renovation or restoration to ensure that proposed changes will not harm the historical nature of the environment? 5. How should the notion of salesperson be redefined in Metaverse? 6. How should sales events be conducted in metaverses (e.g., how should Black Friday events be implemented in such digitized 3D reality)?
8	User Experience	1. What are the implications of the rise of metaverses for different industries and sectors (e.g., acceptance and use of metaverses for education, entertainment, financial services, health services, news media, real estate)? 2. How does the rise of metaverses impact the consumption of digital goods/NFTs and the adoption of cryptocurrencies? 3. What are Business model innovations in the Metaverse? 4. Exploring design variables and interesting interaction effects of design features to further enhance Metaverse design? 5. Fully understand the potential for distance and distributed learning using Metaverse. 6. How to design Metaverse hospital learning environments for realistic learners' interactions with patients and staff, virtual patients exhibit more sophisticated physiological responses to clinical interventions and users are afforded a greater focus on improving their clinical decision-making skills?

4. CASE-BASED ANALYSIS

To further the insights from the extant literature, evidence and clarifications were searched for in the industrial manifestations of metaverses. Since this process involves inductive logic building, the authors delved into four metaverse operationalizations by technical players from industry, such as Meta, Microsoft, Decentraland, and Nvidia.

Meta: Meta (formerly Facebook) is among the pioneers of the modern metaverse economy. Meta enables the creation of avatars in an interactive way, with a variety of features based on a deep demographic understanding of users across the world. Furthermore, the ability of the avatars to interact among themselves, or with bots or humans, is well developed and part of the larger reason and strategic existence of Meta. On the architecture and infrastructure side, Facebook, from the earliest days, has been on a highly distributed and scalable architecture, which Meta inherits as an advantage. Meta has an active research program that focuses on virtual object synthesis and manipulation from various perspectives and has promoted libraries and utilities, such as Spark AR and Origami. Meta has been active in haptics technology, and some of its latest prototypes are Tasbi and Bellowband, both developed by Facebook Reality Labs. While a well-developed haptic technology group has been present, less focus could be placed on spatial movement and wayfinding. As can be ascertained from above, Meta seems to have a more social business–based intent; therefore, it has been at the forefront in respect of "Privacy" and "Governance" issues. According to Elizabeth Carr, Meta's Head of Content Design, "On the Privacy content design team, our mission is to empower Meta to communicate in a way that builds understanding and confidence in how we honor people's privacy. We design transparency controls, such as "Access Your Information," which allow users to see all their personal information in one place so that they can understand it and choose to archive or delete any information they don't want Meta to use. The goal is to give people a simple, straightforward, and human way of understanding what data Meta collects and how we use it to improve their product experiences." Likewise, Meta is a signatory of the Metaverse Standards Forum (MSF), along with 30 other firms, with a primary focus on ensuring that metaverses can develop a common way of communication and be interoperable.

Microsoft: Microsoft has established Mesh as its version of the metaverse. Both technologically and architecturally, Mesh benefits from the entire Microsoft development ecosystem, including the Azure cloud (Stergiou et al., 2021; Gupta et al., 2021) ecosystem. Mesh enables a variety of avatar choices for users, and, similar to other platforms, it enables users to connect with presence, share across space, and collaborate in an immersive way. Bot-to-human voice–based interaction has long been activated in the form of a Cortana-based digital assistant and is being utilized in Mesh as well. Researchers at Microsoft have been exploring haptics for many years, and their work has covered three overlapping areas: the psychology of perception (and the illusions we can apply to manipulate it), the development of prototype haptic input and output devices, and user studies on the effectiveness of haptic techniques. This research could be applied to compensate for or augment other senses (such as through the CaneController for people with visual impairments) or to create a greater sense of immersion in VR and AR environments. To further leverage VR or XR capabilities and core platform features, Mesh provides a cross-platform developer, SDK, so that developers can create apps targeting their choice of platform and devices. It supports Unity alongside native C++ and C#, Unreal, Babylon, and React Native. SDK also provides pre-built UX constructs for developers to utilize in apps to make the development process simpler and faster for engaging MR experiences. Spatial maps in Mesh allow for the reliable placement of holograms that can persist across time, space, and devices. Mesh can generate the same understanding aligned with the precise layout and geometry of a given object, allowing developers to easily build apps that may require overlaying objects with visual information, such as instructions, service records, and other important data precisely aligned to the components of the object. Mesh helps create a map of the world that is, with regard to magnitude, more accurate than GPS, and it can even work in places without GPS access. Overall, Microsoft offers a highly developed and ready-to-go market metaverse with multiple capabilities. It is also an important member of the MSF as a signatory.

Decentraland: Decentraland is based on a blockchain architecture using VR and open-source technologies, thereby offering a different flavor and use case focus for its metaverse form. Decentraland features fully customizable avatars with hundreds of free outfits and accessories. Each avatar is assigned a passcode that allows it to explore the VR world and engage in commerce (buy or trade) with other users. Avatar names are also purchasable in the market if one is looking to monetize brand names (Burberry, Versace, etc.) or common keywords (theater, cybersecurity, etc.). Decentraland supports various VR headsets; however, the focus is not on converting all physical sensations into digital formats. A key feature of Decentraland is its ability to build scenes and entire environments, as the platform comes with a pre-built scene pool. The notion of the adjacency of virtual land makes Decentraland parcels similar and yet different from web domains. New land parcels must be contiguous with existing ones. This adjacency allows for the spatial discovery of new content and the creation of districts devoted to a special topic or theme. While each web domain can have an unlimited number of hyperlinks to other content, parcels in Decentraland have a fixed number of adjacencies. Additionally, the content of adjacent parcels can be seen from a distance. This allows the creation of a marketplace for blocks of real estate. In fact, tradeable real estate was among the primary use cases for launching Decentraland. All items in the market are perishable, with a preassigned expiry date. Like many other crypto-based metaverse platforms, Decentraland is not a signatory of MSF. As opposed to other players, in-game advertising, property markets, non-fungible tokens, and in-world events seem to be the greater focus areas for Decentraland. However, Decentraland, similar to Meta, has an elaborate code of ethics for existence and functioning.

Nvidia: Nvidia has its own version of the metaverse, which is known as the omniverse. Omniverse is a distributed, scalable, multi-GPU, and real-time simulation environment with a rich set of libraries and utilities that can enable ready-to-market real–virtual applications. Omniverse comprises an Avatar Cloud Engine (ACE) (Mishra et al., 2021; Al-Qerem et al.,2020), which enables the creation of avatars of varied capabilities of interaction as well as a suite of artificial intelligence services, such as vision and language. Nvidia is a proponent and supporter of material definition language (MDL) and its development kit known as MDL SDK, allowing the integration of physical material into rendering applications, thereby giving support to 3D development in multiple ways. Nvidia also has an active VR and AR program, together with haptic technology intervention, enabling varied actuators and controllers to be used, not just for gaming but for multiple purposes.

The most important pillar of Nvidia's omniverse is its large ecosystem, comprising players from manufacturing, gaming, and many other industry verticals. Nvidia and Siemens have joined together for real-time real-life digital twin creation and management to create an "industrial metaverse." Nvidia is a part of the larger metaverse forum for common standards and has been working on USD, PhysX, and MDL open-source standards to ensure interoperability and to establish common acceptable principles for metaverse across the board.

5. FRAMEWORK FOR METAVERSE DESIGN

In this section, we draw on the learnings about the design characteristics of the metaverse identified through cluster analysis of the literature and our analysis of the cases, listing different metaverse implementations to present a framework for understanding the design of metaverse artifacts that afford specific goals to their users. The motivation for this exposition lies in the fact that metaverse artifacts neither cater to all the audience nor do they offer the same possibilities to all kinds of users. For example, a metaverse catering to gamers is likely to be starkly different from a metaverse dedicated to industrial applications, as our cases comparing Decentraland and Nvidia succinctly show. The needs of the users are completely different; therefore, similar utilities, especially at a deeper level, cannot be expected.

Since the metaverse is designed by human designers for human users, both situated in the larger context of a complex world, we draw upon the domain of design science to understand metaverse artifact design (Norman, 2013). Research on design science has emerged along the two distinct dimensions of function and affordance (Maier & Fadel, 2002). Function refers to what an artifact is intended to do. A specific focus on usability in design has led designers to adopt an affordance-based stance that focuses on the interaction between the user and the artifact, rather than merely on the characteristics of the artifact when designing the latter.

IS research has adopted the notion of affordance, rooted in ecological psychology (Gibson, 1986), to understand the possibilities for goal-oriented action offered by an information technology (IT) artifact to users (Markus & Silver, 2008). It is well established that affordances may enable a user to either achieve a goal or work as a constraint (Leonardi, 2013; Hutchby, 2001). Further, while affordances are cognitively perceived (Davern et al., 2012a, 2012b) by a user based on the user's capabilities in relation to the technical artifact's features, they serve as preconditions for action (Greeno, 1994). In extant IS research, the concept of affordance has been applied in scenarios in which the technical object in question has been accepted as upcoming from a general adoption perspective but is well proven in the given context (Treem & Leonardi, 2013; Krancher & Luther, 2015). However, in developing our framework for metaverse design, we use this concept in *the context of completely new and different IS products or services being developed in a high-tech environment for consumption by other organizations with novel products still under a high level of flux such as metaverse.*

We go beyond the predominant focus in IS research, in which scholars have primarily explored the affordances offered by an IT artifact to its users, to reconceptualize IT artifact design using affordances from the perspective of the technology designer. Going ahead, we draw on the concept of affordance-based design to inform metaverse design. Affordance-based design retains the entangled relationship between the designer and the metaverse artifacts (Maier & Fadel, 2003; Maier & Fadel, 2009), in that the designer specifies all the properties of the artifact in terms of the form (as in geometry), the function (as in behavior), and the aesthetics (as in color and shape). Thereby, the artifact affords specific uses to varied users. Hence, the affordance-based design approach overcomes the relational and dispositional divide that has existed in IS research, where relationality implies affordances as relationships between actors and technical artifacts (Faraj & Azad, 2012; Fayard & Weeks, 2014), and dispositionality implies action possibilities arising from properties designed into the technical artifact by its designers (Hartson, 2003; Norman, 2013).

While an artifact may afford a specific use, the quality of the affordance may vary (Maier & Fadel, 2009). For example, a chair may afford to sit and carry, but it affords to sit better. The benefit of affordance-based design is that it emphasizes the conscious design of the quality of an affordance so that the artifact is of high value to the user. Hence, affordance-based design specifies a system structure that possesses desirable qualities to support desired behavior while preventing undesirable affordances to avoid undesirable behavior.

Recent research suggests that creating a metaverse is a design problem in which designers create distinct experiences that are integrated into a meta-design space (Seidel et al., 2022). According to this work, user experience in the metaverse is a combination of tensions along the dimensions of space (e.g., navigation), time (e.g., pace at which an action completes with respect to real time), utilities (e.g., fidelity and imagination with respect to virtual objects), actor (e.g., managing identity or identities), and transition (e.g., managing coherence and continuity of user experience). Numerous combinations of these dimensions can exist in a particular design space of the metaverse—each design space reflects the specific design choices made by the designer (Seidel et al., 2018). We propose that these design choices, made in the form of specific design characteristics of the metaverse, are based on the target affordances—the affordances offered to the user of the metaverse.

Proposition 1: Target metaverse affordances perceived by the designer determine metaverse design characteristics.

The design of a new technology artifact also involves the delineation of appropriate architecture and governance mechanisms. We use the term metaverse architecture to refer to the physical computing infrastructure (servers, network, sensors, and input and output devices, etc.) and its logical structuring through the use of appropriate protocols (Cheng et al., 2022). Because metaverse implementation usually happens through a platform, the architecture of the metaverse is expected to include design features that enable network effects and allow scaling by matching users' expectations with complementors' offerings (Seidel et al., 2022). Furthermore, metaverse governance refers to the regulations and policies that enable or constrain user behaviors (Humphreys, 2008), possibly through modular, composable, versatile, interoperable, and computational components (Schneider et al., 2021). This is an essential aspect of the metaverse phenomenon that has been recommended, even in the early discussion of the metaverse (Bourlakis et al., 2009).

We believe that the choices made by designers to design the target affordances for the metaverse determine the architecture, as well as the governance mechanisms available in the metaverse. For example, if privacy is one of the target affordances for the metaverse, the governance rules and architecture of the metaverse might allow for the creation of private spaces by a metaverse user, where access to other users is restricted (Humphreys, 2008). Furthermore, given the close interaction between affordances and their architecture and governance, it can be said that these are like constraints that facilitate or inhibit final metaverse design characteristics.

Proposition 2a: Target metaverse affordances perceived by the designer determine the metaverse design in terms of its architecture and governance.

Proposition 2b: Architecture and governance of the metaverse moderate the target affordances, leading to unique metaverse design characteristics.

Hence, the target metaverse affordances perceived by the designer are provided through metaverse characteristics, subject to the boundary of the metaverse architecture and governance. We define this as the metaverse design principle, as it governs the creation of other artifactual instances of the metaverse (Sein, 2011). Design principles prescribe how to design and develop an artifact (Gregor & Jones, 2007); hence, they determine the eventual materialization of the target metaverse affordances.

Proposition 3: Metaverse design principles determine the materialization of target affordances in the metaverse artifact.

The materialization of the target metaverse affordances, which can indeed be perceived as affordances by the user (Norman, 2013), happens in two ways. For the end user, materialization is the form of the user experience, and for the complementor, materialization is the form of the complementor ecosystem of the metaverse artifact. Figure 5 depicts the framework for the design of a metaverse artifact, as detailed above.

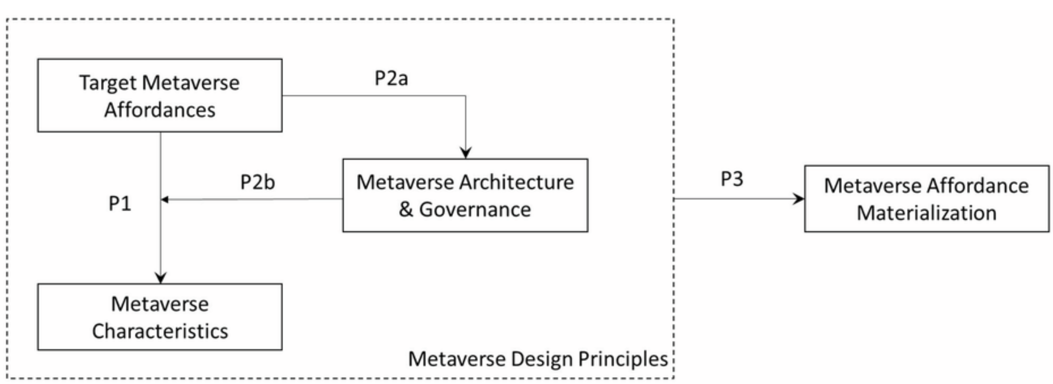
6. LIMITATIONS AND CONCLUSION

The metaverse design framework that evolved as a result of the current study reveals that the metaverse is an ecosystem comprising affordances. These capabilities derived from HTI help in the manifestation of the socio-technological characteristics of the metaverse, which together influence the design, architecture, and governance of the metaverse. This evolved metaverse then creates value via the tangible materialization of the capabilities and artifacts part of the metaverse. The study spurs several directions for future research, particularly in the streams of literature that are at the cusp of human–computer interaction, information management, and business value.

This study is detailed in its approach; however, it has a few limitations. First, it presents a broad view of the metaverse research landscape and suggests directions for future research. Furthermore, an in-depth analysis of each cluster could be considered in the future. Second, the bibliometric analysis considers only titles, abstracts, and keywords for analysis. Future research could employ big data analysis to cover full-text analysis. Third, Scopus is a dynamic database that is continuously updated. Therefore, the results might change altogether when the analysis is published. The same keywords could give different results if applied later.

The metaverse will make it possible for businesses to offer immersive items, such as VR spectacles. One Scottish whiskey company collaborated with a hotel to produce a new cocktail and then designed an immersive experience that takes customers to Scotland, teaches them how whiskey is manufactured, and provides a virtual tour of a distillery. You remove your VR glasses and check the whisky in your glass. To innovate customer engagement, businesses may use immersive brand narrative experiences (Forbes, 2022). The metaverse intends to expand the boundaries of the virtual workplace by integrating extra social interaction, mobility, and collaboration features. It adds to an avatar-based immersive reality platform that supports interactive working, collaboration, and

Figure 5.
Framework for metaverse design



learning solutions in an attempt to remove the isolation and workforce separation that remote and hybrid employment could bring (HBR, 2022). These are a few instances of how the metaverse might provide economic possibilities via the introduction of new types of digital business assets and value exchange systems. Businesses may leverage the metaverse to improve the customer experience for both humans and robots. Nevertheless, the metaverse's success is contingent on its grasp of crucial economic and financial or business model components (Gartner, 2022).

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