SPATIAL EXPERIENCE IN METAVERSE EXHIBITIONS: A COMPARATIVE ANALYSIS OF REALITY-BASED AND VIRTUALITY-BASED DESIGN APPROACHES

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By

Zeynep Uzun

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We certify that we have read this thesis and that in our opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science.

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ABSTRACT

Spatial Experience in Metaverse Exhibitions: A Comparative Analysis of Reality-Based and Virtuality-Based Design Approaches

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M.S. in Architecture

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Technological advancements have initiated the realisation of the metaverse concept, which provides an alternative environment for human experience. Within this digital frontier, while some architectural designs transcend the boundaries of reality ` adaptation, certain spaces adhere to mimicking the physical realm. As a consequence, two design approaches have emerged in the metaverse: reality-based (RB), which replicates the appearance of real-life architecture, and virtuality-based (VB), which takes advantage of the flexibility and limitlessness of virtual environments. However, the impact of these different approaches to the design on spatial experience remain to be investigated.

This thesis aims to find out how these two different approaches in metaverse environment's designs impact spatial experience of the users. By concentrating on two different exhibition spaces in metaverses, the effect of architectural design approaches on spatial experience is intended to be find out. Within this framework, an experimental study was conducted with 118 architectural design students. The spatial experience was analysed through the Questionnaire on Spatial experience in exhibition environments with 6 subcategories (presence, immersion, engagement, flow, judgement, and wayfinding) through a 5-point Likert Scale. As a result of the research, the participants who experienced the RB environment felt significantly more present than those who experienced the VB environment. The result aid in comprehending the impact of design on spatial experience by providing insights from the perspectives of architecture, art, and spatial experience. Future research may validate and expand upon these discoveries in a more comprehensive framework through the utilisation of spaces featuring diverse design methodologies, and in collaboration with individuals from other disciplines.

Keywords: Metaverse, Spatial Experience, Virtual Environment, Exhibition Spaces, Non-fungible Token

ÖZET

Metaverse Galerilerinde Mekansal Deneyim: Gerçeklik-Temelli ve Sanallık-Temelli Tasarım Yaklaşımları Arasında Karşılaştırmalı Analiz

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Teknolojik gelişmeler, insan deneyimi için alternatif bir ortam sağlayan metaverse kavramının hayata geçirilmesine ön ayak olmuştur. Bu dijital ortamda, bazı mimari tasarımlar adaptasyon yoluyla gerçekliğin sınırlarını aşarken, bazı mekanlar fiziksel alanı taklit etmeye bağlı kalmaktadır. Sonuç olarak, metaverse'de iki tasarım yaklaşımı ortaya çıkmıştır: gerçek hayattaki mimarinin düzenlemelerini taklit eden gerçeklik temelli (GT) ve sanal ortamların esnekliğinden yararlanan sanallık temelli (ST). Tasarıma yönelik bu farklı yaklaşımların mekânsal deneyim üzerindeki etkisi araştırılmaya devam etmektedir.

Bu tez, metaverse ortamlardaki bu iki farklı yaklaşımın kullanıcıların mekânsal deneyimlerini nasıl etkilediğini ortaya koymayı hedeflenmektedir. Metaverse ortamlardaki sergilere odaklanılarak, mimari tasarım yaklaşımlarının mekânsal deneyim üzerindeki etkisinin ortaya çıkarılması amaçlanmıştır. Bu çerçevede 118 mimari tasarım öğrencisi ile deneysel bir çalışma yürütülmüştür. Ortamlardaki mekânsal deneyim, mekânsal deneyim anketi ile 6 alt kategoride (mevcudiyet, sürükleyicilik, katılım, akış, yargı ve yön bulma) 1-5 Likert Ölçeği ile analiz edilmiştir. Araştırma sonucunda, GT ortamını deneyimleyen katılımcılar, ST ortamını deneyimleyen katılımcılara kıyasla kendilerini anlamlı ölçüde daha mevcut hissetmişlerdir. Bu çalışma, mimarlık, sanat ve mekânsal deneyim perspektiflerinden içgörüler sağlayarak sanal ortam tasarımının mekânsal deneyim üzerindeki etkisini anlama konusunda yardımcıdır. Gelecekteki araştırmalar, farklı tasarım metodolojilerine sahip mekânların kullanılması ve diğer disiplinlerden kişilerle işbirliği yapılması yoluyla bu keşifleri daha kapsamlı bir çerçevede doğrulama ve genişletme fırsatına sahip olabilir.

Anahtar sözcükler: Metaverse, Mekansal Deneyim, Sanal Ortam, Sergi Alanları, Değiştirilemez Token

To Suzan Ulucenk, my dearest grandma, and Feriha Uzun, my beloved grand aunt

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LIST OF ABBREVIATIONS

2D	Two Dimensional
3D	Three Dimensional
AR	Augmented Reality
CPU	Central Processing Unit
DAPP	Decentralized Applications
GAC	Google Art & Culture
GPS	Global Positioning System
MPOVE	Multi-Participant Online Virtual Environment
MUD	Multi User Dungeon
NFT	Non-fungible Token
RB	Reality-based
VB	Virtuality-based
VR	Virtual Reality

CHAPTER 1

INTRODUCTION

With cryptocurrencies and advancements in computer technology, virtual environments have reached a whole new level, and almost like in Neal Stephenson's *Snow Crash* novel (1992), the concept of the "metaverse" is turning into reality. In Stephenson's metaverse, users can engage through avatars, create their own houses, attend events, explore museums, and buy digital assets tailored for utilization. The incorporation of ownership into virtual environments is becoming a reality through cryptocurrency technology, realizing Stephenson's notion of the metaverse.

Although the term "metaverse" is commonly associated with a single concept, there are numerous platforms that function as metaverses, including Decentraland, Roblox, and The Sandbox. Each of them distinguishes themselves through their unique user experiences, aesthetics, and economies. For example, Roblox and The Sandbox provide users with gamified experiences via their low-poly, pixel environments, whereas Decentraland provides players with the freedom to explore an open map and attend events. Despite the apparent diversity among the platforms, their creation is guided by a singular objective: to provide an alternative to the physical world by imitating real life's functions and sometimes its appearance.

Exhibition spaces in the metaverse are such examples, which redefine the artworks as NFTs. Such implementations support the appeal to wider audiences without regard to time or location (Marty, 2011). As Ortaç (2021) states, virtual spaces allow displaying artworks that would be impractical to do in physical venues logistically and physically.

However, while virtual spaces, especially metaverses, offer flexibility in what one can do, such as experiencing zero-gravity space and the creation of customisable environments, the current state of design approaches for these spaces doesn't fully utilise their limitlessness. As Moneta (2020) mentions, virtual environments can transcend the boundaries of mimetic realism by adopting an unconventional approach to using the virtual environment's limitlessness as a catalyst for being creative. Also, according to Novak (1991), these environments are visionary habitats, which allow "*it-can-be-so*" to take priority over "*it-should-be-so*". Nonetheless, many metaverses replicate the architectural style of the physical realm, while a few test the limits of virtual space.

Currently, metaverses encompass various design approaches that can be categorised under two titles: reality-based environments (RB), which represent the real world accurately with high representational fidelity, and virtuality-based environments (VB), which refer to a surreal environment with low representational fidelity (Chung et al., 2024). The objective of this thesis is to determine how these two attitudes in design impacts the users' spatial experience in metaverse exhibitions. Within this framework, the thesis focuses on exploring the concept of the metaverse, exhibition spaces, and the increasingly varied experiences of art as technology develops. It also explores the use of NFTs in both the physical realm and metaverses, the implementation of the RB and VB approaches to exhibition spaces within metaverses, and the correlation between the design approach and the visitors' spatial experience.

1.1 Problem Statement

For many years, the technology behind virtual environments had a gradual growth that led to the introduction of metaverse environments. However, the design of these environments does not fully respond to the technology behind them, and most of the environments in the metaverse act as reproductions of the physical environments by underutilizing the limitlessness of virtuality. There are some studies that discuss the issue of virtual reality and real-life architecture (Moneta, 2020; Horne & Thompson, 2008), but they do not investigate the impact of applying a realistic design approach to the virtual world and how it effects the spatial experience of users.

There is a recent study by Chung et al. (2024) that aims to analyse the effect of different design styles, the RB and VB, in terms of presence and enjoyment in virtual reality exhibitions. In this study, VB design styles are defined as a surreal, abstract space without any boundaries. However, there is still a research gap that focuses on the spatial experience from a broader perspective, looking at diverse subscales rather than focusing on two subscales and comparing the RB and VB environments. Also, there is still room for focusing on the metaverse environments and investigating the potential of art within the metaverses. This thesis specifically focuses on the experiences of young architects, who are the potential future designers of such environments. The findings may aid designers in designing exhibition spaces in virtual environments, especially metaverses.

1.2 Aim and Scope of The Thesis

This thesis aims to reveal the effects of exhibition space designs in the metaverse on the spatial experiences of, especially, younger generations. Within this conception, an experiment is conducted about spatial experience in two different exhibition environments in metaverses: *Verses Gallery* (https://www.spatial.io/s/VERSES-Gallery-62053ee64202c9000136e63e?share=7454859656663147052), which mimics real-life architectural styles (i.e., RB), and *NFT Biennial-Ouroboros Pavilion* (https://www.spatial.io/s/NFT-Biennial-Ouroboros-Pavilion-63a8bcc15b82ea00013a981a?share=3767397328367021398), which features space that is free of physical building characteristics (i.e., VB). These two exhibition settings, while not entirely comprehensive like real-life exhibition spaces, provide a distinct viewpoint on exhibition and redefine them in the metaverse. The participants of the experiment are the students at İhsan Doğramacı Bilkent University, Department of Architecture, who are in the second, third, and fourth grades and are graduate students. The participating students were divided into two groups, and each group experienced one of the exhibition spaces and responded to the questionnaire regarding their spatial experience in the environment. The experiment was carried out on the personal computers of students during their scheduled studio hours. After providing their demographic information via the Google Forms link, respondents were then redirected to the designated exhibition space in the metaverse. After they completed touring the exhibition space, they responded to 32 items on a five-point Likert scale and 3 open-ended inquiries.

With this experiment, this thesis aims to discuss the effects of different architectural approaches on the spatial experience of the participants by focusing on the *presence*, *engagement*, *immersive*, *flow*, *judgement*, and *wayfinding* subscales. Frequency and percent analysis, relationship analysis (independent sample t-test and Pearson correlation analysis), and reliability analysis (Cronbach's alpha) were applied, and the results of the questionnaire were analysed by SPSS software. In addition, the answers to open-ended questions were analysed with the Voyant tool. This free web-based tool operates a range of text analysis functions, including *summary*, *circus*, *correlation*, and *context*, within its framework.

This thesis hypothesises that implementing RB design approaches in exhibition spaces within metaverses leads to an enhanced spatial experience. Consequently, it is expected that this thesis can respond to the following research questions:

- What are the differences in design approaches between RB and VB exhibition spaces within metaverses?
- How do visitors perceive space in VB compared to RB exhibition spaces within metaverses?
- When designing spaces in the metaverse in the future, should designers adopt a design approach that closely follows the principles of the physical realm, or should they innovate and create an entirely new design language?

1.3 Structure of the Thesis

This thesis consists of five chapters. The chapters are arranged, respectively, as follows: The first chapter states the problem, aim, and structure of this thesis. The second chapter defines the concept of the metaverse, discusses its evolution both conceptually and technologically, and mentions sample metaverse platforms. The following chapter highlights the museum and exhibition spaces by discussing their evolutions throughout history and the impact of technology in the process. Additionally, in this chapter, RB and VB approaches to the design of virtual exhibition spaces, and spatial experience in virtual environments are presented. The fourth chapter presents the experiment conducted using a *Questionnaire on Spatial Experience in Exhibition Spaces within the Metaverse.* This chapter explores several subjects, including the matrix system that outlines the selection criteria for selecting RB and VB environments, subscales of the questionnaire, and the sample group. In Chapter Five, the findings regarding the spatial experiences in RB and VB exhibitions within metaverses are discussed. The Sixth Chapter discusses the results of this study within three subtitles: spatial experience, architecture, and art, and states the suggestions for further studies. Finally, the thesis concludes with references and appendices.

CHAPTER 2

METAVERSE ENVIRONMENTS

The concept of metaverse is defined as a ground-breaking technological development that redefines human interaction and activities in virtual environments and digital commerce. Technological advancements, from immersive technologies to the blockchain, assist in the creation of the notion of the metaverse as a parallel universe to socialise, entertain, and educate.

The concept of the metaverse is first mentioned in Neal Stephson's book *Snow Crash* (1992). The book envisions the metaverse as an alternative world where individuals redefine their identities as avatars, cultivate relationships with others, and engage in social activities. In the book, the metaverse also embodies the vision of exceeding the limits of the physical world and blurring the boundary between physical and virtual realities (Stephson, 1992). However, a more comprehensive definition of the term has yet to be established based on the evolution of technological advancements and existing metaverse platforms.

As in the book, the metaverse is introduced as an environment where people can meet with their friends online, attend virtual events, and engage in collaborative work with their colleagues (Lee et al., 2022). The definition of the metaverse remains unsettled, with researchers expressing multiple perspectives on the concept. For instance, according to Park and Kim (2022);

"*Metaverse is a compound word of transcendence meta and universe and refers to a three-dimensional virtual world where avatars engage in political, economic, social, and cultural activities. It is widely used in the sense of a virtual world based on daily life where both the real and the unreal coexist.*" (p.3)

Yang et al. (2023) define the metaverse concept as a hybrid world that encompasses both physical and virtual realms, surpassing the physical realm's boundaries and created by merging the terms meta (beyond) and verse (universe abbreviation). Also, Lee (2021) state that the word "metaverse" highlights the vision of a shared, immersive, unified realm at its core. Despite variations in defining the notion of the metaverse, Lee, et al. (2022) suggest that it is a unique space that blends virtual environments and physical reality within a computer-generated environment, and they refer to it as a crucial milestone of today's cyberspace.

2.1 The History of Metaverse

The advent of the metaverse opened a different door in many disciplines, such as economics, architecture, and art, through its advanced technology and infrastructure. Thanks to technological advancements, the metaverse is transformed from a basic concept into a tangible reality. The advancements in technology, including virtual reality glasses, augmented reality, touchscreens, and controllers, substantiate the era of the metaverse, which is a blend of two realities and relies on the disappearance of the boundary between them (Ball, 2022). The evolution of the metaverse represents an intricate and diverse process of creation that comprises several layers. Therefore, it should be comprehended both conceptually and technologically.

As Yuang et al. (2023) state, the evolution of the metaverse started with the conception forming period. Before the idea was transformed into an actual encounter, it underwent conceptualization. One concrete instance of these notions is cyberspace, which serves as the primary term for literature and films. Then these conceptualizations were amplified with technology into virtual worlds and then into the metaverse.

The term “cyberspace” was introduced and became popular with the release of the *Neuromancer* novel by William Gibson (1984). It is defined as:

“Consensual hallucination that felt and looked like a physical space but actually was a computer-generated construct representing abstract data” (p. 79)

Consequently, Benedikt (1991) defined cyberspace as a parallel universe that relates to “virtual reality", “data visualisation", "networks" and "multimedia". Cyberspace has a broad definition as a virtual space, which includes communication interactions over networks and the internet. It involves digital networks and systems that are connected, such as websites, social media, and more.

One way of interacting in cyberspaces was achieved by multi-user dungeon (MUD) games that enable users to have a text-based interaction with their specific roles inside the context. They were first introduced in 1985 and provided the groundwork for social interactions through gaming. (Ball, 2022; Lee, 2021). With the introduction of the online game “Habitat” by Lucasfilm, users got a chance to experience MPOVE (a multi-participant online virtual environment) that actualizes cyberspace, as in Gibson’s *Neuromancer*. In this game, players can depict virtual environments and avatars in a

2D pixelated format (Ball, 2022). As Ball (2022) mentions, during the ’90s, users started to experience the premature 3D worlds (known as 2.5D virtual worlds), which commonly allowed them to interact with other users and enabled them to experience the environments through the movement along two axes. Then, the first 3D virtual environment game, Active Worlds, was launched. In this game, people create their avatars and build their worlds collaboratively in real-time, with the support of web-based chat with their friends (Ball, 2023; Wikipedia contributors, 2023). In the late 90s, many other 3D games were launched, such as Tomb Raider and EverQuest, which assisted the immersive experience in 3D game environments with human-like avatars and environments (Lee et al., 2022). The experience within these environments laid the foundation for the metaverse concept.

After the conceptual framing of the metaverse, technical formation is started, as mentioned by Yuang et al. (2023). In this period, 3D virtual environments and virtual reality (VR) technologies evolved. The popular multiplayer virtual platform, Second Life, made its debut in 2003. It is defined as an early attempt at creating a metaverse where users do not have any specific objective other than experiencing the environment through using their avatars, constructing their properties, buying assets (using the game currency, Linden dollars), and attending events. (Lee et al., 2022; Sparkes, 2021) (Figure 2.1). Soon after it was released, real-life corporations participated in the platforms, such as Adidas and BBC (Ball, 2022).

Figure 2.1: Second Life (Source: https://www.polygon.com/second-life-studio-working-on-a-spiritual-sequel)

The emergence of Second Life was followed by Roblox in 2006, which is defined as a precursor to the metaverse since users interacted online with others by creating their avatars in 2006 (Yang et al., 2023). Minecraft emerged as another platform that functions similarly to Roblox and can be considered an early version of the metaverse. These two platforms differ from Second Life in terms of their technology and user-friendliness, with a specific focus on children and teenage users (Ball, 2022). After thirteen years, the popularity of Roblox reached another level, with over 100 million monthly active users (San Matteo, 2019). In addition, another well-known metaverse platform, Fortnite, is known to have over 45 million players around the globe (Yang et al., 2023) (Figure 2.2).

Figure 2.2: Roblox (Source: https://www.xbox.com /games/roblox)

During the early 2000s, the advent of augmented reality (AR) and virtual reality (VR) headsets, including Google Glass and Meta Oculus, provided users with the opportunity to interact with computer-mediated environments in virtual physical blended environments, including VR Chat and Horizon (Lee et al., 2022).

Metaverse's formation accelerated in the 2000s. This was a period when metaverse platforms and technology reached more people and attracted more attention (Damar, 2021). With COVID-19, which led to a worldwide lockdown in March 2020, people's offline social activities were restricted, and therefore interest in virtual worlds grew (Dwivedi et al., 2022). During the lockdown, the blockchain technology that forms the metaverse's infrastructure and NFTs, which were introduced in 2014, gained popularity (Yang, et al., 2023). At the same time, Roblox, which went public in the US in 2021, started to attract more attention. Facebook, one of the big ventures, has also drawn attention to this concept by changing its name to "meta" (Yang et al., 2023).

Various statements question the full realization of the metaverse's potential. Developments support the shift of the metaverse from a concept that is introduced in a novel to an alternative world. According to Ball (2022), the metaverse has gained significant prominence among consumers with its technology, from MUDs to Fortnite. It combines digital and physical realities in various aspects such as socializing, entertainment, and work. The continuous progress in its technology is expected to be implemented in a more immersive and interactive way to the metaverse (Yang et al., 2023).

2.2 Technological Advancements Behind Metaverse

Metaverses are digital environments that are created through the implementation of Web3 technology, blockchain, cryptocurrencies, and NFTs. Metaverses are differentiated from traditional three-dimensional virtual environments through the implementation of advanced technologies, such as decentralized ownership, enhanced security, and the seamless capability to create and exchange digital content. In addition to these technological advancements, there are features that elevates the experience in metaverses including virtual-reality (VR) technology, real-time rendering and avatar integrations.

VR technology offers an immersive environment that can be implemented by some metaverse platforms. The first VR headset was introduced by the Japanese company Sega in 1993 to provide a synthetic view (Lee et al., 2022). With their ongoing development, these headsets offer a conventional method to immerse users in virtual settings by separating them from physical reality (Lee et al., 2022).

VR technology is crucial for metaverses since these virtual environments offer an alternative world, and feeling immersed in this virtual world may leverage the experience. Various metaverse platforms support VR, like Horizon Worlds, Spatial io, and VRChat. However, the support of VR headsets requires specific hardware, and several metaverses are unable to implement this technology, such as Decentraland and Voxels.

Another important feature of the metaverse is its real-time rendering capacity, which affects the experience. In the absence of real-time rendering, the experience of the users would be constrained to the pre-rendered images that are depicted in a sequence

(Ball, 2022). With this feature, users can have a fluent experience with infinite choices (Ball, 2022). As Yang et al. (2022) suggest, high-quality and real-time rendering creates stunning metaverse environments, and these features support immersion in virtual worlds.

Moreover, virtual worlds offer users the chance to define their identity as avatars. In metaverses, the interpretation and designs of avatars are evolved. As Dwivedi et al. (2022) define the concept of an avatar, it is a representation of a person as a digital twin within the metaverse. Also, Lee et al. (2021) suggest that avatars serve as digital representations of users that communicate with other avatars (users) and with non-player characters. The virtual worlds allow users to have multiple personas and identities (Park & Kim, 2022). Various metaverse platforms are offering diverse advancements for the creation of avatars so that users can redefine their personas, genders, and appearances with the assistance of virtual world tools. For instance, in VR chat, users are enabled to scan their faces, and the system automatically generates an avatar that looks like their real-life appearance (Lee et al., 2021; Figure 2.3). However, in Spatial IO, users design their avatars within the options among those the platform offers.

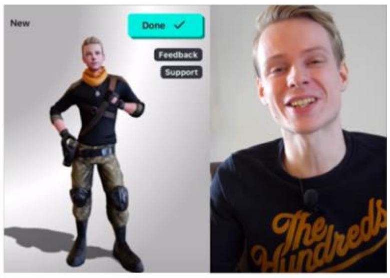


Figure 2.3: Avatar in VRChat (Source: Lee et al., 2021)

2.2.1 Web 3.0

Web 3.0, also known as the third-generation Internet, evolved from Web 1.0 and Web 2.0 (Yang et al., 2023). Web 1.0, which was introduced around the 1990s, enabled "readable" or "read-only" files and offered websites that could be accessed via desktops only (Yang et al., 2023). Web 2.0 created a shift from "readable" to "readable and writable" with the arrival of blogs, Twitter, and WeChat that provide a platform for users to generate their content and interact with other users within the platforms. These platforms are controlled by big tech companies such as Google, Meta, and Amazon (Gilbert, 2022). Web 3.0, on the other hand, offers the ownership feature, which enables users to possess authority over the content data and accelerates the addition of "writable" to "readable" (Yang et al., 2023).

Metaverse platforms utilise the decentralised architecture of Web 3.0. However, as Figure 2.4 by Yang et al. (2023) shows, there are Web 2.0-based closed metaverses that are overseen by a centralised authority and also Web 3.0-enabled metaverses that operate on a decentralised system with their own blockchains. While all of these metaverse platforms share the goal of creating a 3D virtual environment and providing various experiences to users, the specific experiences offered vary, depending on whether they are based on Web 2.0 or Web 3.0 technology.

Figure 2.4: Different styles of metaverses, empowered by Web2.0 and Web3.0 (Source: Yang et al., 2023)

2.2.2 Blockchain Technology

Metaverse merges the physical and digital worlds and enhances the experiences and interactions within them. According to Ball (2022), people's interests, leisure time, work, and social connections can be transferred to metaverse environments since they offer a parallel world of existence in every aspect of life, including the economy.

Blockchain technology is an advancement that enables this economic system. It is essential for ensuring the security and transparency of this digital realm's economy and data. It enables the virtual world to establish its own decentralized economy system, enabling users to own digital assets in the form of both non-fungible tokens, which define a unique digital asset, and fungible tokens, which refer to interchangeable assets, for financial transactions to enhance the user experience (Gilbert, 2022).

Blockchain and cryptocurrencies are the main elements that enable this financial structure. As Harwick (2016, p. 570) states,

"A cryptocurrency is a method of constituting virtual "coins."".

In this system, each user has a unique wallet ID, and the transactions are stored on the network as "blockchain," whereas they are recorded in central banks in the physical realm. This blockchain system is decentralised since it consists of many blocks that govern each transfer, in contrast to the real-life scenario where there is only one central bank (Harwick, 2016).

It is a distributed database that stores each transaction with a string of "blocks" of information (The Economist Group Limited, 2021; Lee et al., 2022). The blockchain generates a block for each transfer, generating data from users, and connects these blocks to the preceding block in chronological order (Yang et al., 2023). Each user is defined as a node on the blockchain, and once it is linked, every node retains a comprehensive record of the data saved on the blockchain. If any error happens on the chain, millions of other nodes can reference and rectify the issue (Lee et al., 2022; Yang et al., 2023) (Figure 2.5). Since there are thousands of nodes around the globe, the blockchain system functions as a decentralised system of individuals (The Economist Group Limited, 2021). Thus, the system is secure as it is decentralised, not under the authority of a single entity like a firm or a bank but rather governed by multiple centers. Users can use this technology easily without worrying about hidden fees or sharing individual data; all transaction processes happen transparently (Ball, 2022).

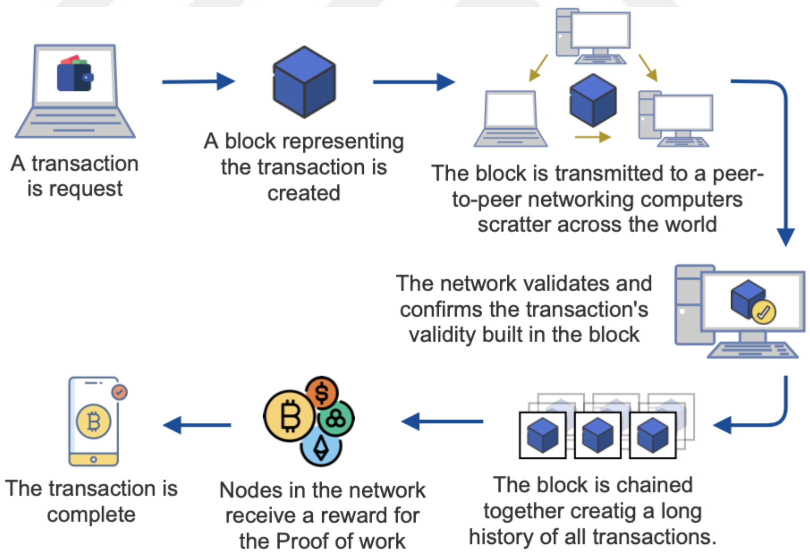


Figure 2.5: Illustration of a transaction by the blockchain technology (Source: Gadekallu et al., 2022)

Gilbert (2022) outlines three fundamental characteristics of blockchain technologies: first, decentralisation, achieved through the absence of a central authority; second, immutability, ensuring the storage of all data without deletion or undoing; and third, transparency, enabling the public to track all transactions. Additionally, the main element of this system, wallets, enables users to access blocks and transfer cryptos. (Gilbert, 2022)

One of these blockchains, Bitcoin, known as the first digital coin, is a digital current proposed in 2009 (Lee et al., 2012). It was introduced in an article called "*Bitcoin: A Peer-to-Peer Electronic Cash System*" by Nakamoto (2008). In this article, decentralisation is highlighted by peer-to-peer transactions.

Vitalik Buterin and Gavin Wood introduced Ethereum in 2015 as a decentralised mining network and software platform following the creation of the Bitcoin blockchain (Ball, 2022). Ethereum, being the second-largest cryptocurrency, serves as a foundation for the creation of other cryptocurrencies (Gilbert, 2022). The ERC-20 serves as the foundational framework for the extensive range of tokens developed on the Ethereum platform, including coins like SAND and MANA (Gadekallu et al., 2022).

The advanced blockchain provides users with not only a token to use, as in the Bitcoin blockchain, but also a base for developing decentralized apps. With the Solidity programming language, users are enabled to build without permission and trustless apps (Cai, et al., 2018). These apps, referred to as "decentralized apps" (Dapps), can utilize their tokens, akin to cryptocurrencies (Ball, 2022), and function independently on the blockchain system, free from central authority control. This technology is employed in several domains, such as finance and entertainment. Metaverses function as Dapps, which are applications developed on a blockchain. For instance, Decentraland is a 3D virtual world that functions on the Ethereum blockchain, which allows users to purchase and own properties, like land and homes, and immerse themselves in the virtual environment (Decentraland, n.d.).

2.2.3 Non-Fungible Tokens (NFT)

Non-fungible tokens (NFT) represent unique assets that cannot be modified. In recent years, the popularity of NFT technology is increased in many industries, with particular relevance to the art industry.

The main feature that differentiates non-fungible tokens from fungible tokens, such as Bitcoin, is their uniqueness. In fungible tokens, users can purchase fractions as tiny as 0.1, while the lowest unit available for purchase is 1 with non-fungible tokens, as it represents a specific digital asset (Cheng, et al., 2022).

These tokens establish an innovative space of practice for blockchain technology with their creative content that answers the needs of users, creators, and collectors with digital objects as a form of assets/video/ images, etc. (Cheng et al., 2022). NFTs are particular indications on the blockchain that have a link with a digital asset, and their prices vary depending on their rarity (Wang et al.,2021).

Even though any person can download a copy of that NFT file as a digital asset format, it does not represent the ownership of the token since its ownership can be proved with the smart contracts (Cheng et al., 2022). Smart contracts are the main innovation that Ethereum blockchain (Gadekallu et al., 2022). It is a contract that is automatically executed, and the conditions of the contract between the buyer and seller are encoded inside the logical structure of the code (Yang, et al. 2023) In other words, the rules of smart contracts are stored in blockchain and establishes an ecosystem that fulfill the terms of the agreement without any intermediaries (Techtarget, 2023).

As Murray (2021) states, NFTs are digital or physical assets that can be a game asset, a video, clothes, painting, etc. that utilizes blockchain technology for ownership. As an example, the ownership of an object, like an artwork, in the physical realm can also be defined with a file in the form of NFT (Murray,2021). However, since NFTs are working as a block on the blockchain, there is a tendency to make a correlation between NFTs with digital assets (Murray, 2021).

With the establishment of Blockchain technology, and the introduction of Bitcoin, the investigation of NFT's potential gained momentum. Also, the participation of auction houses, such as Christie's and Sotheby's along with other galleries encourage the familiarity of NFTs especially in the art industry (We Are Museums, 2023).

2.3 Metaverse Platforms and Their Features

Various metaverse platforms are shaped around the same concept and utilise similar technologies. Despite their establishment in decentralised ecosystems, each platform maintains its uniqueness. As the transition phase from Web 2.0 to Web 3.0 progresses, the features of each platform differ based on their web capacities. Roblox, Fortnite, and Second Life are examples of Web 2.0 metaverse platforms that act as forerunners of metaverse platforms with the potential to mimic real-life experiences with interactions and social activities (Dwivedi et al., 2022).

As previously mentioned, Second Life, the oldest of these three examples, is a simulated environment that allows users to experience the world through their avatars. The virtual currency used is Linden Dollars, which can be exchanged for US dollars, thereby establishing a robust economy (Boulos et al., 2007). It provides a platform where users can meet, play games, create their own locations, and trade assets with one another.

Roblox is another widely recognised platform where players create their experiences within virtual worlds. On this platform, individuals have the opportunity to meet with others, engage in social interactions, participate in gaming activities, and exchange their assets. Based on the 2021 statistics, Roblox had monthly users of around 150 million individuals, with 40 million users engaging in the platform on a daily basis (Lee, 2021).

On the other hand, the typical Web 3.0 metaverses that allow ownership are Decentraland, The Sandbox, and Voxels. Each of them offers unique experiences with the shared aim of creating a virtual world that has decentralised, user-created content and various engaging activities to immerse in. Decentraland is a metaverse that operates on the Ethereum blockchain and enables users to experience the world and monetize economic assets (Gadekallu et al., 2022). On the platform, users can see the upcoming events or attend the current events, ranging from art exhibitions to music to fashion events (Figure 2.6). Decentraland presents a virtual world that is partitioned into parcels. Users can trade these parcels as NFTs, and by purchasing a parcel, they can customise their own experiences. Additionally, when a player visits a parcel, they may observe both the neighbouring parcel and the activity taking place there. Users must link their Ethereum digital wallets to trade NFTs, as the platform operates on the Ethereum blockchain (Guidi & Michienzi, 2022).

Figure 2.6: Decentraland (Source: https://decentraland.org/play/?position=47%2C-45)

The Sandbox is another example of a user-generated and Ethereum blockchain-based (using SAND coin for monetized activities) metaverse platform (Gadekallu et al., 2022). Basically, this platform allows players to design digital assets as NFTs and upload them to the marketplace or integrate them into the games (Figure 2.7). Similar to Decentraland, individuals can trade lands as NFTs and create their own experiences upon purchase (Figure 2.8). It was launched in 2021 and attracts almost 30,000 monthly active users now (Weinberger & Gross, 2023). The unique feature that distinguishes The Sandbox from other metaverse platforms is the play to earn (P2E) specialty, which allows users to earn SAND coins by completing the game's quests. Also, it has a voxelated style in terms of graphics. It cannot be reached via the web but through The Sandbox application.

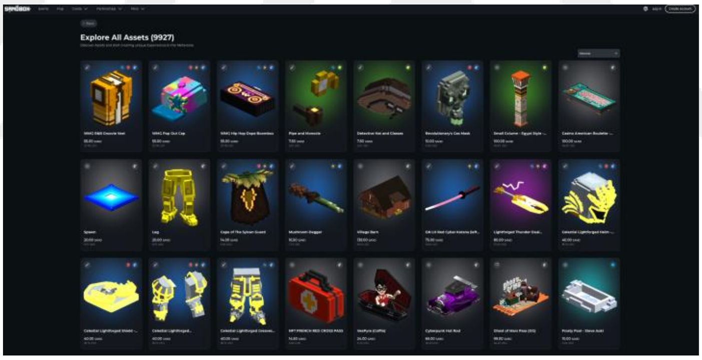


Figure 2.7: The Sandbox Marketplace (Source: https://www.sandbox.game/en/shop/)

Figure 2.8: The Sandbox Map (Source: https://www.sandbox.game/en/map/)

Voxels, formerly known as Cryptovoxels, is another metaverse where parcels can be traded on the Ethereum blockchain, while assets of avatars are in the Polygon blockchain as NFTs. In 2022, it is reported that there are 7355 land parcels on the Ethereum blockchain (Dappradar, 2023) (Figure 2.9; Figure 2.10). Voxels bears a similarity to Decentraland in that it allows users to interact with nearby parcels. On the platform, avatars can also interact via messages. This metaverse's focus is more on socialising activities with various events and exhibitions.

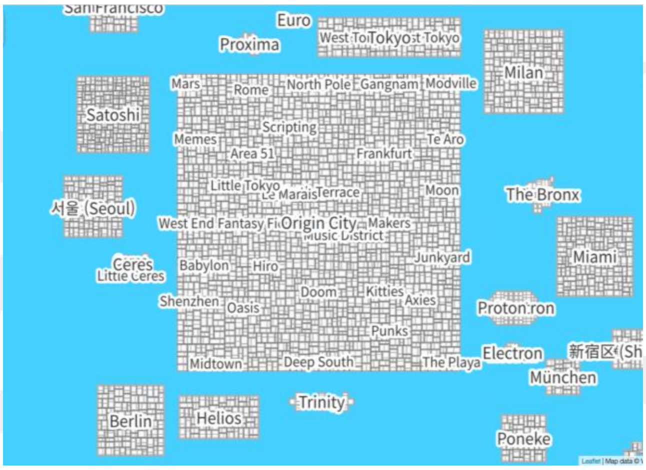


Figure 2.9: Map of Voxels (Source: https://www.voxels.com/map)

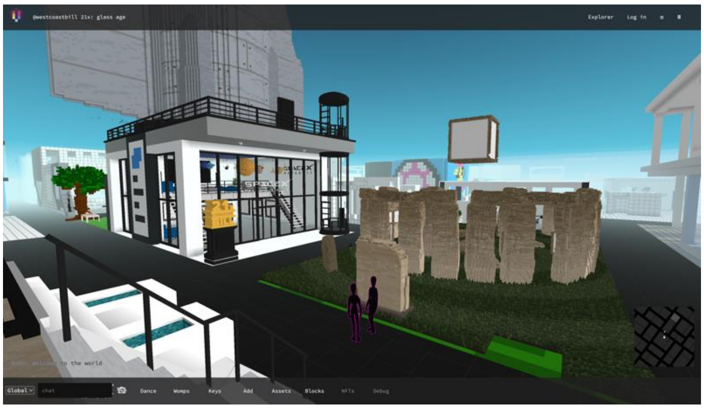


Figure 2.10: Voxels Metaverse (Source: https://www.voxels.com/play?coords=NE@6W,14S,3U)

Spatial io is another metaverse platform, where users can attend to events and play games. It is a Unity-powered platform that enables users to construct their environment or game inside the platform. It provides pre-designed environment templates and empty places to upload new models (Figure 2.11). The platform is accessible through web browsers, mobile devices, and VR glasses. The platform offers games, art galleries, and architectural experiences created by brands or users for visitors to explore (Figure 2.12).

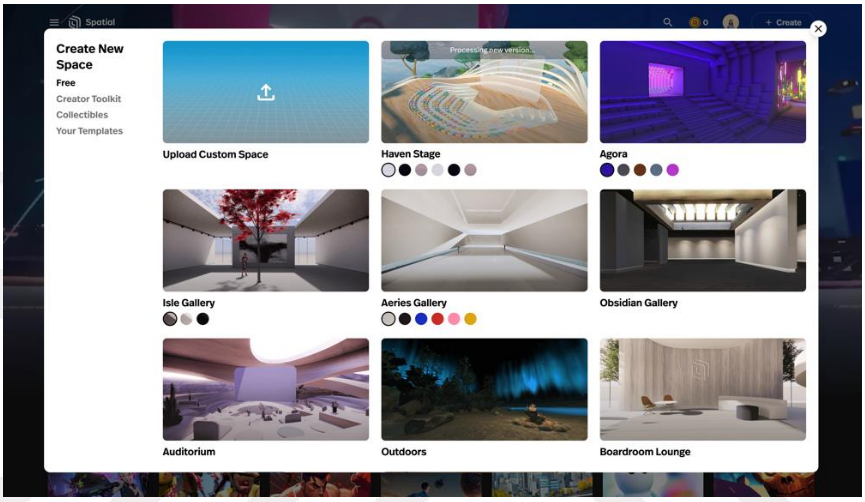


Figure 2.11: Templates in Spatial io (Source: https://www.spatial.io/)

Figure 2.12: Boss Immersive Showroom’s space on Spatial io (Source: https://www.spatial.io/s/BOSS-Immersive-Showroom)

CHAPTER 3

EXHIBITION SPACES AND SPATIAL EXPERIENCE

Exhibitions and museums are the areas where artistic expressions are encountered by audiences. These spaces enable audiences to acquire knowledge and experience about various fields such as art, history, and science. The exhibited materials range from artworks to multimedia installations that offer unique experiences. Beside the exhibited materials, the architectural design of these spaces is another factor that impacts the experience inside of these spaces (Chung et al., 2024). As Schorch (2014) stated, the visitor experience has a relationship with the physical context of the space, the design, the content, and the narrative.

An exhibition is defined as an organised presentation of selected items in a designated place, such as a museum or a gallery (Tzortzki, 2016). Inside museums, exhibitions play a crucial role in providing information in a narrative context that can be permanent or temporarily allocated in a museum space. The word "museum" comes from the Greek word "mouseion," which originally refers to a temple dedicated to the Muses, the goddesses of art and science (Tzortzki, 2016). Over time, the concept expanded to include institutions that store collections used for recreational and educational purposes. During the Renaissance, there was a developing interest in antiques (Macgreggor, 2007), and collectors exhibited their collections in their private residences to invitees, scholars, and experts. Among the other Renaissance palaces that are used to display the collections, Palazzo Medici in Florence (around 1440) was defined as the first museum in Europe (Greenhill, 1992). In the late 17th century, the museums' architectural design mirrored the Neo-classical and Renaissance styles of the palaces (Manssour & Morsi, 2018). After the World Wars, the approach to museums changed. In the 20th century, the rise of architectural pioneers and schools implemented a new vision of architecture, which affected the design of museums (Greenhill, 1992).

In terms of architectural style, museums depart from conventional columnar structures and layouts (Figure 3.1) and reinterpret them by developing a new approach, such as Frank Lloyd Wright’s Guggenheim Museum (Figure 3.2) (Tzortzki, 2016). As time progresses, technological breakthroughs continue to impact museums. Museums are technology intertwined, as seen by digital interactions in physical places, creating "wall-less" museums with virtual spaces (Schewibenz, 2004).

Figure 3.1: Palazzo Medici's Courtyard (Source: https://en.wikipedia.org/wiki/Palazzo_Medici_Riccardi)

Figure 3.2: Guggenheim Museum's Atrium (Source: https://www.guggenheim.org/about)

Furthermore, even though the content, the way of displaying the materials, and the architecture of the exhibition spaces in the museums have all undergone changes, the primary goal of facilitating social interaction remains. Flame (2013) asserts that museums do not prioritize any particular belief; instead, they present various aspects of a concept, fostering a multifaceted environment where individuals can interact with those who are different from them. Museums offer a space for people to express themselves and broaden their perspectives with their participation (Wollentz & Kuhlefelt, 2021). Additionally, museums aid in alleviating the feelings of loneliness and disconnection from society by engaging in social activities (Christidou & Hansen 2015).

The International Council of Museums (n.d.) (ICOM) defines a museum as follows:

"*A museum is a not-for-profit, permanent institution in the service of society that researches, collects, conserves, interprets, and exhibits tangible and intangible heritage. Open to the public, accessible, and inclusive, museums foster diversity and sustainability. They operate and communicate ethically, professionally and with the participation of communities, offering varied experiences for education, enjoyment, reflection and knowledge sharing.*"

3.1 Architecture of Exhibitions

The design of conventional museums follows the architectural style of Grace-Roman structures (Johnson, 2019), characterized by classical columns, pediments, stairs at the entrances, and giant iron gates that may overwhelm visitors (Flame, 2013) (Figure 3.3). This conventional approach to museum architecture, which resembles a "temple," reveals an authoritarian protection over the spaces that guard intellectualism and knowledge, characterised by cordoned routes, glass cases, security guards, and "do not touch" labels (Johnson, 2019). Tzortzki (2016) asserts that the current state of museum architecture resembles a sculpture. For instance, Guggenheim Museum Bilbao, with its organic form, is referred to as "p*lastic architecture"* by Naredi-Rainer & Hilger (2004), which breaks conventional approaches aesthetically, and its plan does not evolve the sequence of rooms nor a conventional square plan (Figure 3.4; Figure 3.5).

Figure 3.3: British Museum (Source: https://simple.wikipedia.org/wiki/British_Museum)

Figure 3.4: Guggenheim Bilboa (Source: https://www.guggenheim-bilbao.eus/en)

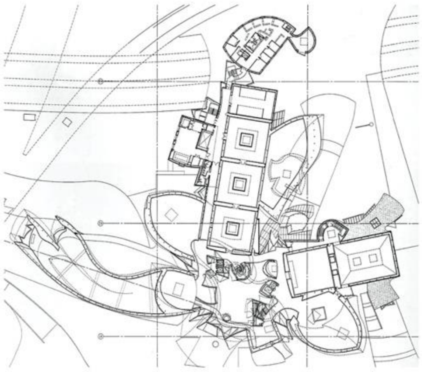


Figure 3.5: Guggenheim Bilbao Plan (Source: https://archeyes.com/the-guggenheim-museum-bilbao-by-frank-gehry-a-symphony-of-shapes/)

Artefacts and architectural elements influence the spatial experience in exhibition spaces. As Tröndle and Tschacher (2012) state, artworks create their own space that affects the visitor's perception and spatial experience. Artworks become an integrated element of architecture and cannot be isolated (Tzortzi, 2016). Museum displays and exhibition spaces allocate sculptures on pediments and paintings in a content and sequence that aligns with the curatorial message of the exhibition (Tröndle et al., 2014).

Spatial arrangement with the architectural elements in the exhibitions plays a crucial role in shaping both the experience and effectively showcasing the artworks. As Self (2014) states, architectural elements and the layout of the space guide visitors to have an experience in a narrated atmosphere that may affect their appreciation for art and history. The architecture in museums and exhibition spaces provides new definitions for the narratives within them, thereby nourishing them. (Burke et al., 2020)

The circulation path establishes a thematic relation between the content of the spatial arrangement (Psarra, 2005). In the exhibition spaces, the circulation path is shaped by the architecture and layout of the spaces. The organisation pattern that links the spaces can be linear, radial, network, or other forms, assisting visitors's orientation and movement in the museums, and these paths can operate as an integrated element to the spaces or additional circulation corridors (Hsu, 2004). According to Hsu (2004), the relation between the circulation paths and spaces can be in three ways: the circulation paths, or corridors, can be open to the gallery spaces, pass through the space, or terminate the space and operate as a way to the final destination. Black (2005) and Tzortzki (2016) define exhibition layouts in two forms: the first is sequential exhibitions that allow visitors to experience exhibitions in an order, and the second is organised as discovery lines that enable them to move independently without any specific path and many entry points. Additionally, Zang and Zhou (1998) stated that there are four types of spatial regulations in exhibitions (Figure 3.6). The rooms can be allocated as in the tandem type, which allows visitors to move in a specific order, while the radial type provides flexibility. However, these flexible spatial organisations may also cause overlapping visitor routes and noise (Zang and Zhou, 1998). In addition to spatial layout, wayfinding aids, signs, and maps are the design elements that impact the visitor's orientation, their position, and their spatial awareness (Chiu, et al., 2000).

Also, Tzortzki (2016) refers to the Lynchean urban concept of *districts*, *edges,* and *landmarks* to define the impact of architectural elements in a museum building. He mentions that *districts* resemble each section or room in the building that can be noticed by the visitor during their visit. Also, *edges* are the boundaries that distinguish each area from others, and *landmarks* are the visual elements that assist visitors in orienting themselves (Tzortzki, 2016). Although the architecture dictates the artworks inside of the constructed space, each viewer has their unique relationship with artworks in each time (Repina & Sopin, 2023).

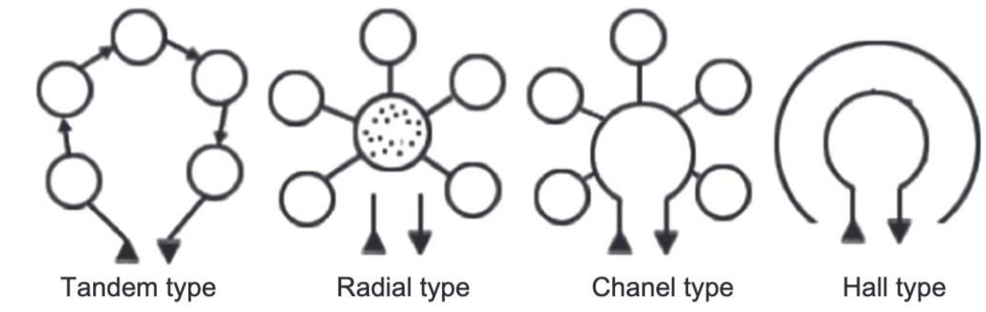


Figure 3.6: Types of spatial combination (Source: Zang and Zhou, 1998)

Furthermore, architectural design influences the overall spatial experience within these areas while also mirroring the intended functions of those areas (Self, 2014). As stated by Bayer (1961), architectural elements, which are fundamental components that shape and define space, influence visitors' perceptions of space through their interactions. Hence, the aesthetic qualities and diverse approaches to architectural arrangement and flow influence the experiences of visitors.

3.2 The Impact of Technology

The integration of technology facilitated the expansion of museums and exhibition spaces by transforming their role from solely conserving to also providing entertainment (Vom Lehn & Heath, 2005). The limitations of conventional displays are transformed into interactive experiences with the implementation of multimedia, touchscreens, AR, VR simulations, and also NFTs. As a result of the technological development, exhibitions and museums evolve from a static context to a participatory environment. Additionally, technology allows individuals to experience artistic expressions and artefacts without the constraints of geographical locations.

Fernström & Bannon (1997) assert that transforming the artefacts from still images to video and sound creates a more engaging experience, as opposed to showcasing them within identical "black boxes" for a more captivating encounter. It enables a shift from a passive observation to interactive engaging experiences. According to Paul (2008), the progress of technology has led to a redefinition of the traditional roles of artists, curators, and the presentation of artworks, creating a new world for people to experience.

3.2.1 NFTs in the Art Industry

NFT is a technological advancement that enhance the exhibition experience/ NFT enables artists to tokenize their work by providing evidence of ownership and validity. Therefore, it is a pivotal development in the creative sector. It establishes a new platform for artists to interact directly with viewers, bypassing traditional intermediaries. It enriches the collector's collections by including a diverse range of digital assets that combine the physical and digital art markets.

During the COVID-19 pandemic, individuals adapted to virtual environments due to global lockdowns. Their educational, professional, social, and leisure activities (concerts, exhibitions, etc.) shifted to virtual platforms. Since all the museums and art galleries were closed, digital platforms were used to exhibit the artworks. For instance, the Google Arts and Culture Platform enabled virtual 360-degree tours by applying Google's Street View Technology (Burke et al., 2020). In the meantime, metaverse platforms offered an alternative space to experience art galleries and museums within a 3D virtual world. They expanded the method of exhibiting by engaging users and displaying NFT collections. Diverse metaverses, like Decentraland and Voxels (formerly known as Cryptovoxels), offer an interface for exhibitions, but they rely on land ownership. In contrast, metaverses like Spatial and Oncyber provide a more affordable option because they allow users to create and share exhibition spaces using templates without requiring land ownership (We Are Museums, 2023). These metaverse platforms assist in having an immersive engagement with the environment and NFTs, which in turn redefines the value of artworks. (Wang et al., 2021). In other words, people interact in virtual spaces by accepting the value of virtual assets, and thanks to NFT collectibles, users can trade and transfer these virtual goods (Cheng et al., 2022). Furthermore, the websites of these marketplaces showcase NFTs for visitors to view. On the selected marketplace, the digital asset owner initiates the NFT minting process (Guljajeve & Sola, 2023). Various markets showcase NFTs ranging from art to music and serve as an interface for both their presentation and sale, thus acting as real-life auction houses. Some of the marketplaces have a curated selection, such as Art Blocks, fx(hash), and Superrare, while others do not, and their sizes also vary, such as OpenSea and Objkt (Guljajeve & Sola, 2023).

Both the pandemic and the significant sales in the NFT industry contributed to the exaggerated enthusiasm around NFTs. The sale of Beeple's work "Everydays: The First 5000 Days" for 69.3 million at Christie's auction boosted their popularity on Google Trends, marking the first time Christie's accepted Ethereum as a payment (Kastrenakes, 2021) (Figure 3.7). Following this sale, there was a notable increase in both demand for NFTs and production of NFTs (Guljajeve & Sola, 2023). There are other noteworthy NFTs, such as NBA Top Shots by Dapper Labs, Cryptopunks, which are algorithmically generated 24 x 24 pixelated monkey avatars (Figure 3.8), Pokemon-inspired NFTs called Axies, and Bored Apes, which serve as profile pictures (Figure 3.9) (Ball, 2022).

Figure 3.7: Everydays: The First 5000 Days by Mike Winkelmann (Source: The New York Times, 2021)

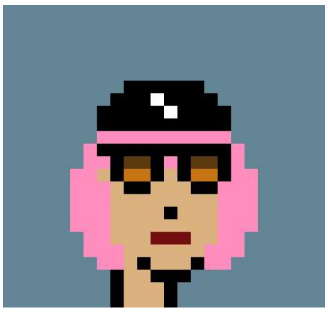


Figure 3.8: One of the Cryptopunks NFT (Source: https://opensea.io/collection/cryptopunks)

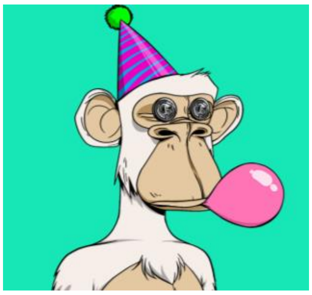


Figure 3.9: Bored Ape Yach Club NFT (Source: https://opensea.io/collection/boredapeyachtclub)

The increase in the popularity of NFTs is created an opportunity for artists who have previously struggled to gain recognition. Simultaneously, NFT technology provides an opportunity for well-known artists in the art realm to expand their popularity through digital formats as well. Marina Abramovic, for example, sold her performance video as NFT, which enables collectors to acquire specific frames of her performance (Guljajeve & Sola, 2023). Refik Anadol had a dynamic video mapping on Gauidi's Casa Battlo's facade that was sold as a video NFT format at Christie's New York. (Guljajeve & Sola, 2023).

3.2.2 Impact of Technology in Physical Settings

The technology implementation in the museum and exhibition spaces can be defined as adding a digital layer over the physical environment and enhancing the visitor's experience with both tangible and digital components. As Devine & Tarr (2019) state, the digital layer in museums is dispersed seamlessly throughout the whole museum experience. All these digital layers work with the physical context coherently, tell a story, and connect themes, which contribute to the visitor's experience (Devine & Tarr, 2019).

This integration of the digital layer into the physical setting affects the visitor's interactions and experiences (Mason, 2020). For instance, the Native American Voices exhibition in the Penn Museum integrates screens and projections into the physical setting in order to present information about objects. On those screens, visitors acquire the object type, date, and location and observe it from all directions by rotating the 3D model on the screen. Also, tall screens are allocated in the exhibitions to display interviews with the Native Americans about their problems (Mason, 2020). The significance of such implementations lies in their ability to reinterpret conventional labels and offer a wide range of opportunities across multiple media types. (Vom Lehn & Heath, 2005) (Figure 3.10).

Figure 3.10: Penn Museum (Source: Baugh, 2020)

As Li & Huang (2023) state that immersive experiences centralize the whole experience itself rather than each object, by creating an illusion of being inside of a virtual world. The immersive art exhibitions enable visitors to engage with the experience and construct a connection between the artwork and the ideas behind it (Li & Huang, 2023). *The Story of the Forest* (2017) exhibition at the National Museum of Singapore serves as an example of an immersive exhibition (Figure 3.11). The collection features flora and fauna native to the region, by the historical drawings of William Farquhar (teamLab, 2023). The exhibition is interactive, meaning that as visitors move around, the forest reacts by displaying animated creatures.

Figure 3.11: The Story of Forest (Source: teamLab, 2023)

The digital layer in a physical setting can be experienced via augmented reality. AR applications for smartphones work with a Global Positioning System (GPS) that detects the location and orientation of the users with a compass and overlays new information to the existing physical setting (Ding, 2017). Visitors can get further information about artwork engagingly and observe details of the display. According to Ding (2017), augmented reality (AR) enhances the understanding of artwork by providing an additional layer of information and allowing users to absorb more detailed information instead of only relying on labels. For instance, Artlens 2.0 by the Cleveland Museum of Art is an AR app that utilises image recognition software for two-dimensional pieces to provide a deeper understanding of the artworks to visitors (Ding, 2017; Figure 3.12). Another example that enhances the visitor's experience is *Revivre* by *the Muséum National d'Histoire Naturelle,* which displays various animals and plants that are extinct. It is equipped with AR glasses that display 3D models of animals while a narrator tells the story of the animals and their relation to humankind (Muséum national d'Histoire Naturelle, 2023; Figure 3.13).

Figure 3.12: Artlens 2.0 (Source: https://www.clevelandart.org)

Figure 3.13: AR experience by Muséum national d'Histoire naturelle (Source: https://www.mnhn.fr/fr/revivre-itinerance)

Furthermore, instead of superimposing the digital layer onto the physical environment, the digital realm can function as a separate reality through the use of VR technology. VR creates a more immersed experience that makes paintings more alive while enhancing the experience and, as a result, increasing appreciation of the artwork (Shehade & Stylianou-Lambert, 2020). As Shehade and Stylianou-Lambert (2020) mention, VR provides a strong narrative where visitors are immersed and allows them to time-travel in history. The Louvre Museum's Mona Lisa: Beyond the Glass is one example of VR technology in museum experiences. It is a VR experience into Mona Lisa's painting that allows visitors to learn about the painter's techniques and the sitter's identity (Louvre Museum, 2021), (Figure 3.14). The experience, which was presented in 2019 to commemorate the 500th anniversary of Leonardo da Vinci’s death, revealed the latest scientific research about artistic breakthroughs via VR. This experience can be accessed by downloading the app, which enables users to engage with the art even when they are physically.

Figure 3.14: Musee de Louvre (Source: https://www.louvre.fr/en/explore/life-at-the-museum/mona-lisa-beyond-the-glass-the-louvre-s-first-virtual-reality-experience)

With the NFT technology, the digital and physical layers are superimposed through displaying NFTs on the screen in a physical realm. There are NFT art galleries that showcase NFTs on the screens positioned around the room, such as *imnotart Chicago NFT Gallery* (We Are Museums, 2023) (Figure 3.15). The world's first NFT Biennial took place in nine different countries over a two-month period in 2023, featuring special curation of NFTs at each location (We Are Museums, 2023).During the biennial, the NFTs can be experienced in three different settings: screens, metaverse galleries with VR, and the physical realm with AR (Heller, 2023), which is further example that reveals the impact of technology in the art industry.

Figure 3.15: imnotArt NFT Gallery in Chicago (Source: https://www.bizjournals.com/ /chicagos-first-nft-art-gallery-imnotart.html)

3.3 Artworks in Virtual Spaces

There are various virtual exhibitions in cyberspaces, including a virtual tour of the area and a multimedia archive (Shioede & Kanoshima, 1999). These virtual exhibitions may be two-dimensional representations created with a set of 2D images or 3D virtual environments that enable exploration with an avatar. They create an environment that allows visitors to experience artefacts without any physical or time limitations (Marty, 2011), enables spontaneous conversations with other visitors (Bandelli, 1999), facilitates updating the collection (Kim, 2018), and provides further information about the artworks (Pivec & Kronberger, 2016).

One of the best-known examples of digital platforms to experience artefacts is Google Art & Culture (GAC). Within the platform, users can see various museums' collections, acquire information about artistic movements through stories, and play games about artworks. As Vosinakis & Tsakonas (2016) state, GAC replicates the experience of visiting a museum. It is a recent platform that is already featuring a large number of well-known museum collections (Diziekan & Proctor, 2011). By including navigation mechanisms, visitors can explore the captured spots and have a virtual tour of the exhibition space (Vosinakis & Tsakonas, 2016). It also allows users to zoom in and out of artefacts, move around them, and observe cracks or spots that the human eye would miss, creating a "hyperreal" experience (Davis, 2011). In general, these reinterpretations of the experience contribute to the creation of more dynamic spaces as opposed to static environments, and the integration of gamified experiences onto platforms facilitates an enjoyable and efficient art visitation (Çetin & Erbay, 2021).

In addition to GAC, some of the museums also develop digital platforms that allow them to observe their collections. The Rijksmuseum in Amsterdam established its own application, which is called Rijksstudio. It provides high-resolution images of the artworks and a detailed story behind them. Additionally, users can create new products using images, such as personal sets, and distribute digital artworks (Pivec & Kronberger, 2016).

According to Shioede & Kanoshima (1999), a virtual museum is an electronic reproduction of an art gallery with a collection of artefacts with all relevant information and a space for visitors to interact. They also add that these kinds of museums have both advantages and disadvantages when they are compared with conventional museums. Virtual museums eliminate the physical barrier between visitors and the collection, making it accessible online. This allows visitors to examine the objects based on their interests, and the artefacts may include texts, sounds, and movies (Shioede & Kanoshima, 1999). However, virtual museums may lack an immersive art experience if the design and curation are not visually pleasing and replicate reality, resulting in a monotonous encounter (Shioede & Kanoshima, 1999).

The advent of metaverse platforms enabled the creation of museum and exhibition spaces within these platforms. For instance, Spatial io, Decentraland, Voxels, and The Sandbox are more instances of metaverses that exhibits artworks. In these metaverses, the approach towards design may vary. While in the physical world, special architectural elements assist in forming the identity and establishing the functionality of museums and exhibitions (Scarpa, 2006), virtual settings prioritize interactivity and content richness to mirror the digital identity of museums and exhibitions (Pivec, Kronberger, 2016). Despite these differences; virtual spaces may also employ the architectural elements of physical realms to create a cohesive experience.

Even though architectural elements define the space and spatial experience within virtual spaces (Chung et al., 2022), they may also lead to a variety in the design approaches within virtual exhibition spaces. Chung et al. (2022) categorise these two different approaches as reality-based and virtuality-based. A reality-based environment is one that specifically represents the real world without any aspects of imagination (Chung et al., 2022). The virtuality-based environment definition, Bukatman's (1992) statement, which describes it as an imagined area that abstracts or contradicts ordinary elements, is cited in Chung et al. (2022) (Figure 3.16). Without a binary distinction between these two types of spaces, the virtual world can be categorised as either a less familiar reality-based place or a less abstract virtuality-based space (Figure 3.17; Chung et al., 2022).

Types	Virtuality -based	Reality–based
Characteristics	fictional/imaginary/unrealised	realistic/ordinary/realised
Sense of place	undefined	defined
Denotative meaning	abstract space	familiar place (e.g. auditorium, home)
Connotative meaning	freedom	limited with rules
Example (Source: Spatial)		

Figure 3.16: Virtuality-based and Reality-based environments (Source: Chung et al., 2022)

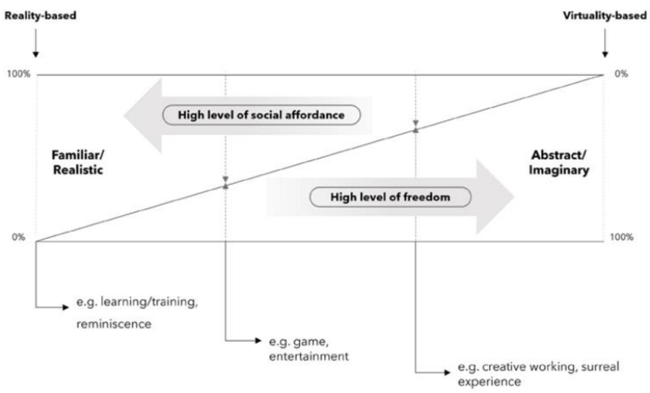


Figure 3.17: Spectrum of VB and RB environments (Source: Chung, et al., 2022)

For instance, Decentraland constructs the digital twin of Sotheby's Auction House in London that can be defined as a reality-based environment (Figure 3.18; Figure 3.19). The model of the auction house reflects the original space, which includes the facade, indoor circulation, and even the commissioner. Sotheby’s hosts various NFT art sales and utilises this space to showcase that curation (NFT Plazas, 2024). In contrast to this example, *World of Colours* in Spatial io is closer to virtuality-based on the spectrum (Figure 3.20)

Figure 3.18: Sotheby's in Decentraland (Source: https://play.decentraland.org/?position=53%2C83&realm=hela&island=hela2sr)

Figure 3.19: Sotheby's in London (Source: https://www.sothebys.com/en/about/locations/london)

Figure 3.20: World of Colours in Spatial io (Source: https://www.spatial.io/s/World-Of-Colours-642029f36127ed8eaffa03ad?share=99566991124710089)

3.4 Spatial Experience in Virtual Environments

Developing technology creates virtual environments that offer a unique spatial experience, similar to physical reality. Several factors that affect the user's spatial experience have an impact on their engagement in all of virtual environments, including virtual exhibition spaces. Therefore, virtual environments also create a sense of presence (Takato et al., 2008) as physical realm do. This sense of presence is defined as the state of cutting ties with the media and forgetting that this experience is within the cyber world (Hartmann et al., 2015; Kljajevic, 2021). Feeling present is an important factor affecting immersion and interaction in the virtual environment, and it may vary according to people's prior experiences, abilities, and the characteristics of the virtual environment (Azarby & Rice, 2022). According to Laarni (2003), physical presence in virtual realms is linked with three elements: the realism of the virtual environment, the ability to navigate in the virtual environment, and immersion in the virtual environment rather than the physical environment (Takatalo et al., 2008). The person's physical space, which have an impact on their level of presence, can either enhance or diminish their presence in the virtual environment (Slater et al., 1994).

One of the factors that impacts the sense of presence is the projection of users as avatars in the virtual environment. Virtual realities support user bilocation and create a sense of presence through avatars in both the physical realm and virtual space (Kljajevic, 2021). Havranek et al. (2012) stated that the first-person perspective creates a stronger sense of presence in digital environments than the third-person perspective. According to Kljajevic (2021), the first-person view allows visitors to perceive their avatars as virtual bodies. As Slater (2009) notes, self-positioning in a virtual environment creates an illusion of place through avatars, which is an important component of feeling present in a computer-generated environment (Kljajevic, 2021).

Interaction in a virtual environment is significant aspect affecting the spatial experience and the sense of presence (Takatalo et al., 2008). According to Azarby & Rice (2022), interaction is a factor that facilitates understanding the environment by allowing users to have an active experience through manipulation. It also has a relationship with navigation, which allows users to change their perspective while moving inside the environment (Azarby & Rice, 2022). According to Meijer et al. (2019) navigation utilizes visual realism to help visitors identify landmarks and navigators to provide a semantic value in virtual environments.

Feeling immersed in the virtual environment is crucial for the spatial experience. According to Azarby & Rice (2022), immersion is associated with the perception that a person experiences and interacts with. The feeling of immersion is defined as feeling physically present in a non-physical environment (Carlos et al., 2022). There are different technologies that offer users different levels of immersion. This can range from highly immersive systems like virtual reality (VR) headsets to less immersive presentations on computer screens, which are often called "low-immersion desktop environments" (Pallavicini et al., 2021; Carlos et al., 2022). These desktop-based systems provide a lower sense of presence compared to immersive virtual reality (George et al., 2017). Desktop computers provide users with a 360-degree view of the complete environment. Various navigation interfaces, such as abstract navigation, keyboard, and mouse, accomplish this (Zhao et al., 2020). Users can observe the virtual environment from various perspectives by using the mouse to pan, rather than relying on head movements and rotations as performed with VR headsets (ibid.). In these environments, movements by pressing keys and mouse lack appropriate bodily engagement that may not be associated with physical space movements (Kljajevic, 2021).

Additionally, avatars in virtual worlds enable the formation of digital representations of real-life individuals. The avatar helps the user comprehend the size of the place and proxy (Waltemate et al., 2018). Furthermore, they enhance our sense of presence and immersion within the virtual realm by serving as direct extensions of our physical body image (ibid.).

The level of detail in virtual environments is another component that affects people's spatial perception (Azarby & Rice, 2022). Spatial perception helps people form a mental image of the environment (ibid.). The detailing of the wall displays and illumination, in addition to the rendering quality of the spaces, influence individuals' judgements regarding the environment and their perceptions of distance (Paes et al., 2017). Stanney et al. (1998) state that the effectiveness of the virtual environment as a spatial experience is dependent upon a comparison of real and virtual environments or various virtual environments.

CHAPTER 4

THE STUDY OF TWO METAVERSE EXHIBITIONS

This study locates itself at the intersection of art, architecture, and the metaverse by analysing the effects of changes in the exhibition space environment's design on the users' spatial experience. Two virtual spaces within metaverses that differ in terms of their design approaches are selected. The first one incorporates more realistic approach in the selection of architectural elements, creating a reality-based metaverse exhibition space. The latter implements freer forms, which can be defined as a virtuality-based metaverse exhibition space. This study utilises a mixed-methods approach involving a 5-point Likert scale combined questionnaire and open-ended questions to gather quantitative and qualitative data, ensuring a comprehensive exploration of both environments in terms of spatial experience.

4.1 The Selection of Exhibition Environments within Metaverses

This study aims to investigate changes in spatial experience in relation to exhibition settings with diverse visual characteristics within the metaverse. The selection process for these exhibition spaces within metaverses involves highlighting the distinctive architectural features of numerous potential spaces. As discussed in Chapter 2, there are various exhibition spaces within metaverses. With the increasing popularity of metaverses and the developing technology, most of the metaverse platforms already introduce exhibition spaces. To simplify the selection process, a filter for these spaces is utilised, and only the exhibition spaces that display NFTs are taken into account.

As highlighted in Chapter 2, NFT is an important development in the concept of metaverses, not only for the technical aspect but also for the digital art sector. NFTs can be exhibited in different ways both in the tangible realm and in the virtual world, as stated in Chapter 3. This thesis specifically focuses on exhibitions that display NFTs on metaverse platforms and categorises these virtual exhibition spaces as reality-based and virtuality-based, following the framework applied by Chung et al. (2024). According to Chung et al. (2024), RB environments keep to the regulations of the physical world and display architectural characteristics, whereas VB designs utilise the infinite possibilities of the virtual world to create an imaginary setting. To enable the representation of these diverse design approaches, a selection within NFT galleries in metaverses is performed. This selection includes exhibitions of NFT marketplaces on metaverse platforms, metaverse versions of galleries that are popular in the physical world, such as Serpentine Gallery, galleries of the NFT Biennial, and other popular galleries.

The exhibition spaces within metaverses are analysed using a systematic observation method with the criteria for reality-based and virtuality-based environments as specified by Chung et al. (2024). The observation method examines structural elements, architectural components (windows, doors, staircases, ramps, and ventilation systems), interior furnishings, as well as the exhibition materials, including wayfinding aids, nametags, and the modes of display of the artworks (Table 4.1). Then, the frequent features are grouped under two categories: features that can be depicted in the physical realm, RB features, and the ones that can be implemented in metaverses, VB features, as in the following:

- Reality-based features: enclosed spaces, openings, realistic textures, structural elements, interior furniture, plan of the museum at the entrance, guidebook, room labels, nametags of the artworks, stanchion ropes, lighting fixtures, vertical circulation with stairs, artworks on the walls, artworks with frames, ramps with railings.

- Virtuality-based features: portals, ramps without railings, interaction with artworks by clicking, flying 3D objects; open spaces, flying planes, moving 3D objects, freestanding artworks, artworks without frames.

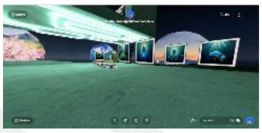
The features and the metaverses are then combined on a matrix system to determine the most representative environments (Table 4.2). The matrix indicated the environment with the most RB features, such as Sotheby's Gallery on the Decentraland platform. However, due to the high CPU requirement of the Decentraland platform, it is preferred Verses Gallery on the Spatial IO platform to avoid potential problems during the experiment (Figure 4.1). For the VB environment, the NFT Biennial Ouroboros Pavillion is selected based on the matrix (Figure 4.2).

Figure 4.1: Verses Gallery

Figure 4.2: NFT Biennial Ouroboros Pavilion

Table 4.1: The list of selected exhibition spaces within metaverses and their features

Photo	**Name of The Space**	**Platfrom**	**Features**
	Serpentine Gallery	Fortnite	Enclosed building, architectural elements (windows, appliances, fire alarm, ventilation, exit sign), structural elements, realistic textures, artworks on the wall, freestanding 3D object
	Museum of Crypto Art	Somnium Space	Free plan of artworks, architectural elements (windows, railings), structural elements, artworks on the walls, freestanding artworks , ramps for vertical circulation, flying sphere in the middle
	Museum of Crypto Art	Voxels	Space defined with divided walls, textures. nametags, artworks on the wall, architectural elements (lighting appliances) , stairs for vertical circulation
	Momus Collection	Decentraland	structural elements, architectural elements (rails, ramps), moving platform for vertical circulation, realistic textures, freestanding artworks
	The Vordun Museum	Second Life	Enclosed building, architectural elements (window, door, appliances), interior furnitures , artworks on the walls, nametags, gift shop, stanchion ropes
	The Muzee Dezantral	The Muzee Dezantral	Enclosed building, architectural elements (lighting fixtures, doors, stairs) , interior furnitures, wayfinding aids (arrows, a map to show the areas), artworks with frames, nametags

	Sotheby's	Decentraland	Enclosed building, digital twin, architectural elements (doors, windows, stairs, escalator), artworks on the wall, artworks with frames, roomtags, stanchion ropes
	Neustras Art Gallery	Spatial io	Freestanding roof structure, nametags, artworks on walls, freestanding artworks, portals
	hi CeeCee AI gallery	Spatial io	Flying platforms, interior furnitures, portals, ramps, artworks with frames
	Makersplace Gallery	Decentraland	Enclosed building, architectural elements (door, window, lighting fixtures), interior furnitures, artworks with frame on the walls
	Rarible Gallery	Decentraland	Realistic textures, architectural elements (stairs, ramps, windows, doors) interior furnitures, artworks on the walls with frames
	Makersplace Gallery	Voxels	Artworks on the walls, further information by clicking
	Primakolor Gallery	Voxels	Open space, realistic textures, interior furnitures, freestanding 3D Objects
	imnotArt	Voxels	Enclosed building, digital twin, architectural elements (doors, windows, stairs) interior furnitures, artworks with frames on the walls, nametags of the marketplaces, more information by clicking

	knownorigin	Voxels	Open area, artworks on the wall, interior furnitures, more information by clicking
	Sciart Lab District	Decentraland	Moving platforms for vertical circulation, freestanding artworks, structural elements, interaction by clicking
	Tower Art Gallery	Spatial io	Structural elements, architectural elements (ramps without railings for vertical circulation), interior furnitures, portals, freestanding artworks
	Chill Henge	Spatial io	architectural elements (stairs for vertical circulation) , portals, interior furnitures, freestanding artwork with frames, nametags
	Metaqueen's Lobby	Spatial io	Enclosed building, architectural elements (windows, doors, escalator) , frestanding artworks in frames, 3D objects (elephant , tree, flying particules), nametags, more information by clicking , interior furnitures
	Galleria granen	Spatial io	Enclosed building, a virtual gallery of a gallery in sweeden, architectural element (windows, doors, stairs), portals artworks with frames on the walls , interior furnitures
	Rubiks Cube	Spatial io	Cubes for artwork exbihition areas, ramps for vertical circulation and also as a design itself,moving platfrom, flying objects, artworks without frames, freestanding artworks with frames

	Pink Gallery	Spatial io	Open space, vertical circulation with freefall, architectural elements (stairs, lighting fixtures) vertical circulation with stairs, realistic textures, structural frames
	Asleep Awake Mode Gallery X2	Spatial io	Open space, a vertical circulation with platforms, realistic textures, structural frames , architectural elements (windows, doors), interior furnitures,more information by clicking
	Asleep Awake Mode Gallery X3	Spatial io	Open space, architectural elements (stairs, lighting fixtures), realistic textures, structural frames, going a space through portals
	World of colors	Spatial io	Open space, flying 3D elements, more information by clicking, going another space through portals
	The Happy Gallery	Spatial io	Open space defined with artworks, more information by clicking, going another space through portals
	Parallel Exhibition	Spatial io	Enclosed building, architectural elements (window, door, lighting fixtures), more information by clicking, going another space through portals, artworks on the walls, interior furnitures
	Async Gallery	Voxels	Enclosed Building, architectural elements (stairs, lighting fixtures), stanchion ropes, more information by clicking

	Verses Gallery	Spatial io	Enclosed Building, architectural elements (windows), artworks on walls, roomtags, nametags, artworks within frames, textures, interior furnitures
	ACCA	Oncyber io	walls to define the boundary, architectural elements (windows, stairs), wayfinding aids, wayfinding map, name tags
	NFT Collection Museum	The Sandbox	Enclosed Building ,architectural elements(window, door), artworks on the walls, interaction by clicking, interior furnitures
	NFT Biennial Sublime Shift Pavilion	Spatial io	open space, going another space through portals, exhibiting artworks through portals, nametags, interaction by clicking, freestanding artworks
	NFT Biennial Chrysalis Pavilion	Spatial io	open space, going another space through portals, nametags, roomtags wayfinding aids, interaction by clicking
	NFT Biennial Ouroborus Pavilion	Spatial io	open spaces, freestanding artworks, nametags, interaction by clicking, going another space through portals

Table 4.2: A Matrix System for the RB and VB Features of Exhibition Spaces within Metaverses

			REALITY-BASED FEATURES														VIRTUALITY-BASED FEATURES								
GALLERIES NAME	PLATFORM	ACCESS	Enclosed Buildings	Opennings	Texture	Structural Elements	Interior Furniture	Plan of the exhibition space	Room label	Nametags of the artworks	Stanchion ropes	Lighting Fixtures	Stairs	Artworks on the walls	Artworks with frames	Ramps with railings	Ramps without railings	Moving platforms	Artworks without frames	Freestanding artworks	Portals	Interaction with artworks by clicking	Flying 3D objects	Unrealistic open space	Flying planes
Serpentine Gallery	Fortnite	Program	X	X	X	X	X			X		X		X	X					X			X		
Museum of Crypto Art	Somnium Space	Website			X	X								X		X			X				X	X	
Museum of Crypto Art	CryptoVoxel	Website			X					X			X	X					X						
Momus Collection	Decentraland	Website				X										X		X							
The Vordun Museum	Second Life	Program	X		X	X	X	X	X	X	X	X		X	X										
The Muzee Dezantral	The Muzee Dezantral	Website	X	X	X	X	X	X		X		X	X	X	X										
Sotheby's	Decentraland	Website	X	X	X	X	X				X	X	X	X	X										
Neustras Art Gallery	Spatial io	Website								X				X	X				X	X	X	X	X	X	X
hi CeeCee AI gallery	Spatial io	Website			X		X								X		X			X	X		X	X	X
Makersplace Gallery	Decentraland	Website	X	X	X		X					X		X	X										
Rarible Gallery	Decentraland	Website	X	X	X		X						X	X			X					X			
Makersplace Gallery	CryptoVoxel	Website		X	X									X								X			
Primakolor Gallery	CryptoVoxel	Website			X		X												X	X		X	X	X	
imnotArt	CryptoVoxel	Website	X	X	X		X			X		X	X	X								X			
knownorigin	CryptoVoxel	Website		X	X		X							X										X	
Sciart Lab District	Decentraland	Website																X	X	X		X			
Tower Art Gallery	Spatial io	Website					X										X		X	X	X				
Chill Henge	Spatial io	Website			X		X						X		X					X		X	X	X	
Metaqueen's Lobby	Spatial io	Website	X	X	X										X					X	X	X	X		
Galleria granen	Spatial io	Website	X	X	X		X						X	X					X				X		
Rubiks Cube	Spatial io	Website												X	X		X		X	X	X	X	X	X	X
Pink Gallery	Spatial io	Website			X							X	X	X	X				X	X	X			X	
Asleep Awake Mode Gallery X2	Spatial io	Website	X	X	X		X							X	X			X				X			
Asleep Awake Mode Gallery X3	Spatial io	Website			X	X	X					X	X	X	X						X		X	X	
World of colors	Spatial io	Website			X							X			X						X		X	X	
The Happy Gallery	Spatial io	Website																	X	X	X	X		X	
Parallel Exhibition	Spatial io	Website	X	X	X		X					X			X						X	X			
Async Gallery	CryptoVoxel	Website	X								X	X	X									X			
Verses Gallery	Spatial io	Website	X	X	X	X	X		X	X		X		X	X										
ACCA	oncyber io	Website	X	X									X	X											
NFT Collection Museum	The Sandbox	Program	X	X			X							X								X			
NFT Biennial Sublime Shift	Spatial io	Website								X											X		X	X	
NFT Biennial Chrysalis	Spatial io	Website	X	X						X				X				X	X		X	X	X	X	X
NFT Biennial Ouroborus	Spatial io	Website								X							X	X	X	X	X	X		X	

4.2 Sample Group

Before starting the experiment, the necessary permissions are acquired from the Bilkent University Ethics Committee in order to be able to handle the experiment with Bilkent University students. Each student signed a consent form containing information about the study, its aim, procedure, and topics related to confidentiality before the experiment began. The students participated in the experiment voluntarily and were divided into two different groups randomly.

The study's participants are Bilkent University Department of Architecture second, third, and fourth graders and graduate students. The purpose of this focal group is to gain insights into the spatial experience of individuals with architectural design and art backgrounds. The main experiment was conducted with 118 students in total (34 males and 84 females) ages 18–27. The participants were randomly assigned to groups experiencing either one of the exhibition spaces, and each group included 59 participants.

4.3 The Questionnaire

The questionnaire that analyses users’ spatial experience in the metaverse exhibition spaces within metaverses consists of three parts in general terms. The first part consists of demographic questions. In the second part, there are questions about their spatial experience in the metaverse exhibition spaces. The last part poses three open-ended questions to elicit individuals' perspectives on the experience.

In the demographic section, questions are about participants' gender, age, technological abilities, familiarity with the metaverse, and virtual exhibition venues. These questions aim to determine their demographic profile and understand their familiarity with virtual exhibition spaces and metaverses.

The second part of the questionnaire is about the spatial experience in the exhibition space within the metaverse. This part of the questionnaire is formed by combining two questionnaires: Carbonell-Carrera et al.'s (2021) and Kim, Han, et al.’s (2015). This combined questionnaire is formed by taking five of the subscales, presence, engagement, immersion, flow, and judgement, from Carbonell-Carrera et al.'s (2021) research and adding the wayfinding subscale from Kim et al.’s (2015) research.

Carbonell-Carrera et al.'s (2021) study incorporated nine subscales, including presence, engagement, immersion, flow, emotion, usability, technology adoption, judgement, and experience consequence. Carbonell-Carrera et al.'s (2021) assessment of participants' perceptions of interactive 3D geo-visualisation environments using the Questionnaire on User Experience in Immersive Virtual Environments on desktops. In this study, 25 architecture students were engaged in landscape design tasks within an interactive 3D geo-visualisation environment displayed on a low-immersive desktop screen. The researchers assessed participants' perceptions of this 3D environment using the Questionnaire on User Experience in Immersive Virtual Environments across various aspects, including presence, engagement, immersion, flow, usability, emotion, judgement, experience consequence, and technology adoption. Participants are asked to do various tasks by using their personal computers, like seeing selected places, manipulating the design, and carving the landscape. To adopt the questionnaire for this thesis, the devices are revised and questions about further technical means are excluded, as the media of the two studies are different. Also, questions about the judgements of other people are removed, and questions related to sound are eliminated due to the absence of audio.

Wayfinding is added as an additional subscale from Kim et al. (2015). Kim et al. (2015) developed a wayfinding questionnaire to understand why people become lost in a large, complex hospital. Kim, Wang, et al.’s study evaluated wayfinding in a complex environment, a university hospital. The questionnaire comprises 33 items, focusing on four subcategories: the lobby's environmental image, information factors, environmental factors, and the relationship between environmental factors and information factors. While adapting this questionnaire, the questions about wayfinding aids and vertical circulations are excluded. The remaining questions are converted from question format to sentence format and are added to the thesis questionnaire.

The final questionnaire, titled 'Questionnaire on Spatial Experience in Exhibition Spaces within Metaverses,' includes six subscales with a total of 32 items (Table 4.3).

The open-ended question part is also adapted from Carbonell-Carrera et al.'s (2021). The open-ended questions are the following:

- “In your opinion, what were the positive effects of your experience?”
- “In your opinion, what were the negative points of your experience?”
- “Do you have any suggestions to improve the virtual exhibition space?”

Table 4.3: Items of the Questionnaire on Spatial Experience in Exhibition Spaces within Metaverses

	Subscale	Definition	Origin Questionnaire
Subscales from Carbonell-Carrera et al.'s (2021) research	**Presence**	“The user’s ‘sense of being there’ in the virtual environment”	The Presence Questionnaire, The Immersive Tendency Questionnaire (ITQ) by Witmer, Singer (1998)
	Engagement	“The energy in action, the connection between a person and its activity consisting of a behavioral, emotional and cognitive form”	
	Immersion	The “illusion” that “the virtual environment technology replaces the user’s sensory stimuli by the virtual sensory stimuli”	
	Flow	“A pleasant psychological state of sense of control, fun and joy” that the user feels when interacting with the virtual environment."	Flow 4D16 by Heutte (2011)
	Judgement	“The overall judgment of the experience in the virtual environment”	AttractDiff2 questionnaire by Pekrun, Goetz, et al., (2011)
Additional Subscale	**Wayfinding**	"Wayfinding is an exceedingly complicated cognitive process, especially in complex environments"	User experience of environmental/information/linking environmental factors and information factors by Kim, Wang, et al. (2015)

- **Presence, Engagement, Immersion Subscales:**

The definition of presence is linked to the sense of “being there” and is a subjective experience (Witmer et al., 1998). In virtual environments, presence is related to being in a computer-generated environment rather than physical reality. Therefore, the presence subscale is crucial to assess in this study. The persuasiveness of these virtual settings is evaluated according to the user’s feelings of presence and engagement (Souza et al., 2021).

Presence depends on the environment that supports the feeling of immersion, involvement, and interaction (Witmer et al., 1998), and engagement is related to the dynamic relationship between an individual and their activity, including behavioural, emotional, and cognitive aspects (Tcha-Tokey et al., 2016 as cited Carbonell-Carrera et al., 2021). According to Tcha-Tokey et al. (2016 as cited Carbonell-Carrera et al., 2021), immersion creates an illusion by substituting real sensory experiences with virtual ones. This thesis integrates these three subscales to measure the impact of environmental style on participants' sense of presence, engagement with the surroundings, and feelings of immersion.

- **Flow Subscale:**

The flow subscale is about a sense of control over the experience, as well as excitement. This factor is evaluated by the Flow4D16 questionnaire, which consists of 16 items and is utilised to detect the user and his or her level of immersion in an activity constructed by Heutte in 2011 (as cited Carbonell-Carrera et al., 2021). The flow subscale implementation provides insight into how exhibition space provides a more exciting and controlled user experience.

- **Judgement Subscale:**

This subscale is about the overall judgement about the experience and was constructed by Hassenzahl, Burmester, and Koller in 2003 in the AttracDiff 2 questionnaire. The purpose of this questionnaire is to analyze people's perceptions of websites using contrasting adjectives. This questionnaire is adapted for this thesis to comprehend participants' experiences and their judgements about its beauty and originality in the virtual architectural environment.

- **Wayfinding Subscale:**

This subscale is added to Carbonell-Carrera et al.'s (2021) user experience questionnaire to address the changes in exhibition styles and wayfinding. As Passini (1984) stated, it is a complex problem-solving process that involves making and implementing decisions. The goal of incorporating this subscale is to determine the degree to which changing approaches to design in exhibition spaces within metaverses impact the process of identifying pathways and arriving at the intended destination.

4.4 Pilot and Main Study

This thesis comprises a pilot study and the main study. The survey sessions are conducted during the participants' architectural design studio hours via Google Forms. The survey starts with a confirmation of consent form. At the request of the Ethics Committee, this procedure is handled in hard-copy format.

4.4.1 Pilot Study

The pilot study was conducted with the participation of 12 people. 3 participants were randomly selected from each grade. The pilot study was concluded in a week with 4 different sessions (Table 4.4). Undergraduate students participated in the pilot study in their studios during the studio course, whereas graduate students were designated a time slot to join in the pilot study.

The pilot study’s questionnaire included an experience subscale that dealt with the relationship between interaction devices and the user experience. The pilot study showed that this subscale was not easily comprehended by the participants. Given that this study focuses on the spatial experience rather than the user experience, this subscale was excluded from the main study. Also, the pilot study showed that the participants had some hesitations about the meaning of some statements in the questionnaire. For instance; “I was so involved in the virtual environment experience” was not well understood, so it was replaced with “I was so engaged in the virtual environment experience” for the main study. The additional clarification is provided within the judgement subscale, in which all statements were originally written as referring to a virtual environment. These statements are specifically modified to refer to an architectural virtual environment to enhance clarity. For example, in the judgement subscale, the statement "I found this virtual environment ugly (1)/beautiful (5)." changed to "I found this virtual architectural space ugly (1)/beautiful (5).

Table 4.4: Pilot Study's Sessions

Sessions	Grade	Gender
1st Session	Third grade	3 Female
2nd Session	Masters	1 Female
		2 Male
3rd Session	Fourth grade	1 Female
		2 Male
4th Session	Second grade	3 Female

4.4.2 Main Study

The main study was conducted in nine sessions (Table 4.5, Figure 4.1). Each student participated in the study during their studio hours, using their own laptops and maintaining their assigned seating positions. The study started with an explanation of the experiment and the distribution of consent forms to the students. The students were briefed that this study is about their experience in metaverse exhibition spaces, and it analyses how virtual exhibition spaces in metaverses should be developed (following conventional architectural styles similar to the real world or free of styles only possible in cyberspace). Students were informed that after they receive the link to the digital survey, they will be directed to one of the exhibition spaces, and the study was conducted in a semi-controlled environment, meaning that it was allowed for the participants to interact and communicate. The participants were divided into two groups according to their seating locations before sharing the link to the surveys as Group A and Group B. The art exhibition environment varies depending on the group. The ones in Group A experience the RB exhibition space, whereas Group B experiences the VB exhibition space. Participants were initially required to respond to demographic questions, after which a link to the metaverse environment became visible. The survey highlighted that participants could experience the exhibition without any time limit. When a participant's tour was completed, the link to Google Forms was revisited to continue with the evaluation of the spatial experience. Throughout the study, the participants' reactions to the experience were observed and logged by the researcher. The duration of their presence in the art exhibition space was recorded.

Figure 4.3: Photos from *Session 6* (top row), *Session 2* (bottom left), *Session 7* (bottom right)

Table 4.5: Main Study's Sessions

Sessions	**Grade**	**Gender**
1st Session	Fourth grade	15 Female
		4 Male
2nd Session	Fourth grade	10 Female
		6 Male
3rd Session	Fourth grade	4 Female
		2 Male
4th Session	Second grade	5 Female
		5 Male
5th Session	Second grade	9 Female
		5 Male
6th Session	Third grade	18 Female
		5 Male
7th Session	Third grade	15 Female
		6 Male
8th Session	Masters	3 Female
9th Session	Masters	7 Female

CHAPTER 5

RESULTS

This section presents the users' spatial experience in exhibition spaces within metaverses. The data obtained from the analysis of the study are analysed using SPSS 29v software. Frequency and percent analysis, relationship analysis (independent sample t-test and Pearson correlation analysis), and reliability analysis (Cronbach's alpha) are carried out.

The analysis of the data uses descriptive statistics such as frequency, percentage, arithmetic mean, standard deviation, minimum, and maximum. The Kolmogorov-Smirnov test was used as the normality distribution test, and parametric tests were used because normality assumptions were provided as a result of the analysis. An independent sample t-test was implemented in order to compare the means of two distinct groups. The Pearson correlation coefficient was computed in order to examine the relationships among the dimensions of the scale. Multivariate regression analysis was used to estimate the dependent variable using independent (explanatory) variables. Cronbach's alpha coefficient was used in the reliability analysis of the scales. All test results were evaluated at 0.05 significance levels.

5.1 Socio-Demographic Characteristics of Students

The overall number of participants is 118, including 59 in the reality-based (RB) group and 59 in the virtuality-based (VB) group. The mean age in the RB group is 21.47±1.52 years, with a minimum of 18 and a maximum of 26 years, with 18 male and 41 female participants (Table 5.1), (Figure 5.1). %88.1 use computers for more than 10 hours in a week (Figure 5.2); %20.3 experienced a metaverse environment before (Figure 5.3). %18.6 of the participants in the metaverse previously experienced Minecraft, %8.5 Fortnite. 16.9% of the participants have been in a metaverse environment for gaming purposes (Table 5.1). Out of the 28.8% who experienced virtual exhibition space before, 22% accessed Google Arts & Culture, and 18.6% experienced 3D online exhibition platforms (Table 5.1).

The mean age in the VB group is 21.83±1.72 years, with a minimum of 18 and a maximum of 27 years, with 16 male and 43 female participants (Table 5.1), (Figure 5.1). %91.5 use computers for more than 10 hours a week (Figure 5.2); %18.6 experienced a metaverse environment before (Figure 5.3). %15.3 of the participants previously experienced Minecraft, %8.5 Roblox. 16.9% of the participants have been in a metaverse environment with the purpose of gaming (Table 5.1). Out of %35.6 who experienced virtual exhibition space before, %35.6 accessed Google Arts & Culture (%20.3), and %20,3 practiced 3D online exhibition platforms (Table 5.1). Table 5.1 provides the overall demographic structure of participants.

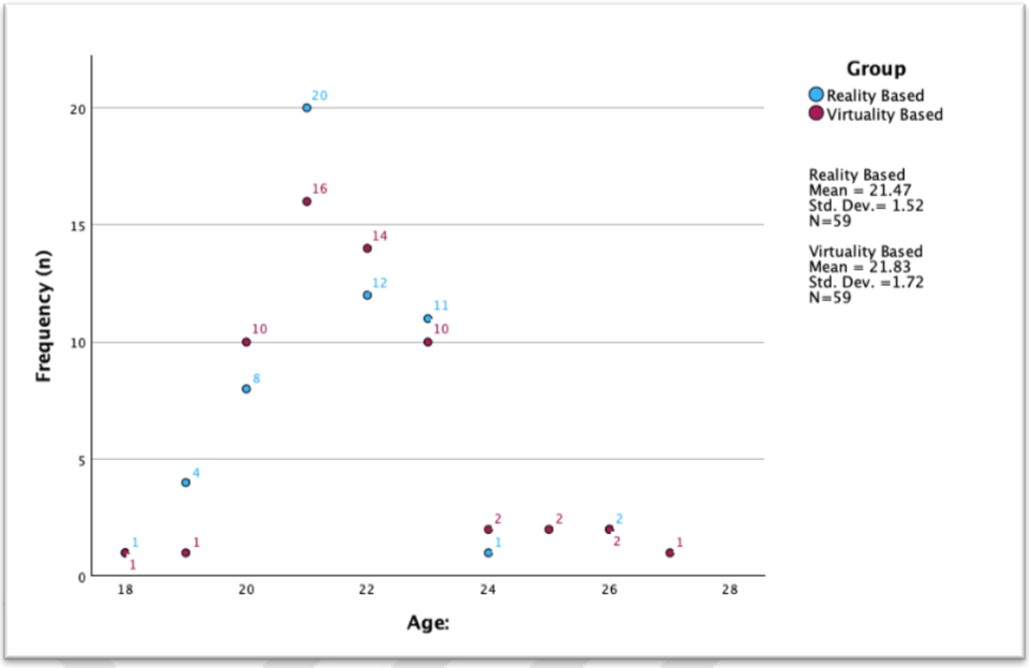


Figure 5.1: The Ages of the Participants

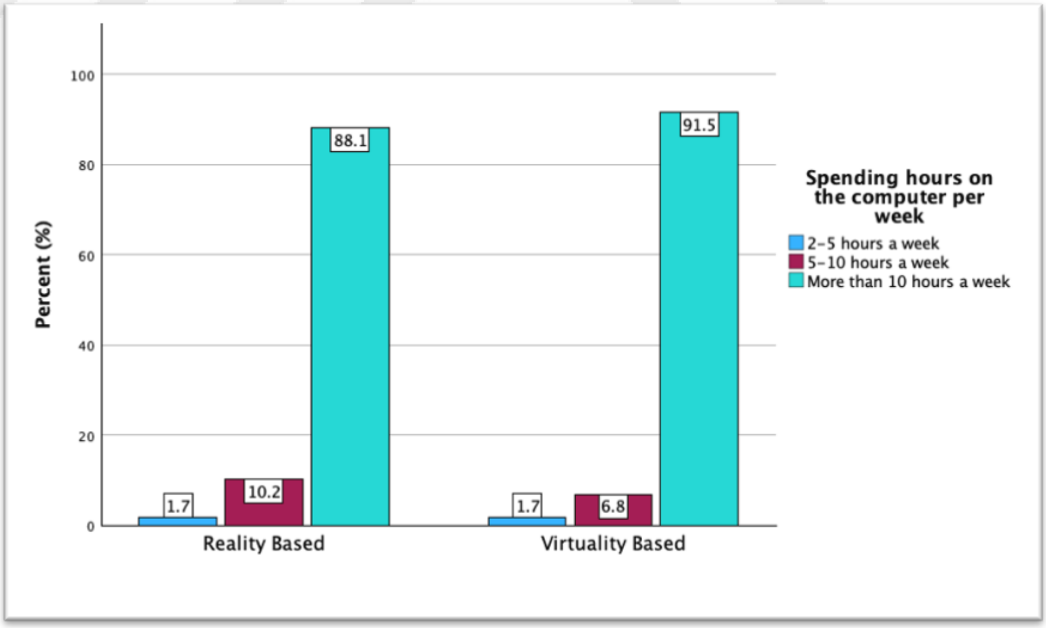


Figure 5.2: Spending Hours on the Computer Per Week

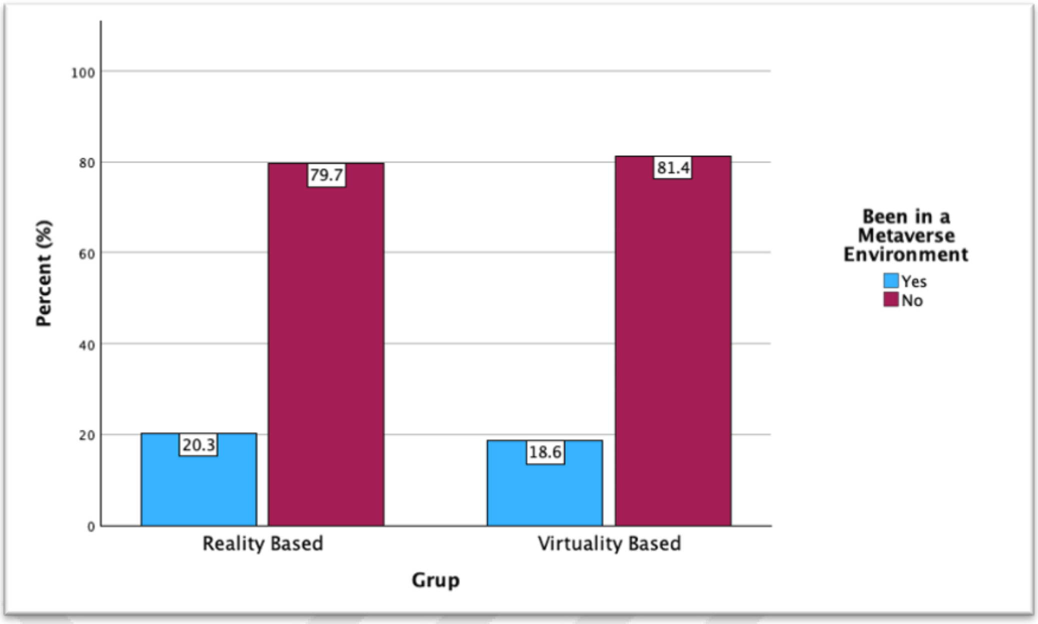


Figure 5.3: Been in a Metaverse Environment Before

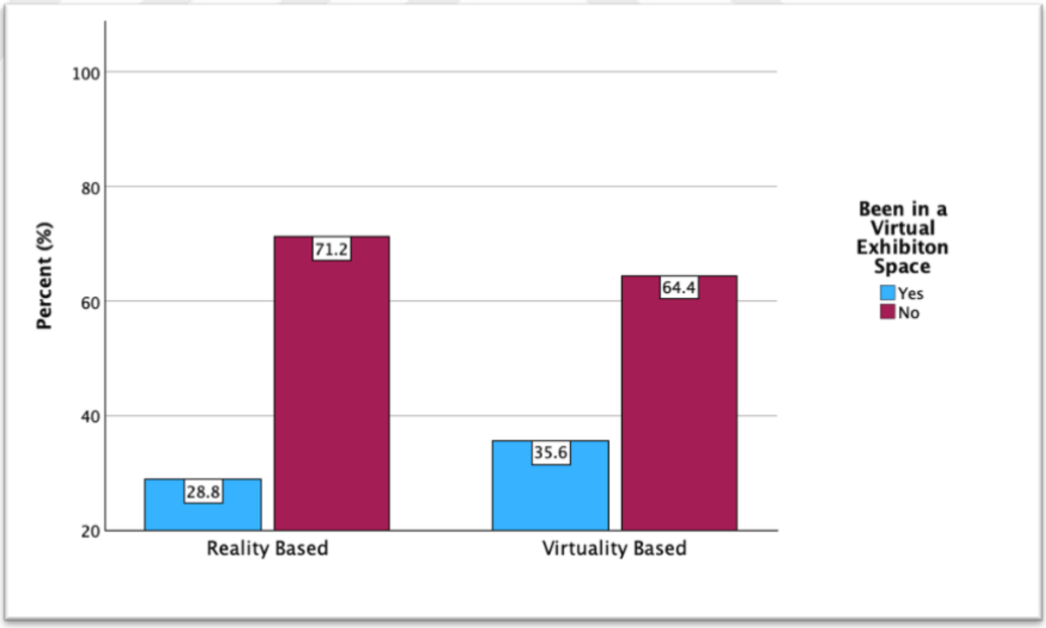


Figure 5.4: Been in an Exhibition Space Before

Table 5.1: Descriptive analysis

		Reality-based (n=59)		Virtuality-based (n=59)	
		±SD	Min.-Max	±SD	Min.-Max
Age		21.47±1.52	18-26	21.83±1.72	18-27
		n	%	n	%
Gender:	Male	18	30.5	16	27.1
	Female	41	69.5	43	72.9
Spending hours on the computer per week	2-5 hours a week	1	1.7	1	1.7
	5-10 hours a week	6	10.2	4	6.8
	More than 10 hours a week	52	88.1	54	91.5
Been in a Metaverse Environment	Yes	12	20.3	11	18.6
	No	47	79.7	48	81.4
Metaverse Environment Experienced*	Decentraland	0	0,0	1	1.7
	Fortnite	5	8.5	3	5.1
	Minecraft	11	18.6	9	15.3
	Roblox	2	3.4	5	8.5
	Second Life	1	1.7	0	0,0
	Spatial io	1	1.7	0	0,0
	The Sandbox	2	3.4	3	5.1
	Other	1	1.7	3	5.1
Purpose of have been in Metaverse*	Museum/Art exhibition experience	6	10.2	3	5.1
	Game	10	16.9	10	16.9
Been in a Virtual Exhibition Space	Yes	17	28.8	21	35.6
	No	42	71.2	38	64.4
Virtual Exhibition Experienced*	Google Arts & Culture	13	22.0	12	20.3
	Exhibition on Metaverse platform	4	6.8	3	5.1
	3D Online exhibition platform	11	18.6	12	20.3

*Multiple response test results

5.2 Descriptive Analysis

The descriptive analysis of each subscale in the Questionnaire on Spatial Experience in Exhibition Spaces within the Metaverse is as follows: the mean of presence is 3.83 (Table 5.2), engagement is 4.18 (Table 5.3), immersion is 2.56 (Table 5.4), flow is 3.26 (Table 5.5), judgement is 3.58 (Table 5.6), and wayfinding is 3.58 (Table 5.7) in the RB group. However, in the VB group, the mean of presence is 3.49 (Table 5.2), engagement is 3.92 (Table 5.3), immersion is 2.65 (Table 5.4), flow is 3.13 (Table 5.5), judgement is 3.45 (Table 5.6), and wayfinding is 3.51 (Table 5.7).

Table 5.2: Questionnaire on Spatial Experience in Exhibition Spaces within the Metaverse: Presence Subscale

Items	Reality-based (n=59)		Virtuality-based (n=59)	
		SD		SD
1. I was able to actively observe the virtual environment.	4.49	.73	4.20	.85
2. I was able to examine artworks closely.	4.42	.79	3.97	1.10
3. I could examine artworks from multiple viewpoints.	4.41	.87	3.92	1.00
4. I felt proficient in moving and interacting with the virtual environment at the end of the experience.	4.29	.89	3.85	1.10
5. I found my experiences in the virtual environment to be consistent with my real-world experience.	2.68	1.02	2.31	.97
6. The visual display quality distracted me from visiting the virtual exhibition space.	2.93	1.03	3.02	1.06
7. The devices (keyboard and mouse), that controlled my movement, distract me from experiencing the space.	2.53	1.26	2.81	1.46
Total	3.83	.61	3.49	.62

Table 5.3: Questionnaire on Spatial Experience in Exhibition Spaces within the Metaverse: Engagement Subscale

Items	Reality-based (n=59)		Virtuality-based (n=59)	
		SD		SD
1. The visual aspects of the virtual environment engaged me.	4.03	.79	3.56	1.09
2. The sense of moving within the virtual environment was interesting.	4.39	.81	4.17	1.02
3. I was involved in the virtual environment experience.	4.12	1.00	4.02	.90
Total	4.18	.70	3.92	.82

Table 5.4: Questionnaire on Spatial Experience in Exhibition Spaces within the Metaverse: Immersion Subscale

Items	Reality-based (n=59)		Virtuality-based (n=59)	
		SD		SD
1. I felt excited by the virtual environment.	4.12	.87	3.90	1.08
2. I became so engaged in the virtual environment that I was not aware of things happening around me.	2.69	1.12	2.80	1.24
3. I got scared by something happening in the virtual environment.	1.22	.49	1.44	1.05
4. I become so involved in the virtual environment that I lose all track of time.	2.19	1.18	2.46	1.28
Total	**2.56**	**.63**	**2.65**	**.86**

Table 5.5: Questionnaire on Spatial Experience in Exhibition Spaces within the Metaverse: Flow Subscale

Items	Reality-based (n=59)		Virtuality-based (n=59)	
		SD		SD
1. I felt I could perfectly control my actions.	3.46	1.07	3.14	1.02
2. At each step, I knew what to do.	3.56	1.12	3.15	1.14
3. I felt I controlled the situation.	3.83	1.10	3.54	.99
4. Time seemed to flow differently than usual.	2.61	1.07	2.75	1.17
Total	**3.26**	**.66**	**3.13**	**.61**

Table 5.6: Questionnaire on Spatial Experience in Exhibition Spaces within the Metaverse: Judgement Subscale

Items	Reality-based (n=59)		Virtuality-based (n=59)	
		SD		SD
1. I felt I could perfectly control my actions.	3.46	1.07	3.14	1.02
2. I found that this virtual architectural space was original.	3.39	.97	3.41	1.18
3. I found that this virtual architectural space was lame (1) / exciting (5).	3.92	.90	3.71	.93
4. I found that this virtual architectural space was easy (1) / challenging (5) in terms of wayfinding.	2.17	1.23	2.64	1.36
5. I found this virtual architectural space amateurish (1) / professional (5).	3.53	.99	3.14	.99
6. I found this virtual architectural space unpresentable (1) / presentable (5).	3.83	.91	3.58	.93
7. I found that this virtual architectural space is ugly (1) /beautiful (5).	3.85	.94	3.54	1.01
8. I found that this virtual architectural space is disagreeable (1) / likeable (5).	4.02	.90	3.93	.83
9. I found that this virtual architectural space is discouraging (1) / motivating (5).	3.93	.98	3.68	.92
Total	**3.58**	**.68**	**3.45**	**.67**

Table 5.7: Questionnaire on Spatial Experience in Exhibition Spaces within the Metaverse: Wayfinding Subscale

Items	Reality-based (n=59)		Virtuality-based (n=59)	
		SD		SD
1. Entering the virtual exhibition space, I felt good about the environmental image.	3.76	.97	3.66	1.03
2. With the help of the virtual exhibition space's environmental image, I felt confident in wayfinding.	3.73	.98	3.47	1.07
3. I relied on the virtual space's environmental image to decide how to reach my destination.	3.51	1.21	3.73	1.01
4. I had to make an effort to identify the locations of the pathways.	2.68	1.12	2.83	1.13
Total	**3.58**	**.74**	**3.51**	**.56**

Upon evaluating the normality distribution of the scale scores of students in the RB and VB groups, the Kolmogorov Smirnov test confirms that the data belonging to the scale scores are normally distributed since the kurtosis and skewness values, which are the assumptions of normal distribution, are between ±2 and the sample volume was n>30 and above (Table 5.8).

Table 5.8: The Normality Distribution Results of Virtual Exhibition Space Scale by Group

		Kolmogorov-Smirnov			Skewness	Kurtosis
Group		Statistic	df	Sig.		
Reality-based	Presence	.117	59	.042	-.584	-.100
	Engagement	.145	59	.003	-.964	.912
	Immersion	.126	59	.021	.018	-.734
	Flow	.092	59	.200*	-.002	-.298
	Judgement	.088	59	.200*	-.524	-.069
	Wayfinding	.138	59	.007	.006	-.995
Virtuality-based	Presence	.102	59	.200*	.015	.614
	Engagement	.151	59	.002	-.659	-.042
	Immersion	.114	59	.055	.579	.518
	Flow	.108	59	.087	-.097	-.479
	Judgement	.075	59	.200*	-.247	-.049
	Wayfinding	.116	59	.046	-.129	-.589

Kolmogorov-Smirnov test, *p>0.05

5.2.1 Analysis of Spatial Experience Subscales

The average scores of the participants' spatial experience in RB and VB metaverse exhibition spaces are assessed with an independent sample t-test according to RB and VB. The mean value of the presence subscale in the RB group (X = 3.83, SD = 0.61) is significantly higher than the mean value (X = 3.49, SD = 0.62) of the same subscale in the VB group ($t(116) = 3.075$, $p = 0.003$, $p<0.01$).

On the other hand, the mean values of engagement, immersion, flow, judgement, and wayfinding subscales do not show any significant difference ($p > 0.05$) (Table 5.9).

Table 5.9: Independent Sample t Test Result of Virtual Exhibition Space Scale by Group

	Group	N		SD	t	Df	p
Presence	Reality-based	59	3.83	0.61	3.075	116	0.003^{**}
	Virtuality-based	59	3.49	0.62			
Engagement	Reality-based	59	4.18	0.70	1.893	116	0.061
	Virtuality-based	59	3.92	0.82			
Immersion	Reality-based	59	2.56	0.63	-0.674	116	0.501
	Virtuality-based	59	2.65	0.86			
Flow	Reality-based	59	3.26	0.66	1.154	116	0.251
	Virtuality-based	59	3.13	0.61			
Judgement	Reality-based	59	3.58	0.68	1.006	116	0.316
	Virtuality-based	59	3.45	0.67			
Wayfinding	Reality-based	59	3.58	0.74	0.595	107.97	0.553
	Virtuality-based	59	3.51	0.56			

5.2.2 Analysis of Spatial Experience Subscales in Relation to Previous Metaverse Experiences

The objective is to determine whether there are any differences between those who have previously experienced a metaverse setting and those who have not. When the mean scores of the spatial experience subscales of the students in the RB group are evaluated with the independent sample t-test according to the metaverse environment experience status, no significant difference is observed ($p > 0.05$) (Table 5.10).

Table 5.10: RB Group's Independent Sample t-Test Result (Previous Metaverse Experience)

	Metaverse Environment	N		SD	t	Df	p
Presence	Yes	12	3.94	0.51	0.687	57	0.495
	No	47	3.81	0.63			
Engagement	Yes	12	4.22	0.66	0.227	57	0.821
	No	47	4.17	0.72			
Immersion	Yes	12	2.65	0.48	0.557	57	0.579
	No	47	2.53	0.66			
Flow	Yes	12	3.49	0.63	1.317	57	0.193
	No	47	3.21	0.67			
Judgement	Yes	12	3.49	0.72	-0.502	57	0.618
	No	47	3.60	0.68			
Wayfinding	Yes	12	3.46	0.74	-0.636	57	0.527
	No	47	3.61	0.75			

Independent sample t-test, *p<0.05, **p<0.01, ***p<0.001

When the mean scores of the spatial experience subscales of the students in the VB group are evaluated with the independent sample t-test according to the metaverse environment experience status, it is seen that the mean score of immersion of the students who experienced metaverse environment before (=3.11, SD=0.96) is significantly higher than the mean score of the students who did not (=2.54, SD=0.80) ($t(57)=2.053$, $p=0.022$, $p<0.05$). However, the mean scores of presence, engagement, flow, judgement, and wayfinding from the dimensions of the virtual exhibition space do not differ significantly according to the previous metaverse experience of the students in the VB group ($p > 0.05$) (Table 5.11).

Table 5.11: VB Group's Independent Sample t-Test Result (Previous Metaverse Experience)

	Metaverse Environment Experienced	N		SD	t	Df	p
Presence	Yes	11	3.77	0.51	1.689	57	0.097
	No	48	3.42	0.64			
Engagement	Yes	11	4.06	0.73	0.650	57	0.259
	No	48	3.88	0.84			
Immersion	Yes	11	3.11	0.96	2.053	57	0.022*
	No	48	2.54	0.80			
Flow	Yes	11	3.33	0.81	1.243	57	0.110
	No	48	3.08	0.56			
Judgement	Yes	11	3.60	0.49	0.818	57	0.208
	No	48	3.42	0.70			
Wayfinding	Yes	11	3.59	0.56	0.537	57	0.593
	No	48	3.49	.59			

Independent sample t test, *p<0.05, **p<0.01, ***p<0.001

5.2.3 Analysis of Spatial Experience Subscales in Relation to Previous Virtual Exhibition Space Experience

Another aim is to determine whether there are any differences between those who have previously experienced a virtual exhibition space and those who have not. When the mean scores of the spatial experience subscales of the students in the RB group are evaluated with the independent sample t-test according to the previous virtual exhibition experience, no significant difference is observed ($p > 0.05$) (Table 5.12).

Table 5.12: RB Group's Independent Sample t-Test Result (Previous Virtual Exhibition Experience)

	Virtual Exhibition Space	N		SD	t	Df	p
Presence	Yes	17	3.77	0.70	-0.548	57	0.586
	No	42	3.86	0.57			
Engagement	Yes	17	4.29	0.70	0.787	57	0.434
	No	42	4.13	0.71			
Immersion	Yes	17	2.53	0.57	-0.198	57	0.844
	No	42	2.57	0.66			
Flow	Yes	17	3.37	0.79	0.808	57	0.423
	No	42	3.22	0.61			
Judgement	Yes	17	3.44	0.85	-0.983	57	0.330
	No	42	3.63	0.61			
Wayfinding	Yes	17	3.47	0.76	-0.721	57	0.474
	No	42	3.63	0.74			

Independent sample t-test, *p<0.05, **p<0.01, ***p<0.001

On the other hand, the evaluation of the mean scores of the spatial experience subscales of the students in the VB group with the independent sample t-test reveals that the mean score of immersion of the students who experienced virtual art exhibition space before (=2.83, SD=0.95) is significantly higher than the mean score of the students who did not (t(57) = -2.632, p = 0.011, p<0.05). Nevertheless, the mean scores of presence, engagement, flow, judgement, and wayfinding from the dimensions of spatial experience do not change substantially according to the previous virtual exhibition experience of the students in the VB group (p > 0.05) (Table 5.13).

Table 5.13: VB Group’s Independent Sample t-Test Result (Previous Virtual Exhibition Experience)

	Virtual Exhibition Space Experienced	N		SD	t	Df	p
Presence	Yes	21	3.51	0.56	0.215	57	0.830
	No	38	3.47	0.66			
Engagement	Yes	21	3.75	0.69	-1.186	57	0.259
	No	38	4.01	0.88			
Immersion	Yes	21	2.32	0.53	-2.632	56.97	0.011*
	No	38	2.83	0.95			
Flow	Yes	21	3.10	0.66	-0.221	57	0.826
	No	38	3.14	0.60			
Judgement	Yes	21	3.30	0.60	-1.290	57	0.202
	No	38	3.54	0.69			
Wayfinding	Yes	21	3.42	0.56	-0.934	57	0.354
	No	38	3.56	0.56			

Independent sample t test, *p<0.05, **p<0.01, ***p<0.001

5.2.4 Analysis of the Effects of The Exhibition Space within Metaverse Duration on Spatial Experience

The relationship between the average time spent by the students in the RB and VB groups and the average scores of the spatial experience dimensions is evaluated with a Pearson correlation test. It is highlighted that there is a negative, weak, and significant correlation (relationship) between metaverse time and engagement ($r = -0.265$, $p<0.05$) and judgement ($r = -0.291$, $p<0.05$) of the students in the RB group and a positive, weak, and significant correlation (relationship) between metaverse time and immersion ($r = 0.310$, $p<0.05$) of the students in the VB group.

This analysis indicates that the duration of time spent in the RB exhibition space is increasing, while the average value of the engagement subscale, which measures interest in the experience, and the average score of the judgement subscale, which reflects participants' thoughts on the virtual architectural space, are decreasing. However, in the VB group, as the period increases, so does the average score on the immersion subscale (Table 5.14).

Table 5.14: The Pearson Correlation Results of Questionnaire on Spatial Experience in Exhibition Spaces within the Metaverse by RB and VB Group

Virtual Exhibition Space	Pearson Correlation	Metaverse time (Minutes)	
		Reality-based	Virtuality-based
Presence	r	-.138	.079
	p	.299	.550
Engagement	r	-.265*	.149
	p	.042	.259
Immersion	r	-.082	.310*
	p	.539	.017
Flow	r	-.018	.215
	p	.892	.102
Judgement	r	-.291*	.170
	p	.026	.198
Wayfinding	r	.007	-.071
	p	.958	.593

Pearson correlation, *p<0.05, **p<0.01, ***p<0.001

5.3 Reliability Analysis

In the study, the Cronbach's alpha coefficient value range for the RB group is 0.634–0.846, and the Cronbach’s alpha coefficient value range of the students in the VB group is 0.637–0.802. The results render the phenomenon measured in the two groups reliable (Table 5.15).

Table 5.15: Reliability Analysis Results of Virtual Exhibition Space by RB and VB Group

Virtual Exhibition Space Subscale	Cronbach's alpha		N of Item
	Reality-based	Virtuality-based	
Presence	0.749	0.649	6
Engagement	0.728	0.745	3
Immersion	0.662	0.714	4
Flow	0.667	0.655	6
Judgement	0.846	0.802	8
Wayfinding	0.634	0.637	4

5.4 Correlation Analysis

In the study, a Pearson correlation test evaluated the correlation between the students in the RB group's mean scores for the virtual exhibition space's spatial experience level.

There is a positive, normal, and significant correlation (relationship) between the presence dimension and engagement ($r = 0.438$, $p<0.001$), flow ($r = 0.440$, $p<0.001$), judgement ($r = 0.416$, $p<0.05$), and wayfinding ($r = 0.461$, $p<0.001$). Also, there is a positive, normal, and significant correlation (relationship) between engagement and immersion ($r = 0.483$, $p<0.001$), flow ($r = 0.463$, $p<0.001$), judgement ($r = 0.422$, $p<0.05$), and wayfinding ($r = 0.491$, $p<0.001$). Additionally, there is a positive, statistically significant correlation between immersion and flow ($r = 0.577$, $p<0.001$) and wayfinding ($r = 0.497$, $p<0.001$), as well as a positive, weak, and significant correlation between judgement ($r = 0.285$, $p<0.05$). Furthermore, there is a positive, strong, and significant correlation between flow and judgement ($r = 0.458$, $p<0.001$) and wayfinding ($r = 0.605$, $p<0.001$), as well as a positive, normal, and significant correlation between judgement and wayfinding (r = 0.363, p<0.001). Nevertheless, no significant correlation was found between presence and immersion (p > 0.05) (Table 5.16).

Table 5.16: The Pearson Correlation Test Results of Virtual Exhibition Space Scale Score by Reality-Based Group

		Presence	Engagement	Immersion	Flow	Judgement	Wayfinding
Presence	r	--					
	p						
Engagement	r	$.438^{***}$	--				
	p	0.001					
Immersion	r	0.245	$.483^{***}$	--			
	p	0.061	0.001				
Flow	r	$.440^{***}$	$.463^{***}$	$.577^{***}$	--		
	p	0.001	0.001	0.001			
Judgement	r	$.416^{***}$	$.422^{***}$	$.285^{*}$	$.458^{***}$	--	
	p	0.001	0.001	0.029	0.001		
Wayfinding	r	$.461^{***}$	$.491^{***}$	$.497^{***}$	$.605^{***}$	$.363^{**}$	--
	p	0.001	0.001	0.001	0.001	0.005	

Pearson correlation, *p<0.05, **p<0.01, ***p<0.001

When the relationship between the mean scores of the virtual exhibition space scale dimension scores of the students in the virtuality-based group was evaluated with a Pearson correlation test;

There is a positive, strong, and significant correlation (relationship) between the presence dimension and engagement (r = 0.541, p<0.001), flow (r = 0.434, p<0.001), judgement (r = 0.359, p<0.05), and wayfinding (r = 0.403, p<0.001) of the students in the virtuality-based group. Also, there is a positive, strong, and significant correlation between engagement and immersion (r = 0.572, p<0.001), flow (r = 0.520, p<0.001), judgement (r = 0.468, p<0.05), and wayfinding (r = 0.368, p<0.001). Additionally, there is a positive, strong, and significant correlation between Immersion and flow (r = 0.562, p<0.001) and judgement (r = 0.545, p<0.001). Furthermore, there is a positive, weak, and significant correlation between flow and judgement (r = 0.291, p<0.001), as well as a positive, strong, and significant correlation between flow and wayfinding (r = 0.390, p<0.001). However, no significant correlation was found between immersion and wayfinding and judgement and wayfinding (p > 0.05) (Table 5.17).

Table 5.17: The Pearson Correlation Test Results of Virtual Exhibition Space Scale Score by Virtuality-Based Group

		Presence	Engagement	Immersion	Flow	Judgement	Wayfinding
Presence	r	--					
	p						
Engagement	r	.541**	--				
	p	0.001					
Immersion	r	0.146	.572**	--			
	p	0.269	0.001				
Flow	r	.434**	.520**	.562**	--		
	p	0.001	0.001	0.001			
Judgement	r	.359**	.468**	.545**	.291*	--	
	p	0.005	0.001	0.001	0.026		
Wayfinding	r	.403**	.368**	0.132	.390**	-0.023	--
	p	0.002	0.004	0.319	0.002	0.860	

Pearson correlation, *p<0.05, **p<0.01, ***p<0.001

5.5 Analysis of Open-ended Questions

The open-ended questions about participants' spatial experience (Table 5.18) ask for both qualitative and quantitative analysis of their spatial experiences. For quantitative analysis of these questions, the web-based Voyant tool is used.

Table 5.18: Open-ended Questions in the Questionnaire on Spatial Experience in Exhibition Spaces within Metaverses

Question 1	In your opinion what were the positive effects of your experience?
Question 2	In your opinion, what were the negative points of your experience?
Question 3	Do you have any suggestions to improve the virtual exhibition space?

The Voyant tool offers a range of characteristics that enable the analysis of texts on different subjects. These features include visual representations of the most commonly used words, the rate of word occurrences, the identification of frequently used keywords, and the identification of word associations (Figure 5.5). There are diverse studies that use Voyant's various features to analyze textual data (Hetenyi, et al., 2019; Masood, et al., 2020).

This thesis utilises four elements of the Voyant tool for analysing the responses to open-ended questions. The initial feature is the *Summary* tool, which examines the texts and presents the overall word count, vocabulary density, readability index, average words per sentence, and the most often mentioned terms and their frequencies in the text. This tool has a stop-word feature that automatically generates a list of excluded words, such as to-be words, articles, and subjective pronouns. This feature can be deactivated, but it is used in this research to have a noteworthy list of words.

The second feature utilised for textual analysis is the *Cirrus* tool, which visually presents the most frequently used words in a way that reflects their frequency by adjusting their sizes, respectively.

Thirdly, the *correlation* tool analyses the relationship of a word with other words with a correlation value. It calculates the selected terms and their correlated terms by comparing the relative frequencies of phrases in the document with the Pearson correlation. If the correlation value approaches 1, it indicates that there is a positive correlation between these words. Conversely, if it approaches -1, it displays the negative relationship between those terms.

The last tool is the *context* tool, which displays how the words are used in the text by allocating the selected keyword in the centre and adding the words that are mentioned on the left and right sides of the term.

The analysis is done by converting the answers for each question into separate Excel files and uploading them to the Voyant tool. The tool divides these files into sections after uploading them, and uses each section for distinct analyses. The answers to each question are analysed separately for the RB and VB groups, in order of: summary analysis, cirrus analysis, correlation analysis, and context analysis.

Figure 5.5: A Screen View from voyanttools.org

5.5.1 Analysis of Open-ended Questions: Question 1

For the first open-ended question, “In your opinion, what were the positive effects of your experience?” The RB group’s answers’ average words per sentence is 28.3, whereas in the VB group, this value is 25.0. The words that received the most mentions are "experience," "different," "able," "artworks," and "exhibition" in the RB group, and "different," "experience," "space," "exhibition," and "artworks" in the VB group, respectively (Table 5.19). The Cirrus graphic, a visualised version of the most frequent words in both groups’ answers, is shown below (Figure 5.6, Figure 5.7).

Table 5.19: The Most Frequent Words in Question 1

Reality-based		**Virtuality-based**	
The most frequent words	**Frequency of the word**	**The most frequent words**	**Frequency of the word**
Experience	21	Different	22
Different	15	Experience	20
Able	15	Space	19
Artworks	13	Exhibition	15
Exhibition	11	Artworks	14

Figure 5.5: Cirrus Graphic of Open-ended Question 1, RB Group

Figure 5.6: Cirrus Graphic of Open-ended Question 1, VB Group

The correlation test is conducted with the list of the most frequent words in both groups. In the RB group, “experience” is significantly correlated with "different” (p > 0.05), “able” with “artworks”, and “exhibition” with “avatar” (p< 0.05). In the VB group, “different” is correlated with “angles”, “experience” with “different”, “space” with “explore”, “exhibition” with “exciting”, and “artworks” with “able”. However, there is no significant relationship between these words (p<0.05) (Table 5.20).

Considering the fact that all correlation values lie within the range of 0 to 1 for both groups, it can be concluded that there is a positive association between the words.

Table 5.20: Correlation Analysis of Open-ended Question 1

	The most frequent words	**The correlated term**	**Correlation (r)**	**Significance (p)**
Reality-based	Experience	Different	0,797	0,005*
	Different	Experience	0,797	0,005*
	Able	Artworks	0,326	0,357
	Artworks	Able	0,326	0,357
	Exhibition	Avatar	0,642	0,044
Virtuality-based	Different	Angles	0,771	0,008
	Experience	Different	0,663	0,035
	Space	Explore	0,649	0,042
	Exhibition	Exciting	0,539	0,107
	Artworks	Able	0,172	0,633

The contextual analysis in the Voyant tool is utilised to comprehend the usage of the words within a given context. This analysis reveals the manner in which a keyword is employed in a text. After a comprehensive analysis of all analyses, three full sentences are selected. Table 5.21 displays three instances of how each word is used in a phrase in the RB group and Table 5.22 in the VB group.

Table 5.21: Contextual Analysis of RB group Open-ended Question 1

Left	**Frequent words**	Right
"It was a very different	***experience***	*since it is in the metaverse environment and different from the virtual exhibitions since in here I can arrange my perspective myself. "*
"It was being a new kind of an exhibition space		*without waiting in the line for tickets etc."*
"Walking around such a museum was interactive and different,		*for me."*
"Interesting and a	***different***	*approach mingled with creativity and fun."*
"This feeling got me excited to explore the space and look at		*artworks as if it were an open-world video game."*
"It was a unique activity to visit		*works of art and see them on the computer."*
"Positive part is that I have not moved to experience art making me more capable to use my time efficiently	***able***	*to be experience the in virtual environment."*
"I can reach more artworks, and I was		*to jump from the sky"*
"The art pieces were inspiring and cool, being		*to interact with people was also exciting."*
"Quality of the	***artwork(s)***	*are generally great, especially presented ones."*
"I was able to experience various		*without the need to physically its accessibility."*
"I loved feeling free in the environment. I liked the interaction between the user and the movement possibilities, and also perceiving the variety of		*that are grouped together."*
"Although I am not into art, being immersed in a virtual	***exhibition***	*space gave me a sense of joy due to the reminiscent feeling of playing video games all through my childhood."*
"I liked how customizable and varied the avatars you can choose from are, it helps in making a person feel more immersed in the		*if their avatar looks like them."*
"It is very hard to spare some of my time to visit art galleries or exhibitions these days, so being able to visit an		*virtually is a very beneficial thing for me."*

Table 5.22: Contextual Analysis of VB group Open-ended Question 1

Left	**Frequent words**	Right
"I was able to see	***different***	*angles like real life. It was a social experience; the layout was easy to wander around."*
"Various perspective views and unique design of the space made the experience better. It is very interesting for me to experience virtual images in		*medium."*
"It's nice to wander around to see various exhibitions. It was challenging and		*experience with the real experience but it is not an alternation for the real one."*
"Different perspective views unique designs of the spaces made the	***experience***	*better."*
"It made me motivated as a designer. It was good to		*the artwork as in a real-life gallery perspective and also closer."*
"The positive effects of the		*was the circulation helped me to follow the path of the exhibition."*
"The artworks, the	***space***	*and the visual environment are like a sci-fiction movie."*
"I was able to explore the		*with my friends."*
"The opportunity to explore different types of artworks in the same		*is quite interesting and the way we choose what we wanted to see is a great."*
"In my metaverse experience, I felt very excited about the being part of the new technological developments, exploring to new things and the	***exhibition***	*space."*
"I think it was nice to have platforms within different levels so that we can experience		*in a more active way compared to the real-life exhibitions by jumping or running etc."*
"I find the concept of		*space within the metaverse positively intriguing."*
"It was interesting being able to see so many	***artworks***	*within a little time and effort."*
"The ability to view all the		*from ground level truly excited me."*
"It seems like a game being able to see the		*closely by clicking on them was great."*

5.5.2 Analysis of Open-ended Questions: Question 2

For the second question, "In your opinion, what were the negative points of your experience?" the average words per sentence in the RB group's answers is 32,4; for the VB group this value is 21.5. The most frequent words are "real", "feel", "like", "experience" and "space" sequentially in the RB group, and "feel", "like", "exhibition", "artworks" and "space" in the VB group (Table 5.23). The visualisation of the most-mentioned words is displayed graphically below (Figure 5.8, Figure 5.9).

Table 5.23: The most frequent words in Question 2

Reality-based		Virtuality-based	
The most frequent words	**Frequency of the word**	**The most frequent words**	**Frequency of the word**
Real	15	Exhibition	27
Feel	15	Artworks	15
Like	14	Feel	13
Experience	13	Like	12
Space	11	Space	11

Figure 5.7: Cirrus Graphic of Open-ended Question 2, RB Group

Figure 5.8: Cirrus Graphic of Open-ended Question 2, VB Group

According to the correlation analysis of the most frequent words in the RB group, “like” is correlated with “artworks” and “space” with “negative” significantly. In the VB group, “like” is correlated with “exhibition” significantly ($p > 0.05$). Additionally, in the RB group, “real” is correlated with “game”, “feel” with “environment”, and “experience” with "able,” and in the VB group, “exhibition” is correlated with “different”, “artworks” with “able”, “feel” with “exhibition”, and “space” with “different”. There is no significant relationship between these words ($p<0.05$). Since all correlation values are in the range of 0 to 1 for each word, it states that there is a positive relationship between the terms (Table 5.24).

Table 5.24: Correlation Analysis of Second Open-ended Question 2

	The most frequent words	**The correlated term**	**Correlation (r)**	**Significance (p)**
Reality-based	Real	Game	0,714	0,02
	Feel	Environment	0,631	0,05
	Like	Artworks	0,869	0,001*
	Experience	Able	0,772	0,008
	Space	Negative	0,842	0,002*
Virtuality-based	Exhibition	Different	0,428	0,216
	Artworks	Able	0,371	0,29
	Feel	Exhibition	0,633	0,049
	Like	Exhibition	0,73	0,005*
	Space	Different	0,791	0,006

The contextual analysis is conducted with the most frequent words in the responses to the second question and completed with the selection of three examples of full sentences that are stated by the Voyant tool (Table 5.25., Table 5.26.).

Table 5.25: Contextual Analysis of RB Group Open-ended Question 2

Left	**Frequent words**	Right
"It does not give the	***real***	*effect of experiencing an exhibition."*
"The experience felt more like playing a game more than visiting the gallery which I cannot came across in the		*life."*
"I felt like I am in a game environment that I did not feel real		*and instead of focusing on the artwork It felt like I was playing a game and the art was just a mere background decoration rather than the focus of the space."*
"The resolution was low so it makes harder to	***feel***	*really engaged with the environment."*
"I		*like I am in a game environment."*
"The way the works were plastered on the walls also felt unnatural, so looking at them didn't		*nice either (maybe due to my personal dislike for NFTs)."*
"The empty areas made it seem more	***like***	*a game."*
"Controlling my character felt		*was my main purpose rather than looking at the artworks."*
"The path is kind of hard to follow and when compared with the real experience actually it is kind of made me feel		*this is a game not as experience that I had."*
"It is not the real	***experience***	*mimicking the same architecture not impressing enough and dull a little bit."*
"Cannot getting out of the "box" like structure is bad for		*, open or semi open spaces might be good."*
"The		*was not directing our focus to the art."*
"I couldn't access to the exterior	***space***	*which make me aware of that I am in a closed fake building."*
"The guide of the inner		*is not sufficient."*
"The quality of the		*is a bit lacking although I have no other example to compare it with."*

Table 5.26: Contextual Analysis of VB Group Open-ended Question 2

Left	**Frequent words**	Right
"Being in the	***exhibition***	*space environment makes me feel different. I felt like I am part of the exhibition by experiencing the space and artworks with the people around me."*
"The		*did not portray the authentic feeling of a real exhibition."*
"Doing emotes, jumping around kind of loses the sense of being in a quiet		*and loses its seriousness."*
"Not being able to touch or seeing the details or textures of the	***artworks***	*is a lacking experience."*
"It does feel like the		*'s are the main points."*
"The		*, the screen and all the movements make me feel distracted, preventing me from focusing on the essence of the artwork."*
"I found myself in a very unrealistic world, and I didn't	***feel***	*like I was in a suitable exhibition environment for art pieces."*
"I want to		*the artworks if I would have a chance."*
"I do not		*like I am in a meaningful exhibition when I do dancing emotes."*
"I was lost at some point since it was felt	***like***	*the exhibition is endless."*
"It is more		*playing a game rather than walking in an exhibition."*
"I didn't feel		*I was in an appropriate exhibition environment."*
"I felt lost in my way in the	***space***	*and confused where to go."*
"The open		*confused me; I didn't know where to begin, and at some point."*
"Only being in a circular		*was a different experience, and also It was hard to move."*

5.5.3 Analysis of Open-ended Questions: Question 3

The average word count in the answers to the third question, “Do you have any suggestions to improve the virtual exhibition space?” in the RB group is 30.4, whereas it is 25.6 in the VB group. The words most mentioned in the RB groups are “maybe”, “space”, “realistic”, “experience”, “better” and in the VB group, these words are “space”, “environment”, “real”, “exhibition” and “virtual” sequentially (Table 5.27). The cirrus graphs are added to have a more comprehensive understanding of the words and their frequency below (Figure 5.10, Figure 5.11).

Table 5.27: Frequent words of responses to Open-ended Question 3

Reality-based		**Virtuality-based**	
The most frequent words	**Frequency of the word**	**The most frequent words**	**Frequency of the word**
Maybe	21	Space	19
Space	7	Environment	13
Realistic	7	Real	12
Experience	7	Exhibition	10
Better	7	Virtual	9

Figure 5.9: Cirrus Graphic of Open-ended Question 3, RB Group

Figure 5.10: Cirrus Graphic of Open-ended Question 3, VB Group

The correlation analysis shows that the most frequent words in the RB group, “maybe”, are correlated with “like”, “space” with “feeling”, “realistic” with “feel”, “experience” with “art”, and “better” with “artworks”. However, these correlations between the words are not significant (p<0.05). In the VB group’s answers, the most frequent words, such as “environment” and "real," are significantly correlated with “attention” and "life,” respectively (p > 0.05). In the same group, “space” is correlated with “able”, “exhibition” is correlated with “better”, and “virtual” is correlated with “design” without a significant value (p<0.05). The correlation values for each word fall within the range of 0 to 1, indicating a positive correlation between the words (Table 5.28).

Table 5.28: Correlational Analysis of Open-ended Question 3

	The most frequent words	The correlated term	Correlation (r)	Significance (p)
Reality-based	Maybe	Like	0,496	0,144
	Space	Feeling	0,780	0,07
	Realistic	Feel	0,647	0,042
	Experience	Art	0,47	0,226
	Better	Artworks	0,512	0,13
Virtuality-based	Space	Able	0,692	0,26
	Environment	Attention	0,813	0,004*
	Real	Life	0,836	0,002*
	Exhibition	Better	0,609	0,611
	Virtual	Design	0,643	0,044

The contextual analysis is conducted with the most frequent words in the responses to the third question and completed with the selection of three examples of full sentences that are stated by the Voyant tool (Table 5.29, Table 5.30).

Table 5.29: Contextual Analysis of RB Group Open-ended Question 3

Left	**Frequent words**	Right
"The gallery	***maybe***	*designed in more intriguing way rather than a realistic gallery."*
"Background could be something else,		*more abstract but not like located in an isolated area."*
"The information receiving aspect		*pressing on the art a window can appear showing information."*
"The sense of seeing a gallery how light reflects on the artworks or surfaces, the textures, shadows might make the	***space***	*more engaging."*
"Maybe rendering could be improved especially in the interior		*, so that the person who got there totally forget the real world."*
"The environment's outdoor		*should be changed to something lively and maybe by adding more furniture, such as exhibition spaces in the center and also some vegetation for colour would be nice."*
"Maybe adopting a more	***realistic***	*sort of graphic style would help making it feel more serious than a simple game."*
"NPCs will help the environment feel more		*rather than empty and lonely space."*
"The graphics may be more		*."*
"Computer screen and mouse made the	***experience***	*less interactive and authentic for me."*
"It would be great to see other people during the		*to feel the texture of the artworks and to read their narratives."*
"Enlarging spaces and including several more spaces in different height levels might enhance the		*."*
"It would be	***better***	*to experience the world through VR glasses."*
"Implementing more realistic effects and selection of		*artworks could be nice."*
"The experience of viewing a gallery and how light reflects on the artworks or surfaces, textures, and shadows may make the environment more interesting and a		*experience."*

Table 5.30: Contextual Analysis of VB Group Open-ended Question 3

Left	**Frequent words**	Right
"I think the galaxy-space background takes the attention from the exhibition	***space***	*."*
"The quality of the architectural		*could be improved by adding some arrows for wayfinding, giving more clear instructions about the controllers, and making it also operable and also having more eye-catching explanations about each room."*
"Widening the paths of the		*may able us to see the art pieces better."*
"Visual quality can be better and more like the real-life	***environment***	*so that we can pay attention to the artworks."*
"Circular shapes in the virtual		*were unpleasant to look at because the screen experience differed from real-life spatial perception."*
"It would be a better experience if the virtual		*had similar rules of engagement as the physical environment."*
"It would be good if it is fitted inside of a	***real***	*life building"*
"Maybe a more realistic background rather than a galaxy or different selection of the artworks from		*life."*
"It would make more sense for user experience to enter spaces sequentially like in the		*world rather than appearing in one space at the same time."*
"Seeing the	***exhibition***	*space from the perspective of avatar is really helpful."*
"Paths for the		*could be defined better."*
"The		*signs can be bigger to get more attention."*
"Seeing my	***virtual***	*character distracted me sometimes."*
"It would be a better experience if the		*environment had similar rules of engagement as the real one."*

5.6 Takeaways

- The mean scores of RB in the questionnaire for the subscales of presence, engagement, flow, judgement, and wayfinding are higher than the VB. Nevertheless, the mean score of the immersion subscale in the VB is higher than that in the RB group.

- According to the independent sample t-test, the presence score of the RB group is significantly higher than that of the VB group, as indicated by the independent sample t-test. However, there is no significant difference between the two groups in the other subscales.

- Individuals who had previously encountered the metaverse environment report a greater sense of immersion in the VB environment, whereas the former experience has no significant impact on the RB group's subscales.

- The VB group members who had previously experienced virtual exhibition spaces indicate higher levels of immersion, whereas their prior experiences do not substantially influence the other subscales in either group.

- The duration of the experiment influences the subscales of spatial experience. The immersion score increases as the time spent in the RB environment increases, while the participation and judgement scores decrease substantially as the time spent in the VB group increases.

- The correlation test indicates that there is no significant relationship between presence and immersion, stating that being present in the RB exhibition environment does not have a relationship with feeling immersed. The other subscales have a positive and significant correlation with each other. Furthermore, in the VB group, there is no robust and statistically significant association between presence and immersion, engagement and wayfinding, or judgement and wayfinding. This implies that the degree of users' subjective presence in a virtual world does not always correlate with their level of immersion. Additionally, the level of engagement with the virtual environment does not influence users' capacity to navigate it effectively. Furthermore, users' cognitive ability to make judgements does not affect their skills in navigating the virtual space. The other subscales exhibit a positive and statistically significant association with one another.

- In the initial open-ended question, participants from both groups frequently use similar phrases when discussing the positive consequences of their experiences. The RB group predominantly utilise the words "experience", "different", "able", "artworks" and "exhibition", whereas the VB group specifically highlight the words "different", "experience", "space", "exhibition," and "artworks." In the RB group, there is a significant correlation between the term "different" and the word "experience." In contrast, the VB group associate the word "different" with "angles". This indicates that both groups focus on distinct parts of their experiences. Simultaneously, both groups express in their responses that their experiences are unique and different.

- In the second question, when the participants discuss the negative aspects of their experiences, both groups employ similar vocabulary. The terms "real", "feel", "like", “experience”, and “space” are the most commonly mentioned words in the RB group, whereas the VB group mostly employ the words "exhibition", "artworks", "feel", "like" and "space". The RB group significantly associate the term "like" with "artworks", whereas the VB group link it with "exhibition." Both groups state that the spatial encounters are unrealistic and reminiscent of a game, which impact their experiences within virtual exhibition spaces.

- In the third open-ended question, participants discuss their suggestions to improve the experience. Both groups specifically highlight the importance of enhancing the realism of the environment and improving the graphics. Within the RB group, participants emphasize the necessity of enhancing the environment's realism and elevating the graphics' quality. Notable terms like “maybe”, “space”, “realistic”, “experience”, and “better” are frequent. Since one of the most used words is “maybe”, the participants express their hesitations while giving suggestions to improve the experience. Within the VB group, the terms “space”, “environment”, “real”, “exhibition”, and “virtual” are the most commonly mentioned. Within the VB group, there is a strong correlation between the terms “environment” and “attention”; and “real” and “life”.

CHAPTER 6

DISCUSSIONS AND CONCLUSION

This study's main concern is the impact of different design approaches in metaverse exhibition spaces on the spatial experiences of the users. However, it is crucial to highlight that this exploration goes beyond the spatial experience and discusses aspects related to architecture and art in virtual realms. Therefore, this section explores the interrelationship of these topics by examining qualitative and quantitative data collected throughout the survey. The outcomes are mentioned under three subtitles: spatial experience, art, and architecture.

6.1 Discussions About Spatial Experience

This section of the study focuses on the overall spatial experience in the metaverse exhibition spaces. It provides a framework to understand the impacts of diverse design approaches on users' spatial experiences. Participants in the RB group have higher mean scores in the subscales of presence, engagement, flow, judgement, and wayfinding than the VB. However, the mean score of immersion subscale, that describes the substantial illusion of real experience with virtual experience in the VB is higher than RB. Even the difference between mean scores is insignificant, it provides insight into how the spatial experience is changing between the groups.

Specifically, the survey's presence subscale indicates that users who experience RB exhibition spaces have a considerably higher sense of presence compared to those who visit VB spaces. This finding supports Laarni's (2003) assertion that a realistic design approach in the environment enhances the feeling of being present. However, the finding contradicts the theory by Chung et al. (2024), who claim there are no significant differences in the effects of different design approaches to exhibition spaces on visitors’ spatial experiences. In this research, the RB environment's implementation of design elements that mirror the physical world had an impact on the visitors' spatial experience. As Schorch (2014) states, the context of an exhibition environment affects the visitors’ spatial experience and certain design features may promote the sensation of physically "being there" (Takatalo, et al., 2020).

Moreover, the effect of prior experiences in virtual environments that create a frame for future experiences on the spatial experience cannot be denied. According to the findings, participants who had not experienced the metaverse before felt more immersed in the VB environment. An identical result is observed for the individuals who had not been in any virtual exhibition spaces. Being in a VB setting that does not incorporate realistic architectural components allowed participants who were unfamiliar with metaverse environments or virtual exhibition spaces felt more immersed.

In addition, although the sensation of presence is acknowledged as a crucial element for experiencing immersion (Azarby & Rice, 2022), no significant association was observed between the presence and immersion subscales in either of the groups. Simultaneously, it was discovered that the wayfinding subscale in the VB environment does not exhibit any link with the engagement and judgement subscales. However, within the RB group, wayfinding is positively and significantly connected with the presence of subcele, which aligns with Laarni's (2003) assertion that the ease of navigation in the virtual environment positively influences the sense of presence. These findings emphasise the complex and diverse connections between different components of spatial experience in metaverse environments, suggesting that the parameters that affect spatial experience might vary depending on the design characteristics of the virtual world.

Additionally, the duration of time that individuals spend in the locations has varying impacts on their spatial experience. Based on the findings, participants who spent more time in the RB environment experienced a decrease in their levels of engagement and judgement. However, the longer participants spend time in the VB environment, the higher their level of immersion becomes.

Furthermore, experiences in the RB and VB environments are unique to each participant. In RB, one of the most mentioned words is "different”, which is significantly related to the word “experience”. In contrast, the word “different” is insignificantly associated with the word “angles” in the VB environment. This result supports the fact that each participant focused on a different aspect of their experience. Therefore, open-ended questions in both environments are distinguished by their distinct and unique spatial experiences (Table 6.1).

Table 6.1: Quotations from Open-ended Questions about Spatial Experience

Example 1. (RB-1st question)	*"It was a different experience for me to walk around the museum, and also it was really fun to be in there. "*
Example 2. (RB-3rd question)	*“The spatial experience could be made more interesting. I think more complex and articulated spaces would make the experience more interesting and unique.”*
Example 3. (VB-2nd question)	*"It was an interesting experience to travel around an exhibition without walls or boundaries. The visual freedom of the environment excited me to see different places.”*
Example 4. (VB-2nd question)	*"Being unable to touch or perceive artwork details or textures is bad. Because we can only see and hear, other emotions remain unsatisfied. I also want to smell the exhibition. If possible, I want to touch the art. I would touch art in a real exhibition place even if it's forbidden. Because I can connect with art when I feel its texture. I feel different and like I'm part of the show by experiencing the space and artworks alongside others. "*
Example 5. (RB-3rd question)	*“The spatial experience could be made more interesting by designing more unique spaces. I think more complex and more articulated irregular spaces would make the experience more interesting and unique.”*

6.2 Discussions About Architecture

The architectural design of the metaverse exhibition spaces is one of the fundamental components that affects the spatial experience. Both realistic and unrealistic design approaches in the environments influences participants' perceptions of the environment and navigation.

The open-ended questions expose the participants' perspectives on these two distinct design methodologies. As Moneta (2020) states, current virtual worlds do not go beyond mimetic realism; even virtual architecture has the potential to be creative without constraints. In the open-ended question, participants experience support Moneta's (2020) perspective, since the word "real" was frequently referenced when discussing the negative aspects of the RB environment. Their statements refer to the fact to the fact that the virtual world needs to offer a new interpretation of architecture and implement utopian visions.

Within the VB environment, users are enabled to jump into the skybox, navigate between platforms via freefall, teleport to other spaces with portals, and observe the freestanding artworks in open space. In contrast, the RB environment offers a conventional exhibition, with all the architectural elements like windows and doors displaying the artworks on the walls in an enclosed space. These differences in architecture affect the feelings of participants. Participants in the RB group mentioned a sense of restriction, whereas statements in the VB group are about a sense of freedom.

This is further supported by observation log data, indicating that individuals in the VB setting are more likely to explore the capabilities of avatars and activities like freefalling and jumping facilitated by the spatial design design. Furthermore, following the experiment, a total of 6 students from the VB setting inquired about the process of creating such a design and the tools used to model it. This suggests that the VB design approach captures the students' attention more effectively. Additionally, the RB group frequently mentioned the word "may be" in the question about their suggestions. Compared to the RB group, the participants exposed to the VB setting showed reduced hesitancy while providing suggestions.

Moreover, the data reveals that one of the most mentioned words is “space” in both groups in the second open-ended question. However, in the RB group, “space” is significantly correlated with “negative” while it is related to “different” in the VB group. The RB group’s participants mentioned how the space is insufficient in terms of rendering quality and is like a replica of a physical building. The VB group reported feeling confused during the experiment. This confusion was attributed to the absence of vertical limits, navigational aids, and directions in the open-space architecture of the virtual environment. Therefore, all these data state that individuals anticipate a high degree of similarity when they find themselves in an environment resembling the physical world, and encountering a different architectural environment might lead to ambiguity (Table 6.2).

Table 6.2: Quotations from Open-ended Questions about Architecture

Example 1. (RB-1st question)	*"Experiencing a new way of architecture profession was great for me while I, as a " generation Z" also have the intention to these kind of new digital transformation in architecture."*
Example 2. (RB-2nd question)	*"It did not feel real even it is mimicking the physical world and instead of focusing on the artwork it felt like i was playing a game and the art was just a mere background decoration rather than the focus of the space. Controlling my character felt like was my main purpose rather than looking at the artwork presented."*
Example 3. (RB-3rd question)	*"The experience that is offered to the user, is an imitation of real. However, I believe that the virtual world finds its meaning when it offers something new and different than real. I think we should talk about new cognitive effects of this environment, rather than everyday life."*
Example 4. (VB-1st question)	*"When I jump into this metaverse environment, I felt different and the first question that coming to my mind is that which application that the creator use. And the artworks, the space area and the visual environment create like a sci-fiction movie or game in my mind. "*
Example 5. (VB-3rd question)	*"The environment is different from the reality, utilizing ramps and platforms that make this exhibition unique. The ability to view all the artwork from ground level truly excited me. Walking around all the artworks was a great experience for me. Additionally, the background image captured all my attention during the exhibition."*

6.3 Discussions About Art

Based on the symbiotic relationship between spatial experience, art, and architecture, this section highlights points that may be impactful for the art industry. Firstly, the existence of exhibition spaces on online platforms is a crucial milestone for the art industry, as it allows users to experience the whole curation with one click. The quantitative data of open-ended questions about the positive sides of the spatial experience supports this since one of the most used words is “artworks” and correlates with the word “able” in both groups. Even though these correlations are insignificant, numerous students from both groups mentioned the ease of visiting an exhibition space online. As Shiode and Knoshima (1999) state, the Internet enhances accessibility to the collections of museums, whereas real museums limit this interaction with physical distance, and it also enables the exhibition of a larger number of collections online at any time. In the open-ended questions, participants mentioned that being in an online exhibition allows them to experience the artworks from their comfort zone.

In response to the initial open-ended question regarding the positive aspects of the experience, the term "exhibition" was frequently cited, with some noting that the approach to designing exhibition spaces needs to differ from that of real-life surroundings in both settings. Both groups also draw parallels between their experiences and gaming experiences. Even though the present condition of exhibition spaces is improving with the integration of technology, creating places to experience art more interactively and in a gamified fashion, there are still those who have a prejudice against the notion of art exhibition spaces as answers to the question about the negative sides of the experiences in the VB group mentioned.

The data based on the observation log indicates that 28 students got more information about NFTs by following the links in the exhibition, checking out the other works of the artist, and downloading the PNG versions of NFTs. This validates Shiode and Knoshima's (1999) claim that virtual exhibitions encourage visitors to focus on the artworks they are interested in and learn more about the artist and their works through the Internet. Furthermore, NFTs, which encourage engagement, have significantly improved this interaction with their advanced technology and unique concept. In addition, 3 students from the VB group inquired about the selection process of curation and expressed their interest in participating in future curations of the NFT Biennial, which demonstrates the interest of younger generations towards NFTs. Unusual curating approaches affect the ambiance of the artworks (Aydoğan, 2021), which may lead to curiosity about both the NFTs and the artworks (Table 6.3).

Table 6.3: Quotations from Open-ended Questions about Art

Example 1. (RB-1st question)	*“It's very exciting to look around; so it was more attractive in some ways than an actual exhibition. I was also able to navigate among others quickly and without wasting time on foot.”*
Example 2. (VB-1st question)	*“Although I am not into art, being immersed in a virtual exhibition space gave me a sense of joy due to the reminiscent feeling of playing video games all through my childhood. This feeling got me excited to explore the space and look at different artworks as if it were an open-world video game. In doing such, this also allowed me to actually closely inspect and observe different artworks in a way that gave me joy.”*
Example 3. (RB-1st question)	*“It is very hard to spare some of my time to visit art galleries or exhibitions these days, so being able to visit an exhibition virtually is a very beneficial thing for me. It will provide more opportunities to people to visit various places and see many different things. It is also very easy to follow the path of the gallery and very easy to adapt to the environment.”*
Example 4. (RB-3rd question)	*" Doing emotes, jumping around kind a loses the sense of being in a quiet exhibition and makes it lose its seriousness. I do not feel like I am in a meaningful exhibition when I do dancing emotes."*
Example 5. (VB-2nd question)	*"I tend to think more traditionally, believing that virtual reality experiences detract from the essence of why we create artwork. I don't think viewing a piece from a screen can ever replicate the experience of seeing it in an actual exhibition. For me, VR is distracting and diminishes the value of artwork."*

6.4 Conclusion

Metaverses are platforms that allow the creation of 3D virtual worlds by going beyond the limits of the physical realm (Yang et. al., 2023). The ability to construct a parallel universe in metaverses and the NFT concept have led to the emergence of exhibitions spaces within metaverses. By evaluating NFTs as values of engagement drivers, this thesis reviews the impact of different design approaches in exhibition spaces within metaverses on people’s spatial. This study highlights the significance of metaverse development in the fields of art and architecture, aiming to comprehend people’s perspectives both towards the architecture of these environments and towards the NFTs.

The study comprises two phases: a pilot study and the main study. The main study involves 118 students from Bilkent University's Architecture Department, comprising students in the second, third, fourth grades, and graduate studies. The results of the participants’ spatial experience were obtained with a 5-point Likert scale survey that was analysed through frequency and percent analysis, relationship analysis (independent sample t-test and Pearson correlation analysis), and reliability analysis (Cronbach's alpha). In addition to the survey, three open-ended questions, which were analysed via the Voyant tool, required more general knowledge about participants’ spatial experience. The demographic data provides insights into the participants' knowledge of metaverses and virtual exhibition spaces, while their responses to open-ended questions indicate a more profound comprehension of their spatial experience. In response to the first research question, the findings indicate that participants feel significantly more present when the design of the metaverse exhibition space reflects the real-life architectural elements.

This study investigated a range of metaverse galleries that employed unique design methodologies. This analysis presents a framework for analysing the execution of RB and VB methods in metaverse environments, specifically addressing the second research question. It also identifies the most appropriate RB and VB environments for conducting the experiment. This thesis reveals important implications for the optimal design of exhibition spaces in metaverses. While certain participants preferred to experience a more realistic space reflecting traditional galleries, others stated that these spaces should deviate from physical reality and push the boundaries of cyberspace. The incorporation of exhibition spaces into metaverses that allow people to experience curation online is a significant achievement in the arts sector, providing a more accessible experience and inclusivity to a wider audience. At the same time, it is observed that some people have a prejudiced perspective regarding the ideal design of virtual exhibition spaces. The virtuality-based environment arouses curiosity about the artworks and the making process of the exhibition space. This work has revealed the impact of architectural features within metaverse exhibitions on the user's experience. In response to the third research question, this study establishes a framework for a forthcoming metaverse exhibition that clarifies the relationship between different architectural approaches employed in these environments and the subsequent reactions of participants.

This thesis is one of the first and few efforts to understand the impact of the design of exhibition spaces within metaverses on the spatial experience. The implemented research methodology provided insights into various aspects of spatial experiences, such as presence, engagement, immersion, flow, judgement, and wayfinding. The study is done with the participation of many students on the platforms simultaneously, causing overload due to the requirement of a certain internet connection for Spatial io.

In addition to this, since the students experimented on their personal computers, a few of them encountered difficulties in establishing a connection to Spatial io using their web browsers. For further studies, conducting this research in a controlled laboratory environment, equipped with instruments and a powerful internet connection, might potentially address any technical issues that may arise throughout the experiment. This study was conducted with students in architecture on the Spatial io platform with two design approaches: VB and RB. Further studies may engage students from various disciplines on a different metaverse platform with diverse design methodologies.

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APPENDICES

APPENDIX A

Questionnaire on User Experience in Exhibition Spaces within the Metaverse

Demographic Questions

1) Age: ______

2) Gender:

    - Male
    - Female

Metaverse environment familiarity questionnaire

3) How many hours do you spend on the computer per week?

    - 2-5 hours a week
    - More than 5 but less than 10 hours a week
    - More than 10 hours a week

4) Have you ever been in a Metaverse Environment?

    - Yes
    - No

5) If It is yes;
   Which Metaverse Environment have you experienced?
    - Cryptovoxels
    - Decentraland
    - Fortnite
    - Minecraft
    - oncyber io
    - Roblox
    - Second Life
    - Spatial io
    - Somnium Space
    - The Sandbox
    - Other:_______

6) For which purpose have you been in a Metaverse?
   - o Museum / Art exhibition experience
   - o Game
   - o Research
   - o Other:________

Virtual exhibition space familiarity questionnaire

7) Have you ever been in a Virtual Exhibition Space?
   - o Yes
   - o No

8) If It is yes;
   Which Virtual Exhibition Space have you experienced?
   - o Google Arts & Culture
   - o Virtual Exhibition on Metaverse platfrom
   - o 3D Online exhibition platform
   - o Other:________

Visit the Virtual Exhibition Space

Group A: Please go to the link: Verses Gallery to take a tour inside the environment and examine the artworks. After you finish your tour, return to this link and proceed with the questionnaire by clicking 'next' button below.

Group B: Please go to the link: NFT Biennial Gallery to take a tour inside the environment and examine the artworks. After you finish your tour, return to this link and proceed with the questionnaire by clicking 'next' button below.

Questionnaire on User experience in Virtual Exhibition Environments within the Metaverse

Referring to the experience at virtual exhibition space, please answer the following questions using the rating scale below.

Presence Subscale

1) I was able to actively observe the virtual environment.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

3) I could examine artworks from multiple viewpoints.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

4) I felt proficient in moving and interacting with the virtual environment at the end of the experience.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

5) I found my experiences in the virtual environment to be consistent with my real-world experience.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

6) The visual display quality distracted me from visiting the virtual exhibition space.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

7) The devices (keyboard and mouse), which controlled my movement, distract me from experiencing the space.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Engagement Subscale

8) The visual aspects of the virtual environment engaged me.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

9) The sense of moving within the virtual environment was interesting.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

10) I was involved in the virtual environment experience.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Immersion Subscale

11) I felt excited by the virtual environment.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

12) I become so engaged the virtual environment that I was not aware of things happening around me.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

13) I got scared by something happening in the virtual environment.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

14) I become so involved in the virtual environment that I lose all track of time.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Flow Subscale

15) I felt I could perfectly control my actions.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

16) At each step, I knew what to do.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

17) I felt I controlled the situation.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

18) Time seemed to flow differently than usual.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

19) I was losing the sense of time.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

20) I felt I was experiencing an exciting moment.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Judgement Subscale

21) I found that this virtual architectural space was original.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

22) I found that this virtual architectural space was lame (1) / exciting (5).

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

23) I found that this virtual architectural space was easy (1) / challenging (5) in terms of wayfinding.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

24) I found this virtual architectural space amateurish (1) / professional (5).

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

25) I found this virtual architectural space unpresentable (1) / presentable (5).

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

26) I found that this virtual architectural space is ugly (1) /beautiful (5).

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

27)

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

28) I found that this virtual architectural space is discouraging (1) / motivating (5).

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

Wayfinding Subscale

29) Entering the virtual exhibition space, I felt good about the environmental image.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

30) With the help of virtual exhibition space's environmental image, I felt confident in wayfinding.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

31) I relied on the virtual space's environmental image to decide how to reach my destination.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

32) I had to make an effort to identify the locations of the pathways.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Open-ended Questions

Referring to the experience at virtual exhibition space, please answer the following questions.

1) In your opinion what were the positive effects of your experience?

____
____
____

2) In your opinion, what were the negative points of your experience?

____
____
____

3) Do you have any suggestions to improve the virtual reality environment?

____
____
____

APPENDIX B

Research Participation Consent Form

Purpose
The aim of this research is to how virtual exhibition spaces in metaverses should be developed, following conventional architectural styles similar to the real world or any styles that fit cyberspace. As a participant, I am asked to tour one of the two experiment spaces of this research.

Participation
I am one of the approximately 100 participants of this research study. I understand that the assignment of the virtual space I will tour will be done by the investigator. My participation is entirely voluntary. I feel comfortable taking part in this research. As a participant, I can decide to withdraw from participation while informing the researcher at any stage of the experiment or I can be excluded from the research if deemed necessary by the researcher. I am aware that my relation with Bilkent University and my academic evaluation will not be affected if I don't participate or if I withdraw from participation. Also, if I have any questions regarding this research, I can contact the investigator, advisor of the investigator or Bilkent University Local Ethics Committee.

Procedure
As a participant in this research, I will fill an initial questionnaire about my gender, age, familiarity with metaverses,virtual exhibition spaces, spatial ability and flow state of mind. Then I will tour a virtual exhibition space and examine the artworks. Finally, I will fill in a questionnaire about my experience in the virtual exhibition space.

Benefits and Risks
There will be no direct benefit to me from this study. However, the findings have the potential to make a contribution to the field of design. Participating in this research will help the research collect the necessary data to test the theories and therefore, add to the existing limited knowledge and research on virtual exhibition spaces. I understand that this research will not cause me any harm, there are no known or expected risks caused by the participation in this study.

Compensation

I will not be compensated for my participation in this research. No money will be paid for participating in this research study nor will extra credits be given within the courses.

Confidentiality

Any information obtained in relation to this research study will be reported and published for scientific purposes. As a participant, any information about my identity will remain confidential and placed in investigator's locked secure storage for two years after the completion of the research.

By signing below, I am accepting that I have read and understood this form. I have asked all the questions I have and I understand what I am being asked to do. By signing below, I accept that I am willing and would like to participate in this study.

Name of the Participant: ______________________________________
(First) (Last)

☐ I am above 18 years old.

______________________________	______________________________
Signature of the Participant	Date
______________________________	______________________________
Signature of the Investigator	Date
______________________________	______________________________
Signature of the Advisor	Date