Journal of Humanities and Tourism Research

Research Article

Advantages and Disadvantages of Nvidia Omniverse in Metaverse Game Design

NVIDIA Omniverse'in Metaverse Oyun Tasarımındaki Avantajları ve Dezavantajları

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Citation: Özturan, G. ve Şahin, C. (2026). Advantages and disadvantages of Nvidia omniverse in metaverse game design. *Journal of Humanities and Tourism Research*, 16 (1), 135-144..

Submitted: 11.02.2026
Accepted: 10.03.2026

Abstract

This study assesses the technical, creative, and communicative capabilities of NVIDIA's Omniverse platform and applies them in the metaverse-based game design process. By way of a literature review, the conceptual framework, and comparative analysis, the article highlights the capabilities of Omniverse at delivering interoperable technology across multiple software environments, ranging from USD (Universal Scene Description) to RTX (Real-time Rendering Technologies) to synthetic data generation tools. The platform is modular and extensible enough to support not just game development but also interdisciplinary innovative workflows, user experience, interaction strategies, and communication methods in digital culture. However, there are also limitations, including high hardware requirements, a steep learning curve, and the lack of cloud-based accessibility. Our findings suggest that Omniverse provides a strategic infrastructure that marks an entire paradigm shift in the metaverse landscape and reshapes the cultural paradigm of digital production and game communication.

Keywords: *Omniverse, Metaverse, Game Design, Real-Time Collaboration, User Experience*

Özet

Bu çalışma, NVIDIA tarafından geliştirilen Omniverse platformunun metaverse tabanlı oyun tasarımı süreçlerinde sunduğu teknik, yaratıcı ve iletişimsel olanakları incelemektedir. Literatür taraması, kavramsal çerçeve ve karşılaştırmalı analiz yöntemiyle yürütülen araştırma, özellikle Universal Scene Description (USD) mimarisi, gerçek zamanlı render teknolojileri (RTX) ve sentetik veri üretim araçları aracılığıyla Omniverse'in çoklu yazılım ortamlarında birlikte çalışabilirlik sağlama kapasitesini ortaya koymaktadır. Omniverse'in modüler ve genişletilebilir yapısı, yalnızca oyun geliştirme süreçlerini değil, aynı zamanda disiplinlerarası yenilikçi iş akışlarını, kullanıcı deneyimini, dijital kültürde etkileşim biçimlerini ve iletişim yöntemlerini de desteklemektedir. Bununla birlikte, yüksek donanım gereksinimleri, öğrenme eğrisinin dikliği ve bulut tabanlı erişim eksiklikleri gibi sınırlılıklar tespit edilmiştir. Bulgular, Omniverse'in Metaverse ekosisteminde teknik bir araç olmanın ötesinde, dijital üretim kültürünü ve oyun temelli iletişim deneyimlerini dönüştüren stratejik bir altyapı sunduğunu göstermektedir.

Anahtar Sözcükler: *Omniverse, Metaverse, Oyun Tasarımı, Gerçek Zamanlı İşbirliği, Kullanıcı Deneyimi*

1. INTRODUCTION

Digital content development and digital video games are moving ahead very fast now. Digital content production is now much more than technology; it is cultural, artistic, and communicative. At the same time, games have changed from entertainment tools to something of a virtual construct, which is used in some form for interactive, educational, simulation-driven, and collective experiences. There are interactive and participatory digital universes in the metaverse, one of the most striking domains of this shift, where users don't just consume content, they produce it. Described as persistent virtual environments and digital interaction spaces created from the convergence of physical and digital worlds, the metaverse reflects this transition. In this regard, the NVIDIA Omniverse platform brings a whole new potential for metaverse game design with tools like real-time collaboration, interdisciplinary innovative production processes, and high visual fidelity. The combination of Pixar's Universal Scene Description (USD) and NVIDIA's RTX technology allows Omniverse to create 3D modelling, visual effects, virtual reality (VR), and augmented reality (AR) solutions. Thus, Omniverse is an important piece of the metaverse's technical infrastructure that allows for such critical modules as virtual collaboration, real-time simulations, and digital twins.

This research thus also attempts to highlight, according to the extant literature, some of the possible implications of Omniverse within metaverse game development, and the role of its technical infrastructure with regard to communication, user experience, and cultural production.

2. CONNECTION BETWEEN OMNIVERSE AND THE METAVERSE

NVIDIA has developed Omniverse as a significant platform across virtual environments and simulation technologies. Utilizing the Universal Scene Description (USD) format, the framework aims to influence future metaverse applications. Omniverse is being utilized in many domains, including gaming, architecture, engineering, manufacturing processes, scientific simulations, robotics, and digital twin technologies. The primary goal of the platform is to form an integrated environment to allow collaboration and interaction with other people (Dwivedi et al., 2022; Vatanen, 2024). The entire platform consists of extensions and microservices that provide developers with a high degree of personalization (Ahmed et al., 2024; Vatanen, 2024). Omniverse is composed of the following core components and applications:

- Universal Scene Description (USD): Open-source framework to store and exchange 3D information, created by Pixar. It offers a shared approach to 3D scenes and asset descriptions based on a framework for different software tools to cooperate across the board.
- Omniverse USD Composer (formerly Create): The main application in Omniverse for creating and collaborating on 3D content. It allows users to create, modify, and plot 3D scenes with their friends in real time.
- Omniverse Replicator: A state-of-the-art synthetic data generation program for AI training, robotics, and simulation.
- Isaac Sim: A simulation to test and develop robotic scenarios, allowing users to create virtual environments where robots can be tested before real-world deployment.
- Drive Sim: A development and testing model for a self-driving vehicle simulation in a virtual environment, with the objective of establishing a driving prototype before it's integrated into the real world.
- Audio2Face: Generative AI-powered user interface that generates authentic facial effects using audio stimuli.
- Create XR: An application for immersive interaction in extended reality (XR), which covers both virtual reality (VR) and augmented reality (AR) environments. It enables engagement with digital content via virtual reality (VR) headsets or AR devices.

- Nucleus: A central service for the storage, exchange, and management of digital assets and information. It allows several users to work together on projects instantly; it also provides version control to keep track of changes.
- Omniverse Code: A unified Development Environment (IDE) for development - creating custom Omniverse extensions and applications for developers as needed, allowing users to build specialized tools and functions for 3D workflows.
- NVIDIA RTX GPU: You can use a very efficient graphics processing unit (GPU) made by NVIDIA called the NVIDIA RTX GPU, which can do real-time ray tracing, a rendering technology that simulates how light interacts to provide rich 3D rendering.
- Connectors: Enable interoperable 3D (USD linked) exchange of data and USD-based 3D assets in connection and trade between Omniverse and different 3D software, such as Autodesk Maya, Unreal Engine and Blender etc. Developers can develop their own Omniverse connectors and offer omnidirectional (bidirectional) connectors that provide a widespread collaboration and intermingling of information.
- Digital Twins: Virtual physical copies of physical items, hardware, systems, or procedures that are instantly transferable based on the virtual world and reflect changes, which the actual world can immediately compare and reproduce.

3. THE RELATIONSHIP BETWEEN THE METAVERSE, COMMUNICATION, AND DIGITAL GAMES

3.1. Digital Games as Interactive Communication Platforms

While games used to be considered part of the entertainment mix, the concept shifted from being an entertainment tool to a complete life journey. Digital games are predicated on communication and interaction by design. Although such games act as mass communication media, they also serve to promote interpersonal and group interaction between players. Indeed, through communicative actions, people essentially carry out their gameplay processes (Boyali, 2023).

3.2. Baudrillard's Simulation Theory and Communication in the Metaverse

Baudrillard's simulation paradigm has been an important theoretical basis for examining how communication is played out through game contexts in the metaverse. Simulation, in Baudrillard and Adanır's (1998) view, is the erosion of the connection between reality and representation, when visual representations without an original referent replace reality. This process blurs reality and fiction, leading to a new perceptual domain known as hyperreality. In hyperreality, representation does not reflect reality, but has become a separate order, an order separated from reality. On this point, Görgülü (2022) argues that in the metaverse, things that happen in the real world are replicated in the virtual world, creating radically changed communication. By replicating this, communication is not just a matter of passing messages or information but a practice of meaning-making that occurs through virtual representations. In the metaverse context, "simulation is always more effective than reality" (Baudrillard & Adanır, 1998). Over time, such relationships can replace their physical counterparts, and users have developed relations in areas of virtual culture without a physical foundation. That's when communication happens in a space ruled by representations that replace reality.

3.3. Metaverse as a Hyperreality Communication Space

In conclusion, the metaverse (interaction between users through avatars, digital twins, and virtual objects, and the interconnection of physical and virtual worlds) stands as a concrete manifestation of the hyperreality ecosystem postulated by Baudrillard and Adanır (1998). In this environment, communication takes place in a plane of virtual representations sufficient to allow virtual reality to surpass the boundaries of real-world content and potentially substitute for it. It is

these dynamics that make the metaverse and communication significant domain in the landscape of digital gaming, now as well as in the future.

3.4. Reciprocal and Transformative Relationship Between Games and the Metaverse

The interplay between games and the metaverse is a reciprocal one, fundamentally influencing the formation (Jo et al., 2025; Mohammed et al., 2024). Fundamentally, the metaverse is essential to this evolution, as the metaverse provides an immense and interconnected 3D virtual world network, which could be defined as the broad and interrelated (i.e., interconnected and interdependent) 3D virtual world space to which all game and platform platforms converge, supporting social interactions, commerce, and creativity (Dwivedi et al., 2022). At the heart of this transformation, there is evidence that games were initially a form of entertainment and eventually shifted from that to become a way to enjoy life, thus blurring the demarcation between a game and a metaverse. The metaverse offers potential to enhance people's experience by integrating the offline and virtual worlds, fostering a collective life by enabling social engagement (Alaeddinoğlu, 2023; Mohammed et al., 2024), and bringing new economic dimensions such as the creation and exchange of virtual assets. Current virtual worlds and immersive virtual games such as Fortnite, Roblox, or VRChat are considered preeminent forerunners of the metaverse; all these include the windows to the socio-economic concerns for the metaverse in operation (Dwivedi et al., 2022).

Advanced technology is the core of metaverse games. Virtual Reality (VR) and Augmented Reality (AR) technologies serve as the primary infrastructure and platforms connecting the metaverse and games. They are creating new and more vibrant immersive environments for playing games in this way (Mohammed et al., 2024). Game engines are instrumental towards crafting the metaverse; engines like Epic Games' Unreal Engine and Unity Technologies supply platforms for metaverse applications and Extended Reality (XR) experience. Outside of game development, these engines are a platform that enables automated cultural production (Chamusca et al., 2024; Chia, 2022).

4. METHODOLOGY

The study used qualitative methodology to investigate the potential for the use of NVIDIA Omniverse in metaverse game design procedures and the influence of Omniverse's technical framework on communication, user experience, and cultural production. The Omniverse platform developed by NVIDIA was analyzed in terms of its relationship with metaverse technologies and its capabilities in game development, as well as from the perspectives of user experience and communication.

In the data gathering process, 19 academic studies that were reported on the Web of Science and Scopus were reviewed utilizing the keywords: "Metaverse", "Omniverse", "game development", and "communication". Of these articles, 11 articles about game and application development and communication within the metaverse environment were included and summarized. From the collected data, inferences were made regarding how the platform fits into the game development process, its technical/innovative capabilities, and its limitations. Through the comparative study, Omniverse was assessed regarding its development of games and applications, communication, learning curve, and hardware requirements.

In the interpretive analysis of the study, Jean Baudrillard's simulation theory was used as a theoretical framework to analyze the concept of digital twin in terms of virtual reality. In addition, the conceptual analysis involved the effects of new design processes due to AI-assisted design and post-digital art theories on aesthetics and novel production.

The limitations of this study are the use of only academic sources, the lack of any direct game development projects generated with Omniverse in the market, and the inability to perform a comprehensive analysis of how the platform's high hardware requirements affect accessibility. Ethically, all information sources cited in the research had been clearly quoted, and an ethics committee approval was not required for this research.

5. FINDINGS

In this research, we studied the influence of the Omniverse platform on metaverse game development in terms of technical structure, creative potential, communication dimension, and industry evolution. Results were achieved by SWOT analysis (Table 1) and review of the literature. There are several significant findings to emerge from the literature review on the synergy of Omniverse technologies and metaverse game design.

Ahmed et al. (2024) examined the transformation effect of NVIDIA's Omniverse platform on simulation and content creation. They spotlight tools like the Omniverse Replicator, Isaac Sim, MDL, Audio2Face, and XR in their article. They acknowledge that simulation technology and the creation of synthetic data can improve the game's environment with new realism and authenticity.

Aloqaily et al. (2023) investigate the integrated use of digital twins (DT) and cutting-edge technologies in metaverse technology. Their assertion is that using DT, XR (AR/VR/MR), AI, blockchain, 6G, IoT, and APIs can give secure, practical, realistic, scalable gaming experiences.

In their study entitled Collaborative Virtual Design on the Virtual Design Teams in Second Life, Bardzell and Shankar (2007) provide a discussion of collaborative virtual design. Using MMOG technologies, 3D avatars, and VR environments, they show how avatar-based collaboration fosters content production. Their research shows that gamified simulations work best when embedded in the virtual environments themselves; that is to say, gamified simulations do better in that virtual environment.

Bayezit (2023) has explained the evolution of interaction from virtual reality to physical reality using virtual reality. In this paper, using the technology of the VR/metaverse medium technology, sociological interaction has been influenced by this technological platform, what virtual reality, particularly with respect to communication and the virtual world in an interaction, impacts from this domain, and why the virtual visual representations have also changed how we interact with other humans while keeping social bonds with the social interaction going in the interaction, the significance of the virtual reality and metaverse.

Boyali (2023) deals with how social interaction dynamics in digital games work. The researchers stated that various features of interactive players and their social structure, including in-game chat, on-board group communication, and in-game multiplayer interaction, have already been established to demonstrate how these characteristics support player cooperation community dynamics in games, and facilitate the formation of communities and social bonding in people during gameplay.

Chamusca et al. (2023) researched intuitive VR content creation tools that could be designed using metaverse production. Utilizing Omniverse, USD, XR, and VR authoring tools plus Audio2Face technologies, they found democratizations of content creation and interoperability at the system level. Chia (2022) analyzes the infrastructural role of game engines on metaverse platforms. Game engines (Unreal Engine, Unity, MetaHuman Creator, and Metacast) represent the backbone of the metaverse, the study says – providing a world where the platform can design, create, or distribute large formats of content automatically.

Jo et al. (2025) in the metaverse – player interactions, dynamic game worlds, and game reality. They find that through 3D virtual worlds, augmented reality, and immersive environments, players generate creativity as a method of content creation and socialization in the interrelated digital environment.

Mirza-Babaei et al. (2022) explore the intersection of game research, the metaverse users' experience, and content development. Their findings show the importance of 3D social environments, avatars, user-generated content (UGC), and virtual economies to establish a sustainable culture of content production in the metaverse.

Mohammed et al. (2024) meta-review the symbiosis between the gaming industry and the metaverse. With a focus on VR, AR, AI, blockchain, high-speed internet, and avatar/content trade, the metaverse works for socialization, content generation, and economic growth at the same time.

Finally, Sun et al. (2022) studied how the metaverse facilitates user-generated contributions in stable virtual environments. They identify XR, AI, blockchain, NFTs, digital twins, and content-making platforms as major facilitators and state that production through AI and digital twin capabilities is at the heart of producing high-fidelity content. Altogether, the studies discussed above offer substantive evidence that Omniverse technologies and metaverse infrastructures are at the heart of the future of digital game development, through the integration of a high-level technical infrastructure, creative affordances, emergent communication relationships, and sectoral change. Rather than serving as yet another toolbox, Omniverse is a community that connects many different domains of the design, simulation, and interaction space and embodies the overall ambitions of the metaverse. The results of the studies are broadly disparate, highlighting different strengths and failings of the platform.

First, we see interoperability enabled by USD standards and RTX-based rendering technologies that guarantee a far greater diversity of visual fidelity, accuracy, and performance than standard approaches have permitted. USD also allows designers and developers (in different systems) to work in coordination on a similar scene, avoiding conflict and data loss, as well as speeding up project execution. Light, shadow, and reflection can be accurately simulated using RTX-based real-time ray tracing. Immersion, emotional engagement, and cinema benefits can be increased further in the immersive experience. These technical benefits not only widen the gaming world's graphics landscape but, to a greater extent, provide a foundation for various field applications, including simulation, robotics, and industry.

Second, the combination of complementary technologies (digital twins, AI, XR, blockchain, and 6G networking) has scale and security dimensions, and that may give a gaming activity a personalized growth space. Digital twins lead to more interactive experiences for authors, and authors can create avatars or virtual entities that will be dynamic based on real data. Blockchain establishes the credibility and authenticity of digital transactions, and XR extends immersion to AR, VR, and MR devices. Together, all of this transforms the metaverse from entertainment to a multi-dimensional proposition for healthcare, education, automobile design, engineering, and the preservation of cultural heritage. Omniverse also embodies how the metaverse can be turned into a socio-technical system, able to sustainably serve a multitude of industry needs through simulation, real-time collaboration, and intelligent data integration.

Third, the participatory element is the core of the metaverse, where user-generated content and creative potential (aka, by means of participation in a community) shine. Interactive features that are part of their journey from passive consumers to active co-creators or co-makers in certain cases, including avatar customization, collaborative building, multiplayer socialization, collaboration utilities, and social interaction types. Research surrounding such activities might

include virtual avatar personalization, team building, or co-creation with players. And that's great work — an elevated level of game play and an acceleration for innovation and digital economy across our industry. A participatory culture can also feel suffocating. Technical obstacles, steep learning curves, and high hardware requirements could even hinder inclusivity — a challenge that young developers simply can't afford. Also, with many of its socio-ethical issues like toxic community, digital harassment, gaming addiction, etc., it points to an array of its social problems to drive platforms to consider ethical and proper construction, community management, and safety systems in their platforms as part of their platform.

These results also illustrate large competitive and infrastructural challenges. Common engines (think Unity, Unreal) have developer communities, open-source assets, and teaching assets based just above those. Omniverse, though, provides real-time synchronization, photorealism, cross-platform interoperability, and cross-platform support, which sets Omniverse apart. But its long-term success depends on creating an environment similar to that of a community, where communities develop together. Key aspects of growing the platform in the future are providing training content, open documentation, and user-generated assets in the open-access toolkit and building them. Also, high-class local systems are often a barrier to access, especially in places where hardware resources are limited. Thus, cloud-based collaboration and effective client size will increase inclusion and narrow the digital gap.

Taking a look at the SWOT analysis (Table 1), NVIDIA Omniverse is one of the unique options competing for a place in the metaverse ecosystem. On the other hand, where it can, its key strengths are technical innovation, interoperability, and a way to stimulate collective creativity, all in a collaborative setting; but its main weaknesses are the need for relatively high technical requirements and a lack of community support to compete with other platforms. It points to the potential of Omniverse to become both a technological enabler of future-first gaming and a player in the imaginative and economic rebirth of the metaverse. Omniverse will be more than a specialist in this space — its solutions to questions of inclusion, accessibility, and ethics will be in play — as we lay the groundwork for a continually evolving ecosystem.

Table 1. SWOT Analysis of Omniverse as a Game Development Platform for the Metaverse

Category	Internal Factors	External Factors
Strengths	USD-based universal compatibility	Growth of the metaverse trend
	Real-time collaboration capabilities	Alignment with Industry 5.0
	High-quality graphics and physical simulation	Expansion of the gaming market
	Modular and extensible structure	
	Digital twin integration	
	AI integration and synthetic data generation	
Weaknesses	High hardware requirements	Advancement of competing platforms
	Steep learning curve for new developers	Emergence of cloud-based alternatives
	Operating system compatibility limitations	Early-stage market maturity
		Cost and licensing constraints
Opportunities	Potential for user-generated content (UGC) and social platforms	Widespread adoption of XR technologies
	Increased AI integration	Expansion of the digital twin market
	Reduction in development costs and timelines	Gamification potential across different industries
Threats	Open-source alternatives	Data security concerns
	Hardware costs are limiting accessibility	Lack of standardization
	Security and privacy risks	Negative social and human impacts
	Data size and processing capacity challenges	Misuse and inappropriate user behavior
	Technical complexity and infrastructure dependency	

CONCLUSION AND DISCUSSION

With technologies such as real-time synchronization, photorealistic rendering, digital twins, and artificial intelligence integration, Omniverse provides a new technology-centric approach to digital content production from video game design to architecture, engineering, and media. By integrating USD and RTX technologies, it ensures compatibility with multiple software environments, resulting in a quicker production process for teams of developers. In addition, it generates an interactive ecosystem that makes users go from passive consumers to active creators of the content.

The unique aspect of metaverse game development, through the aid of Omniverse's graphical features, is its help in real-time multiplayer communication, interaction, and dynamic narrative structures. Gamified systems that developers have access to expose social, economic, and cultural systems in virtual worlds to testing, so users can use their roles in the virtual environment. This is taking game design out of the static box, making it more adaptable, modular, and scalable.

However, this platform has a complicated interface and a large and complicated set of hardware dependencies, which have a negative effect on the wider diffusion to the educational

community. However, differences in expertise are likely to create disparities in users' experiences, affecting digital inclusivity in various ways.

In addition, the social/ethical factors related to digital harassment, toxic interactions, and gaming addiction could be relevant in the case of the community system of this type. We conclude that Omniverse is more than a technical environment focused on development; it is an entire digital ecosystem that promotes interdisciplinary collaboration, creative design, high-level communication, and digital learning. Beyond metaverse usages, the platform participates strategically in paving a user-centric, innovative, and collaboration-oriented future.

Finally, the results indicate Omniverse may have the potential to shape our and the future's communication, digital design, games, and production models beyond today. The platform is expected to continue to be used on a larger scale for multi-disciplinary activities and metaverse infrastructures in the years to come. This evolution poses significant and inspiring challenges to all fields of digital transformation, tech-enabled teaching, and the creative economy. At the same time, a number of technological issues have to be overcome in order for a smooth transition, such as high system requirements, long learning time, network infrastructure latency, interoperability limitations, and data security issues. For answers related to these problems, solutions will depend mainly on having wider availability of hardware solutions, better cloud services, open standards, and deep security protocols. By enabling synthetic data generation and game creation as fast as possible in real time and helping team members, Omniverse accelerates the game development process and enables developers to develop more socially interactive, scalable, and immersive virtual worlds. Finally, Omniverse itself can be seen as a technology tool that powers (rather than creates) creative, cooperative, and sustainable digital ecosystems.

Artificial Intelligence Usage Statement

During the preparation of this work, the authors used Grammarly to edit the grammar of the translation. After using this tool/service, the authors reviewed and edited the content as needed and assume full responsibility for the content of the published article.

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