What is the metaverse? Definitions, technologies and the community of inquiry

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The term *metaverse* appeared for the first time in a novel published in 1992. Since the early 2000s, researchers have started to use this term to refer to digital technologies for learners to interact with other users with avatars. The term came to prominence in around 2020 due to the rebranding of Facebook. However, there was no consensus on what kind of technologies should belong to the metaverse and how to conceptualise the term. As such, this paper presents an exploratory review for conceptualising the metaverse based on 19 articles from the Web of Science database. This review focuses on the metaverse trend, how researchers in the past and present conceptualizing the term, and key technologies identified in the metaverse world. The findings identify the major types of technologies used in the metaverse studies and offers a sound theoretical foundation in terms of cognitive, social and teacher presence to understand what future potential of these technologies could bring to online learning. Five major types of technologies are identified which could map to four key elements of the metaverse (i.e., immersion, advanced computing, socialisation, decentralisation). At the end, a model is proposed to connect the key elements of the metaverse and its three presences in the community of inquiry that enhance students' learning outcomes in the metaverse learning environment.

Implications for practice or policy:

- Educators and researchers could rethink what types of technologies belong to the metaverse and how it has the potential to influence the education sector.
- Instructional designers could create meaningful learning experiences through the four key elements of the metaverse – immersion, advanced computing, socialisation and decentralisation.
- Policy-makers and educators could refer to the model of metaverse learning environment to guide their future policy and practices.

Keywords: metaverse, avatar, exploratory review, community of inquiry, virtual reality

Introduction

The term *metaverse* appeared for its first time in the novel *Snow Crash*, published in 1992 by a cyberpunk writer, Neal Stephenson (Díaz et al., 2020). Over the decades, educational researchers have used this term to describe how learners engage and socialise in the metaverse using digital technologies such as augmented reality (AR), virtual reality (VR) and mixed reality (Di Natale et al., 2020), avatar-based learning platforms (Jin, 2011) and Second Life software (Cheng, 2014). The metaverse takes advantage of technological advancements. A decade ago, the metaverse was considered as a virtual space for real-world socialisation, where learners used avatars or life-like identities and interacted with others (Schlemmer et al., 2009). With technological advancements in recent years, innovative technologies such as artificial intelligence (AI), blockchain, advanced mobile networks with 5G and the Internet of Things have been incorporated in the virtual world. The metaverse is considered as an immersive, three-dimensional (3D), virtual and multi-user online environment (Díaz et al., 2020; French et al., 2021). Second Life has been an important virtual world platform for 20 years (Warburton, 2009). At first, this early desktop-based iteration of the metaverse included different virtual worlds and agent-based social simulation platforms (e.g., The Sims, OpenSimulator) (Hazan et al., 2022; Mystakidis, 2022). However, with more emerging technologies such as VR, the metaverse has emphasised a more social, simulated and collaborative authentic experience that links different virtual objects and people displayed as interactive multimedia formats (Gandasegui, 2013; Huh, 2022).

The term came to prominence in around 2020 (Kanterman & Naidu, 2021). The world's largest online social network Facebook rebranded itself to Meta, which indicated a shift in how students engaged in the new digital world (Stassen, 2021). However, researchers have interpreted and used the term in diverse

ways. The rapid and unprecedented teaching modality shift as a response to the pandemic has encouraged educators to engage students in learning in alternative modes of communication and collaboration in a virtual world (Henriksen et al., 2020).

With this background, the term metaverse presents transformational new opportunities across industries to enhance user experience, through engaging in social activities such as having meetings, collaborating on projects, playing games and learning in virtual environments (Hwang & Chien, 2022). Although some may argue that the metaverse is merely a new term for existing technologies, it is much more (Park & Kim, 2022). Metaverse should be different from conventional terms since it offers other features of "shared", "persistent" and "decentralised" (Hwang & Chien, 2022, p. 2). Simulation, AR and VR could merely present the virtual content and environment, and not provide a shared social connection between learners. Although multi-user interactive systems such as Second Life can enable people to adopt new identities and interact with others, they are unable to offer a persistent world or culture that enables users to live, work, learn and create. With decentralised technologies (e.g., blockchains, non-fungible tokens), users' personal property and logs in the metaverse can be protected to ensure the safety of economic activities (Hwang & Chien, 2022). Therefore, strictly speaking, defining whether a technology belongs to the metaverse should involve more than consideration of whether it has AR, VR, simulation or Second Life applications. Instead, people should take these embodied features (i.e., "shared", "persistent" and "decentralised") into account to combine and implement these technologies into a brand-new perspective on educational technology.

I identified several research gaps. First, there was no consensus on what kind of technologies should belong to the metaverse world. Moreover, few studies explored how the meaning of metaverse has changed and what educational theories should be used to conceptualise the term. I first examined the definitions of the metaverse mentioned by researchers and identified the common conceptualisation across them. After exploring how researchers defined the term with examples, I identified the major types of technologies used in the studies and developed a sound theoretical foundation in terms of cognitive, social and teacher presence to understand how metaverse technologies could bring potential to online learning. I came up with four research questions:

- RQ1. What is the metaverse trend and why does the trend suddenly emerge in 2020?
- RQ2. How have researchers defined the term *metaverse*?
- RQ3. What key technologies have been identified in the metaverse world?
- RQ4. How could the metaverse potentially be connected to the community of inquiry?

Literature review

Origin and definition of the metaverse

Researchers have interpreted and used the term *metaverse* in diverse ways. Ondrejka (2004) first described it as an online environment and as a real place for users to interact and socialise with others, conduct business and entertain themselves using the real world as a metaphor. However, at that time, creating the metaverse was technically impossible. Years later, with technological advancement, the time has come to rehabilitate the idea of the metaverse that 3D graphics allow. Network connectivity and bandwidth enable users to explore how to create digital content collaboratively in the digital games called MMORPGs. Players can convert creations into real-world capital and wealth (Ondrejka, 2004).

Dionisio et al. (2013) conceptualised the term *metaverse* in terms of the prefix "meta" (meaning "beyond") and the suffix "verse" (meaning "universe"). Dionisio et al. (2013, p. 7) referred to the term as "a computer-generated world beyond the physical world that is a fully immersive 3D digital environment that reflects the totality of shared online space across all dimensions of representation". With advances in technology, the metaverse became a large network of interconnected virtual worlds, instead of merely individual virtual worlds (Dionisio et al., 2013). The fourth Industrial Revolution saw the rapid development of technology, industries, and societal environments and processes in the 21st century due to the growth of innovative technologies such as blockchain, AI, AR and VR and advanced mobile networks (French et al., 2021; Philbeck & Davis, 2018).

With these advances, the metaverse came to the forefront in around 2020 (Kanterman & Naidu, 2021). The metaverse revenue opportunity was recorded in 2020 as about $500 billion; it is estimated to reach $800 billion in 2024 (Kanterman & Naidu, 2021). Facebook defined it as a new phase of interconnected virtual experiences using technologies like VR and AR that users can hang out with friends, work, play, learn, shop, create and more (Stassen, 2021). The enhanced social activities in the metaverse require a new definition. Several researchers have proposed the essential concepts and technologies of the metaverse. Hollensen et al. (2022) proposed eight blocks that are crucial to the metaverse in the business world: hardware; networking; computing; virtual platforms; interchange standards and tools; payment; content services and assets; and consumer and business behaviours. Ball (2022, p. 29) referred to the metaverse as "a massively scaled and interoperable network of real-time 3D virtual worlds in which users can experience synchronously and persistently with unlimited numbers of other users, and with continuity of data such as identity, entitlements, objects, communications and payments". Park and Kim (2022) based the definition on the social value of Generation Z that online and offline selves are indifferent. Their paper proposed essential technologies for realising the metaverse into three dimensions (hardware, software and content) and three approaches (user interaction, implementation and application). Kye et al. (2021) presented four types of the metaverse (AR, lifelogging, mirror worlds, virtual worlds).

Metaverse as a community of inquiry (CoI)

Although there are no theories or pedagogical frameworks on how metaverse technologies influence educational fields, the intersection of networked virtual worlds and online learning could create meaningful experiences for learners (Keskitalo et al., 2011; Mystakidis et al., 2021). Recent studies have suggested the need to connect the metaverse to pedagogical theories and redefine these theories taking into account the features of the metaverse.

Metaverse technologies have been identified as intersecting with a CoI, which is worth further exploration. Keskitalo et al. (2011) identified the use of Second Life as process characteristics of meaningful learning that were released during the learning process in a virtual world. In that study, they discussed that students preferred collaborative activities in Second Life, which might lead to the creation of a CoI. A study conducted by Mystakidis et al. (2021) suggested the use of a CoI, where students could build their personal connections to establish collaboration, communication and social presence, thus offering deep and meaningful learning experiences for students in social VR environments. I have highlighted the importance of social and cognitive support to discuss how to foster students' engagement in an aviation virtual laboratory setting with the use of flight simulation and virtual tours (Ng, 2022a, 2022b). Similarly, Williams et al. (2022) integrated meaningful learning in VR organic chemistry laboratories to provide immersive and realistic experiences for students, and reduce students' attendance challenges and safety concerns. These studies used the CoI framework as the educational model to investigate students' knowledge and skill construction in the metaverse in terms of teacher, social and cognitive support/presences. The model offers the important roles of the three presences in the metaverse for students to gain knowledge and socialise with others through well-designed virtual learning activities.

Method

Search and manuscript selection process

To understand the term *metaverse* and its technologies involved, this review examined studies from 2009 to 2022 and analysed how researchers conceptualised the term. In search of literature on metaverse, I included both peer-reviewed articles and conference papers from K-12 to higher education levels published from a renowned database called the Web of Science. I included only educational studies from "Educational Research" and "Education Scientific Disciplines" in the database. I included and analysed articles that contained the phrase "metaverse" in either the title, the abstract, keywords or main text. The last search as of 21 March 2022 resulted in 27 articles.

After excluding irrelevant articles (e.g., editorial materials, book chapters), I identified a total of 19 studies. I reviewed the definitions of, and technologies used in the metaverse during the document analysis. To ensure the validity of the articles, I invited another online learning researcher to determine whether the examination is suitable for this study. During this analysis, I developed a coding table to answer the research

questions proposed in this study. I worked with a professional researcher to examine the articles together and ensured the generalisation of the findings to avoid bias.

Data coding and analysis processes

The full text of the selected articles was purposefully analysed in terms of its definitions and technologies used. This classification method is based on the constant comparative method (Kolb, 2012). Through studying the content in each study, the concepts of metaverse were identified for further thematic analysis. The text segments were extracted and coded under a coding scheme. Disagreements for all articles were resolved through discussing the disputed studies to reach a final decision. After validating the coding processes, the findings were then descriptively analysed and summarised according to their frequency, percentages and identified themes. This research implemented a quick review that focuses on how to conceptualise the term metaverse and identify technologies used in the studies. It focused on the educational settings in the metaverse world as an online community. As such, this suggested using the CoI framework in RQ3 to explain a process of creating a deep and meaningful (collaborative-constructivist) learning experience (Garrison et al., 2010). The framework is suitable for establishing a theoretical basis and for educators to conceptualise the term metaverse.

Results and discussion

RQ1. What is the metaverse trend and why does the trend suddenly emerge in 2020?

According to a Google Scholar search conducted on 21 March 2022, there was a steady trend of how people used the term *metaverse* in research publications from 2009 to 2020 (see Figure 1), until the largest social network company Facebook first announced its rebranding as Meta (Stassen, 2021). Since then, the term *metaverse* became suddenly popular again. The Web of Science search produced a consistent trend that before 2020, the term *metaverse* was not frequently mentioned. Among 19 selected studies, there were 15 (78.9%) articles from 2009 to 2019; however, after the rebranding, the use of the term grew. From 2020 to 2022, there were four articles (21%) mentioning the term.

Before 2020, different types of digital technologies were used to provide learners a computer-generated environment with digital functionalities such as online discussion and "networked collections of inexpensive, self-configuring and immersive environments" in the Internet driven world (Rospigliosi, 2022, p. 1). Students could interact with each other through social media tools, simulation software and avatar-based platforms. Recent technologies such as AR and VR and AI have emerged to provide users a deeper and embodied experience, not just looking at the digital artefacts (Kye et al., 2021; Reyes, 2020). Although the term *metaverse* was not widely used before 2020, its related technologies were widely discussed in educational studies (Cheng, 2014; Tseng et al., 2013). These researchers did not explicitly claim these as a metaverse technologies. However, why does the use of the term *metaverse* suddenly emerge in around 2020?

As cited by Stassen (2021), Mark Zuckerberg announced that Facebook has changed its name to Meta in 2021. This suggested the move from merely offering a social media environment to an embodied virtual experience in which users and learners are more engaged in the metaverse, going from plain to rich-media technologies. In addition to the impact of the Facebook remarketing, the pandemic has catalysed the digital transformation accelerating the utilisation of varied emerging technologies in the Internet world (Henriksen et al., 2020; W. Suh & Ahn, 2022). Digital technologies serve to provide users and learners to visualise concepts, communicate through digital identities of avatars and interact in different platforms. These technologies provide learners with realistic, authentic and engaging online learning experience (Ng et al., 2020). Metaverse breaks down the social boundaries between people using a combination of digital technologies. For example, simulation is another quintessential aspect of VR with the potential to reshape education (Pellas et al., 2021; Williams et al., 2022). Simulation technologies such as virtual laboratories, tours and visits can sustain people's authentic problem-solving and site visiting experience via digital formats, which could hardly be conducted online due to the pandemic (Díaz et al., 2020; Ng, 2022a, 2022b; Studente et al., 2021). AI offers intelligence agents that imitate human behaviours in a digital world; as a result, learners cannot tell whether the agent is a real person or not (Reyes, 2020). It also connects with other AI technologies to analyse learners' behaviour in the metaverse, expand the immersive world and create contents (Hwang & Chien, 2022).

The pandemic has accelerated the growth of metaverse that sustains students' learning to enhance their knowledge and skills acquisition, their communication and collaboration skills. As such, studies after 2020 have shed light on interactive multimedia formats, advanced computing technologies as well as collaboration and communication features to enhance students' online learning experience (e.g., Hollensen et al., 2022; Ng et al., 2020). These enhanced features in the metaverse enable students to learn in new ways that interconnect virtual experiences with advanced networks (Stassen, 2021). This requires hardware, networking, computing and virtual platforms with interoperable digital tools to facilitate users to easily access and interact with different metaverse technologies (Hollensen et al., 2022). Therefore, the connection between these studies using educational technologies and the metaverse demonstrates a new learning ecosystem.

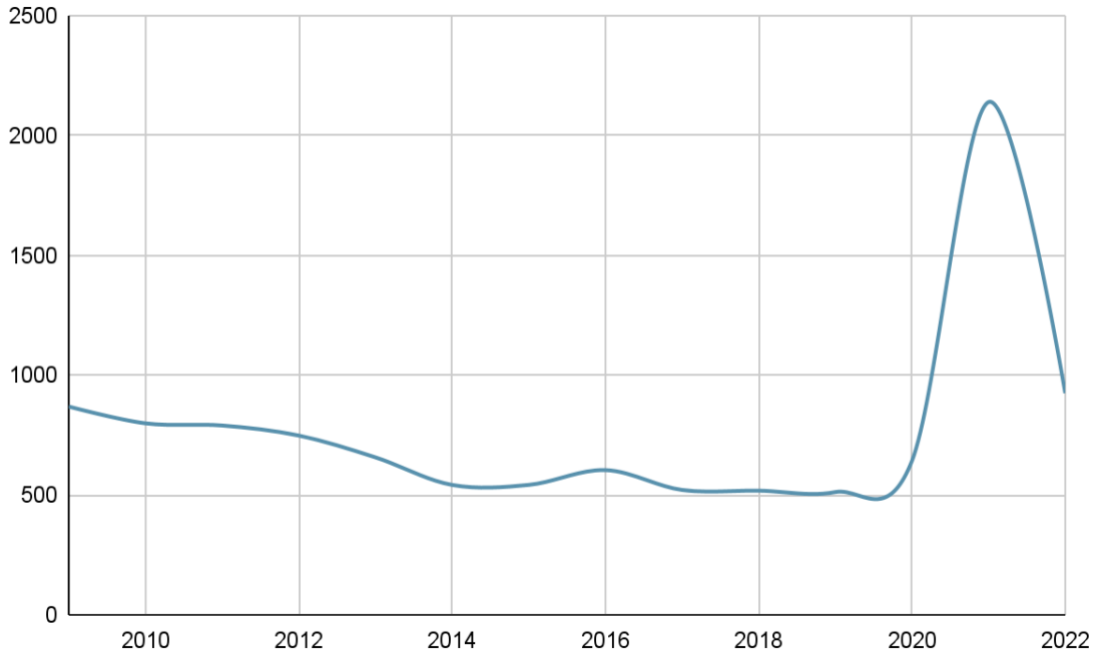

Figure 1. Growth of metaverse in Google Scholar (2022)

RQ2. How have researchers defined the term *metaverse*?

To answer this question, this section explains how researchers have defined and used the term *metaverse* before and after 2020. From late 2000s to mid-2010s, researchers have discussed the term *metaverse* across digital or virtual settings such as gamifications and avatar-based learning platforms. Schlemmer et al. (2009) defined metaverse as 3D digital virtual worlds that allow the people to live in them and build their identities through their avatars and digital bodies. Life-like private and public utility could extend the physical world's real space within an Internet virtual space. Metaverse generates a mix of technologies to offer new scenarios and experiences of learning where the teacher's role turns from knowledge transmitter to students' guidance to access information (Garcia, 2010). With this, metaverse provides opportunities for many subject disciplines, such as language and engineering education, so that learners can act, solve problems and communicate within the online environment. Students can apply innovative ideas for second-language acquisition and examine the potential of various pedagogies in English and Spanish language courses (Dominguez-Noriega et al., 2011). They can collaborate and interact with each other to solve problems (Aziz & McKenzie, 2020; Tarouco et al., 2013), and display interactive media and objects via engineering simulations and experiments (Schaf, 2012). Metaverse gives an immersive, 3D, virtual and multi-user environment which allows people to socialise with each other (Arcila, 2014). Metaverse takes advantage of technological advancements. Although different types of technologies have been mentioned in different contexts, one common point is that metaverse can make a virtual world that generates different authentic learning scenarios to enrich students' learning experience and enhance their motivation.

After the mid-2010s, although AR and VR technologies became more mature, the definitions of metaverse did not vary substantially. Barahona et al. (2016) described metaverse as a 3D simulated environment that encourages communication, interaction and collaboration and provides active agents to construct students' learning process. They observed two types of communication. First, users and learners interacted with digital objects (e.g., laboratory apparatus, environment, machines) in the virtual platforms. Second, they interacted with other participants to develop and promote multi-user role-playing environments. Metaverse will become a hot topic again. Based on my analysis, the meanings of metaverse do not have great changes. According to Díaz et al. (2020), metaverse provides virtual spaces that imitate the real-world recreation, learning and living of those learners who use an avatar to interact with other users just like everyday lives. Metaverse is a fictitious construction in which participants interact through avatars created by themselves trying to reproduce participation or real life in a virtual metaphor environment without space-time limitations.

A study conducted by Kye et al. (2021) described metaverse as a space for new social communication with freedom for learners to create and share their thoughts, ideas and digital artefacts with a high immersion through virtualisation. The virtual world is not limited to a multi-user interactive learning environment focusing on communication and collaboration; instead, in recent years, metaverse has offered more immersive experiences to scaffold mathematical knowledge (Reyes, 2020) and healthcare and medicine training (Kye et al., 2021). It is not limited to a 2D digital space to use avatars to socialise, talk and communicate with each other through simulations, interactive whiteboards and Second Life software. Furthermore, learners can behave more dynamically, such as doing experiments, conducting virtual visits in hospitals (Huh, 2022) and visualising mathematical concepts (Reyes, 2020) in a 3D environment.

Although several definitions of metaverse have been proposed, the common idea is that metaverse is a 3D digital virtual world that enables people to "live" and "learn" through their avatars in immersive learning environments. Other than similarities, a study conducted by Reyes (2020) gave the most complete description of the metaverse in terms of three concepts: interactivity, corporeity and persistence. First, interactivity enables users to interact and communicate with others in the metaverse. Although existing platforms (e.g., Facebook, Snapchat) can implement this concept, they expand the possibilities of global interaction and link other technologies within the virtual world that facilitates a dynamic learning scenario of autonomous and collaborative learning (Reyes, 2020). Second, corporeity enables learners to represent themselves as avatars. With a higher computing power, technical challenges could be overcome with new servers and high bandwidth to present learners a high degree of immersion and interactivity. Third, persistence creates a virtual world that imitates the real-world settings that digital content can be saved and retrieved once learners are reconnected to the virtual world (Reyes, 2020). In the future, avatars can be AI-empowered so that they can learn from its user via machine learning and imitate humans to make decisions within the virtual world while it is disconnected (Hwang & Chien, 2022).

RQ3. What key technologies have been identified in the metaverse world?

This section summarises the types of technologies found in the metaverse studies. There are five major types: AR and VR; avatar-based and Second Life systems; learning management systems and social media; simulation; and AI (see Figure 2).

AR and VR

Ten of the selected articles have shown that AR and VR technology offers many advantages when used in educational settings (Di Natale et al., 2020; Radianti et al., 2020). AR facilitates students to engage in authentic explorations through displaying virtual elements alongside real objects in the real world. Researchers have identified that people can visualise objects and concepts that cannot easily be observed with the naked eye (Reyes, 2020). Research has shown its effectiveness in increasing students' motivation and knowledge and skills acquisition. It combines digital and physical objects, which create immersive learning environments for learners to develop practical skills (Huh, 2022) and processing skills (e.g., communication, critical thinking, problem-solving) (Potkonjak et al., 2016). Moreover, researchers agree on immersion, presence and interactivity that VR technologies that made it increasingly attractive to educators. VR offers learners "the subjective experience of being in one place or environment, even when one is physically situated in another" (Witmer & Singer, 1998, as cited in Radianti et al., 2020). Researchers suggest VR learning environments can facilitate learners in gaining positive effects from immersion

(Schlemmer et al., 2009) and interactivity to enhance their learning outcomes (Díaz et al., 2020), and collaboration and communication in online settings (Wagner et al., 2013).

Avatar-based and Second Life systems

Among the studies, avatar-based and Second Life systems are popular virtual environments that provide entertainment mediums for multiplayer online gaming and social networking (Gregory & Masters, 2012). This offers students great possibilities for socialising and interacting with virtual objects and actors via online settings (Chow et al., 2012; Jin, 2011). Metaverse studies have applied avatar-based and Second Life systems communication for language, business, engineering and medical education. 3D multi-user virtual environments have been used in various settings to allow users to construct avatars and virtual bodies, interact and solve problems with others in realistic scenarios using verbal and non-verbal interactions (Díaz et al., 2020; Gandasegui, 2013; Schlemmer et al., 2009). For example, students can undertake role-playing activities in personalised settings through avatars. Tseng et al. (2013) examined the learning perceptions of 38 student teachers of second language interaction to teach Chinese as a foreign language in a 3D multi-user virtual classroom. On top of providing opportunities for socialisation, metaverse offers an important driver in the development of safe and virtual environments to conduct virtual laboratories (Kye et al., 2021). Furthermore, these environments are attractive for students for applying their knowledge without endangering other people (e.g., patients, engineers). They provide students with social and cognitive support so that they can gain knowledge through visualising the concepts and participating in hands-on experiences in a virtual environment.

Learning management systems and social media

Learning management systems (LMSs) offer an online environment for teachers to administer, document and arrange online lessons. Studies have demonstrated LMSs can improve students' learning experience, facilitate learning management and develop their understanding on certain topics (Kasim & Khalid, 2016). Similarly, social networking sites have also been used as an LMS but focused more on socialisation, collaboration and communication (Chu, 2020). The two platforms allow learners to discuss and communicate using visual identities for learning objectives. For example, Facebook is a popular social network site (SNS) that is useful not only for developing interpersonal relationships and interaction but also for enabling the sharing of articles, multimedia files, knowledge and views (Rambe, 2013; Staines & Lauchs, 2013). It is a form of information and communication technology that offers rich socio-technical features for informal learning (Greenhow & Askari, 2017).

Although some may not consider 2D web-based systems (e.g., LMSs, SNSs) to be a type of metaverse technologies, they can facilitate learners in enriching their metaverse learning experience. The metaverse has become an extension of social media (e.g., Facebook, Instagram, Snapchat), adding immersion into these platforms, which brings new experiences to learners and users in the virtual world (Gentina et al., 2021; Reyes, 2020). This will generate a dynamic educational scenario of autonomous and collaborative learning that allows learners to access the resources available in the virtual world (e.g., Second Life software, virtual reality) (Díaz et al., 2020; Dominguez-Noriega et al., 2011). In recent years, LMSs and social media have started to combine avatar, virtual identities, or even AI elements that enrich user experience to socialise with others. Facebook's metaverse has brought the trend of incorporating AR headsets and Second Life immersive worlds into social media (Mohasseb, 2021). According to Mark Zuckerberg (as cited in Rospigliosi, 2022, p. 1), metaverse can allow "people at the office without a commute, at a concert with friends, or in your parents' living room to catch up, which is an embodied internet where you're in the experience, not just looking at it". This statement is also supported by other studies that metaverse needs interconnected platforms that can link up different devices and platforms (Hollensen et al., 2022; Mystakidis, 2022). Metaverse could interconnect with hardware and software into LMSs and SNSs (Hollensen et al., 2022). Therefore, LMSs and social media are no longer merely platforms to store, share and create content and posts. Instead, LMSs and SNSs can incorporate metaverse technologies to enable learners to socialise in an authentic and lifelogging world, as well as record, share and accumulate their everyday life activities (e.g., using AR in Facebook) (Tlili et al., 2022).

Simulation

Simulation is a technology that effectively improves students' knowledge, skills and behaviours, which enables students to physically participate in authentic scenarios replicating real-world practice (O'Regan et al., 2016; Rooney & Nyström, 2018). It has been reported as an effective replacement for clinical hours for students in medical education, engineering practices, business communication and scientific experiments

(Arcila, 2014; Pinchuk et al., 2017). Dai and Bal (2009) used simulation to provide virtual learning environments for problem-solving and game creations. It encourages learners' communication and collaboration by allowing them to be active agents in the construction of their learning process through interaction between participant and objects and between participants (Barahona et al., 2016). With more high-quality multimedia resources in virtual environments, future virtual games, AR and VR, Second Life games, Minecraft, Roblox and simulation games that build and shape authentic environments for socialisation, learning and working will become near-ubiquitous (Ng, 2022b; Pinchuk et al., 2017).

AI

AI has spread across industries including business, science, art, education to enhance user experience, increase work efficiency, and create job opportunities (Ng et al., 2021a, 2021b). Although researchers have seldom discussed how to add AI elements into the virtual world, some have started to incorporate data mining and autonomous tutors in their metaverse platform. Díaz et al. (2020) designed a metaverse environment that allows learners to function and develop their positions, conversations and property objects. They foresaw that in a future virtual world avatar will integrate with AI, where they learn from their user and make decisions to give autonomous responses. Schaf et al. (2012) gave an example of an autonomous tutoring system employed in distance education scenarios and based on data mining user interactions, providing students with guidance and feedback. In another example, learners can interact with smart devices such as wearable displays and computer agents to interact in a metaverse (Lee et al., 2021). With these AI features, metaverse could enhance students' online learning, acceptance of technologies and learning motivation.

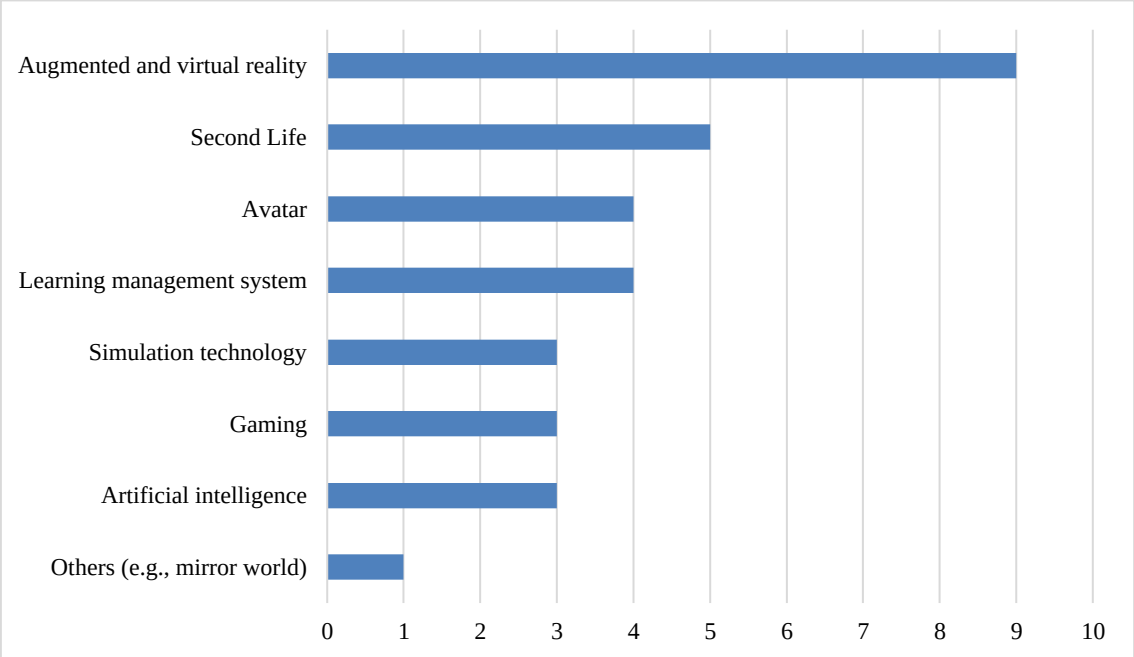

Figure 2. Types of technologies used in a metaverse
Note. The technologies can be mentioned more than once in an article.

A proposal: Four key components of metaverse

This section presents the major technological components of the metaverse. I suggest that metaverse is a combinatorial technological innovation that brings existing technologies together to create exponential gains in (educational) values and applications. Instead of using previous terms, prior studies present transformational new opportunities in the educational field to enhance learner experience in terms of knowledge gain, collaboration and communication (Díaz et al., 2020; Rospigliosi, 2022). Therefore, there is a need to understand the new term that offers other features in metaverse-based contexts to enhance the values of existing technological affordances (Hwang & Chien, 2022). Several studies have tried to map the major technologies to a set of key components of metaverse; for example, Hwang and Chien's (2022) three features (i.e., shared, persistent and decentralised), Hollensen et al.'s (2022) eight building blocks, Kye et

al.'s (2021) two axes (i.e., intimate versus external, and augmentation versus simulation), and Reyes's (2020) interactivity, corporeity and persistence. Likewise, this study proposes four key components of metaverse: immersion, advanced computing, socialisation and decentralisation (see Figure 3).

- *Immersion.* Immersive technology is a technology that blurs the boundary between the physical and virtual environment in a way that enables users and learners to experience a sense of immersion through AR and VR (A. Suh & Prophet, 2018). A metaverse could be a fully virtual world like a VR system, or a partially virtual world like the use of AR in real-world contexts (Mystakidis, 2022; Tlili et al., 2022). Immersive technologies enhance learning experiences, foster participation and collaboration, enhance students' creativity and engagement (A. Suh & Prophet, 2018).
- *Advanced computing.* With advanced computing technologies, technical challenges could be overcome with new servers and high bandwidth to present users/learners a high degree of immersion and interactivity (Hollensen et al., 2022). The high computational power enables AI to simulate authentic environments (e.g., plant and animal growth as time passes) and act like humans in the metaverse via non-player characters. The platform developers could program the pre-defined rules and consequences to engage learners to work and learn with intelligent agents.
- *Socialisation.* Learners can create their digital avatars and profiles in the metaverse in ways in which students can socialise with others through online discussion, project collaboration, entertaining and creating, and experiencing scenarios and solving problems in authentic settings (Park & Kim, 2022). It enables learners to have digital identities that act like real persons (Díaz et al., 2020; Kye et al., 2021).
- *Decentralisation.* In the business world, blockchains and digital currencies have become a common form of payment in the metaverse, and non-fungible tokens enable people to manage assets and digital certificates without a centralised authority (Hollensen et al., 2022). In the educational field, the use of blockchains and cryptocurrencies is not very common (Loukil et al., 2021), and decentralisation technologies were not identified across the selected studies. This element can be optional until more publications illustrate its successful implementations.

RQ4. How could the metaverse potentially be connected to the CoI?

Although none of the articles mentioned educational theories or theoretical frameworks, some common ideas were mentioned. With the four key elements of metaverse proposed in RQ3, metaverse could interconnect existing technologies and offer a combinatorial technological innovation that enhances students' learning performance in terms of social and cognitive gains. As suggested by recent studies, there is a need to connect the metaverse to existing pedagogical theories and refine the theories by taking into account the important components of the metaverse. This section elaborates on the evidence and discusses how metaverse could be potentially mapped to the CoI framework (see Table 1). Studies have shown rich evidence of metaverse as online communities for supporting collaboration and communication and enhancing students' cognitive learning gain (Keskitalo et al., 2011; Mystakidis et al., 2021).

Table 1
Coding framework of social, cognitive and teacher presence (adapted from Garrison, 2007)

Presence	Definition	Sample references	Indicators
Social presence	Subjective experience of being present with a "real" person and gaining access to their thoughts and emotions	Scalable *sociability*, the use of social media on *social networks* as a way of keeping in touch with family and friends (Rospigliosi, 2022, p. 2).	Expression, communication, collaboration, group cohesion
Cognitive presence	Experience of constructing inquiry, meaning and knowledge through sustained communication	Metaverse considered issues of trends in usage of game-based learning and modelling as *cognitive technologies* (Pinchuk et al., 2017, p. 43).	Exploration, integration, resolution, problem-solving, knowledge exchange, connecting ideas, apply new ideas

Teacher presence	How teachers engage students in the learning environments as instructional designers	Generation of a mix, offering new scenarios of learning, physical or otherwise, in which the *teacher* becomes *guided to access* information (Garcia, 2010, p. 147).	Sharing personal meetings, focusing discussion, facilitating discourse, direct instruction

Social presence

Social presence is described as the ability to demonstrate oneself (e.g., avatar, virtual identities) and establish personal and purposeful relationships (Procter, 2021). The selected studies in this literature review have shown that social presence has important roles for student motivation to sustain their online learning, socialise with other learners and construct knowledge together through avatar-based, Second Life, social media and AR and VR activities (Barahona et al., 2016; Pinchuk et al., 2017). Metaverse researchers have identified that utilising cognitive support could have a greater impact than only delivering content through presentation support tools. Gandasegui (2013) promoted the participation of students through collaboration in a virtual network. Students (especially those introverts who refuse to talk and interact in real life) can communicate with their classmates in their leisure time to explore career-related topics. M. J. Wang and Chen (2013) utilised online discussion and project construction tasks to determine the extent of social presence and collaborative learning for 22-pair students to attend a hospitality culture exchange. They found these activities could enhance language and cultural understanding, and promote critical thinking and awareness. Overall, cognitive support is an important element that metaverse must have so as to help students construct knowledge and inquiry skills using different types of technologies. With open communication and group discussions, students can freely interact, express and collaborate with other learners in a metaverse.

Cognitive presence

Cognitive presence refers to the exploration, construction, resolution and confirmation of understanding through collaboration and reflection in a CoI (Guo et al., 2021). In my review, the selected studies have shown that cognitive presence has important roles in motivating students to learn, help them scaffold their understanding, visualise concepts and enhance higher-order thinking skills and dispositions through simulation, AR and VR and AI-driven learning activities (Díaz et al., 2020). These features allow students to explore, integrate their knowledge, and solve problems in a metaverse so that they can exchange knowledge, connect to ideas, and apply new ideas in a virtual world and laboratory environment. Tarouco et al. (2013) designed an immersive learning environment called OpenSim that offers the possibility of collaborative learning and high degree of interactivity to visualise the principles of calculus in an engineering context. An example suggested by Wagner et al. (2013) provided students digital learning content in a way closer to the real world to expand how knowledge is acquired. Furthermore, metaverse could also encourage students' creativity and they freely create visual art content and express themselves using digital objects (Noh et al., 2022).

Teacher presence

Design and implementation of a metaverse learning world is an important issue. Teacher presence facilitates the construction, design, facilitation and instruction in the virtual classroom (Akyol & Garrison, 2011). The body of evidence addressed the importance of teacher presence to enhance students' learning satisfaction, perceived learning and sense of community. In a metaverse, the roles of the teachers will not be the direct instructor who merely delivers knowledge; instead, they are the platform designers of the virtual learning environments. They choose what types of elements and technologies used in the metaverse. Teachers designed learning scenarios for students in which teachers provided guidance and information access to students, instead of knowledge delivery (Garcia, 2010). Gandasegui (2013) aligned with this; instead of teaching language and communication skills, teachers used the Second Life software to connect between students and avatars to reduce the digital divide and encourage them to express what they have learnt. Huh (2022) introduced medical training using AR and VR, mirror world, and lifelogging to develop students' medical knowledge through professional licensing examinations in a metaverse platform. Teachers could guide and help students to provide feedback and scaffolding when solving the problems (Huh, 2022). These examples have been successful with students, in terms of motivation and engagement to develop their knowledge construction, and facilitate communication and collaboration.

Figure 3 illustrates a model of the metaverse learning environment to indicate the input-context-output relationship of the three presences (inputs), four key elements (contexts) and students' learning outcomes (outputs).

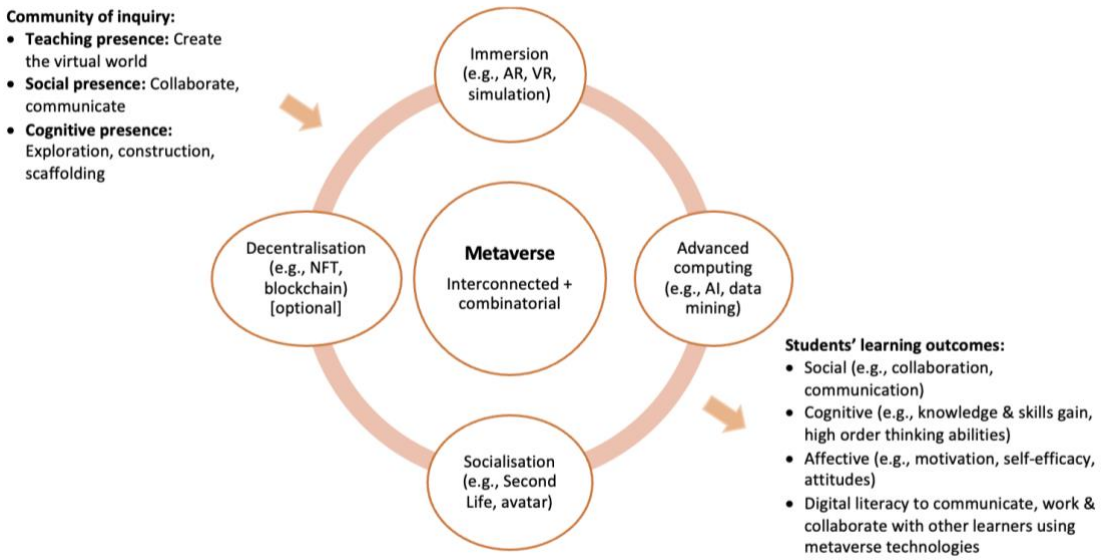

Figure 3. A model of the metaverse learning environment

Recommendations

The metaverse is transforming online education to allow creation of an engaging and life-like online classroom, promote communication, support immersive learning, make learning fun, and enrich students' learning experience (Pappas, 2022). Metaverse-based education uses a combinatorial technological innovation that leverages on its educational potential across disciplines. With the three presences in an online CoI, metaverse provides a virtual learning space that encourages learners to learn, interact, communicate and collaborate with others using digital identities. I suggest a set of recommendations for educators to implementing online learning practices as follows:

- As students may not have rich experience using metaverse-related technologies before, it is necessary to foster students' related digital technological literacies. Metaverse literacy could be one of the important 21st century technological skills that students should learn to facilitate their learning and living.
- With government policy and funding support, schools could upgrade related infrastructure and equipment to offer a higher computational power and authentic environments with rich multimedia resources. Teachers should enhance their technological knowledge to boost their students' learning outcomes.
- The CoI framework provides guidelines to design metaverse-based learning environments by presenting learning supports, processes and outcomes. Students could engage actively in online learning environments to deepen their understanding in the form of social and cognitive presence. Teacher presence enables authentic space creation with life-like objects for students to learn and interact with others just like real classrooms.
- A list of new technologies was incorporated into metaverse learning environments. Educators need to consider suitable activities, pedagogies and supports that fulfil students' needs, using elements such as challenge, curiosity, creativity, authenticity, collaboration and competition.
- Educational researchers and practitioners could design suitable assessments to examine students' learning outcomes and related digital literacy using metaverse technologies.

Conclusion

A variety of definitions of metaverse was identified. However, most of the existing studies considered it as a digital virtual world that allows the people to live, learn (or even work) in it and build virtual identities using avatars. Learners can visualise objects and information that represent knowledge, skills and concepts in the virtual world. They can also interact, communicate, collaborate and co-construct knowledge in it.

Although recent articles started to discuss the metaverse, researchers have not yet derived educational theories to interpret the term. Few studies have provided comprehensive explanations on how to conceptualise the term. To achieve a better understanding of the concept of metaverse, this study explored how 19 studies from the Web of Science database defined and selected the technologies used in the metaverse. The recent trend of metaverse started in 2020 (the year of Facebook rebranded). The five existing metaverse types – AR and VR; avatar-based and Second Life system; learning management system and social media; simulation and AI – are accelerating the utilisation of the metaverse to sustain students' online and blended learning. With more emerging technologies, metaverse is no longer offering learners a digital world; instead, it brings holistic ways or combined modes to enrich students' learning experience. This review can see that metaverse has become a combination of different types of technologies that breaks down the boundaries between them. These technologies complement each other to give a more authentic and engaged digital world that reaches to larger audiences. Therefore, there is a need to conceptualise the new term and present the new opportunities that metaverse brings to existing technologies in the educational field to enhance learner experience (Díaz et al., 2020; Rospigliosi, 2022). This study proposed four key elements of metaverse (i.e., immersion, advanced computing, socialisation, decentralisation) to enhance the values of existing technological affordances (Hwang & Chien, 2022). Moreover, this study proposed to use online communities of inquiry as the theoretical framework to explain how social, cognitive and teacher presence could be supported in the metaverse.

Several limitations are identified. First, six of the studies are conference papers, and only five articles were published after 2020. Since this term emerged again after 2020, it needs more publications to conceptualise it. Future research is necessary to review articles in more databases to identify its definitions and the types of technologies used. Second, there is a larger pool of studies discussing metaverse teaching without mentioning the term *metaverse*. These studies were not included in this review; however, their interventions could be comparable to metaverse instructional design. This suggests that future reviews could broaden the scope of search to related common themes and to capture more literature in understanding metaverse.

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