METAVERSE IN HIGHER EDUCATION – A SYSTEMATIC LITERATURE REVIEW

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Due to the COVID-19 pandemic and the resulting restrictions, the need for a rapid conversion of teaching to digital formats has increased significantly. Not all teaching formats and content are suitable for traditional video conferencing, so the Metaverse, an interconnection of virtual worlds, has experienced a significant upswing in the education sector. Therefore, we conduct a systematic literature review to determine the current state of research on the Metaverse in higher education and to identify its definitions, benefits and challenges, types, and technologies. The initially found 5,539 papers were systematically filtered to 92 fully coded articles. Our findings reveal a lack of standardized definitions, early-stage prototyping, a lack of prescriptive design knowledge, and a lack of pedagogical and methodological concepts and blueprints. These findings reveal significant research gaps and lead to the derivation of future research streams.

Keywords: metaverse, higher education, immersive learning, systematic literature review, pandemic

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1 Introduction

Amid the COVID-19 pandemic and its resulting restrictions, the Metaverse, an interconnection of virtual worlds, saw a significant surge in the education sector, as teaching swiftly shifted to digital formats (Chamorro-Atalaya et al., 2023; John Lemay et al., 2023). The Metaverse offers numerous benefits in education, such as social and collaborative aspects (Lin et al., 2022; López et al., 2022), but also faces challenges like high requirements and costs (J.-E. Yu, 2022). Understanding the development and current state of the Metaverse research in education is crucial, especially given its impact not just as a technological innovation, but also on pedagogical concepts and learning methods (Lin et al., 2022; Prakash et al., 2023). There are already several reviews that address education in the Metaverse (e.g., Roy et al., 2023; Samala et al., 2023; Sunardi et al., 2022; Tlili et al., 2022). Recent literature reviews focus on bibliometric aspects (X. Chen et al., 2023; De Felice et al., 2023) or a limited number of articles (Asiksoy, 2023; Chamorro-Atalaya et al., 2023; López-Belmonte et al., 2023). They also cover specific solutions like Roblox in educational settings (J. Han et al., 2023), student engagement in the Metaverse (Asiksoy, 2023), or virtual/augmented reality (Chua & Yu, 2023). Roy et al. (2023) and Tlili et al. (2022) provide comprehensive insights into the Metaverse in education but identify the need for further research. De Felice et al. (2023) recommend continuously reviewing developments in the Metaverse. The Metaverse in higher education is only considered by Chamorro-Atalaya et al. (2023). However, they only included 16 articles in their systematic literature review (SLR), all published before 2020. Higher education is a constantly evolving sector, making it a favorable field for applying disruptive technologies (Zuñiga et al., 2021). Our work aims to present a current holistic overview of the Metaverse research in higher education by conducting a SLR. To this aim, we derive two main research questions:

RQ 1: What is the status quo of research on Metaverse in higher education?
RQ 2: Which future research directions exist in Metaverse in higher education?

Our paper is structured as follows: detailed methodology (section 2), results and future research areas (sections 3 & 4), and key findings in the conclusion.

2 Methodology

We conducted a SLR based on Page et al. (2021) and Schoormann et al. (2021). Our search spanned the databases *AIS eLibrary, Taylor&Francis, ACM Digital Library*, *Scopus*, and *IEEE Xplore* to include journal articles and conference proceedings from interdisciplinary fields such as computer science, education, and pedagogy. The SLR was conducted in December 2023 using the following search phrase: *ALL ("Metaverse" AND "Education")*. Our search query yielded 5,539 hits. Figure 1, which is based on the PRISMA flowchart by Page et al. (2021), describes our selection process. Exclusions were based on criteria aligning with our research focus and article timeliness, namely: children, disability, the virtual world (VW), Second Life, systematic literature reviews, and languages other than English. VWs, like Second Life, experienced their hype around 2009 (Rinn, Khosrawi-Rad, et al., 2023). We consider these as precursors and part of the history of the Metaverse development. Due to the technological progress since then, we exclude both. Applying our predefined exclusion criteria, we narrowed down our dataset to 92 articles. Four coders, each with a background in business studies and information systems, systematically analyzed these using MAXQDA software, following Bandara et al. (2015). Their expertise spanned several relevant fields including game-based learning, virtual reality learning, artificial intelligence in education, and design science. We drew our initial deductive coding scheme from Duncan et al. (2012) taxonomy and our research goals. We utilized a coding manual as Mayring (2015) recommended for consistency. A peer review process was established for objectivity.

3 Results

The following morphological box following Ritchey (2011) previews the resulting coding categories.

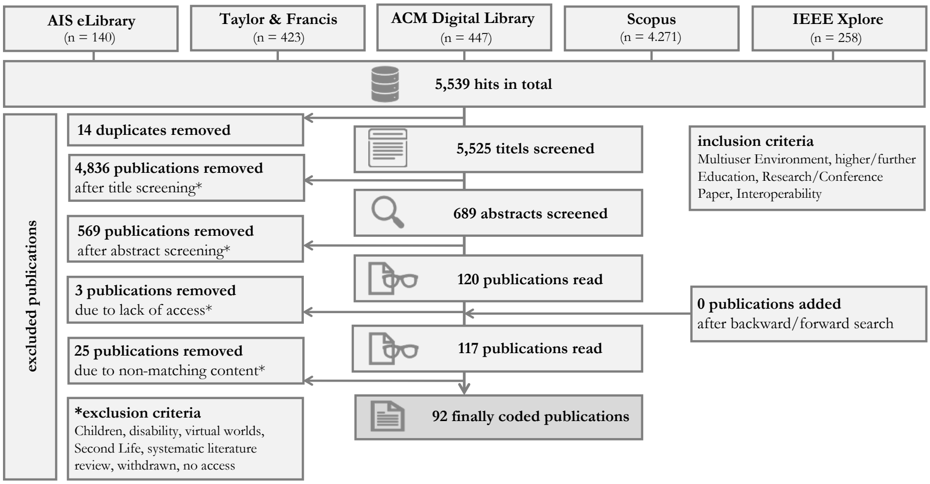

Figure 1: PRISMA Statement

Table 1: Morphological box on resulting categories

Definitions	Metaverse	Edu-Metaverse	Virtual World	
Type of Paper	Concept Paper	Prototype Paper		
	Model Development	Architecture Development		
Advantages	In General	Risk-free Learning	Fun & Motivating	Students Activation
	Game-based Learning	Adaptive & Individualized	High Learning Outcomes	
	Stimulating Learning	Curriculum Flexibility	Transferability to Practice	
Challenges	High Requirements	Users Health Concerns		
	High Costs	Usability	Data Privacy	
	Availability of Content	Fear of Losing Focus		
	Ethics & Principles	Accessibility	Inclusiveness	
Type of Metaverse	Virtual World	AR	Mirror Worlds	Life Logging
Technologies	VR	AI	AR	Blockchain & NFT

3.1 Definition of Metaverse

There is yet no uniform definition for the Metaverse. 77 of the 92 coded papers contain a definition of the term Metaverse, 10 do not define it (e.g., C. Ho, 2022; Iakovides et al., 2022; D. Yu, 2022), 1 defines VWs and 4 define the Edu-Metaverse instead. Regarding the term origin, there are two approaches found: the science fiction novel that spawned the term (e.g., Mantoro et al., 2022; Troja et al., 2023; Y. Zhang et al., 2022) and the word creation (e.g., Iwanaga et al., 2023; J. Lee & Jang, 2023; J.-E. Yu, 2022). Since the Metaverse is yet an outlook in many aspects, the definitions are at least partially prescriptive. There are two directions and a combination of both that was found. First, the technology-oriented definitions that describe how the Metaverse should be built. Second, the vision-oriented perspective explains in varying degrees of detail what action the Metaverse will allow us to do. These can be general like communication and social interaction (e.g., Jacobs et al., 2023; Mitra, 2023) or specific like synchronous learning (e.g., Almarzouqi et al., 2022) or virtual field trips and museum visits (Abraham et al., 2023). The 77 definitions contain one or more references. The most cited references are Mystakidis (2022) with 11 citations, Kye et al. (2021) with 7, Park & Kim (2022), and Hwang & Chien (2022) with 5 citations each. There are 31 definitions without a reference (e.g., W. Ho & Lee, 2023; Kim et al., 2023; Yue, 2022). The aspects taken from Mystakidis (2022) are the Metaverse being described as a multi-user VW combining physical and virtual reality. This computer-generated world is decentralized and persistent, enabling inhabitants to communicate and interact with each other (e.g., Al-Kfairy et al., 2022; Mitra, 2023). Economic and cultural usage examples are named (Wu et al., 2023). Technologies cited are virtual, augmented, and mixed reality, AI, and blockchain (e.g., Mitra, 2023; Onecha et al., 2023). Kye et al. (2021) are referenced when defining the Metaverse as an interactive, three-dimensional environment not limited to the VW, entered with a smartphone or computer via the internet (e.g., Iwanaga et al., 2023; J.-E. Yu, 2022). Park & Kim (2022) are cited with aspects combining reality and virtuality with technologies like augmented and virtual reality (e.g., Z. Chen, 2022; Joshi & Pramod, 2023). But they are also referenced for Second Life being classified as Metaverse (Al-Kfairy et al., 2022). Hwang & Chien (2022) are referenced for the Metaverse being a "new social connection method" (Pangsapa et al., 2023, p. 2).

3.2 Types of Paper

53 papers (58%) do not cover one specific field of education (e.g., Raj et al., 2023; Yuan et al., 2023) but are on education in general. Furthermore, there are four main types of research papers identified (Table 2).

Table 2: Types of Paper

Types of Paper	n	Reference Examples
Concept Paper	48	(Yuan et al., 2023; X. Zhang et al., 2022)
Prototype Paper	26	(Sin et al., 2023; Song et al., 2023)
Model Development	16	(Jacobs et al., 2023; Jang & Kim, 2023)
Architectural Development	2	(Abraham et al., 2023; Joshi & Pramod, 2023)

Concept papers dominate the analyzed literature with 48 mentions. These papers classify the Metaverse and its educational applications, emphasizing their potential and challenges (e.g., Al-Adwan & Al-Debei, 2023). **Prototype papers** present instantiations and evaluations. It is noticeable that virtual reality (VR) is primarily used (e.g., Araújo et al., 2023). It is often combined with augmented reality (AR) (e.g., López et al., 2022) or artificial intelligence (AI) (e.g., Z. Chen, 2022). These papers showcase diverse applications of the Metaverse, ranging from enhancing attention in virtual design classes (Araújo et al., 2023) to improving language skills (Cantone et al., 2023). The most common applications are virtual 3D classrooms. Ibili et al. (2023) describe a virtual classroom in "Spital" to teach computer hardware. They also explore the personalization of learning with AI-based systems (D. Yu, 2023) and the increase of student collaboration and playful engagement (Guillén-Yparrea & Hernández-Rodríguez, 2023). Gamification is used, e.g., in Damaševičius and Sidekersniene (2023) who added list rankings, badges, betting lists, and achievement levels for engagement and better learning outcomes. None of the prototype papers apply the design science research paradigm which ensures the prototype has a decent theoretical grounding (Hevner, 2007). Short papers dominate prototype papers (16 from 26) and concept papers (29 from 48). **Model development papers** focus on creating, formulating, or validating models. These models are mainly (10 out of 16 documents) based on well-established acceptance models like the Technology Acceptance Model (TAM) and Unified Theory of Acceptance and Use of Technology (UTAUT). For instance, Alhalaybeh et al. (2023) propose a model to assess user satisfaction, while Jacobs et al. (2023) add additional influencing factors in the context. Laine and Lee (2023) investigate and evaluate the presence, opportunities, challenges, and potential of collaborative applications of VR by simultaneous users. 13 of the 92 articles (14%; e.g., Al-Adwan & Al-Debei, 2023; Kalınkara & Özdemir, 2023) deal with aspects of acceptance research that emerged in the 1980s (e.g., Davis, 1989). **Architectural development papers** focus on creating and analyzing digital structures and frameworks. For instance, Joshi & Pramod (2023) describe a decentralized architecture.

3.3 Advantages of Metaverse

Advantages of the Metaverse were coded if they could be evaluated as a result of the analyzed article, but not if they came exclusively from references. We clustered the exploratory collected benefits into two areas: "Metaverse in General" and "Metaverse in Education". This division allows us to distinguish underlying general and context-specific characteristics reflected in Table 3 and Table 4. In total, 54 of the 92 articles (59%) analyzed benefits.

Table 3: Advantages of the Metaverse in General

Advantages of Metaverse in General	n	Reference Examples
Immersive Experience	28	(N. Lee & Jo, 2023; Y. Zhang et al., 2022)
Social & Collaborative	22	(G.-J. Hwang et al., 2023; Lin et al., 2022)
Location Flexibility	16	(Al-Kfairy et al., 2022; Hussain, 2023)
Time Flexibility	13	(Hines & Netland, 2022; Lin et al., 2022)
Saving Costs	11	(Al-Kfairy et al., 2022; Braguez et al., 2023)
Customization/Creation	9	(Kim et al., 2023; López et al., 2022)
Equality	8	(Braguez et al., 2023; Hussain, 2023)
Visualization	8	(Lin et al., 2022; Onecha et al., 2023)
Saving Environment	7	(Al-Kfairy et al., 2022; Hussain, 2023)
Interactivity	5	(Braguez et al., 2023; Zhao et al., 2022)

Due to educational innovation, the most frequently cited benefit is that the Metaverse enhances students' fun and motivation. Furthermore, the possibility of adaptive and individualized learning (e.g., personalized content) is often highlighted, which is also associated with a high level of student activation. Practicing dangerous situations without risk is another advantage. Stimulating learning experience, partially playful, reports improved learning outcomes in early studies. The flexibility and transferability of learning from the virtual to the real world are other advantages that have not been discussed in detail in many articles.

Table 4: Advantages of the Metaverse in Education

Advantages of Metaverse in Education	n	Reference Examples
Fun & Motivating	22	(Alvarez et al., 2023)
Students' Activation	15	(Hedrick et al., 2022; W. Ho & Lee, 2023)
Game-based Learning	12	(Kim et al., 2023)
Adaptive & Individualized	11	(Fu & Pan, 2022; Kurniawan et al., 2023)
High Learning Outcomes	9	(Alvarez et al., 2023; Kshetri et al., 2022)
Risk-free Learning	8	(Kshetri et al., 2022; Ruwodo et al., 2022)
Stimulating Learning	8	(W. Ho & Lee, 2023; Y. Hwang, 2023)
Curriculum Flexibility	6	(Z. Chen, 2022; Lin et al., 2022)
Transferability to Practice	4	(Braguez et al., 2023)

3.4 Challenges of Metaverse

We explored the challenges and then clustered them. Table 5 shows the results. 36 (39 %) analyzed articles addressed the challenges of the Metaverse.

Table 5: Challenges of Metaverse

Challenges of Metaverse	n	Reference Examples
High Requirements	22	(Onecha et al., 2023; Troja et al., 2023)
High Costs	17	(Braguez et al., 2023; Z. Chen, 2022)
Data Privacy	16	(Al-Kfairy et al., 2022; López et al., 2022)
Ethics & Principles	9	(Z. Chen, 2022; Iwanaga et al., 2023)
Users Health Concerns	9	(Hines & Netland, 2022; Raj et al., 2023)
Usability	7	(Hedrick et al., 2022; Kim et al., 2023)
Availability of Content	6	(Onecha et al., 2023; Zhao et al., 2022)
Accessibility	5	(Abraham et al., 2023; Hussain, 2023)
Fear of Losing Focus	4	(Al-Kfairy et al., 2022; Troja et al., 2023)
Inclusiveness	4	(Hussain, 2023; Lin et al., 2022)

High requirements and costs were the top challenges mentioned. The requirements include high computational demands (e.g., Lin et al., 2022), but also equipment requirements (e.g., Abraham et al., 2023), necessary support services for different operating systems and devices (e.g., Z. Chen, 2022), time resources (e.g., Braguez et al., 2023), and digital literacy skills (e.g., Lin et al., 2022). Costs are mainly high development costs (e.g., Z. Chen, 2022), but also labor-intensive preparation (e.g., Hines & Netland, 2022). Students' concerns about their data and the security of the system were also frequently addressed. Ethical aspects and principles must be considered or created to regulate the Metaverse. In addition, the consideration of users' health concerns is important and integrates e.g., cybersickness (e.g., Braguez et al., 2023), disorientation, and risk of addiction (e.g., Z. Chen, 2022). Other challenges include current usability (often as beta software) and availability of educational content, in part due to high production costs. Accessibility, especially in remote areas, users' fear of losing concentration, and the risk that the Metaverse may offer less social interaction compared to current educational methods are some of the challenges mentioned as well as inclusiveness, but less often addressed in the analyzed articles.

3.5 Types of Metaverse

Out of a total of 92 fully analyzed articles, 90 addressed the types of the Metaverse according to the 2006 Metaverse Roadmap (Smart et al., 2007). Multiple nominations were possible. VW is mentioned 42 times (e.g., Pangsapa et al., 2023; Raj et al., 2023), AR is mentioned 20 times (e.g., X. Han et al., 2022; López et al., 2022), mirror worlds (MW) is mentioned 11 times (e.g., C. Ho, 2022; Iakovides et al., 2022) and lifelogging (LL) is mentioned 9 times (e.g., Mantoro et al., 2022; Wu et al., 2023).

VWs simulate a virtual environment, parallel to the physical world, in which users can interact via digital avatars. (Areepong et al., 2022). Studies highlight the role of VR, AR, and MR in fostering immersive learning (Al-Adwan & Al-Debei, 2023; Alhalaybeh, Alkhatib, et al., 2023). Platforms like "FrameVR" and "Virbela" offer virtual campus experiences including out-of-class activities (Frydenberg & Ohri, 2023; Liang et al., 2023). **AR** enriches the physical environment with interactive 3D elements in real time (BenedettDörr & BeatrysRuizAylon, 2023). It fosters immersive, collaborative experiences in a hybrid setting, meaning the synchronous encounter of physical and virtual participants (Alhalaybeh, Alkhatib, et al., 2023). AR can be combined with VR for extended reality (XR) (Alkhwaldi, 2023). **MWs** are VWs that copy a real area or building 1:1 (BenedettDörr & BeatrysRuizAylon, 2023), e.g., the virtual copy of Limassol University Library (Iakovides et al., 2022). These MWs are supplemented by technologies like "Azure Digital Twins" and the Internet of Things (IoT). These technologies provide synchronization with physical locations in addition to physical representation (Kryvenko & Chalyy, 2023). MWs may even include real-time location data (López et al., 2022). **LL** uses wearable technology to collect personal data (e.g., heart rate, sleep duration, steps, calorie expenditure), aiding in sectors like health, education, and well-being. It enables the recording of activity patterns, levels of engagement, and the impact on learning activities. (BenedettDörr & BeatrysRuizAylon, 2023; López et al., 2022).

3.6 Technologies

Frequent topics are VR with 23 mentions (e.g., Purahong et al., 2022; D. Yu, 2022), AI with 14 mentions (e.g., Z. Chen, 2022; Lin et al., 2022), AR with 12 mentions (e.g., López et al., 2022; Onecha et al., 2023) and blockchain and non-fungible tokens (NFT) with 12 mentions (e.g., Fu & Pan, 2022; Mantoro et al., 2022). Other technologies mentioned include 5G/6G (9 mentions), digital twins (8 mentions), XR (7 mentions), IoT (6 mentions), and others.

VR enhances immersive learning experiences with the use of head-mounted displays (Riva et al., 2007). Araujo et al. (2023) describe the use of "FrameVR", a software that allows 15 people to collaborate with or without a head-mounted display. Yu (2023) emphasizes that VR enables multisensory experiences through wearable devices and motion sensors e.g., for training chemical experiments and archeological excavations. Sin et al. (2023) show that VR engages students more, and their engagement can improve student performance, while Hines and Netland (2022) point to physical challenges caused by prolonged VR use. Furthermore, papers illustrate the growing role of **AI** in education within the Metaverse. For instance, AI-controlled NPC tutors are intended to support students individually in learning (Agrati, 2023). The accessibility and distribution of technological resources pose challenges especially when transferring large amounts of data (J. Lee & Kim, 2023). AI-enhanced educational programs use adaptive mechanisms to tailor learning based on individual student needs, capabilities, weaknesses, and interests (Weng et al., 2023; D. Yu, 2023). Generative AI is also used to design and adapt the environment and thus support teachers (W. Ho & Lee, 2023). **AR** is seen by Damaševičius & Sidekersniene (2023) as a key technology for interactive learning. They emphasize the need for simple, accessible AR content without programming skills. These include, e.g., 3D models of the environment, characters, and interactive objects or entire simulation scenarios, which may be adapted without much effort. Onecha et al. (2023) and Raj et al. (2023) emphasize the benefits of AR in augmenting the physical learning environment and providing real-time feedback. **Blockchain technology** is highlighted in theory to secure and personalize learning content while ensuring transparent and secure transactions in the Metaverse (Al-Adwan & Al-Debei, 2023; Mourtzis et al., 2023). It enables authentication and protection of digital rights (Weng et al., 2023) and forms the basis for economic interactions using NFTs and digital currencies (Joshi & Pramod, 2023; López et al., 2022).

4 Discussion of Research Gaps

We systematically elicited research gaps from the findings within our code system and gave hints on potential future research streams.

There is no clear definition of the Metaverse. Such inconsistency is not new and was already encountered by the predecessor VW in education (e.g., Girvan, 2018). However, it means that there are no clear distinction criteria for Metaverse towards VW. Hence, a comparison of study results e.g., for meta-studies is impossible. Instead, many papers paint a vision of the metaverse being the next generation of the internet being more social and added by technologies like VR, blockchain and other emerging technologies. Concept papers predominate over practical papers. These rather visionary concept papers reveal three times more benefits than challenges. This unbalanced view might arise from the lack of practical implementations. Disadvantages or challenges are likely to be still unknown. We recommend further practical research in combination with all compatible technologies. Technologies such as blockchain and 5G/6G have not yet arrived in practical research. However, these technologies are necessary to implement the vision of the Metaverse, which includes lawful contracts or ubiquitous access. This lack of emerging technologies in practice also reflects the level of prototypes that ignore data security, data protection, and ethical considerations. Furthermore, the educational field is not specified in most papers, which leads to a generalization that is insufficient for a successful transfer to practice. Since short papers dominate in concept and prototype papers, we conclude that the development is currently rapidly progressing, and the topic has high relevance within the research community. Since prototypes are still infant, disillusionment is likely to occur. In the context of model development type of papers, the predominant source model originates from acceptance research which evaluates the probability of future and regular use of an IT artefact within the target group. Furthermore, the prototypes lack an appropriate theoretical foundation in terms of design research. As a result, the instantiations remain context-bound and there is a lack of generalized and prescriptive design knowledge on future prototypes that could be built upon. Furthermore, this lack also exists in the pedagogical design of content for the Metaverse. In the context of VW, Rinn et al. (2023) proposed a fair-like course design for academic writing as part of a design science research study. Such blueprints or even reference books for teaching methodologies in the Metaverse are missing. These are necessary to increase the adoption of lecturers and scalability for faculties. As a result, 3D classroom environments are used in many contributions. These are often adopted without reflection and unchanged from face-to-face teaching. Consequently, the potentials such as virtual labs or gamified content are not fully exploited yet. These application examples require interactive 3D objects. Such labor-intensive adaptations and developments require low or no code editors for their broad application. Standardized formats for exchanging these between different Metaverses would further increase scalability and efficiency.

5 Conclusion

We conducted an SLR and identified 92 relevant articles we included in our analysis. To answer RQ1 we found the following main categories: Definitions, advantages, and challenges, different types of the Metaverse, and included emerging technologies. To answer RQ2 we identified research gaps, discussed them with research findings from the community, and derived research streams for future research. These are summarized in the following figure.

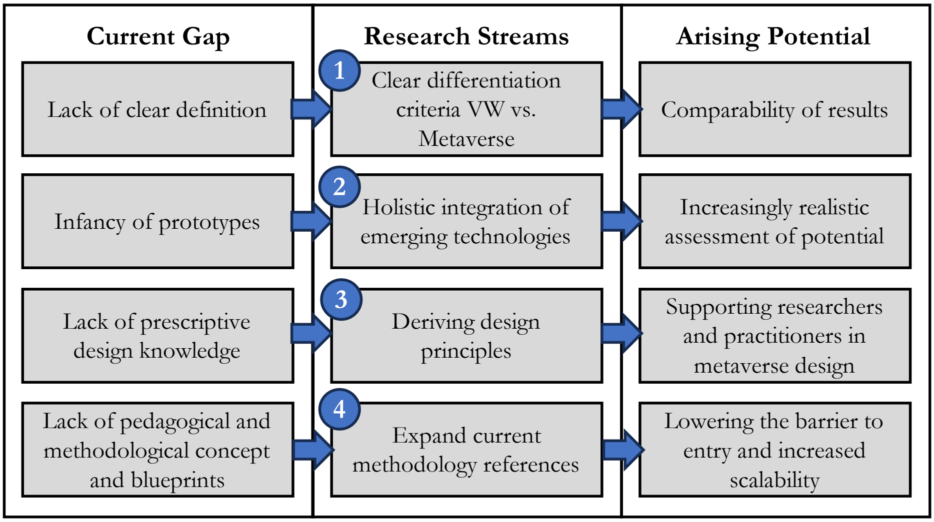

Figure 2: Overview of future research streams

This publication is subject to restrictions. Additional search databases, languages, and search term synonyms may lead to different results. Despite the peer review for paper selection and coding, the process still produces subjectivity.

The study reveals implications for research and practice. We identified research gaps and future research directions. The integrations of technologies like 5G/6G and blockchain are rather theoretical at this point in time, practical evaluations and artifacts are still missing. Furthermore, theoretically sound guidelines should be developed to address spatial design in the Metaverse. In practice, our study provides a starting point for the conceptualization and implementation of the Metaverse in educational contexts. For a practical application in a regular operation at educational institutions, data privacy and security should be considered.

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