A STUDY ON THE METAVERSE SUCCESS FACTORS USING THE ANALYTIC HIERARCHY PROCESS

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ABSTRACT

This study aims to contribute to the development of the metaverse by identifying and evaluating its success factors from a business perspective using the Analytic Hierarchy Process (AHP). Based on recent trends in metaverse research—which expanded rapidly during the COVID-19 pandemic—ten key success factors were identified. These factors were categorized into three primary groups: technological, market, and functional. A hierarchical model was constructed with these three top-level factors and their corresponding second-level sub-factors. Expert opinions were collected through a structured survey, and the relative importance of each factor was analyzed using the AHP. The results show that functional factors are the most critical, followed by market and technological factors. Among the second-level sub-factors, fun emerges as the most important, followed by network and communication, market size, and immersion. The analysis also confirms differences in priority among the three expert groups—academics, researchers, and industry practitioners—through the AHP's compatibility index. These findings provide meaningful insights into the strategic direction and future development of the metaverse.

Keywords: metaverse; research trend; AHP; compatibility; importance

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1. Introduction

The metaverse is a virtual world, digital space, or immersive parallel reality, in which users can interact with a computer-generated environment and other users (Cheng, 2023). The term 'metaverse' first appeared in Stephenson's science fiction (SF) novel 'Snow Crash' (Stephenson, 1992) in which people use digital avatars of themselves to explore the online digital world, often as a way of escaping reality. The situation in the novel is very similar to that in the metaverse which is well-known today. In 2021, Facebook changed its company name to Meta Platforms to focus on the metaverse platform services. The metaverse platform is defined as 'technical infrastructure enabling virtual world creation' (Dwivedi et al., 2022), *that is*, metaverse creation. After the advent of COVID-19, interest in the metaverse rapidly increased. Many metaverse platforms such as Roblox, Zepeto, Ifland, Gather Town, and Spatial have already been developed and are being used. Specifically, generations MZ and Alpha are actively participating in various services based on the metaverse platform.

The metaverse has become feasible using new emerging technologies such as VR (virtual reality), 5G, blockchain, and AI (Huynh-The et al., 2022). Immersive technology is particularly important in the metaverse where the virtual world and the real world are connected. Advances in VR and 3D modeling technology are making it possible to create immersive virtual environments. Blockchain-based technologies such as NFT (Non-Fungible Token) enable commerce in the metaverse. Metaverse platform companies are making various efforts to effectively form and operate a two-sided market ecosystem consisting of content developers and content consumers.

This expansion of metaverse usage is evidenced by the number of metaverse users which was estimated at greater than 100 million in 2023. However, as in-person activity has resumed post-COVID-19, interest in and growth of the metaverse is slowing (Statista, 2023). Looking ahead, advancements in 6G networks and brain-computer interfaces (BCIs) are expected to position the metaverse as a core infrastructure for hyper-connected societies (Zhao et al., 2023). However, governments and corporations must prioritize ethical guidelines and standardization, while user-centric revenue models will be key to long-term viability.

The metaverse has brought about positive changes in social interaction by providing a new virtual space for interaction and collaboration, including virtual meetings, global networking, and multicultural experiences. (Zhang & Chen, 2023). On the business side, the metaverse can generate revenue such as virtual economy, subscriptions, advertisements, platform fees and B2B profit based on technological innovation (Ball, 2022).

As the amount of metaverse research increases (De Felice et al., 2023; Abbate et al., 2022), research on metaverse-specific evaluation is necessary; however, it is not common. The explosion in the number of metaverse studies implies interest in the metaverse, which in turn implies a surge in the number of metaverse constructions in real life. On the other hand, there is limited data on the success of the metaverse. The Gartner Group tracked over 1,600 metaverse-related companies and found a 23% closure rate (Gartner Research, 2023). Another report found that 62% of 450 metaverse projects in 2022-2023 were shut down within a year (McKinsey & Company, 2022).

There is a need for research on the factors that contribute to the success of metaverse as it is likely to become quite common. This is the motivation of this study, and therefore, specific factors are identified through this study.

Since a company's resources are not infinite, it is necessary to choose what to focus resources on (Porter, 1985). In order to succeed in the metaverse, it is important to identify what is relatively more important. Thus, the purpose of this study is to find answers to the following research questions about the metaverse.

1) Which components are more critical to the success of the metaverse?
2) What are the features of those components?

There are still limitations in obtaining objective empirical data to evaluate the components or factors of the metaverse business. Therefore, this study aims to identify and assess the relative importance of the constitutional factors of the metaverse, drawing on the subjective judgments of experts. This study also aims to examine whether differences exist in the perceived importance of the factors across experts' areas of specialization.

The scope and methodology of this study are as follows. For the first research question, we reviewed recently published, accessible articles on metaverse evaluation. Based on the review, we determined the systematic factors for metaverse evaluation. For the second research question, we used the Analytical Hierarchy Process (AHP) to calculate the characteristics, including relative importance, of the success factors.

2. Literature review

2.1 Evolution of the metaverse with platform

Over the past two decades, technological advances in rendering engines, network systems, and content creation tools have fueled the scalable growth of platform ecosystems. These ecosystems have not only supported the development of metaverse services but also shaped their structure, accessibility, and diversity. In this context, while the metaverse denotes immersive virtual environments experienced by users, the platform serves as the enabling foundation that facilitates their creation, distribution, and continuous evolution (Lee et al., 2024; Dionisio et al., 2013).

Metaverses can be categorized into platform-based services and non-platform (standalone) virtual systems (Mystakidis, 2022). However, considering the integration of technological infrastructure, the need for service scalability, and the importance of sustainable ecosystem governance, the majority of contemporary metaverse systems operate within platform ecosystems. In other words, metaverses are typically implemented and executed through platforms to support various activities such as gaming, education, and virtual collaboration. Accordingly, discussions about the growth of metaverses are intrinsically linked to the growth and development of metaverse platforms.

Amir et al. (2025) analyzed the number of metaverse-related articles in the Web of Science (WoS) Core Collection database. As shown in Table 1, they observed a significant surge in the number of core publications on the metaverse between 2021 and

2023. Given the relatively recent emergence of the metaverse, the volume of existing research remains limited (De Felice et al., 2023; Abbate et al., 2022; Damar, 2021).

Table 1
Annual trend of metaverse-related publications

Year	- 1999	2000-2004	2005-2009	2010-2014	2015-2019	2020	2021	2022	2023
Frequency	2	1	14	12	5	2	14	287	863

2.2 Application of the metaverse across industries

Metaverse technologies have been applied across a range of industries. This section reviews representative applications and research trends by the industrial sector.

Computer Science
The field of computer science represents one of the most actively researched domains in relation to the metaverse. Key areas of inquiry include security and privacy issues (Ahsani et al., 2023; Chen et al., 2022; Huang et al., 2022), the integration of blockchain, artificial intelligence, and big data technologies (Huynh-The et al., 2022; Mozumder et al., 2022; Zhu, 2022), as well as research into 3D technologies and extended reality (AR/VR/XR) (Dionisio et al., 2013; Kovacova et al., 2022). Studies have also explored user experience within metaverse environments (Delgado, 2022). Overall, the computer science domain is pursuing convergence with metaverse technologies to establish new forms of digital interaction and infrastructure.

Education
The education sector has also witnessed significant growth in metaverse applications, particularly accelerated during the COVID-19 pandemic. Key research areas include immersive teaching and learning environments (Contreras et al., 2022; Kim, 2022; Phakamach, 2022), development of educational metaverse platforms (Teng et al., 2022), and investigations into opportunities and limitations (De Felice et al., 2023; Kye et al., 2021; Lin et al., 2022). In addition, studies have examined the broader metaverse-enabled educational ecosystem (Wang, Yu et al., 2022; Zhou, 2022). These developments have contributed to the continued evolution of digital pedagogy and learning spaces.

Healthcare
Metaverse technologies are increasingly applied in the healthcare industry. Research has focused on applications in medical education and clinical training (Ganapathy, 2023; Musamih et al., 2022), as well as broader opportunities and challenges (Chengoden et al., 2016; Garavand and Aslani, 2022). Architectural frameworks and technical components for healthcare-related metaverse systems have also been proposed (Chengoden et al., 2016). Mozumder et al. (2022) further presented a technological roadmap that highlights key trends and directions in the application of metaverse technologies to medical domains.

Other Industries
Beyond the aforementioned sectors, the metaverse has been explored in various other industries. In the gaming sector, studies have analyzed the evolving user experience and platform dynamics (S. Park & Y. Kim, 2022; Shen & Ko, 2022). In the tourism industry,

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virtual environments have been used to enhance destination experiences (Koo et al., 2022). The retail sector has also seen early integration of metaverse concepts, particularly in enhancing consumer engagement and virtual shopping experiences (Bourlakis et al., 2009).

2.3 Strategic aspect

The metaverse has been approached and studied from the perspective of technology (Agarwal et al., 2022; Mozumder et al., 2022), industrial application (Ganapathy, 2023; Phakamach et al., 2022; Shen & Ko, 2022), and the architecture or ecosystem (Xu, Ng, et al., 2022; Wang, Yu et al., 2022; Radoff, 2021).

Here is a detailed breakdown of the integrated metaverse framework across four axes (technical, economic, social and legal/ethical), synthesized from Dwivedi et al. (2022) and complementary studies (Mystakidis, 2022; S. Park & S. Kim, 2022) (See Figure 1).

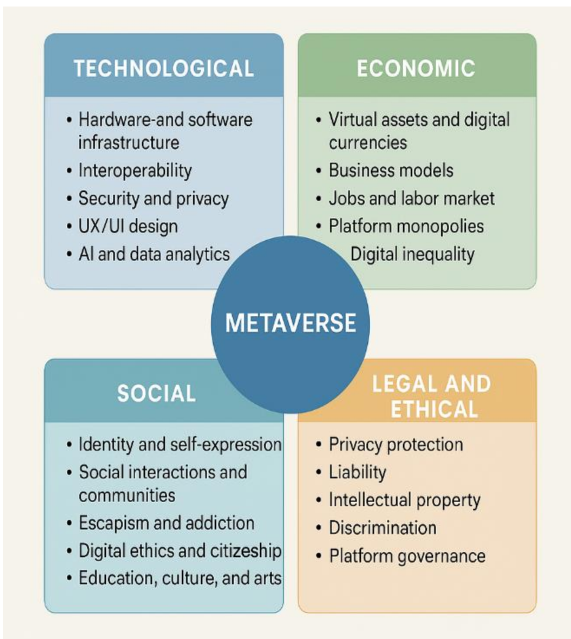

Figure 1 Four-axis metaverse integration model

The technological axis consists of immersive technologies, interoperability, infrastructure, and AI integration as key components. Digital ownership, virtual economics, and business models make up the economic axis. The social axis consists of community building, inclusivity, and cultural impact. Governance, privacy, intellectual property, and ethics make up the legal and ethical axis.

Collectively, the four axes are characterized as follows:

- Interdependency: economic systems rely on technical infrastructure (e.g., blockchain for NFTs), while social norms shape legal frameworks (e.g., harassment policies in VR).
- Policy gaps: current laws lag behind technological advances (e.g., NFT copyright disputes).

- Research priorities: Dwivedi et al. (2022) emphasize multidisciplinary collaboration to address these axes holistically.

Designing a metaverse from a business perspective expands on the four pillars discussed earlier, with a particular focus on value creation and monetization. The four specifics are as follows: virtual space, digital asset economy, open or closed platform integration, and cross-reality between online and offline environments. (Bakos & Katsamakas, 2022).

3. Framework of metaverse analysis

3.1 Analytic Hierarchy Process (AHP) and compatibility

The AHP is a decision-making method that supports systematic evaluation of alternatives with multiple criteria under a goal (Saaty, 1980; 1996). The method developed by Saaty in the early 1970s supports the process of reaching the final decision by clustering evaluation factors (criteria) into a homogeneous set, stratifying them into multiple levels, and then analyzing and synthesizing them at each level. It decomposes a complex decision-making task into a multi-level hierarchical structure in order to simplify it for evaluation, which is one of the major features of the AHP. Another feature is that it is able to derive the relative importance of the elements in the hierarchy through pairwise comparisons among the elements in each group. In order to derive the relative weights vector (*w*) of the elements, the pairwise comparison matrix (A) and its maximum eigenvalue (λ_{max}) are used by the equation of $Aw = \lambda_{max}w$.

Responses to the evaluation questions of the AHP survey are generally obtained from experts, and the inconsistency index is established to determine whether respondents evaluate consistently. An inconsistency index of 0.1 or less is reasonable and 0.2 or less is tolerable. The advantage of the AHP is that it is simple to apply and can easily express judgments for a decision.

To aggregate the pairwise comparison judgments of multiple respondents, the geometric mean is recommended because it satisfies the reciprocal principle inherent in the pairwise comparison matrix (Saaty & Vargas, 2012). In some cases, it may be necessary to check if there are differences between multiple respondents. In order to determine two eigen vectors, *w* and *v* are compatible, corresponding two pairwise comparison matrices from the two vectors are defined as $A = \left({w_i}/{w_j}\right)$ and $B = \left({v_i}/{v_j}\right)$. Then, the compatibility index (SI) of (*w*, *v*) is defined (Saaty, 1996) as in Equation (1):

$$SI_{AB} = n^{-2} \cdot e^T A \circ B^T e \tag{1}$$

$$\text{where } \; e^T = (1, 1, \cdots, 1) \text{ and } \; A \circ B = \left({w_i}/{w_j} \cdot {v_i}/{v_j}\right)_{nxn}$$

The compatibility index has been extended as an alternative formulation to be applicable to a broader range of environments (Garuti, 2016). Garuti & Salomon (2011) attempted to provide a better understanding of compatibility with a proper example using Equation (2).

$$G = \sum \left(\frac{\min(w_i,\ v_i)}{\max(w_i,\ v_i)} \cdot \frac{(w_i + v_i)}{2} \right) \tag{2}$$

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3.2 Evaluation framework

In the field of information systems, the AHP has been widely used to hierarchically identify key factors and quantify their relative importance (Wang et al., 2020; Salmeron & Herrero, 2005; Muralidhar et al., 1990). However, few studies have applied the AHP in the context of the metaverse (Zhou, 2022; Choi et al., 2022). Zhou (2022) applied the AHP to a metaverse-based smart education ecosystem, considering three primary factors, including resource ecology construction, a virtual–real symbiotic environment, and an inquiry-based learning space, along with eight subfactors. Choi et al. (2022) proposed an evaluation model for developers in metaverse platforms, incorporating three main criteria, including market attractiveness, technological readiness, and platform readiness, which are further broken down into nine subfactors.

Although the metaverse is conceptually regarded as independent of platforms, its operation heavily relies on them; thus, platform performance is inevitably reflected in the evaluation of the metaverse. Previous metaverse-related studies were reviewed to construct an AHP-based evaluation model. Additionally, key factors for market entry were taken into account, given that metaverse research is still in its early stages.

In this study, the metaverse success factors were divided into three main categories: technological factors, market factors, and functional factors. Each category consists of three to four subfactors (see Appendix for definitions). The hierarchical structure of these goals is illustrated in Figure 2.

(1) Technological factor

The first sub-factor considered under the technological factor is privacy and security. Most users of IT systems are sensitive to privacy and security concerns. As the metaverse is a type of IT system, many researchers have emphasized the critical importance of privacy and security in the metaverse context (Lee, Braud et al., 2021; Ahsani et al., 2023; Chen et al., 2022). Schöbel et al. (2023) proposed a comprehensive metaverse platform and categorized security under technological factors. Chen et al. (2022) examined privacy and security in relation to five enabling technologies of the metaverse. Wang, Yu et al. (2022) highlighted the importance of data security and privacy policies. Choi et al. (2022) included technological security as a key variable in their AHP-based metaverse evaluation. Lee et al. (2024) and Ahsani et al. (2023) identified privacy and security as core elements in the metaverse ecosystem and system architecture, respectively.

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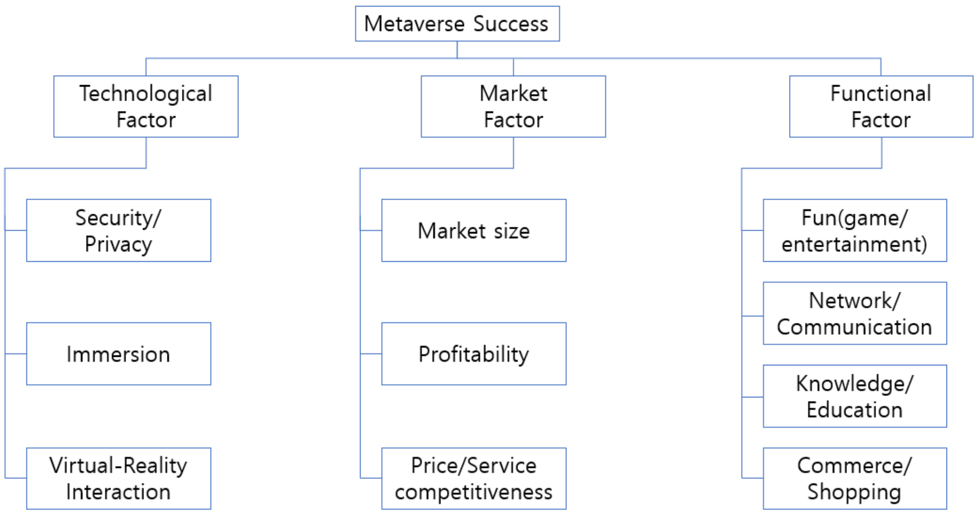

Figure 2 Evaluation hierarchy

The second sub-factor is immersion. Ganapathy (2023) discussed the potential of metaverse applications in creating immersive environments. Koo et al. (2022) suggested that the core technologies of the metaverse will enable a new level of immersive experiences. The metaverse can enhance immersive experiences through the use of virtual reality (VR), augmented reality (AR), extended reality (XR), and 3D technologies. Balica et al. (2022) identified immersive technologies as key enablers for improving operational processes within the metaverse. Valaskova et al. (2022) found that 3D immersive environments contribute to higher customer satisfaction. Carter (2022), however, reviewed metaverse experiences from the employee’s perspective rather than that of the customer. In other words, the metaverse can enhance both user immersion and immersive work environments for employees. Delgado (2022) emphasized that the metaverse must be designed to support immersive environments.

The third sub-factor is virtual-reality interaction. The metaverse is characterized by the connection and interaction between the virtual and physical worlds. This interaction is enabled when data generated from both environments can be shared and utilized. Lim et al. (2022) proposed a metaverse model emphasizing immersive and real-time interaction between the physical and virtual worlds. Huang et al. (2022) identified immersive interaction as one of the four essential characteristics of the metaverse. Sun et al. (2022) argued that medical metaverses require a transition from traditional forms of interaction to more natural interaction between humans and the meta-medical environment. Shi et al. (2022) suggested that virtual-reality interaction constitutes one of the four foundational pillars of the metaverse. Duan et al. (2021) incorporated interaction as a key layer within the three-layer architecture of the Edu-metaverse. Lee et al. (2024) presented a comprehensive metaverse framework and emphasized user interactivity as one of eight core technologies. Li, Cui, Li et al. (2022) highlighted interactivity as one of seven essential requirements for building an IoT-inspired metaverse. Schöbel et al. (2023) underscored the importance of connectivity in the metaverse context.

Typically, avatars serve as key intermediaries for interaction between the virtual and real worlds. Nagendran et al. (2022) proposed a framework designed to assess and enhance

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interpersonal effectiveness during avatar-based interactions. For a given interaction task, an effective and complete interaction process can be achieved through user actions (input) and system feedback (output) delivered via various devices (Zhao et al., 2022).

(2) Market factor

The first sub-factor under the market factor is market size. Market size is considered one of the most important factors in making decisions about entering new markets. Choi et al. (2022) included both market attractiveness and market size as evaluation variables in their AHP-based study on the metaverse.

According to Metcalfe's law, the value of a network increases proportionally to the square of its number of users. Given that the metaverse emphasizes network connectivity and communication, the number of users and overall market size become particularly significant. In most cases, a larger market size increases the likelihood of market entry (Min et al., 2017). Kwak and Whang (2008) identified market size as a key decision-making criterion. Ojala and Tyrväinen (2007) found market size to be one of the two most important entry factors in the software industry. Additionally, an increase in the number of suppliers can expand consumer choice, which in turn attracts more customers to the market.

The second sub-factor is profitability. In general, profitability is highly correlated with market entry decisions. Companies often enter new markets if they are expected to be profitable, even when the market size is relatively small. Most prior research has explained anticipated economic returns from a new product market as a primary driver of firms' market entry decisions (Kim et al., 2015). Christensen and Raynor (2003) argued that profitability is more important than sales volume when entering a market, indicating that it is a critical factor for survival in early-stage markets with low sales volumes.

In fast-changing environments such as the digital economy, previously successful business models may become unprofitable, thereby diminishing their ability to serve existing customers (Kraus et al., 2022). In the case of emerging technologies like the metaverse, new revenue models must be pursued over traditional ones. For example, the metaverse has recently shifted from an advertising-based model to a transaction-based revenue model. As profitability increases, more vendors are likely to enter the market, and this pattern is also observed in the metaverse.

The third sub-factor is price and service competitiveness. One of the primary goals of enterprise systems is to enhance competitiveness (Pace & Stephan, 1996). The competitiveness of a service firm can be understood by analyzing its operational strategy (Meyer et al., 1999). To be competitive, firms must provide products and services that customers are willing to pay for at a fair price (Pace & Stephan, 1996).

Porter (1985) proposed two basic competitive strategies, cost leadership and differentiation. Price (or cost) competitiveness becomes increasingly important as market competition intensifies throughout the product life cycle. Service competitiveness, on the other hand, involves positioning a firm to command premium prices by delivering attributes that customers value.

In the metaverse, competitiveness in the virtual world translates directly into competitiveness in the real world. As metaverse platforms offer services, service competitiveness—including factors such as service quality and diversification—is especially important. Park et al. (2022) analyzed metaverse competitiveness by distinguishing between platform competitiveness and content competitiveness. Shen and Ko (2022) examined Roblox's core competitiveness, highlighting features such as a joint revenue mechanism, strong social networking capabilities, low entry barriers, and high accessibility, all of which contribute to the formation of a robust developer ecosystem.

(3) Functional factor

The first sub-factor under the functional factor is fun. Babu and Mohan (2022) analyzed the potential impact of the metaverse across multiple sectors, including entertainment, healthcare, and education. Zhu (2022) identified entertainment as one of the three core industries within the metaverse ecosystem. Roblox is one of the largest metaverse service providers and is widely recognized by the general public, including those unfamiliar with the concept of the metaverse. Han et al. (2021) considered Roblox to be a type of game platform, suggesting that it can achieve success in the metaverse domain based solely on its gaming features.

Pine and Gilmore (1999) identified entertainment as one of the four domains of experience. Kim and Park (2022) examined metaverse factors influencing the fun experience of Zepeto users. Kim (2022) emphasized that fun and presence are key components in educational metaverses. Lee and Rhee (2022) classified types of fun in the metaverse into sensory fun, challenging fun, imaginative fun, social fun, interactive fun, realistic fun, creative fun, and others. S. Park and S. Kim (2022) investigated the relationship between game-based experiences and learning motivation. Similarly, Kim (2022) confirmed the importance of fun and presence in metaverse-based education, reinforcing previous findings.

The second sub-factor is network and communication. Facebook's rebranding as Meta serves as a symbolic example of the centrality of networking and communication in the metaverse. Zepeto, another major metaverse platform, is widely recognized by the general public, including those unfamiliar with the metaverse. Han et al. (2021) viewed Zepeto as a form of social communication, suggesting that networking and communication capabilities are essential for a successful metaverse. Ulaş and Alkan (2022) described the metaverse as a site for dialogic communication. Shi et al. (2022) and Garavand and Aslani (2022) identified human-centered communication services as core offerings of the metaverse. Xu, Ng et al. (2022) highlighted the importance of strengthening core communication and networking functions. Kim and Kim (2021) considered social networking services and collaborative communication platforms as key variables in categorizing metaverse types. Babu and Mohan (2022) reported that most survey participants believe the metaverse will fundamentally transform digital communication.

The third sub-factor is knowledge and education. The metaverse offers significant benefits for education, especially evidenced during the COVID-19 pandemic, when virtual classes accelerated the adoption of metaverse educational features. Hwang and Chien (2022) highlighted the important educational role of the metaverse. Suzuki et al. (2020) discussed the metaverse's role in establishing virtual learning systems. Wang et al.

(2020) emphasized the significance of knowledge hubs within the metaverse ecosystem. Teng et al. (2022) examined the adoption of educational metaverse platforms.

Zhang et al. (2022) identified four potential applications of the metaverse in education. S. Park and S. Kim (2022) investigated the relationship between game experience and learning motivation. Lin et al. (2022) explored how the metaverse is transforming education, while Contreras et al. (2022) addressed its broader implications for education. Additionally, several studies have focused on medical and healthcare education or physical education within the metaverse context (Ganapathy, 2023; Musamih et al., 2022; Chengoden et al., 2016; Yu, 2022).

The fourth sub-factor is commerce and shopping. Choi et al. (2022) included clear ownership of virtual property as a sub-criterion within the metaverse platform readiness factor. The metaverse serves as a space where service providers and users interact, making the facilitation of transactions between them crucial. Transactions between consumers and suppliers typically take the form of commercial exchanges or shopping activities.

Kovacova et al. (2022) found that metaverse-related technologies play a significant role in enhancing experiential shopping. Balica et al. (2022) highlighted the potential of these technologies to improve operational processes for personalized shopping experiences in virtual commerce. Jeong et al. (2022) proposed an innovative business model combining live commerce with the metaverse.

4. Results of importance analysis

In this study, the relative importance of each metaverse factor was determined using the AHP method. Data for the analysis were collected through a structured questionnaire consisting of three parts. The first part provided basic instructions on how to answer and complete the questionnaire. The second part included pairwise comparisons among constructs within each hierarchical layer. In these comparisons, participants were asked to assess which of the two components was more important, using a scale from 1 (equal importance) to 9 (absolute importance). To synthesize individual responses into a group judgment, the geometric mean method was employed. The final part of the questionnaire collected demographic information about the respondents.

The questionnaire was distributed to experts from three different groups: business-related professors, researchers from national institutes in the field of information and communication technology, and industry practitioners with long-term experience. These groups were selected based on the assumption that their perspectives on metaverse success factors would differ. A total of 32 questionnaires were distributed, and 17 responses that met the AHP consistency threshold were used for analysis.

The results of the demographic analysis are shown in Table 2. Regarding education level, two respondents (11.8%) held a bachelor’s degree, four (23.5%) held a master’s degree, and 11 (64.7%) held a Ph.D. In terms of occupation, five (29.4%) were university professors, seven (41.2%) were researchers at national institutes, and five (29.4%) were industry practitioners. The average professional experience of the 17 respondents was 18.5 years.

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Table 2
Demographic characteristics

Demography	Category	Frequency	Percentage
Gender	Male	13	76.5%
	Female	4	23.5%
Education	Bachelor	2	11.8%
	Master	4	23.5%
	Ph.D.	11	64.7%
Job	Professor	5	29.4%
	Researcher	7	41.2%
	Industry	5	29.4%
Career year (average)	-	18.5	-
Age	20-29	1	5.9%
	30-39	3	17.6%
	40-49	6	35.3%
	Over 50	7	41.2%

First, the 17 consistent responses were aggregated using the geometric mean. The results of the importance analysis were derived from the eigenvector calculation of the pairwise comparison matrix and are presented in Table 3. The AHP analysis revealed that the functional factor held the highest relative importance (0.490) in determining metaverse success. This suggests that user-centric features are perceived as more critical than market conditions (0.293) or underlying technologies (0.218) at the current stage of metaverse development.

The results of the breakdown analysis for each success factor are as follows. Within the functional factor, the fun attribute was found to have the highest importance (0.260), followed by network and communication (0.119), commerce and shopping, and knowledge and education. In the market factor, market size was the most important (0.116), followed by price and service competitiveness (0.104) and profitability. In the technological factor, immersion had the highest importance (0.112), followed by virtual-reality interaction, and security and privacy. The fun attribute (0.260) emerged as the most important sub-factor overall. This is because most end-users engage with the metaverse to pursue fun through gaming, entertainment, and other activities. The metaverse initially gained attention as face-to-face interaction became restricted during the COVID-19 pandemic, prompting people to seek enjoyable experiences online. The second most important sub-factor was network and communication (0.119), followed by market size (0.116), immersion (0.112), and price and service competitiveness (0.104).

The security and privacy attribute was found to be the least important. This may be because most metaverse service providers do not require users to register with their real names. Since the vast majority of users can create accounts using pseudonyms, there is less concern about personal information leakage. Alternatively, it is possible that security and privacy technologies have reached a sufficiently mature level, thereby reducing their perceived importance. The exact reason remains unclear and warrants further investigation in future research.

Table 3
Importance of factors (overall inconsistency=0.01)

Success factor	Sub-factor	Importance		Rank
Technological factor (0.218)	Security and privacy	0.033		10
	Immersion	0.112		4
	Virtual-reality interaction	0.073		6
Market factor (0.293)	Market size	0.116		3
	Profitability	0.073		6
	Price and service competitiveness	0.104		5
Functional factor (0.490)	Fun (game, entertainment)	0.260		1
	Network and communication	0.119		2
	Knowledge and education	0.047		9
	Commerce and shopping	0.064		8

The results of the importance analysis for each of the three expert groups—P (professors), R (researchers), and I (industry practitioners)—are presented in Table 4. The groups differed in the importance they assigned to the three factors at the first level of the hierarchy. Business-related professors prioritized the market factor, researchers emphasized the technological factor, and industry practitioners regarded the functional factor as the most important.

Among the level 2 sub-factors, fun (under the functional factor) is the most important competitive element across all three groups. The other sub-factors that are relatively important to each group are as follows: professors prioritized profitability and price competitiveness; researchers emphasized immersion and virtual reality interaction; and industry practitioners valued network and communication.

Table 5 presents the Compatibility Index (SI) calculated using Equations (1) and (2). This measure was used to assess whether the evaluation results from the three expert groups were consistent with one another. The SI is designed to verify the compatibility between two weight vectors by measuring the consistency between the corresponding pairwise comparison matrices constructed from the respective eigenvectors. If the SI value, calculated using Equation (1), is less than or equal to 1.1, the two vectors are considered compatible; otherwise, they are not compatible (Saaty & Peniwati, 2007). In the case of the G Compatibility Index, derived from Equation (2), Garuti (2016) proposes that if $G < 0.9$, the two vectors should be regarded as not compatible.

All the SI results among the three groups for the three main factors and ten sub-factors in this study satisfy the compatibility threshold. In the case of the level 2 sub-factors, almost all SI values, except for one G-index result, satisfied the threshold condition. These findings suggest that the three groups (P, R, and I) hold significantly different perspectives on the metaverse.

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Table 4
Importance of three groups

Factor / Sub-factor	Professor		Researcher		Industry pr.	
	weight	rank	weight	rank	weight	rank
Technological factor	0.09		0.377		0.177	
Security and privacy	0.016	10	0.046	8	0.027	9
Immersion	0.048	7	0.194	2	0.087	4
Virtual-reality interaction	0.025	9	0.138	3	0.063	7
Market factor	0.546		0.234		0.147	
Market size	0.116	4	0.089	5	0.090	3
Profitability	0.219	1	0.062	7	0.018	10
Price & service competitiveness	0.211	2	0.083	6	0.039	8
Functional factor	0.363		0.338		0.676	
Fun (game, entertainment)	0.186	3	0.198	1	0.378	1
Network and communication	0.071	6	0.119	4	0.138	2
Knowledge and education	0.032	8	0.035	10	0.074	6
Commerce and shopping	0.075	5	0.036	9	0.086	5

Table 5
Compatibility

		Compatibility Index (*SI*)				Garuti (*G*) Compatibility Index			
		P vs R	R vs I	I vs P	Threshold	P vs R	R vs I	I vs P	Threshold
Factor		2.237	1.356	2.174	> 1.017	0.575	0.555	0.440	< 0.9
Global sub-factor		1.247	1.563	1.321	> 1.134	0.526	0.572	0.465	
Local Sub-factor	T	1.075	1.029	1.017	> 1.017	0.856	0.937	0.866	< 0.9
	M	1.187	2.187	1.287		0.724	0.634	0.448	
	F	1.224	1.076	1.077	> 1.053	0.821	0.818	0.858	

The prioritization of success factors differed among the three expert groups. This is believed to be attributable to their differing perceptions of success. Academic experts from the business field tend to evaluate strategic priorities from a conceptual and theoretical perspective, considering factors such as long-term value and market structure. IT experts focus more on technical feasibility, efficiency, and system reliability. In contrast, industry practitioners emphasize user response and operational effectiveness. Ultimately, these groups may hold different interpretations of what constitutes ‘success factors.’

5. Conclusion

The purpose of this study was to identify and prioritize the success factors of the metaverse, which has gained rapid attention and growth since the COVID-19 pandemic. In addition, this study examined whether there is any difference in prioritization among metaverse-related expert groups.

The research began with a review of existing literature on the evolution and success of the metaverse. Due to the rapid emergence of the metaverse during the pandemic, related academic literature has grown significantly within a short period. The evolution of the metaverse has not occurred in isolation but rather in conjunction with the development of its supporting platforms. The study also reviewed prior research on metaverse evaluation models and business dimensions. Based on this review, ten metaverse success factors were identified. As it was difficult to obtain objective data on the relative importance of the success factors, this study relied on subjective expert evaluations and applied the AHP to calculate and analyze their priorities

A total of 32 questionnaires were distributed to the experts, and 17 answers that passed the inconsistency index threshold of the AHP were finally used. First, the functional factor was the most important with the importance of 0.490, followed by the market factor (0.293), and the technical factor (0.218). Therefore, in order to develop the metaverse, it is necessary to focus on metaverse's unique functions that are not provided by other metaverse services. The second was characterized by the importance of the sub-factors. Among all the sub-factors, the fun attribute was the most important (0.260) followed by network and communication (0.119), both of which belong to the functional factor. The third was market size (0.116) belonging to the market factor, the fourth was immersion (0.112) belonging to technology factor.

The experts who participated in the analysis consisted of university professors, researchers from national institutes, and industry professionals. In this study's metaverse evaluation, differences were observed among the three expert groups. The business professors ranked the market factor as the most important, while industry practitioners prioritized the functional factor. Research experts assigned nearly equal importance to the technological and functional factors. These differences may reflect variations in how each group conceptualizes 'success.'

The contributions of this study are as follows; first, the study identified key success factors by comprehensively reviewing recent literature on the metaverse. Second, the AHP evaluation model demonstrated how assigning relative weights to success factors can support more rational decision-making in matters related to metaverse development. Lastly, the AHP model can serve as a guideline for both corporate and governmental entities, offering insights into which areas the metaverse should prioritize for sustainable growth and development.

However, as the metaverse is still in its early stages of development and proliferation, the role and relative importance of success factors are likely to change as related technologies continue to improve and evolve. In the early phase of metaverse research, the scope tends to be broad and conceptual; however, as the industry matures, more specific and in-depth, industry-focused research is expected to emerge.

One limitation of this study is that its evaluation results may have limited generalizability. As the metaverse field continues to expand, a wider range of expert groups is likely to emerge, potentially affecting the priorities of the success factors.

Another limitation of this study is the potential difficulty in generalizing its evaluation results. As the metaverse field continues to expand, new and more diverse expert groups are likely to emerge, which may lead to different perspectives on the prioritization of success factors.

Data Availability Statement: The data from this study are available upon request to the corresponding author for either editorial team or the community in general for replicability and transparency reasons.

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APPENDIX

Success Factors of Metaverse

	Level 1	Leve 2	Definition
Metaverse Success Factor	**Technol-ogical Factor**	**Security and Privacy**	• Security of the system • Protection of personal information (Privacy)
		Immersion	• The realism of virtual reality • Providing an immersive experience
		Virtual-reality interaction	• Interaction in the virtual world • Interaction between virtual and real worlds • Interaction between online and offline
	Market Factor	**Market size**	• Number of customers • Expected sales volume
		Profitability	• Net income size • Net profit margin
		Price and/or Service Competitiveness	• Price competitiveness at the level that customers want • Service competitiveness at the level that customers want
	Functional factor	**Fun (game, entertainment)**	• Feel the fun through the metaverse • Enjoy games through the metaverse
		Network & Communication	• Building networks/communities through the metaverse • Communication (sharing, cooperation) through the Metaverse
		Knowledge & · Education	• Obtaining information or knowledge through the metaverse • Education through the metaverse
		Shopping & Commerce	• Shopping for products (or contents) through the metaverse • Commerce for products (or contents) through the metaverse

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Pairwise Comparisons for the Evaluation of Importance between Items

▣ This is a method to evaluate the level of importance between evaluation items by referring to the definition of each factor in the previous page.
▣ Here's how to make a relative comparison of importance.

Example) Method of relative comparison of importance between evaluation items

		A is important									**B** is important							
standard item	comparison item	**Absolutely** more than B		**Definitely** more than B		**Much** more than B		**Slightly** more than B		**Same** as each other		**Slightly** more than A		**Much** more than A		**Definitely** more than A		**Absolutely** more than A
A	**B**	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
item 1	item 2			✓														
item 1	item 3													✓				
item 2	item 3						✓											

Example

▣ Evaluation method
- Compare the importance of criterion A and comparison item B.
- If A is more important than B, check the left side. If B is more important, check the right side.

☞ Description of [Response Example]

- Item 1 and Item 2: If <Item 1> in column **A is** judged to be **definitely more important** than <Item 2> in column B of the comparison item, mark ✓ on the left 7.

- Item 1 and Item 3: If <Item 3> in column **B is** judged to be **much more important** than <Item 1> in column A, mark ✓ on the right 5.

- Item 2 and Item 3: If <Item 2> in column **A is** judged to be **between slightly more important and much more important** than <Item 2> in column B of the comparison item, mark ✓ on the left 4.

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